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Glass in building — Heat soaked tempered soda lime silicate safety glass

Verre dans la construction — Verre de sécurité de silicate sodocalcique trempé et traité

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 160, *Glass in building*, Subcommittee SC 1, *Product considerations*.

Introduction

Heat soaked tempered soda lime silicate safety glass has a safer breakage behaviour when compared with annealed glass. This behaviour is a direct result of the high surface pre-stress.

It also has a known level of residual risk of spontaneous breakage arising from the possible presence of critical nickel sulfide (NiS) inclusions in the thermally toughened soda lime silicate glass.

Heat soaked tempered soda lime silicate safety glass has a known behaviour under accident human impact together with known mechanical and thermal stress resistance.

Other requirements, not specified in this document, can apply to heat soaked tempered soda lime silicate safety glass which is incorporated into assemblies, e.g. laminated glass or insulating glass units, or undergo an additional treatment, e.g. coating. The additional requirements are specified in the appropriate glass product standard. Heat soaked tempered soda lime silicate safety glass, in this case, does not lose its mechanical or thermal characteristics.

NOTE 1 ISO/TC 160/SC 2 is producing standards for the determination of the design strength of glass and is preparing a design method.

NOTE 2 In Europe, instead of “heat soaked tempered”, the term “heat soaked thermally toughened” is used.

Glass in building — Heat soaked tempered soda lime silicate safety glass

1 Scope

This document specifies product definitions, product characteristics, i.e. tolerances, flatness, edgework, etc., fracture characteristics, including fragmentation, and the physical and mechanical characteristics of flat heat soaked tempered soda lime silicate safety glass for use in buildings.

This document does not cover curved (bent) glass according ISO 11485.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 1288-3, *Glass in building — Determination of the bending strength of glass — Part 3: Test with specimen supported at two points (four point bending)*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1
heat soaked tempered soda lime silicate safety glass
heat soaked tempered safety glass
glass within which a permanent surface compressive stress, additionally to the basic mechanical strength, has been induced by a controlled heating and cooling process in order to give it greatly increased resistance to mechanical and thermal stress and prescribed fragmentation characteristics and which has a known *level of residual risk* (3.2) of spontaneous breakage due to the presence of critical nickel sulphide (NiS) inclusions

3.2
level of residual risk
risk of spontaneous breakage of heat soaked thermally toughened soda lime silicate safety glass, on a statistical basis, due to the presence of critical nickel sulphide inclusions

Note 1 to entry: It is considered that the level of residual risk is no more than one breakage per 400 tonnes of heat soaked thermally toughened soda lime silicate safety glass[6][7][8].

3.3
flat heat soaked tempered safety glass
heat soaked tempered (thermally toughened) glass which has not been deliberately given a specific profile during manufacture

3.4
enamelled heat soaked tempered safety glass
heat soaked tempered (thermally toughened) glass which has a ceramic frit fired into the surface during the tempering (toughening) process

Note 1 to entry: After tempering, the ceramic frit becomes an integral part of the glass.

Note 2 to entry: The application of the ceramic frit may be by a continuous application or discontinuous, e.g. screen printing.

3.5
horizontal tempering process
process in which the glass is supported on horizontal rollers

3.6
air cushion process
process in which the glass is supported by an air cushion with or without additional rollers

Note 1 to entry: In this process, the glass will be between horizontal and 45° of horizontal.

3.7
vertical tempering process
process in which the glass is suspended by tongs

3.8
edge deformation
deformation of the edge caused by the tong marks

3.9
edge lift
edge dip
distortion produced in *heat soaked tempered safety glass* (3.1) which was horizontally tempered, at the leading and trailing edge of the plate, as a result of the glass during the tempering (toughening) process not being supported by a roller

Note 1 to entry: This is a distortion produced by a deviation from surface flatness.

3.10
perimeter deformation
distortion around the edge of *heat soaked tempered safety glass* (3.1) manufactured by *air cushion process* (3.6)

3.11
local distortion
local deformation underneath the tong marks of *heat soaked tempered safety glass* (3.1) which was vertically tempered

3.12
overall bow
deformation of the whole pane of *heat soaked tempered safety glass* (3.1) caused by the heating and cooling process

3.13
roller wave distortion
periodic distortion produced in *heat soaked tempered safety glass* (3.1) which was horizontally tempered as a result of the glass during tempering process being in contact with the rollers

Note 1 to entry: This is a surface distortion produced by a reduction in surface flatness.

3.14
wave distortion
distortion produced in *heat soaked tempered safety glass* (3.1) manufactured by *air cushion process* (3.6) as a result of the tempering process

3.15
heat soak process
heat treatment after the tempering process during which majority of NiS inclusions is removed resulting in a known level of critical NiS inclusions in the heat soaked tempered soda lime silicate safety glass

3.16
in-line heat soak process
heat soak process (3.15) which follows immediately after the quenching process whereby the glass temperature is directly reduced from quenching to the heat soak temperature in an in-line heat soak oven

3.17
off-line heat soak process
heat soak process (3.15) carried out after the quenching process whereby the glass is cooled down to room temperature and heated up again to the heat soak temperature in an off-line heat soak oven

4 Glass products

Heat soaked tempered safety glass is made from a monolithic glass generally corresponding to one of the following standards:

— basic soda lime silicate glass products according to ISO 16293-1;

— float glass according to ISO 16293-2;

— patterned glass according to ISO 16293-5;

— coated glass according to ISO 11479-1.

NOTE For drawn sheet glass, an ISO standard is not available. Therefore, see EN 572–4 or national standards.

Other nominal thicknesses of glass than those covered in the above standards are possible.

5 Manufacturing processes

5.1 General

Heat soaked tempered safety glass is manufactured as follows.

Basic soda lime silicate glass products (see Clause 4) are cut to size, shaped and edgeworked (see Clause 8).

The prepared glass panes are then tempered (see 5.2).

The tempered panes are then subjected to an off-line or in-line heat soak process cycle (see 5.3.1 and 5.3.2)

After manufacture the heat soaked tempered safety glass shall comply with the fragmentation test (see Clause 9) and mechanical strength requirement (see 10.4).

5.2 Tempering process

The cut, shaped and edgeworked glasses are tempered. The heat soaked tempered glass shall comply with the flatness criteria for horizontal or vertical tempering or the air cushion process (see 7.3).

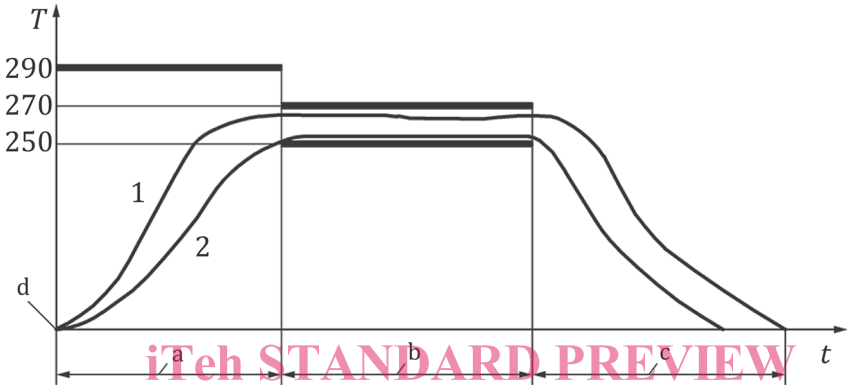
The heat soaked tempered safety glass shall have a level of fragmentation that will ensure that after the glass has been through the heat soak process, and subsequently tested to the fragmentation test (see Clause 9), it shall comply with 9.5.

5.3 Heat soak process cycles

5.3.1 Off-line process

5.3.1.1 General

The heat soak process cycle consists of a heating phase, a holding phase and a cooling phase (see Figure 1).



Key

T glass temperature at any point, °C

t time, h

1 first glass to reach 250 °C

2 last glass to reach 250 °C

a heating phase

b holding phase

c cooling phase

d ambient temperature

Figure 1 — Heat soak process cycle

5.3.1.2 Heating phase

The heating phase commences with all the glasses at ambient temperature and concludes when the surface temperature of the last glass reaches 250 °C. The maximum heating rate is 3 °C per min. The time to reach this temperature is defined in the calibration process. This time will be dependent on the size of the oven, the amount of glass to be treated, the separation between glasses and the heating system capacity.

The glass separation and rate of heating should be controlled to minimize the risk of glass breakage as a result of thermal stress.

To facilitate economic heating, the air temperature within the oven may exceed 290 °C. However, the glass surface temperature shall not be allowed to exceed 290 °C. The period of glass surface temperature in excess of 270 °C shall be minimized.

NOTE Care should be taken to ensure the maximum temperature of the glass does not exceed 270 °C as there is a possibility of the nickel sulphide inclusion reconverting.

5.3.1.3 Holding phase

The holding phase commences when the surface temperature of all the glasses has reached a temperature of 250 °C. The minimum duration of the holding phase is 2 h.

Precise oven control is necessary in order to ensure that the glass surface temperature shall be maintained in the range of 260 °C ± 10 °C during the holding phase.

5.3.1.4 Cooling phase

The cooling phase commences when the last glass to reach 250 °C has completed its holding phase, i.e. been held for two hours at 260 °C ± 10 °C. During this phase, the glass temperature shall be brought down to ambient temperature.

The cooling phase can be concluded when the air temperature in the oven reaches 70 °C.

The rate of cooling should be controlled to minimize the risk of glass breakage as a result of thermal stress.

5.3.1.5 Heat soak process system

5.3.1.5.1 General

The heat soak process system consists of the following:

— oven (see 5.3.1.5.2);

— glass support (see 5.3.1.5.2);

— separation system (see 5.3.1.5.4).

The oven shall be calibrated (see 5.3.1.5.5 and Annex F) and this determines the method of operation of the heat soak process system during manufacture of heat soaked tempered safety glass.

5.3.1.5.2 Oven

The oven shall be heated by convection and shall allow an unhindered air circulation around each glass pane. In the event of glass breakage, the airflow shall not be hindered. The airflow in the oven shall be led parallel to the glass surfaces.

The openings for the air ingress/egress should be designed to ensure that fragments of broken glass do not cause blockages.

5.3.1.5.3 Glass support

Glasses may be supported vertically or horizontally. The glasses shall not be fixed or clamped; they have to be supported to allow free movement.

NOTE Vertically means true vertical or up to 15° either side of true vertical.

The distance between glasses affects the airflow, heat exchange and the heating time. Glass to glass contact shall not be allowed.

5.3.1.5.4 Glass separation

The glasses shall be separated in a manner that does not hinder the airflow. The separators shall also not hinder the airflow, e.g. see Figure 2.

Dimensions in millimetres

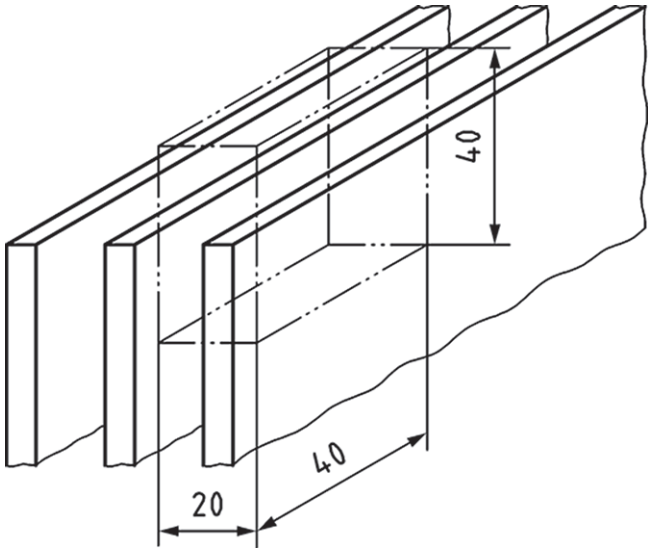


Figure 2 — Example of a vertical glass separator

The minimum separation of the glasses shall be determined during the calibration of the oven, see 5.3.1.5.5 and Annex F.

NOTE 1 Generally, a minimum separation of 20 mm is recommended (see Figure 3).

NOTE 2 If glasses of very different sizes are put on the same stillage, they will require greater separation in order to prevent glass breakage when the furnace is opened after the heat soak process. The same applies to glasses with holes, notches and cut-outs.

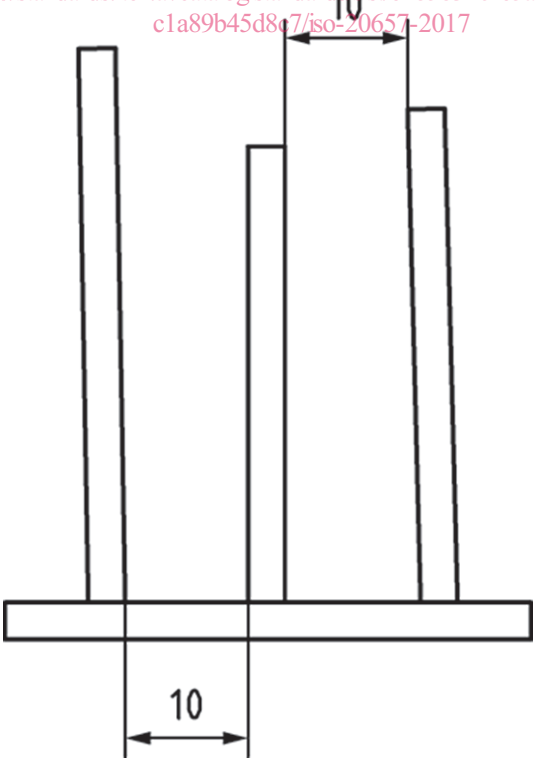


Figure 3 — Recommended separation between glass

The positioning of the separators, material of the manufacture and their shape shall be specified during the calibration test of the oven and shall be reproduced during the manufacturing process.

5.3.1.5.5 Calibration

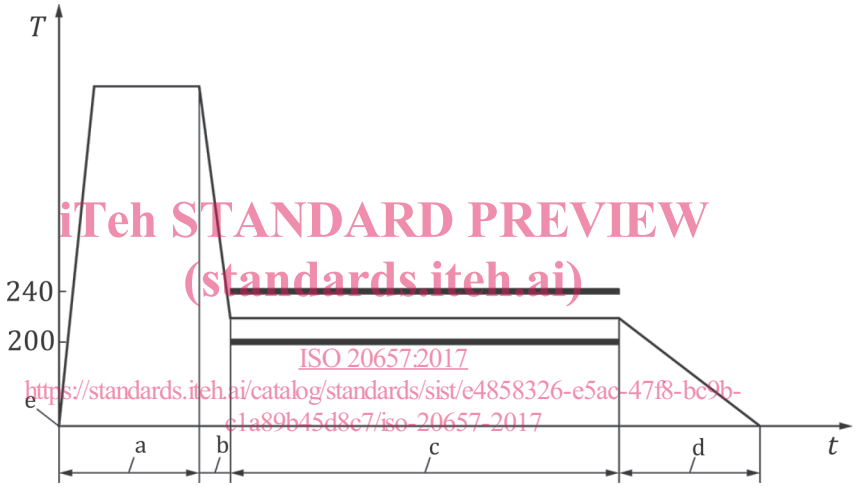
The heat soak system, e.g. oven, glass separation, separators, etc., shall be calibrated. See Annex F.

The calibration shall determine the heating phase of the process, glass separation distance, the positioning, material and shape of separators, the type and positioning of stillage(s) and define the operating conditions for use during manufacture.

5.3.2 In-line process

5.3.2.1 General

The in-line heat soak process cycle consists of only a holding phase subsequent to the quenching (see Figure 4).



Key

T glass temperature at any point, °C
t time, minutes
a heating phase for tempering
b quenching phase for tempering
c holding phase
d cooling phase

Figure 4 — In-line heat soak process cycle

5.3.2.2 Holding phase

The holding phase commences when the glass temperature has reached a temperature of between 200 °C and 240 °C. The duration of the holding phase is 12 min or more.

Precise oven control is necessary in order to ensure that the glass temperature is maintained in the range of 220 °C ± 20 °C during the holding phase.

The glass which has completed its holding phase (has been held at 220 °C ± 20 °C for 12 min or longer) is cooled down by exposure to ambient temperature.

5.3.2.3 In-line heat soak process system

5.3.2.3.1 General

The in-line heat soak process system only consists of the oven subsequent to the quenching furnace.

5.3.2.3.2 Oven

The oven temperature shall be maintained in the range of 220 °C ± 20 °C at all times. The entrance of the oven shall be designed to ensure that the temperature in the oven does not fall rapidly when the glass is moved in and out.

5.3.2.3.3 Glass temperature control

Precise glass temperature control is necessary before the glass enters the in-line heat soak oven in order to ensure that the glass is kept in the range of 220 °C ± 20 °C during the holding phase (see Annex E).

6 Fracture characteristics

6.1 General

In the event of breakage, heat soaked tempered safety glass fractures into numerous small pieces, the edges of which are generally blunt.

Fragmentation in service may not correspond exactly to that described in Clause 9 due to restraint from fixing and external actions or due to the cause of fracture.

There can be different fragmentations if heat soaked tempered glass is used in laminated glass.

6.2 Accidental human impact

6.2.1 When subjected to an accidental human impact, heat soaked tempered safety glass will either not break or break in a manner that will reduce the risk of cutting and piercing injuries.

6.2.2 Heat soaked tempered safety glass can be classified by the use of a pendulum impact test. When tested by this type of test, the safe breakage criteria employed for heat soaked tempered safety glass is that the 10 largest crack-free particles collected within 3 min after the impact shall weigh no more than 6 500 mm^2 of the original test piece.

6.2.3 The quoted break criteria is taken from the standards given in Annex A. Annex A lists the test methods presently employed to classify this product.

NOTE The safe breakage criteria are different to the fragmentation criteria used to determine that the product complies with its definition.

6.3 Fragmentation

This test method is employed to demonstrate that the heat soaked tempered safety glass breaks in the manner expected of this product. The fragmentation test (see Clause 9) details the minimum number of crack-free particles that shall be in a set area, i.e. 50 mm × 50 mm, and the dimension of the largest acceptable splinter.

This fragmentation behaviour ignores any influence of support conditions and is a representation of the effect of the surface pre-stress.

These properties are not size dependent.

7 Dimensions and tolerances

7.1 Nominal thickness and thickness tolerances

The nominal thicknesses and thickness tolerances in Table 1 are those given in the relevant product standards (see Clause 4).

Table 1

Nominal thickness mm	Float glass tolerances mm	Patterned glass tolerances mm
2	±0,2	Not manufactured
3	±0,3	±0,5
4	±0,3	±0,5
5	±0,3	±0,5
6	±0,3	±0,5
8	±0,6	±0,8
10	±0,6	±1,0
12	±0,8	±1,5
15	±0,8	±1,5
19	±1,2	±1,5
22	±1,2	±2,0
25	±1,2	Not manufactured

The thickness of a pane shall be determined as for the basic product. The measurement shall be taken at the centres of the 4 sides, and away from the area of any tong marks (see Figure 6), which may be present.

7.2 Width and length (sizes)

7.2.1 General

When heat soaked tempered safety glass dimensions are quoted for rectangular panes, the first dimension shall be the width, *B*, and the second dimension the length, *H*, as shown in Figure 5. It shall be made clear which dimension is the width, *B*, and which is the length, *H*, when related to its installed position.