AGG Technical Bulletin #3

Thermally induced stress in glass

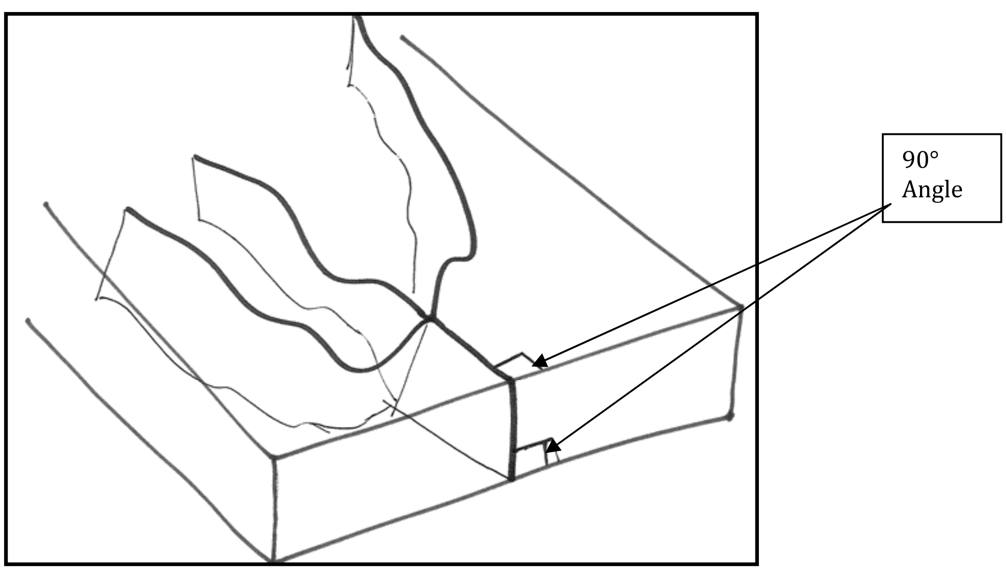
To meet the requirements of energy efficiency in buildings, the use of solar control glasses has become more common.

Careful consideration is required when specifying such glasses to avoid the possibility of thermal venting (fracture).

Venting caused by thermal stress is not covered by the manufacturers' warranty.

What is thermal stress?

Thermal stress is caused by unequal temperatures in the same glass pane i.e. when one part of the glass expands with the heat, and another part resists this expansion because it is cooler. This causes stress in the glass and when the stress generated is greater than the edge strength of the glass, a thermal fracture will occur.



Thermal Vent at Edge of Glass

A thermal stress breakage is easily identified. The start of the crack is at 90° to both the edge and the face of the glass. Depending on the intensity of the released energy, the crack may only travel a few millimetres before branching out and veering offline. *Low stress thermal breakage* forms a single crack that meanders across the glass surface, whereas a *high stress thermal breakage* can be seen to initially have one crack which then branches into a number of separate cracks a short distance from the origin of the thermal break.

Thermal breakage occurs in annealed glasses (not heat treated) which retain (absorb) heat. Such glasses are tinted, reflective (with the coating to surface number #2) and coated types such as low emissivity glasses.

Sometimes thermal breakage can occur if a *solar control film* is applied to clear annealed glass, as this alters the characteristics of the clear annealed glass to that of a solar control glass.

How it happens

Thermal fracture is caused by the *temperature gradient* in the glass, not purely by temperature alone. The temperature gradient is the difference in temperature between the hot and cooler areas of the glass. Let's look at this in more detail.

Tinted solar control glasses reduce solar transmission by absorbing energy into the body of the glass, consequently raising the glass temperature. Generally, as a rule, the darker the tint, the greater the amount of energy absorbed, and the more solar energy a glass absorbs the more chance it has of thermal breakage.

Low emissivity glasses can also increase solar absorption. The coating reduces the passage of radiant heat flow through the glass, thus raising the glass temperature and increasing the thermal stress.

Even different glass types with the same colour have varying levels of absorption; see example below-

Grey Glass	**Solar Energy Absorption**
6mm Standard tint	**45%**
6mm Reflective tint	**63%**
6mm High performance tint	**88%**

This absorbed energy heats up the glass (Try touching tinted glass on a hot day!), causing the glass area to expand. The edges of the glass are normally in a glazing rebate and therefore are kept cooler than the rest of the glass pane. If the band of cool glass is not strong enough to withstand the opposing forces, breakage occurs.

It has been estimated that for every one degree difference in temperature between the edge and centre of the glass, a stress of approximately 0.62 Mpa is generated. Bearing in mind that sometimes this temperature difference can be in the order of 20 to 30 degrees, a stress of 12 to 19Mpa can be generated, which is higher than the design stress used for wind loading.

Glass Edge

The amount of thermal stress a glass can withstand is affected by the quality of the glass edge. The edges that best resist thermal stress are good *clean cut edges.*

Poor quality cut edges can reduce the glass strength by 50% or more. Edge damage caused by manufacturing or installation is the main cause of low stress thermal breakage.

Glass size

The larger the pane of glass is, the greater the area which is absorbing solar energy in comparison to the narrow band of cooler glass at it's' edge. This causes higher levels of thermal stress at the glass edge.

Other causes of thermal stress

There are other contributing factors, which are outside the glass manufacturers' control that can have an adverse effect on glass and thereby cause thermal stress.

i. **External shading of glass.**

   The effect that shading has on glass is governed by the size, shape and location of the glass, and also don't forget that these shadows are *seasonal*. As the sun's position changes with the time of year, so do the shadows.

   Additions to the building after glazing (for example louvered shading devices) and even construction of new buildings close by which may cast shadows are an issue outside the control of glazier and supplier.

   Even the framing itself can cast shadows.

   In essence, shading that covers less than 50% of the glass is an issue, shading that is static is worse than mobile shading, and shading shapes which are V or L shaped with the point of the V or L falling on the edge of the glass induce the highest thermal stress.

ii. **Internal shading**

   Again, unless specified at design stage, we have another issue.

   The use of close fitting curtains and blinds to reduce solar heat gain/loss can add to the levels of thermal stress. The impact this has depends on colour, type and space between the window covering and the glass. The minimum recommended gap is 50mm with a preference of 150mm, and having the window covering vented by leaving a 50mm gap at the head of the blind and a 25mm gap at the sill. This will prevent heat being trapped between the glass and window covering.

iii. **Location of heating registers**

These should be positioned in such a way as to prevent hot air blowing directly onto the glass or between the glass and window covering.

iv. **Method of glazing**

The most common glazing methods do not affect the levels of thermal stress.

v. **Frame colour**

This may cause issues as lighter frames reflect solar energy and reduce the edge temperature of the glass *increasing* the temperature gradient.

Darker frames are more absorptive and raise the edge temperature of the glass thus *decreasing* the temperature gradient.

What is the solution?

The risk of thermal stress breakage can be eliminated by heat treating the glass i.e. heat strengthening or toughening. These processes increase the strength of the glass, thereby resisting the thermal stress caused by the temperature gradient.

The Australian Glass Group recommends that customers request a thermal assessment at time of tendering. The thermal assessment gives a percentile prediction of glass breakage. Please note that this assessment only covers high stress thermal breakage