GLASSWERKS – TECHNICAL BULLETIN

HEAT SOAK TESTING OF FULLY TEMPERED GLASS

TECHNICAL DOCUMENT: GW-TB-004

Fully tempered glass can experience spontaneous breakage due to the presence of nickel sulfide (NiS) inclusions that may exist in float glass. One method used throughout the architectural glass industry to reduce the likelihood of in-service breakage is heat soak testing. This bulletin explains why spontaneous breakage can occur, how heat soak testing works, and when it is commonly recommended.

USE OF FULLY TEMPERED GLASS

Fully tempered glass is often selected because it offers significantly higher strength and meets safety glazing requirements under applicable codes. However, it is sometimes specified in situations that do not require its elevated strength. Current industry practice increasingly encourages the use of fully tempered glass only, when necessary, for example:

- When required by building codes.
- When design loads demand it.
- In applications such as floor to ceiling glass adjacent to walking surfaces on both sides.

Whenever fully tempered glass **must** be used, heat soak testing can provide an added layer of protection against potential spontaneous breakage.

NICKEL SULFIDE INCLUSIONS IN FLOAT GLASS - HOW INCLUSIONS FORM

Float glass is produced by melting a mixture of raw materials—silica sand, soda ash, limestone, salt cake, and other constituents—at high temperatures. During melting, most components dissolve completely. However, small undissolved particles, known collectively as inclusions, can remain in the final product.

ASTM C1036, the industry standard for flat glass, describes allowable limits for inclusions, referred to as point blemishes, such as:

- Stones
- Knots
- Gaseous inclusions
- Other unmelted particulates

While most inclusions are benign and only affect appearance, nickel sulfide is a specific type that can lead to breakage under certain conditions.

CHARACTERISTICS OF NICKEL SULFIDE

Nickel sulfide inclusions typically originate when small nickel bearing particles mix with sulfur present in furnace fuel or raw materials. These inclusions:

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- Are usually less than 1/64 in. (≈0.4 mm)
- May undergo a phase change after heat treatment
- Expand at a different rate than the surrounding glass

This expansion is the root cause of spontaneous breakage in fully tempered glass.

BREAKAGE POTENTIAL IN DIFFERENT GLASS TYPES - ANNEALED GLASS

Annealed glass has minimal internal stress. Even when nickel sulfide inclusions are present, breakage related to NiS is extremely uncommon due to the very low stress level.

HEAT-STRENGTHENED GLASS

Heat-strengthened glass has moderate surface compression. Per ASTM C1048, the expected surface compression is **3,500 to 7,500 psi (24–52 MPa).** At this stress level, the likelihood of breakage caused by NiS inclusions is greatly reduced compared to fully tempered glass.

FULLY TEMPERED GLASS

ASTM C1048 requires fully tempered glass to have:

- **Minimum surface compression of 10,000 psi (69 MPa)**

The higher stress state makes fully tempered glass more susceptible to spontaneous breakage if a nickel sulfide inclusion is located near the tension core. When breakage occurs, the fracture pattern is distinctive: the glass often shatters into small particles with a characteristic origin point.

WHAT HEAK SOAK TESTING DOES

The heat soak test is designed to accelerate the expansion of nickel sulfide inclusions, causing susceptible pieces to break before installation.

PROCESS OVERVIEW

In accordance with **EN 14179-1** fully tempered glass is placed in a specialized oven and exposed to:

- **500°F ± 18°F (260°C ± 10°C)**
- A controlled hold period at peak temperature (dwell time)

The elevated heat triggers the transformation of nickel sulfide inclusions from the unstable beta phase to the expanded alpha phase. If an inclusion is capable of causing breakage, the glass will typically fracture during the test rather than after installation.

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A properly executed dwell period is critical to achieving effective results. Heat soak testing does not guarantee that all future breakage will be prevented, but it significantly reduces the probability.

REFERENCES

- **ASTM C1036** - Standard Specification for Flat Glass
- **ASTM C1048** - *Standard Specification for Heat-Strengthened and Fully Tempered Flat Glass*
- **EN 14179-1** – *Heat- Soaked Thermally Toughened Soda Lime Silicate Safety Glass*

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