# White Paper

## Heat Treatment of Glass: Spontaneous Combustion and Thermal Stress

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Australian Glass Group®

# Heat Treatment of Glass: Spontaneous Combustion and Thermal Stress

The Heat Treating of glass includes:

- Toughening (TGH)
- Heat Strengthening (HS)
- Heat Soaking (SOAK)

## Toughening vs Heat Strengthening

Toughening (TGH) is a heat treatment conducted on annealed glass and is also known as 'Tempering'. The process is conducted using a furnace that can go up to 700 degrees Celsius to heat the glass and then a quench process to cool the glass causing stress in the glass. The purpose is to strengthen the glass (up to 5x stronger than annealed glass) to make it more resistant to breakage, including Thermal Stress cracking. It also becomes Grade A safety when done by a certified processor as per *AS 2208: Safety glazing materials in buildings*.

Heat Strengthening (HS) is a heat treatment conducted on annealed glass similar to Toughening (TGH). The process is also the same but not as intense as Toughening. The purpose is to strengthen the glass (up to 2x stronger than annealed glass) to make it more resistant to breakage, including Thermal Stress cracking. It is important to note that Heat Strengthened glass is not Grade A Safety glass but whenever Grade A safety is not required it is a more affordable option versus a Toughening & Heat Soaking combination (see Heat Soaking section).

While Toughened glass is much harder to break compared to annealed or Heat Strengthened glass, being Grade A safety glass if it does break, it breaks into many small unsharp pieces, but can fall out of frame (see Image 1 below).

On the contrast, Heat Strengthened glass is not Grade A safety glass and if it breaks, it breaks into larger pieces, however, these generally stay within the frame rather than fall out like Toughened glass can (see Image 2 below).

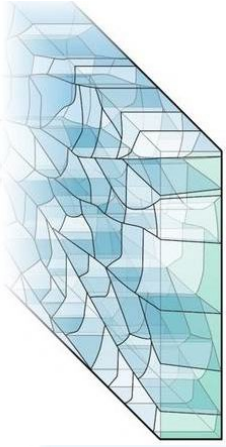

*Image 1: Toughened glass break pattern*

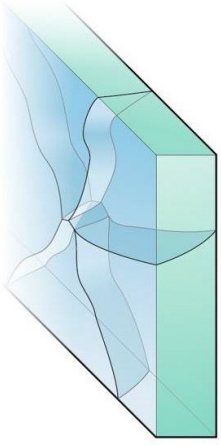

*Image 2: Heat Strengthened glass break pattern*

# Heat Soaking

Heat Soaking (SOAK) is a further process in a separate heat soak chamber conducted on previously Toughened glass. The purpose is to minimise the risk of Spontaneous Combustion.

The Heat Soak test puts Toughened glass panels into a chamber *(see Image 3 example below)* and exposes it to a concentrated period of heat and pressures to attempt to initiate any active inclusions that may be in the glass (like Nickel Sulphide/Sulfide). If glass passes this test (by not exploding in the chamber) then there is a very low risk of any future spontaneous combustion.

***Note: Toughened Glass that passes a Heat Soak test does not mean there are no inclusions in the glass and does not completely eliminate the risk of future Spontaneous Combustion, it does however lower the risk considerably. Toughened glass products that explode due to Nickel Sulphide are not covered by warranty.***

*Image 3: Heat Soak Chamber*

The risk of Spontaneous Combustion in non-toughened glass products is low, even if inclusions are present *(see Summary tables A, B, C, D & E).*

# Spontaneous Combustion

Spontaneous Combustion is the explosion of Toughened glass due to an inclusion, like Nickel Sulphide. These inclusions can exist in the glass from its original raw materials (eg. sand) and gets primed/enlarged during the Toughening process. This can result in the Toughened glass exploding at any future point in time, even years later.

If the glass remains intact (seen in Toughened laminate) you will see a noticeable 'butterfly' pattern of the break style that centres around the inclusion that can be seen as a dark dot with the naked eye *(see image 4 below).*

To minimise this risk, you can conduct a Heat Soak test on Toughened glass or instead, use Heat Strengthened glass (where Grade A safety is not required).

# Thermal Stress

Another risk after installation is Thermal Stress cracking. This is where annealed glass can crack in any future time period due to extreme temperature stress contrasts in the same piece of glass. Most commonly seen after a cold night and then strong morning sun heating up only part of the glass while the other part remains cold due to shadowing from the sun heat (eg. a tree or building casting a shadow on the glass). The risk is seen most in high solar heat absorbing glass – eg. grey tint, tinted laminated and some dark/tinted coatings *(see Summary tables A, B, C, D & E)*.

If the glass remains intact you will see a noticeable pattern of the break style that starts at one edge and then runs off to a 45 degree angle *(see image 5 below)*.

To minimise this risk, you can strengthen the glass by either Heat Strengthening or Toughening.

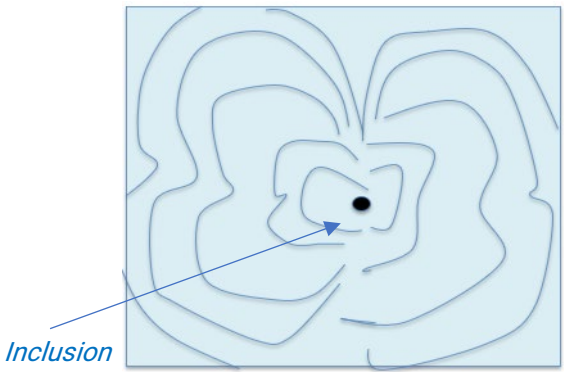


*Image 4: Spontaneous Combustion break pattern*

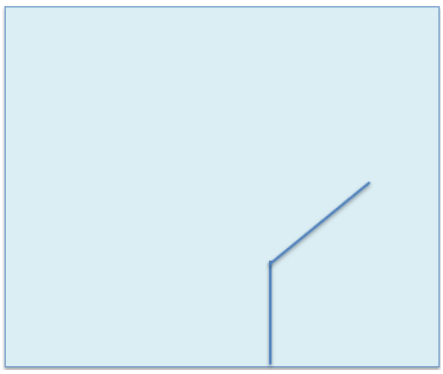

*Image 5: Thermal Stress break pattern*

# Application and Recommendations

As per Australian Standard **AS 1288-2006 Glass in buildings - Selection and installation**, there is specific reference in Section 3 for the requirement of Heat Soaking of all Toughened glass above 5m high used in Buildings, other than non-single dwelling residential homes (Class 1 Buildings) or non-habitable buildings (Class 10 Buildings or Structures). This therefore applies to all Class 2-9 Buildings (ie. Commercial Buildings).

There are also some exceptions to this requirement (*see Excerpt 1 of the standard on the following page)*.

As Toughening and Heat Soaking adds time, complexity and cost to the glass units there are recommendations below to assist with certain applications in Commercial buildings over 5m high that allows the non-requirement of Toughened glass and therefore no Heat Soaking also:

1. Where **Single Glazed** glass is used and Grade A safety is not required, then Heat Strengthening to strengthen the glass to make it more resistant to breakage. Where Grade A safety is required then the use of laminated glass. Annealed laminate will have low risk of Spontaneous Combustion and avoid the requirement for Toughening and Heat Soaking, and if further strength is required due to load factors (eg. Wind load and Human Impact) as well as minimising the risk of breakage like Thermal Stress, then Heat Strengthened laminate and possibly thicker make ups may apply while still not requiring the need for Toughening and Heat Soaking.

2. Where **Double Glazed Units** (DGU) are used, we now have the ability to identify the inner lite and the outer lite as two separate factors in relationship to the need of Grade A safety or not *(as highlighted in Excerpt 1 on the following page)*. An example here is an A Grade option for the inner lite as required (eg. annealed laminate or heat strengthened laminate) and then a non-Grade A glass on the outer (if allowed). As Commercial buildings require further performance it is common to use a monolithic coated outer glass and by Heat Strengthening that glass you also avoid Toughening and therefore the need to Heat Soak. Again, thicker make ups and Heat Strengthening can satisfy load factor requirements and further resistance to breakage. With Heat Strengthening you also have the benefit of glass staying in-frame if it does ever break.

# Australian Standards – AS 1288-2006 excerpt (Section 3, Amendment 2)

Building requirements relating to Heat Soaking

*Note: does not apply to Class 1 & 10 buildings (stand-alone single dwelling residential homes and non-habitable buildings/structures).*

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## 3.8 SELECTION OF GLASS FOR MINIMIZING THE RISK DUE TO GLASS SPONTANEOUS FRACTURE

### 3.8.1 General

The use of toughened glass and some heat treated glasses may involve a relatively small risk of breakage resulting from nickel sulphide. In addition to the other requirements of this Standard, such glass shall be selected to minimize the risk in accordance with Clause 3.8.2.

Class 1 and Class 10 buildings are exempt from the requirements of this Clause.

### 3.8.2 Requirements to minimize the risk

All monolithic toughened glass and heat strengthened glass, (with a surface compression greater than 52 MPa), shall be heat soaked in accordance with Clauses 3, 5, 6 and 12 and Annex A of European Standard EN 14179-1. The heat soaked glass shall be marked in compliance with EN 14179-1. A certificate supplied by the manufacturer providing

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verification that the toughened glass has been heat soaked in accordance with this clause shall be a suitable alternative to marking in compliance with EN 14179-1.

Heat soaking in accordance with this Clause is not required in glazing that conforms to any one of the following:

(a) No part of the glass is glazed more than 5 m from the finished floor or ground level.

(b) Suitable protection by a balcony, awning or the like is provided such that, in the event of glass fracturing, the risk of injury or property damage is minimized.

(c) Laminated glass, (including toughened laminated and heat strengthened laminated) is used.

NOTES:

1 For insulating glass units glazed vertically, greater than 5 m from the ground level, a laminated, monolithic annealed or monolithic heat strengthened outer or inner pane as appropriate may be considered to provide suitable protection.

2 For insulating glass units glazed in sloped overhead glazing greater than 3 m from the finished floor or ground level a laminated inner (lower) pane may be considered to provide suitable protection.

3 A balcony that extends from the building a minimum 2/3 of the height of the adjacent panel may be considered to be suitable to minimize the risk. For example, for a 2700 mm high panel, the balcony or protection should extend a minimum of 1800 mm from the building.

4 Heat soaking will significantly reduce but not totally eliminate the small risk of fracture due to nickel sulphide.

*Excerpt 1: Taken from AS 1288-2006 (incorporating Amendment Nos 1, 2 and 3) Reconfirmed 2016*

# Summary Tables

| Summary Table A: Clear Float | Thermal Stress Risk | Spontaneous Combustion Risk | Grade A Safety? |
|---|---|---|---|
| **Annealed** | Low | Low | No |
| **Heat Strengthened** | Low | Low | No |
| **Toughened** | Low | **High** | **Yes** |
| **Toughened & Heat Soaked** | Low | Low | **Yes** |
| **Annealed** | Low | Low | **Yes** |
| **Heat Strengthened** | Low | Low | **Yes** |
| **Toughened** | Low | **High** | **Yes** |
| **Toughened & Heat Soaked** | Low | Low | **Yes** |

Laminated

| Summary Table B: Tined | Thermal Stress Risk | Spontaneous Combustion Risk | Grade A Safety? |
|---|---|---|---|
| **Annealed** | **High** | Low | No |
| **Heat Strengthened** | Low | Low | No |
| **Toughened** | Low | **High** | **Yes** |
| **Toughened & Heat Soaked** | Low | Low | **Yes** |
| **Annealed** | **High** | Low | **Yes** |
| **Heat Strengthened** | Low | Low | **Yes** |
| **Toughened** | Low | **High** | **Yes** |
| **Toughened & Heat Soaked** | Low | Low | **Yes** |

Laminated

Laminated

| Summary Table C: Clear LowE | Thermal Stress Risk | Spontaneous Combustion Risk | Grade A Safety? |
|---|---|---|---|
| **Annealed** | Low | Low | No |
| **Heat Strengthened** | Low | Low | No |
| **Toughened** | Low | **High** | **Yes** |
| **Toughened & Heat Soaked** | Low | Low | **Yes** |
| **Annealed** | Low | Low | **Yes** |
| **Heat Strengthened** | Low | Low | **Yes** |
| **Toughened** | Low | **High** | **Yes** |
| **Toughened & Heat Soaked** | Low | Low | **Yes** |

Laminated

| Summary Table D: Natural LowE | Thermal Stress Risk | Spontaneous Combustion Risk | Grade A Safety? |
|---|---|---|---|
| **Annealed** | **High** | Low | No |
| **Heat Strengthened** | Low | Low | No |
| **Toughened** | Low | **High** | **Yes** |
| **Toughened & Heat Soaked** | Low | Low | **Yes** |
| **Annealed** | **High** | Low | **Yes** |
| **Heat Strengthened** | Low | Low | **Yes** |
| **Toughened** | Low | **High** | **Yes** |
| **Toughened & Heat Soaked** | Low | Low | **Yes** |

Laminated

| Summary Table E: Tinted LowE | Thermal Stress Risk | Spontaneous Combustion Risk | Grade A Safety? |
|---|---|---|---|
| **Annealed** | **High** | Low | No |
| **Heat Strengthened** | Low | Low | No |
| **Toughened** | Low | **High** | **Yes** |
| **Toughened & Heat Soaked** | Low | Low | **Yes** |
| **Annealed** | **High** | Low | **Yes** |
| **Heat Strengthened** | Low | Low | **Yes** |
| **Toughened** | Low | **High** | **Yes** |
| **Toughened & Heat Soaked** | Low | Low | **Yes** |

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