

# Heat soaking of toughened glass

Heat soaking is a test process that attempts to eliminate nickel sulphide inclusions, which can cause spontaneous fragmentation in toughened (tempered) glass.

## Nickel sulphide inclusions

Sodium sulphate is added during float glass manufacture to promote bubble removal from the molten glass during the melting process. When combined with nickel contamination, sodium sulphate forms nickel sulphide (NiS).

Nickel contamination can be caused by:

- an impurity in the raw materials;
- contamination during the storage and handling of raw materials; or
- contamination from the float line equipment, e.g. firebricks and burners.

At temperatures above 350°C, nickel sulphide undergoes a phase change. This is accompanied by a volume decrease of 4%. Conversely, at temperatures below 350°C, the reverse happens – its volume increases by 4%.

## What effect does nickel sulphide have on glass?

During the manufacture of float (annealed) glass, the raw glass materials are heated to around 1100°C and the NiS consequently reduces in size. When the glass is slowly cooled during the annealing process, the NiS expands back to its original size. This expansion does not interfere with the properties of the glass.

However, an issue arises if the glass is toughened.

Glass is heated to around 600°C during toughening, and the NiS consequently decreases in volume. To create toughened safety glass, stress and tension is induced in the hot glass by rapidly cooling it. Unlike the slow cooling of annealed glass, this rapid cooling arrests the transformation of the NiS.

The NiS will expand to its original size over time. If this expansion occurs in the area of the toughened glass that is under tension, it will cause the glass to fragment.

The presence of NiS is quite rare:

- Approximately one 'stone' of NiS is present per 8 tonnes of raw glass (although it can come in batches). The incidence of NiS varies from manufacturer to manufacturer with estimates ranging from one stone per 8 tonnes of glass to one stone per 13 tonnes of glass and some suppliers having a more frequent incidence than this.
- NiS can cause glass to fragment at any time in the product's life – from a few moments after thermal treatment to years after glazing installation.
- NiS can also affect some types of heat-strengthened glass.

Despite the comparative rarity of NiS in toughened glass, the issue caused widespread concern when it first came to light in the 1960's. Recent incidences of failures have caused the National Construction Code (formally the Building Code of Australia) to instigate a requirement that all monolithic toughened glass in commercial buildings five metres or more above floor or ground level, that has no suitable protection against falling toughened glass fragments (e.g. a balcony, awning or the like), to be heat soaked. Class 1 and Class 10 buildings are exempt from this requirement.

## The heat soaking process

A heat soak oven (basically a large insulated box) is used for this process.

Glass is loaded into the oven with a sufficient gap between each pane to allow hot air to circulate evenly.

Due to the absence of an Australian standard, the process follows European Standard EN 14179.

The steps in the heat soaking process are as follows:

- The toughened glass is heated to 280°C (+ or - 10°C). Once all glass has reached that temperature, the cycle begins. (Sensors attached to the glass are used to monitor temperature.)
- After being held inside the heat soak oven for two hours, the glass is then allowed to cool to ambient temperature.
- The test is intended to encourage any NiS inclusions to expand to their original size.
- The test is **not** infallible, however, as transformation may continue after the heat soak process. As it only eliminates around 95% of potential failures, the test should **not** be considered a guarantee against the presence of NiS in float glass.

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