2.6 – Heat-treated glass

Conseil Général des Pyrénées Atlantiques - Pau, France -
Architect: Philippe Ch. Dubois et Associés - Heat-treated glass

▼ INTRODUCTION

Various AGC glass products can be heat-treated for the specific purpose of enhancing their resistance to mechanical and thermal loads

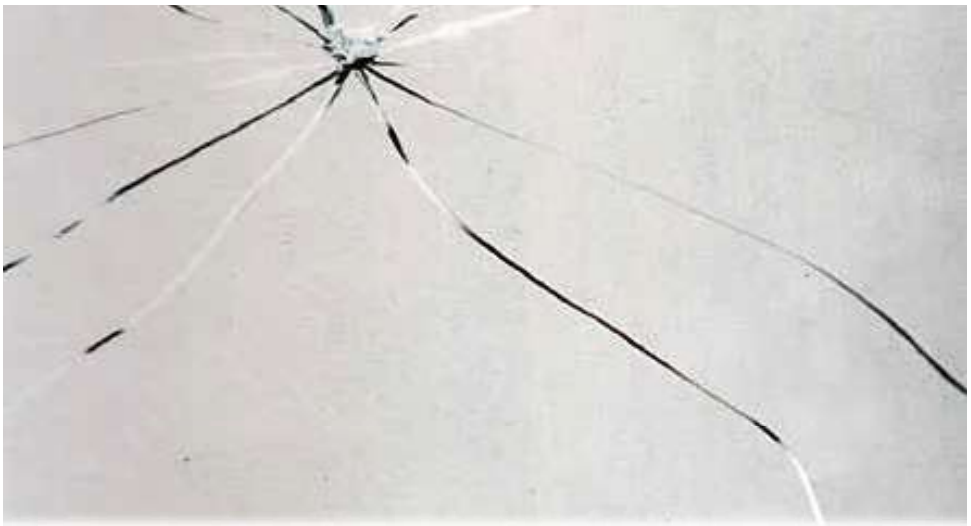
> There are three types of glass after heat-treatment:
  - heat-strengthened glass
  - thermally toughened safety glass
  - heat-soaked thermally toughened safety glass.

> There also are different breakage patterns:
  - into small blunt pieces:
    - for thermally toughened safety glass
    - for heat-soaked thermally toughened safety glass.

  } means that it may be considered safety glass

  - into large sharp pieces:
    - for heat-strengthened glass, meaning that it cannot be considered safety glass.

Heat-strengthened glass



Typical breakage pattern of heat-strenghened glass

▼ DESCRIPTION

> Heat-strengthened glass is heat-treated using a method of controlled heating and cooling which places the outer glass surface under compression and the inner glass surface under tension

> This heat-treatment method delivers a glass with a bending strength greater than annealed glass but less than thermally toughened safety glass. Heat-strengthened glass does not require heat soaking

> Most of AGC glass products can be heat-strengthened: clear and coloured Planibel, Stopsol, Sunergy, some Imagin products and the toughenable versions of the Stopray and iplus low-e ranges

> Some coated glass (eg. in the iplus and Stopray ranges) or painted glass (eg. Lacobel T) can or must be heat-strengthened... Heat-treating these glass products require a specific parameter setting on the furnace

> Silk-screened and enamelled glass need to be at least heat-strengthened. The supplier must undertake a feasibility test if silk-screening or enamelling is applied to coated substrates.

▼ COMMENTS

Mechanical properties

> Use of heat-strengthened glass: single glazing, laminated glazing, insulating glazing. The main goals are:
  - to avoid thermal glass breakage in applications where glass is subject to high energy absorption and / or severe shading
  - to increase bending strength to a maximum of 70 N/mm² (not taking into account the individual partial factors for the structural design).

> Heat-strengthened glass:
  - has a higher resistance to thermal stress than annealed glass. It can withstand differences in temperature of approximately 100 °C
  - has a higher breakage resistance to bending (70 N/mm²) than annealed glass (not considering the individual partial factors for the structural design)
  - breaks into large sharp pieces which can cause injury.

  Accordingly, heat-strengthened glass is not a safety glass.

> Once the heat-strengthening has been executed, no further processing (cutting, drilling holes, edge working, etc.) is possible. Heat-strengthened glass must comply with the standard EN 1863

> Heat-strengthened glass is not subject to breakage caused by nickel sulphide inclusions, also known as 'spontaneous' breakage. Therefore no heat soak test is required.

Optical performance

> The heat-strengthening process causes inherent optical distortion due to surface waviness. Waviness can be measured and evaluated for the overall deformation and local deformation

> The light and energy characteristics of heat-strengthened glass are identical to the announced values for annealed uncoated glass products. For products with heat treatable coatings or enamels, the final light- and energy characteristics are only obtained after the toughening process. Note for coated glass products: compliance with AGC's heat-treatment guidelines is mandatory.

▼ FINISHING AND ADDITIONAL PROCESSING

Edge finishing

The following edge finishings are allowed for heat-strengthened glass:

> Arrissed edge (with blank spots)

> Ground edge (with blank spots)

> Ground edge (without blank spots)

> Polished edge.

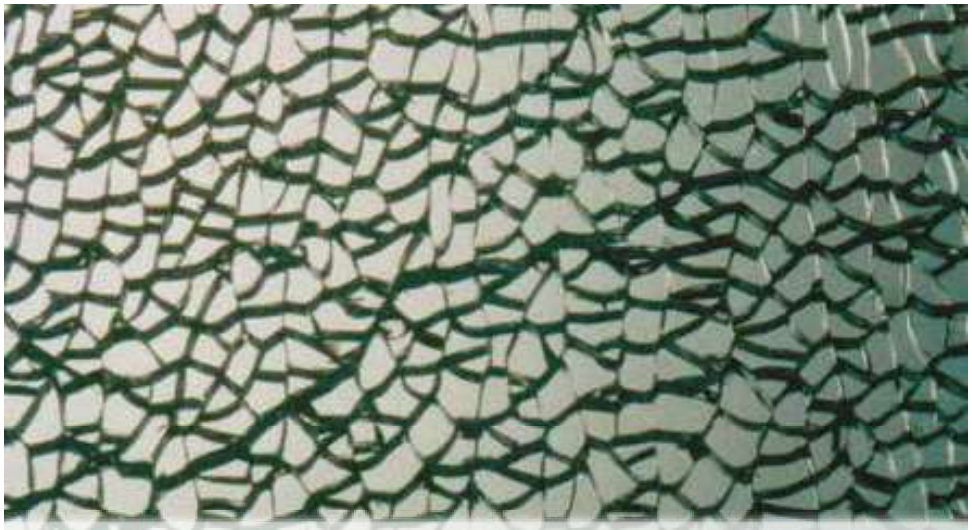
For building applications, heat-strengthened glass is supplied by default with arrissed edges. Other edge finishings are possible upon request by the customer and subject to a feasibility study.

Other finishing options

> Drilled (chamfered) holes

> Notches.

Thermally toughened safety glass



Typical breakage pattern of thermally toughened glass

▼ DESCRIPTION

> Thermally toughened safety glass is heat-treated using a method of controlled heating and cooling which puts the outer glass surface under compression and the inner glass part under tension. Such stresses cause the glass, when impacted, to break into small granular particles instead of splintering into jagged shards. The granular particles are less likely to injure occupants or damage objects

> This heat-treatment method delivers a glass with a bending strength greater than heat-strengthened glass. In addition, heat-soak test is required in certain applications or by national standards, building codes or good practice guidelines

> Most of AGC glass products can be toughened: clear and coloured Planibel, Stopsol, Sunergy and some Imagin products

> Some coated glass (eg. in the iplus and Stopray ranges) or painted glass (eg. Lacobel T) can or must be toughened... Heat-treating these glass products requires a specific parameter setting on the furnace

> Silk-screened and enamelled glass can be toughened. The supplier must undertage a feasibility test if silk-screening or enamelling is applied onto coated substrates

> Use of thermally toughened safety glass: single glazing, laminated glazing, insulating glazing. The main goals are:
  - to deliver a safety glass, thus reducing the risk of personal injury
  - to avoid thermal glass breakage in applications where glass is subject to high energy absorption and / or severe shading
  - to increase bending strength to a maximum of 120 N/mm² (not taking into account the individual partial factors for the structural design).
> Once the toughening has been executed, no further processing (cutting, drilling holes, edge working, etc.) is possible
> Thermally toughened safety glass must comply with standard EN 12150.

▼ COMMENTS

Spontaneous breakage

Toughened glass can be subject to breakage caused by nickel sulphide inclusions, also known as 'spontaneous' breakage. The heat soak test can be executed upon request by the customer or if required by national standards, building codes or good practice guidelines. The heat-soak test is not a 100% guarantee that spontaneous breakage will not occur.

Optical performance

The thermal toughening process causes the surface of the glass to distort in two ways:

> Overall bend of 3 mm/m(1)
> Localised bend of 0.5 mm/300 mm(1).

This phenomenon may be more visible in coated glass.

(1) Values for Planibel heat-strengthened glass using the horizontal process.

Anisotropy

Depending on the angle of light incidence, the amount of light hitting the glass, the time of observation and the position of the observer with respect to the glass, the inherent phenomenon of heat treatment anisotropy can be observed. Anisotropy is caused by compression of the surface of the thermally toughened glass. Under natural lighting conditions, the reflection characteristics vary from one point to another and differently coloured patterns known as "leopard spots" may be seen on the glass.

▼ PERFORMANCE

Thermally toughened safety glass:

> is highly resistant to thermal stress. It can withstand differences in temperature of approximately 200 °C

> has a much higher level of mechanical strength and is more resistant to shocks than annealed glass. Thermally toughened glass is resistant to breakage due to bending of at least 120 N/mm². For certain types of glass, these values can be different (patterned glass 90 N/mm² and enamelled glass 75 N/mm²) (not taking into account the individual partial factors for the structural design)

> breaks into small, blunt pieces. Consequently, thermally toughened glass is always a safety glass (conforming to EN 12150) in certain applications. Its usage always depends on the application and national standards, building codes or good practice guidelines

> toughenable magnetron coatings must be toughened to achieve the desired performance (fragmentation, optical, U_g value).

The light and energy characteristics of thermally toughened safety glass are identical to the announced values for annealed uncoated glass products. Note for coated glass products: compliance with AGC's heat-treatment guidelines is mandatory. For heat treatable coatings the final light and energy characteristics are only obtained after the toughening process.

▼ FINISHING AND ADDITIONAL PROCESSING

Edge finishing

The following edge finishing's are allowed for heat-strengthened glass:

> Arrissed edge (with blank spots)

> Ground edge (with blank spots)

> Ground edge (with no blank spots)

> Polished edge.

For building applications, the heat-strengthened glass is supplied by default with arrissed edges Other edge finishings are possible upon request by the customer and subject to a feasibility study.

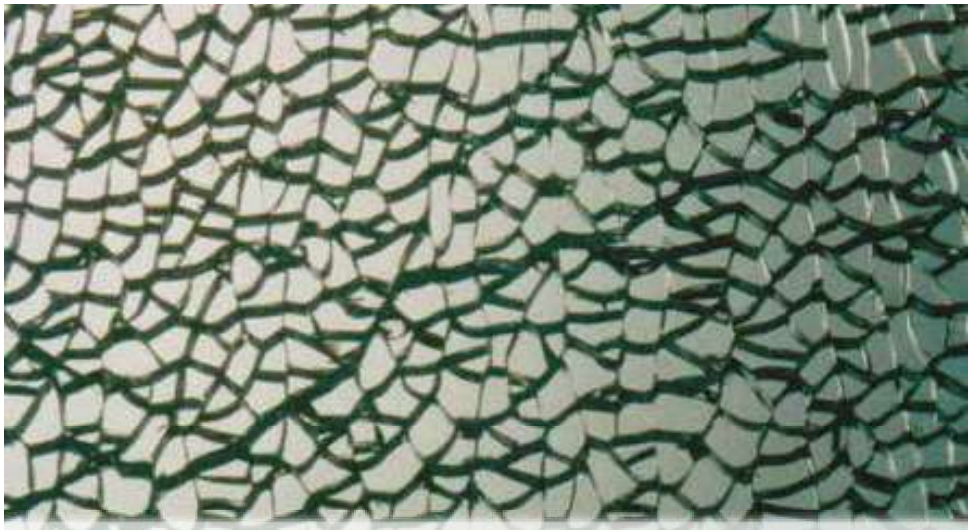
Other finishing options

> Drilled (chamfered) holes

> Notches.

Certain restrictions (dimensions, positioning with respect to the edges, etc.) are defined in standard EN 12150-1.

Thermally toughened HST glass



Typical breakage pattern of thermally toughened HST glass

▼ DESCRIPTION

> The same as for thermally toughened safety glass

> Heat-soaked thermally toughened safety glass must comply with EN 14179.

▼ WHY CHOOSE HEAT-SOAKED THERMALLY TOUGHENED SAFETY GLASS?

The glass product may contain nickel sulphide (NiS) inclusions which can vary in size from a few microns to a few millimetres. These inclusions have a special crystalline structure which is different at low (larger volume) and high (smaller volume) temperatures. In the case of a thermally toughened glass, the inclusions acquire their stable structure at a high temperature when the glass is heated to approximately 650 °C. The rapid cooling involved in the toughening process does not give the NiS inclusions time to acquire their stable low-temperature structure before the glass solidifies. The glass is therefore processed at its operating temperature. During this time, the increase in the volume of the NiS inclusions can cause the sheet of glass to break spontaneously once it has been installed.

To limit the risk of breakage, thermally toughened glass can be heat-soaked. This entails placing the glass in a furnace at a constant temperature for a specific period to process the NiS. Any breakage caused by critical NiS crystals will therefore occur during heat-soak test.

▼ COMMENTS

Refer to the section 'Thermally toughened safety glass'.

▼ PERFORMANCE

Refer to the section 'Thermally toughened safety glass'.

▼ FINISHING

Refer to the section 'Thermally toughened safety glass'.

Certain restrictions (dimensions, positioning with respect to the edges, etc.) are defined in standard EN 14179-1.