Glass in Building and Nickel Sulphide

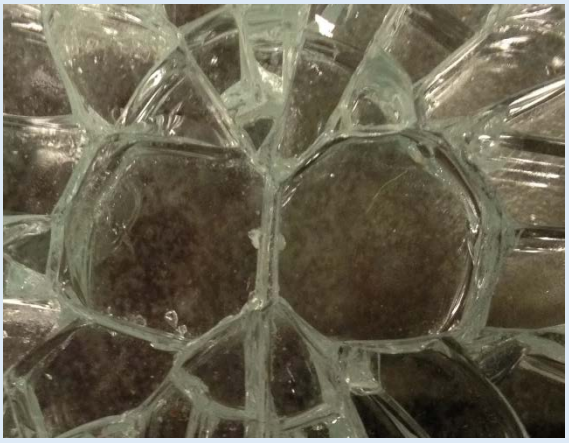
Glass Breakage

There are occasions when toughened glass breaks for no immediately apparent reason. This type of breakage is often referred to as spontaneous fragmentation. In order to understand why the glass has shattered, and how this may be prevented from recurring, it is important to investigate the circumstances of breakage thoroughly and determine the cause through evidence gained during the investigation.

There are many reasons why toughened glass may suddenly break, including handling damage to the glass edges, impact with a hard object, building movement, poor installation, or foreign particles within the body of the glass, sometimes referred to as inclusions.

Toughened glass always displays a characteristic breakage pattern when it remains in place, which appears like the spokes of a bicycle wheel surrounding the hub, which is the origin of the fracture.

Commonly there are two larger pieces of glass at the origin, sometimes called butterfly wings, cats eyes, figure of 8 or mickey mouse ears. This breakage pattern does not automatically indicate the reason for breakage.



If the breakage origin is away from the glass edge, the cause of breakage is unlikely to be edge damage or poor glazing.

Impact breakage will often leave a small area of damage or crushed glass to the surface of the glass at the point of origin. If the glass surface appears undamaged then the breakage may be a result of an inclusion. An inclusion, which results in breakage, is usually situated in the body of the glass between the two large pieces at the origin, normally in the central 3/5ths of the glass thickness. This area is where the tensile stress is concentrated in toughened glass.

Once the inclusion is found, it may be sent for chemical and micrographic analysis in order to determine the nature of the material.

Nickel Sulphide

While there are several types of foreign particles which may cause spontaneous fracture, one type in particular, nickel sulphide, is directly associated with the toughening process. Nickel sulphide has two main states, one of which is stable at

high temperature, and one which is stable at lower temperatures. When glass is toughened, the nickel sulphide transforms to the high temperature state during the heating process, but the glass is cooled too quickly to allow the reverse transformation to the low temperature state.

This reverse transformation to the low temperature state occurs slowly over a period of time, accompanied by a small increase in volume. If the nickel sulphide inclusion is large enough, and within the central tensile portion of the toughened glass, it can cause fracture at some time after manufacture. Commonly this period is around 3 to 5 years after manufacture, but occasionally, it may vary from 1 to 20 or more years.

Nickel sulphide inclusions were a serious problem in the 1960's, when they were first identified, but improvements in the quality of annealed glass has led to a reduction in incidence to less than 1/20th of early levels. Nickel sulphide inclusions are no longer a major cause of "spontaneous fracture" in toughened glass, provided the annealed glass, from which it has been made, is obtained from a reputable manufacturer.

Heat Soaking

A post toughening process has been developed, where most nickel sulphide particles may be identified prior to installation, called a heat soak test.

Once the glass is toughened, it is then placed in an oven and heated to 290 degrees Celsius and heat soaked for 2 hours, before being carefully cooled to room temperature.

This additional heat soak allows the reverse transformation of the nickel sulphide to the low temperature state, which causes most critical inclusions to break the glass during heat soaking. Whilst this process is not 100% effective, it does significantly reduce the incidence of post installation fracture due nickel sulphide inclusions.

If we consider the estimation of nickel sulphide occurrence for toughened glass that has not been heat-soaked, it has been stated that, statistically, the average rate of occurrence in glass of European origin, is one critical nickel sulphide inclusion in every 4 tonnes. When the glass has been heat soak tested, the estimation of nickel sulphide occurrence is for one critical inclusion remaining in 400 tonnes, when heat soaked in accordance with EN 14179.

Statistical occurrence is a way of expressing the risk of an inclusion, based on the current heat soak test. However, in practice, we know that most breakages due to nickel sulphide inclusions tend to occur in batches.

Heat soaking is not necessarily effective for other types of inclusions that subsequently cause toughened glass failure.

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