Flat glass, Griffith flaws, thermal breaks and more…

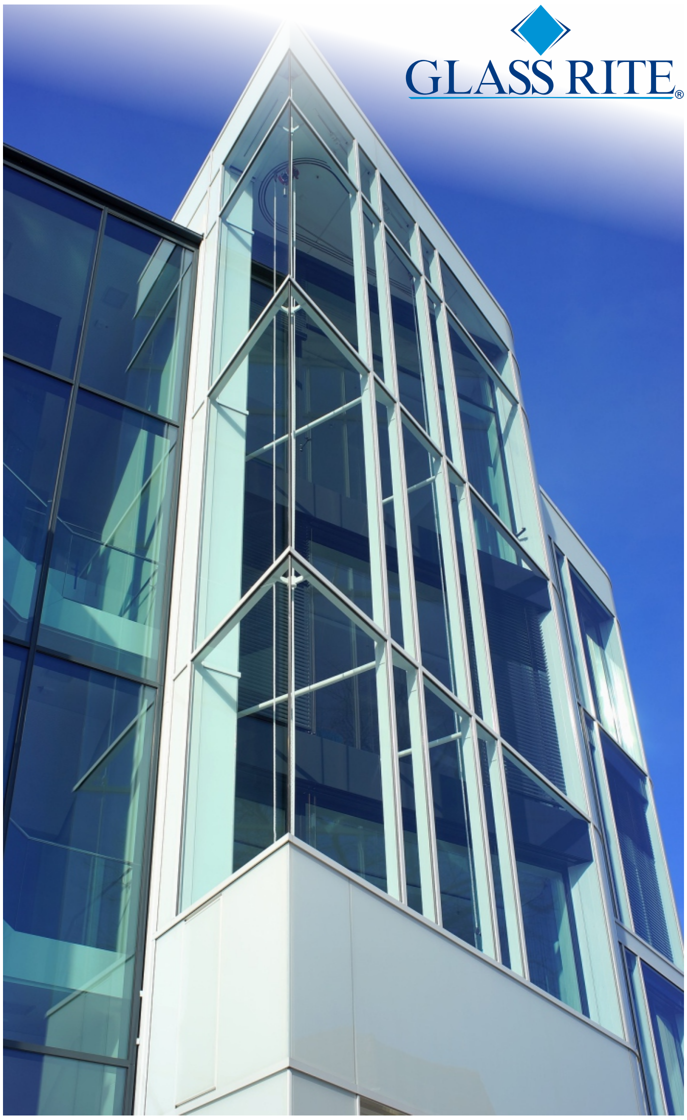
The base composite ingredient to the manufacture of any glass product is, of course sand. The other two critical ingredients being Sodium Carbonate and Calcium Carbonate. These ingredients alter the base molecular structure of the sand and lowers the melting point. This does not mean that a temperature of between 1,427 and 1,538 degrees Celsius can be seen as low! Not only does it take extreme temperatures to melt sand, it also takes an average period of three days.

During the melting process it is critical to minimize the amount of air pockets that can form. The first step is achieved by raking the sand mixture as it starts to melt. Then during a 10-hour period the melted glass is kept at a super-heated temperature to allow gas to bubble up and out of the mixture. These bubbles may seem trivial, but can cause severe problems later.

The next step in the process of achieving flat glass, without bubbles, has been in use since 1959 and was developed by Pilkington. The requirement? Creating a large, stable surface on which the glass can float in order to cool and solidify, flat and bubble free. The answer is ingots of melted tin. Glass and tin do not mix and the lighter glass will float on top of the melted tin, cooling into a perfectly solidified flat sheet. The glass continues the manufacturing process separately from the still melted tin. The flat sheet is cooled further to a manageable temperature and cut in to smaller pieces.

The sheets can now be processed to more specialised types of glass, including tempered and heat strengthened glass, or used as is. These specialised types of glass is where bubbles can become extremely dangerous.
Called Griffith flaws, these tiny air bubbles are very often not visible but place additional internal stress on the glass. As heat strengthened and tempered glass is compressed even more, glass containing Griffith flaws become a potential ticking time bomb. The slightest temperature change or even small bump can cause the glass containing a Griffith flaw to explode. This is however a very rare occurrence due to the strict regulations when glass is manufactured.

Tempered and heat strengthened glass are both similarly produced. Glass is heated to around 649 degrees Celsius. The difference can be found in the cooling process even though both products



are force cooled to create centre tension and surface or edge compression.

With tempered glass the cooling process is accelerated, creating higher surface and edge compression.
Surface compression of at least 10 000 PSI and a required edge compression of at least 9 700 PSI.
This makes tempered glass between 4 and 5 times stronger than untreated glass. The value in this is increased safety.

Tempered glass is less likely to experience a thermal stress break. Thermal stress breaks occur when the glass in a window unit heats-up and expands in the centre, but the edge of the glass remains cold. This disparity causes a break in the glass at a 90-degree angle.

The post breakage characteristics of tempered glass is that this glass is specifically designed to shatter into small, square pieces that, even though it falls from the glazing system when broken, has less potential to cause injury.

This breakage pattern motivates why tempered glass is classified as a safety glazing material, but can cause problems if the glass is meant to stay anchored in the glazing system after breaking. Heat strengthened glass is put through a slower cooling process than tempered glass. This means less surface compression and no required edge compression.

Surface compression is between 3 500 – 7 500 PSI.

This makes heat strengthened glass only approximately two times stronger than untreated glass. The advantage of this process is found in the post breakage characteristics of the glass.

Heat strengthened glass breaks into relatively large pieces, often staying inside of the glazing system.

The pattern of breakage does decrease the possibility of the glass potentially falling and causing injury, but heat strengthened glass is not categorized as a safety glazing material.

With both of these processes there are factors that affect the potential for thermal stress breaks. These include the following:

Glass type: clear glass allows more solar radiation through, where tinted glass retains more radiation, heating up the glass. This means, the more the glass is tinted, the higher the heat absorption and the higher the potential of thermal stress breaks.

Glass coating: type and location in insulating glass units. The coating can change the amount of radiation absorbed, thereby changing the associated thermal stress risks.

Outdoor and indoor shading: the pattern of how outdoor shading will occur as the day proceeds plays a pivotal role in how much heat the glass has to deal with. The challenge here is the fact that the shading patterns are also seasonal and thus should always be calculated accurately to ensure the lowest possible chance of extreme temperature fluctuation in a single unit.

Indoor shading, which includes drapes and blinds, also impact the temperature of the glass. This occurs when the heat is reflected back through the window from the interior reducing the convection and conduction of heat away from the glass.
Another interior factor to keep in mind is heating devices such as vents and heaters that could blow hot air directly onto the window increasing the possibility of thermal stress breakages.

The final important contributing factor is the framing system used. The lower the heat capacity the less the framing system will contribute to potential thermal stress breakages.

The beauty of glass lies in its unpredictability and organic composition, still we are able to manipulate it to some extend and produce great art and structure.

Sources:

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