BS EN 12150-1:2015

BSI Standards Publication

Glass in building — Thermally toughened soda lime silicate safety glass

Part 1: Definition and description

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National foreword

This British Standard is the UK implementation of EN 12150-1:2015. It supersedes BS EN 12150-1:2000 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee B/520/1, Basic and transformed glass products.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Glass in building - Thermally toughened soda lime silicate safety glass - Part 1: Definition and description

Verre dans la construction - Verre de silicate sodo-calcique de sécurité trempé thermiquement - Partie 1: Définition et description

Glas im Bauwesen - Thermisch vorgespanntes Kalknatron-Einscheiben-Sicherheitsglas - Teil 1: Definition und Beschreibung

This European Standard was approved by CEN on 8 August 2015.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

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European foreword

This document (EN 12150-1:2015) has been prepared by Technical Committee CEN/TC 129 "Glass in building", the secretariat of which is held by NBN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by March 2016, and conflicting national standards shall be withdrawn at the latest by March 2016.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 12150-1:2000.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

EN 12150, *Glass in building — Thermally toughened soda lime silicate safety glass*, consists of the following parts:

— *Part 1: Definitions and description*;

— *Part 2: Evaluation of conformity/Product standard*.

This European Standard differs from EN 12150-1:2000 as follows:

a) some figures have been revised and some new figures have been added;

b) new terms and definitions have been included in Clause 3, e.g. air cushion process (3.6), edge lift (3.9) and roller wave distortion (3.13);

c) further nominal thicknesses have been included in Table 1;

d) Subclause 6.2.3 "Tolerances and squareness" has been completely revised; the squareness of rectangular glass panes is now expressed by the difference between its diagonals;

e) Clauses 6 and 7 have been completely revised (including the air cushion manufacturing process);

f) the normative annex "Determination of U value" has been deleted;

g) a new informative annex dealing with an alternative method for the measurement of roller wave distortion has been added.

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

Thermally toughened soda lime silicate safety glass has a safer breakage behaviour when compared with annealed glass. When it should be used to offer protection under accidental human impact, thermally toughened soda lime silicate safety glass also should be classified according to EN 12600.

NOTE CEN/TC 129/WG 8 is producing standards for the determination of the design strength of glass and is preparing a design method.

1 Scope

This European Standard specifies tolerances, flatness, edgework, fragmentation and physical and mechanical characteristics of monolithic flat thermally toughened soda lime silicate safety glass for use in buildings.

Information on curved thermally toughened soda lime silicate safety glass is given in Annex A, but this product does not form part of this European Standard.

Other requirements, not specified in this European Standard, can apply to thermally toughened 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. Thermally toughened soda lime silicate safety glass, in this case, does not lose its bending strength characteristics and its resistance to temperature differentials.

Surface finished glasses (e.g. sandblasted, acid etched) after toughening are not covered by this European Standard.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 572-1, *Glass in building — Basic soda lime silicate glass products — Part 1: Definitions and general physical and mechanical properties*

EN 572-2, *Glass in building — Basic soda lime silicate glass products —Part 2: Float glass*

EN 572-4, *Glass in building — Basic soda lime silicate glass products — Part 4: Drawn sheet glass*

EN 572-5, *Glass in building — Basic soda lime silicate glass products — Part 5: Patterned glass*

EN 572-8, *Glass in building — Basic soda lime silicate glass products — Part 8: Supplied and final cut sizes*

EN 1096-1, *Glass in building — Coated glass - Part 1: Definitions and classification*

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

EN 14428, *Shower enclosures — Functional requirements and test methods*

3 Terms and definitions

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

3.1
thermally toughened soda lime silicate safety glass
thermally toughened 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

Note 1 to entry: The mechanical properties, i.e. thermal durability and mechanical strength, and safety properties, i.e. fragmentation characteristics, are generated by the level of surface compression. These properties are not size dependent.

3.2
flat thermally toughened soda lime silicate safety glass
thermally toughened soda lime silicate safety glass which has not been deliberately given a specific profile during manufacture

3.3
curved thermally toughened soda lime silicate safety glass
thermally toughened soda lime silicate safety glass which has been deliberately given a specific profile during manufacture

Note 1 to entry: See Annex A.

3.4
enamelled thermally toughened soda lime silicate safety glass
thermally toughened soda lime silicate safety glass which has a ceramic frit fired into the surface during the toughening process

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

Note 2 to entry: In the UK, this glass is also known as opaque thermally toughened soda lime silicate safety glass.

Note 3 to entry: The application of the ceramic frit may be by a continuous process or discontinuous application, e.g. screen printing. The enamelled surface could be partially or wholly.

3.5
horizontal 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 process
process in which the glass is suspended by tongs

3.8
edge deformation
deformation of the edge cause by the tong marks for vertically toughened glass

3.9
edge lift
distortion produced in horizontal toughened glass, at the leading and trailing edge of the plate

3.10
perimeter deformation
distortion around the edge of toughened glass manufactured by air cushion process

3.11
local distortion
local deformation of vertically toughened glass underneath the tong marks

3.12
overall bow
deformation of the whole pane of toughened glass caused by the heating and cooling process

3.13
roller wave distortion
distortion produced in horizontally toughened glass as a result of the glass during toughening process being in contact with the rollers

3.14
wave distortion
distortion produced in air cushioned toughened glass as a result of the glass toughening process

4 Glass products

Thermally toughened soda lime silicate safety glass is made from a monolithic glass generally corresponding to one of the following standards:

— soda lime silicate glass according to EN 572-1;

— float glass according to EN 572-2;

— drawn sheet glass according to EN 572-4;

— patterned glass according to EN 572-5;

— supplied and final cut sizes according to EN 572-8;

— coated glass according to EN 1096-1.

Glass of nominal thicknesses other than those covered in the above standards is possible.

5 Fracture characteristics

The fracture characteristics of thermally toughened soda lime silicate safety glass are directly related to the amount of surface compression. These properties are not size dependent.

When the thermally toughened soda lime silicate safety glass is manufactured with the correct degree of surface compression then in the event of breakage thermally toughened soda lime silicate safety glass fractures into numerous small pieces, the edges of which are generally blunt.

NOTE 1 The degree of surface compression required is dependent upon glass type and thickness.

NOTE 2 The fracture characteristics of glass are unaffected by temperatures between – 50 °C and + 100 °C.

The fragmentation described in Clause 8 is undertaken on unrestrained test specimens.

The fragmentation in service may not always correspond to that determined during the fragmentation test due to the imposition of other stresses, i.e. from fixing or from reprocessing (e.g. laminating).

6 Dimensions and tolerances

6.1 Nominal thickness and thickness tolerances

The nominal thicknesses and thickness tolerances are those given in the relevant product standard (see Clause 4), some of which are reproduced in Table 1.

Table 1 — Nominal thicknesses and thickness tolerances

Dimensions in millimetres

Nominal thickness *d*	Thickness tolerances for glass type			
	Float	Patterned	Drawn sheet	New antique drawn sheet
2	± 0,2	not manufactured	± 0,2	not manufactured
3	± 0,2	± 0,5	± 0,2	not manufactured
4	± 0,2	± 0,5	± 0,2	± 0,3
5	± 0,2	± 0,5	± 0,3	not manufactured
6	± 0,2	± 0,5	± 0,3	± 0,3
8	± 0,3	± 0,8	± 0,4	not manufactured
10	± 0,3	± 1,0	± 0,5	not manufactured
12	± 0,3	± 1,5	± 0,6	not manufactured
14	not manufactured	± 1,5	not manufactured	not manufactured
15	± 0,5	± 1,5	not manufactured	not manufactured
19	± 1,0	± 2,0	not manufactured	not manufactured
25	± 1,0	not manufactured	not manufactured	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 2), which may be present.

6.2 Width and length (sizes)

6.2.1 General

When thermally toughened soda lime silicate 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 1. It shall be made clear which dimension is the width, *B*, and which is the length, *H*, when related to its installed position.

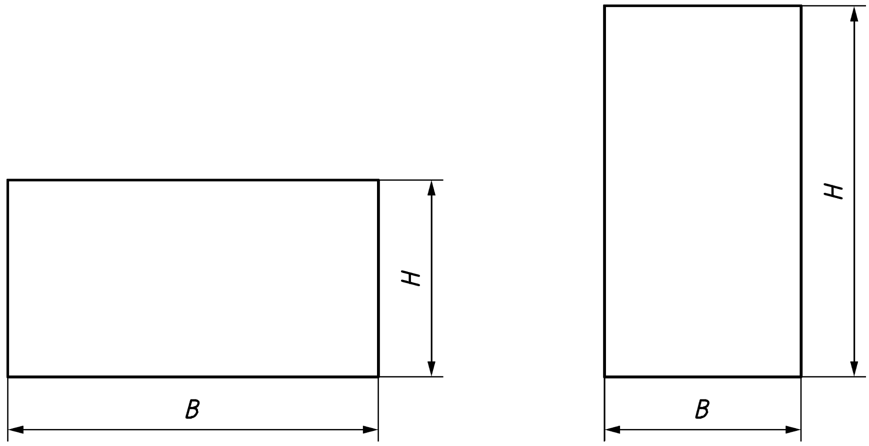


Figure 1 — Examples of width, *B*, and length, *H*, relative to the pane shape

6.2.2 Maximum and minimum sizes

For maximum and minimum sizes, the manufacturer should be consulted.

6.2.3 Tolerances and squareness

The nominal dimensions for width and length being given, the finished pane shall not be larger than the nominal dimensions increased by the tolerance *t*, or smaller than the nominal dimensions reduced by the tolerance *t*. Limits are given in Table 2.

The squareness of rectangular glass panes is expressed by the difference between their diagonals.

The difference between the two diagonal lengths of the pane of glass shall not be larger than the deviation limit, *v*, as specified in Table 3.

Table 2 — Tolerances on width, *B*, and length, *H*

Dimensions in millimetres

Nominal dimension of side, *B* or *H*	**Tolerance, *t***	
	nominal glass thickness, $d \leq 8$	**nominal glass thickness, $d > 8$**
≤ 2 000	± 2,0	± 3,0
2 000 < *B* or *H* ≤ 3 000	± 3,0	± 4,0
> 3 000	± 4,0	± 5,0

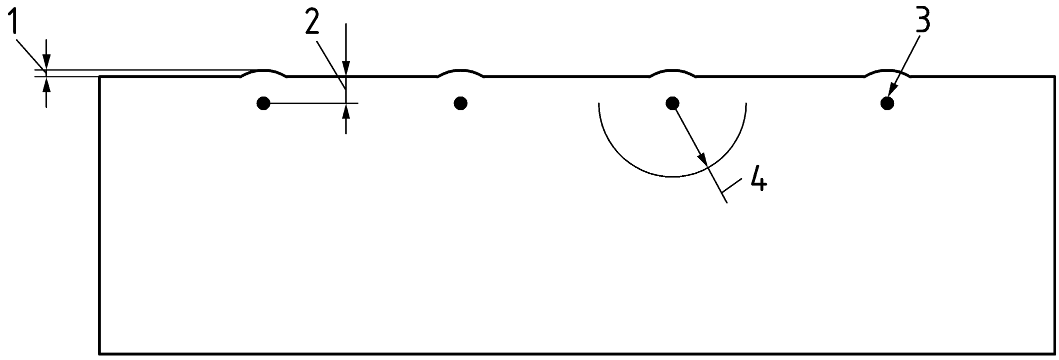
Table 3 — Limit deviations for the difference between diagonals

Dimensions in millimetres

Limit deviation v on the difference between diagonals		
Nominal dimension *B* or *H*	**nominal glass thickness, $d \leq 8$**	**nominal glass thickness, $d > 8$**
≤ 2 000	≤ 4	≤ 6
2 000 < *B* or *H* ≤ 3 000	≤ 6	≤ 8
> 3 000	≤ 8	≤ 10

6.2.4 Edge deformation produced by the vertical process

The tongs used to suspend the glass during toughening result in surface depressions, known as tong marks (see Figure 2). The centres of the tong marks are situated up to a maximum of 20 mm in from the edge. A deformation of the edge less than 2 mm can be produced in the region of the tong mark and there may also be an area of optical distortion. These deformations are included in the tolerances in Table 2.



Key

1 deformation

2 up to 20 mm

3 tong mark

4 100 mm radius maximum area of optical distortion

Figure 2 — Tong mark deformation

6.3 Flatness

6.3.1 General

By the very nature of the toughening process, it is not possible to obtain a product as flat as annealed glass. This difference in flatness depends on the type of glass, e.g. coated etc., glass dimensions, i.e. the nominal thickness, the dimensions and the ratio between the dimensions, and the toughening process employed.

There are six kinds of distortion:

— overall bow (see Figure 3);

— roller wave distortion (for horizontally toughened glass only) (see Figure 4);

— air cushion wave distortion (for air cushion toughened glass only);

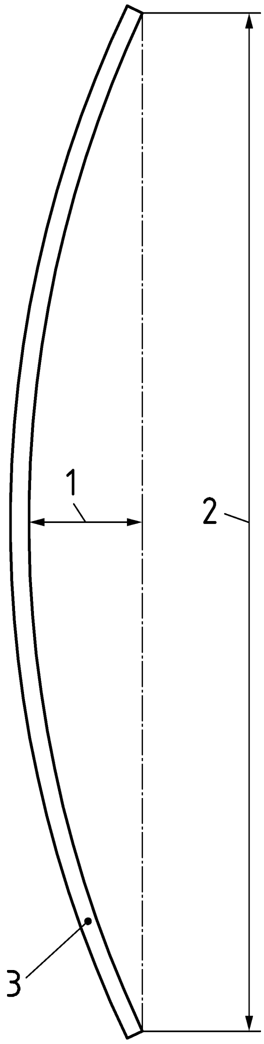
— edge lift (for horizontally toughened glass only) (see Figure 5);

— perimeter deformation (for toughened glass manufactured by air cushion process) (see Figure 10);

NOTE 1 Overall bow, roller wave, edge lift and perimeter deformation can, in general, be accommodated by the framing system.

— local distortion (for vertically toughened glass only) (see Figure 6).

NOTE 2 Local distortion needs to be allowed for within the glazing materials and the weather seals. For special requirements, it is advised to consult the manufacturer.



Key

1 deformation for calculating overall bow

2 *B*, or *H*, or diagonal length

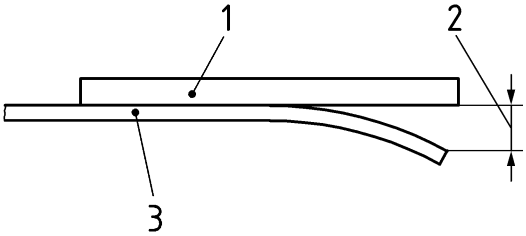
3 thermally toughened glass

Figure 3 — Representation of overall bow

Key

1 thermally toughened glass

Figure 4 — Representation of roller wave distortion



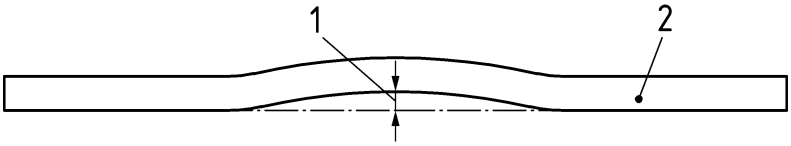
Key

1 straight edge

2 edge lift

3 thermally toughened glass

Figure 5 — Representation of edge lift



Key

1 local distortion

2 thermally toughened glass

Figure 6 — Representation of local distortion

6.3.2 Measurement of overall bow

The pane of glass shall be placed in a vertical position and supported on its longer side by two load bearing blocks at the quarter points (see Figure 7). For glass thinner than 4 mm nominal thickness the support will have an angle between 3° and 7° from the vertical.

The deformation shall be measured along the edges of the glass and along the diagonals, as the maximum distance between a straight metal ruler, or a stretched wire, and the concave surface of the glass (see Figure 3).

The value for the bow is then expressed as the deformation, in millimetres, divided by the measured length of the edge of the glass, or diagonal, in meter, as appropriate.

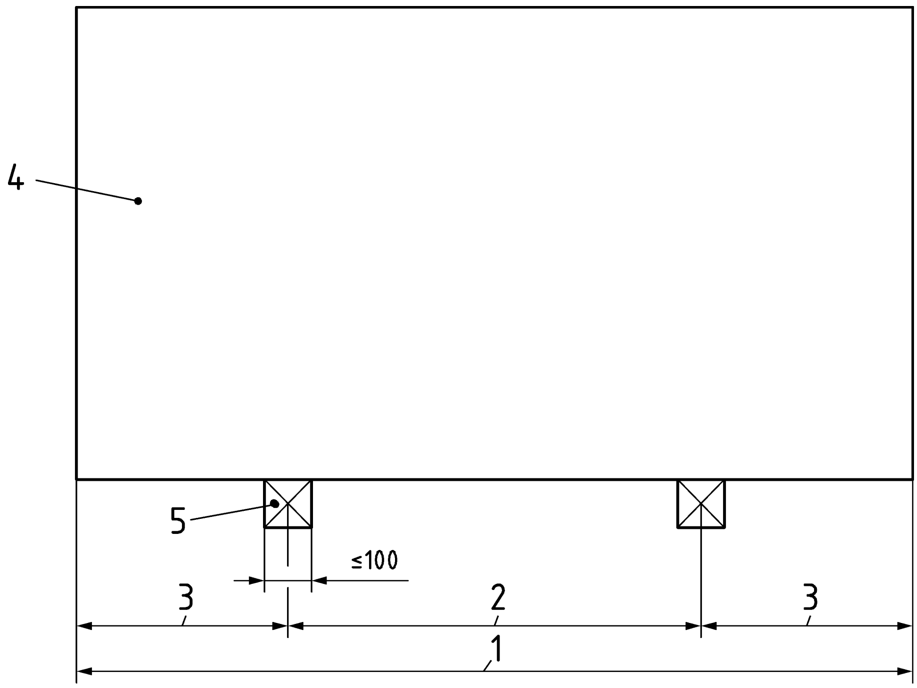
The measurement shall be carried out at room temperature.

Limit the measurement of the overall bow to a maximum pane size or specify dS.

The maximum allowable values are given in Table 4 and Table 6.

NOTE Results from this test method for glasses thinner than 4 mm may be inaccurate.

Dimensions in millimetres



Key

1 *B* or *H*

2 (*B* or *H*)/2

3 (*B* or *H*)/4

4 thermally toughened glass

5 support

Figure 7 — Support conditions for the measurement of overall bow

6.3.3 Measurement of wave and roller wave

6.3.3.1 General

The wave or roller wave is measured by means of a straight edge, or equivalent, being placed at right angles to the wave or roller wave and bridging from peak to peak of the waves (see Figure 8).

NOTE This section deals with measurement using a straight edge and feeler gauges. An alternative method is described in Annex B.

6.3.3.2 Apparatus

A straight edge:

— length of between 300 mm and 400 mm.

NOTE The minimal length of the straight edge needs to bridge two peaks of the roller waves.

Feeler gauges:

— various thicknesses in units of 0,05 mm.

6.3.3.3 Method

Place the straight edge so that it bridges across adjacent peaks. Insert the feeler gauge between the glass surface and the straight edge. Increase the thickness of the feeler gauges until they just fill the gap between glass surface and the straight edge. Record the thickness of feeler gauge(s) to an accuracy of 0,05 mm.

Repeat the measurement at several places over the glass surface.

The measured wave or roller wave distortion is the maximum value measured. The maximum allowable values are given in Table 4 and Table 6.

6.3.3.4 Limitations

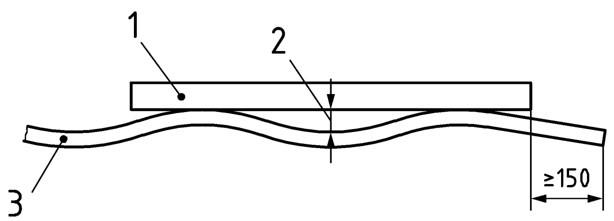
The following limitations apply:

— The wave and roller wave can only be measured on panes with a dimension greater than 600 mm measured at right angles to the wave and roller waves.

— The wave and roller wave cannot be measured in an exclusion area that is 150 mm from the edges of the pane as this is the area of different deformation modes. The apparatus should not be used in the area of these 150 mm.

— Panes with an overall bow can be laid on a flat support. This will allow gravity to flatten out the overall bow and hence give a truer result for the roller wave.

Dimensions in millimetres



Key

1 straight edge

2 wave or roller wave distortion

3 thermally toughened glass

Figure 8 — Measurement of wave or roller wave distortion

6.3.4 Measurement of edge lift (for horizontally toughened glass only)

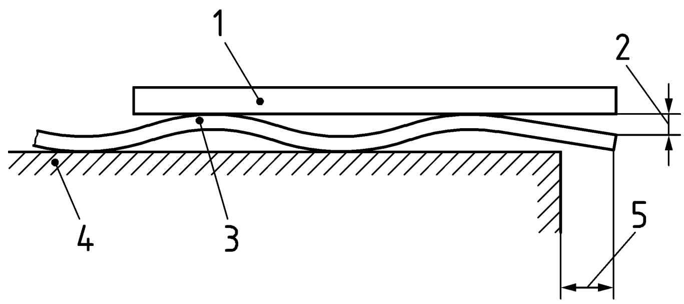
The glass shall be placed on a flat support with the edge lift overhanging the edge of the support by between 50 mm and 100 mm.

The straight edge is placed on the peaks of the roller waves and the gap between the ruler and the glass measured using a feeler gauge (see Figure 9).

NOTE The minimal length of the straight edge needs to bridge two peaks of the roller waves and the length of the edge lift.

The maximum allowable values for edge lift are given in Table 5.

The values in Table 5 only apply to thermally toughened glass having edgework complying with Figures 12 to Figure 15. For profiled edges or other types of edgework contact the manufacturer.



Key

1 straight edge

2 edge lift

3 thermally toughened glass

4 flat support

5 overhang of 50 to 100 mm

Figure 9 — Measurement of edge lift

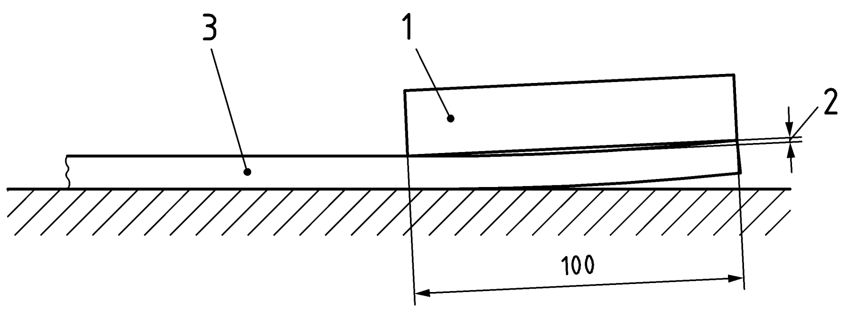
6.3.5 Measurement of perimeter deformation of glass produced by air cushion toughening process

Place the glass on a flat surface with the concave side facing upwards – see Figure 10.

A 100 mm straight edge is laid on the pane at right angles to the edge. The gap between the ruler and the glass is measured using a feeler gauge (see Figure 10). The perimeter deformation is the maximum distance between the surface of the pane and the straight edge.

The maximum allowable values for perimeter deformation are given in Table 7.

Dimensions in millimetres



Key

1 straight edge

2 perimeter deformation

3 thermally toughened glass

Figure 10 — Measurement of perimeter deformation

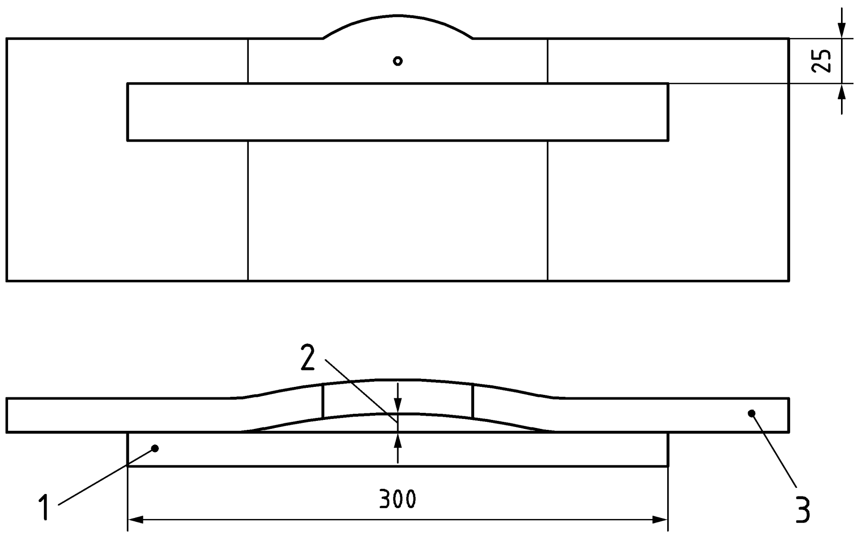
6.3.6 Measurement of local distortion (for vertically toughened glass only)

Local distortion can occur over relatively short distances on the edge of the vertically toughened glass that contains the tong marks (see Figure 2).

Local distortion shall be measured over a limited length of 300 mm by using a straight ruler parallel to the edge at a distance of 25 mm from the edge of the glass (see Figure 11).

Local distortion is expressed as millimetres/300 mm length.

Dimensions in millimetres



Key

1 straight edge

2 local distortion

3 thermally toughened glass

Figure 11 — Measurement of local distortion

6.3.7 Limitation on overall bow, roller waves and edge lift for horizontally toughened glass

The maximum allowable values for the overall bow, when measured according to 6.3.2, for roller waves, when measured according to 6.3.3 and edge lift, when measured according to 6.3.4 are given in Tables 4 and 5. These values only apply to thermally toughened glass without holes and/or notches and/or cut-outs.

Table 4 — Maximum allowable values of overall bow and roller wave distortion for horizontally toughened glass

Glass Type	Maximum allowable value for distortion	
	Overall bow mm / m	**Roller Wave** mm
Uncoated float glass in accordance with EN 572–1 and EN 572–2	3,0	0,3
Others[a]	4,0	0,5

[a] For enamelled glass which is not covered over the whole surface the manufacturer should be consulted.

NOTE Dependent upon the wavelength of the roller wave an appropriate length of gauge needs to be used.

Table 5 — Maximum allowable values for edge lift for horizontal toughening

Type of glass	Thickness of glass mm	Maximum allowable values mm
Uncoated float glass in accordance with EN 572–1 and EN 572–2	3	0,5
	4 to 5	0,4
	6 to 25	0,3
Others[a]	3 to 19	0,5

[a] For enamelled glass which is not covered over the whole surface the manufacturer should be consulted.

NOTE 1 Dependent upon the wavelength of the roller wave an appropriate length of gauge needs to be used.

NOTE 2 For uncoated float glass with a thickness of 2 mm it is advised to consult the manufacturer.

6.3.8 Limitation on overall bow, wave and perimeter deformation for toughened glass manufactured by air cushion process

The maximum allowable values for the overall bow, when measured according to 6.3.2, for waves, when measured according to 6.3.3 and perimeter deformation, when measured according to 6.3.5 are given in Tables 6 and 7. These values only apply to thermally toughened glass without holes and/or notches and/or cut-outs.

Table 6 — Maximum allowable values of overall bow and wave distortion for toughened glass manufactured by air cushion process

Glass Type	**Maximum allowable value for distortion**	
	Overall bow mm/m	**Wave** mm
Float glass in accordance with EN 572–1 and EN 572–2 and coated float glass in accordance with EN 1096-1	3,0	0,3
Others[a]	4,0	0,5
[a] For enamelled glass which is not covered over the whole surface the manufacturer should be consulted.		
NOTE For other glass types it is advised to consult the manufacturer.		

Table 7 — Maximum allowable values for perimeter deformation for toughened glass manufactured by air cushion process

Type of glass	**Thickness of glass** mm	**Maximum allowable values** mm
Float glass in accordance with EN 572–1 and EN 572–2 and coated float glass in accordance with EN 1096-1	2 to12	0,3
Others[a]	2 to 12	0,5
[a] For enamelled glass which is not covered over the whole surface the manufacturer should be consulted.		
NOTE For other glass types it is advised to consult the manufacturer.		

6.3.9 Limitation on overall bow and local distortion for vertically toughened glass

The maximum allowable values for the overall bow, when measured according to 6.3.2 and the local distortion, when measured according to 6.3.6 are given in Table 8. These values only apply to toughened glass without holes and/or notches and/or cut-outs.

Table 8 — Maximum allowable values of overall bow and local distortion for vertical toughened glass

Glass Type	**Maximum allowable value for distortion**	
	Overall bow mm/m	**Local distortion** mm/300 mm
All[a]	5,0	1,0
[a] For enamelled glass which is not covered over the whole surface the manufacturer should be consulted.		

6.3.10 Other distortions

The incorporation of holes and/or notches in a plate gives the possibility of distortions being produced during the toughening process as a result of the absence of glass and/or an increase in unsupported edges.

NOTE The magnitude of these distortions will generally be less than edge lift in horizontally toughened glass or local distortion in vertically toughened glass.

7 Edge and/or surface work, holes, notches and cut-outs

7.1 Warning

Thermally toughened soda lime silicate safety glass shall not be cut, sawed, drilled, edge worked after toughening because the risk of breakage is increased or the glass can be destroyed immediately. Surface finished glasses (e.g. sandblasted, acid etched) after toughening are not covered by this European Standard.

7.2 Edge working of glass for toughening

The simplest type of edge working is the arrissed edge (see Figure 12). Common types of edge working are shown in Figure 13 to Figure 15. For specialist edge work, such as 'water jet cutting', the manufacturer should be consulted. Corners need not to be treated unless required by the customer.

NOTE The rollers used to convey glass produced by the inclined air cushion process may cause slight marks on the edge of the pane. This applies to polished edges in particular.

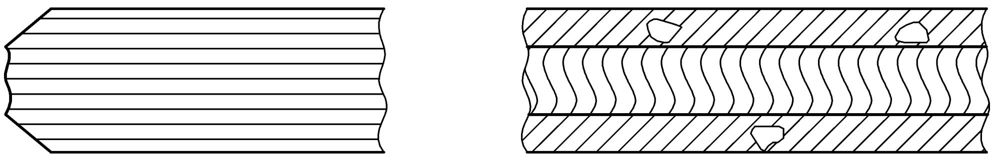


Figure 12 — Arrissed edge (with blank spots)

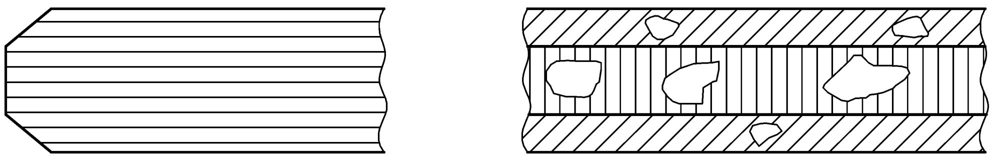


Figure 13 — Ground edge (with blank spots)

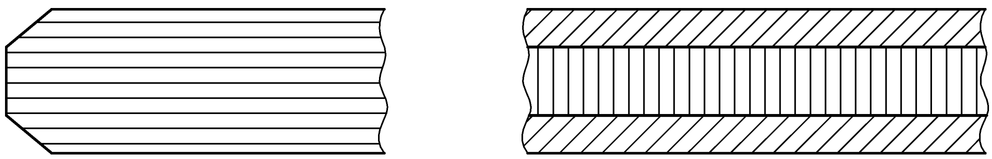


Figure 14 — Smooth ground edge (no blank spots)

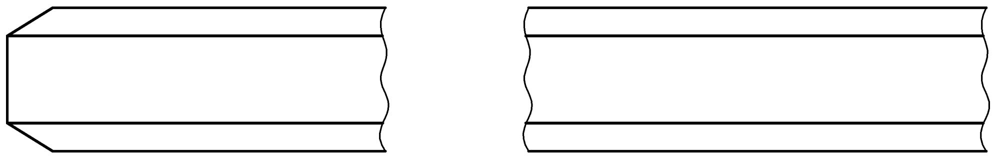


Figure 15 — Polished edge

7.3 Profiled edges

Various other edge profiles can be manufactured with different types of edgework. This kind of product is not covered by Table 5 due to the influence of the profile.

7.4 Round holes

7.4.1 General

This European Standard considers only round holes in glass that is not less than 4 mm nominal thickness. The manufacturer should be consulted about edge working of holes. This edge work applies only to the perimeter of the holes.

7.4.2 Diameter of holes

The diameter of holes, Ø, shall not, in general, be less than the nominal thickness of the glass. For smaller holes, the manufacturer should be consulted.

7.4.3 Limitations on position of holes

In general, the limitations on hole positions relative to the edges of the glass pane, the corners of the glass pane and to each other depends on:

— the nominal glass thickness (*d*);

— the dimensions of the pane (*B*, *H*);

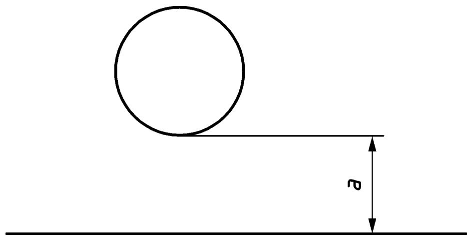
— the hole diameter (Ø);

— the shape of the pane;

— the number of holes.

The recommendations given below are those which are normally available.

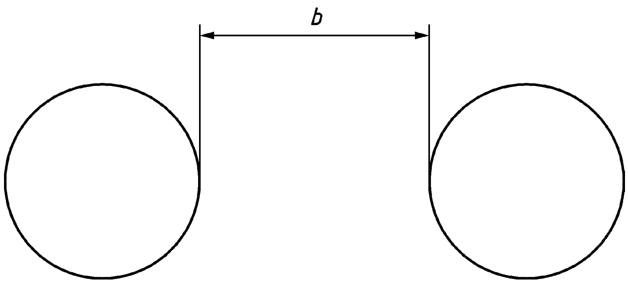
a) The distance, *a*, of the edge of a hole to the glass edge should be not less than 2*d*.



a ≥ 2*d*

Figure 16 — Relationship between hole and edge of pane

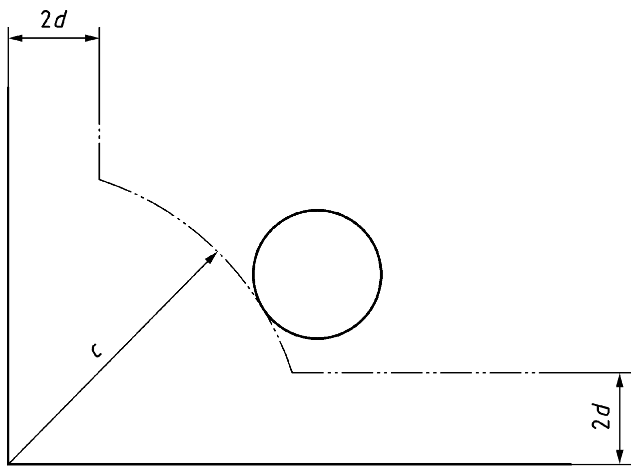
b) The distance, *b*, between the edges of two holes should be not less than 2*d*.



$b \geq 2d$

Figure 17 — Relationship between two holes

c) The distance, *c*, of the edge of a hole to the corner of the glass should be not less than 6*d*.



$c \geq 6d$

Figure 18 — Relationship between hole and corner of pane

NOTE If one of the distances from the edge of the hole to the edge of the glass is less than 35 mm, it can be necessary to position the hole asymmetrically with respect to the corner. It is advised to consult the manufacturer.

7.4.4 Tolerances on hole diameters

The tolerances on hole diameters are given in Table 9.

Table 9 — Tolerances on hole diameters

Dimensions in millimetres

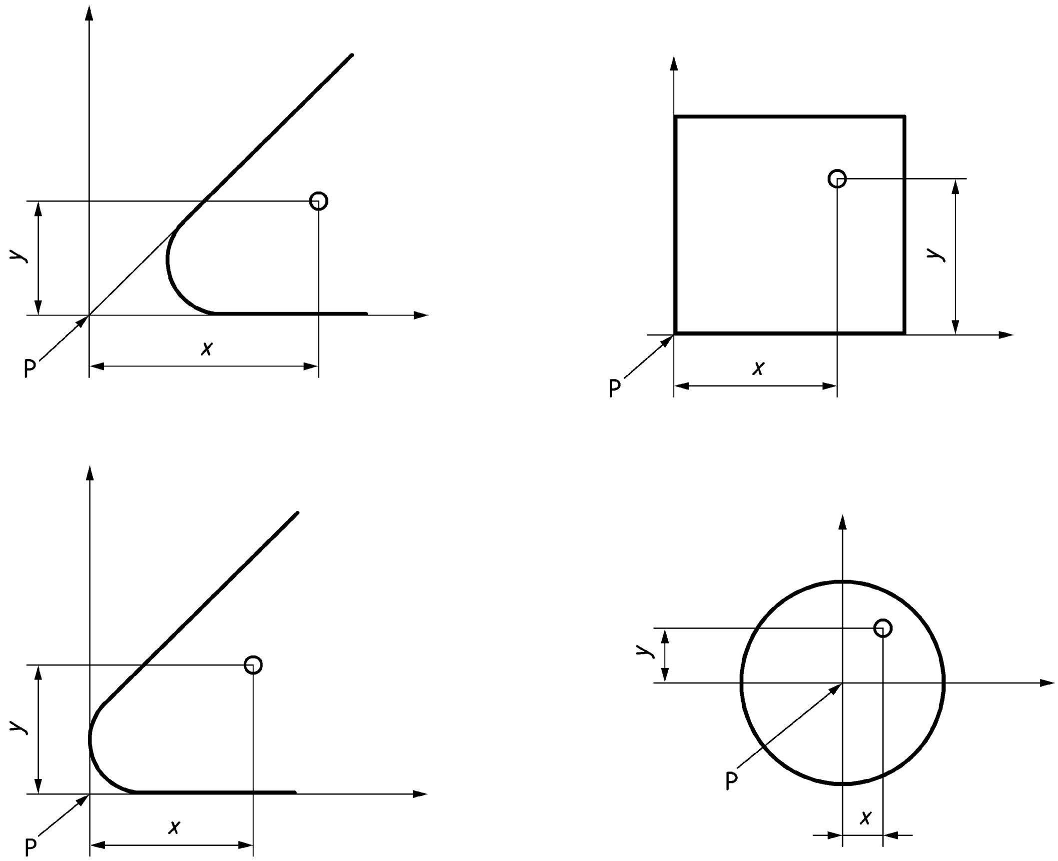
Nominal hole diameter, Ø	Tolerances
4 ≤ Ø ≤ 20	± 1,0
20 < Ø ≤ 100	± 2,0
100 < Ø	consult the manufacturer

7.4.5 Tolerances on position of holes

The tolerances on positions of holes are the same as the tolerances on the width, *B*, and the length, *H* (see Table 2). The positions of holes are measured in two directions at right angles (*x*- and *y*- axes) from a datum point to the centre of the holes. The datum point is generally chosen as a real or virtual corner of the pane (see Figure 19 for examples).

The position of a hole (*X*, *Y*) is ($x \pm t$, $y \pm t$), where *x* and *y* are the required dimensions and *t* is the tolerance from Table 2.

NOTE It is advised to consult the manufacturer if tighter tolerances on hole positions are required.



Key

P datum point

Figure 19 — Examples of the positioning of holes relative to the datum point

7.5 Holes/others

There are available countersunk holes, see Figure 20. The manufacturer shall be consulted for the tolerances on hole position, hole shape/dimensions and edge work.

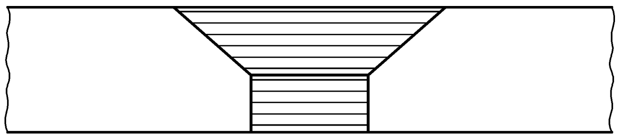


Figure 20 — Countersunk hole

7.6 Notches and cut-outs

Many configurations of notches and cut-outs can be supplied, examples see Figure 21. Corners of notches and cut-outs should be rounded out.

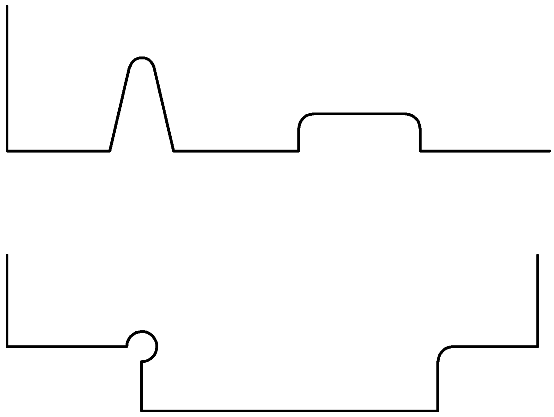


Figure 21 — Examples of notches and cut-outs

The manufacturer should be consulted about edge working of notches and cut-outs.

7.7 Shaped panes

Many non-rectangular shapes can be manufactured and manufacturer should be consulted.

8 Fragmentation test

8.1 General

The fragmentation test determines whether the glass breaks in the manner prescribed for a thermally toughened soda lime silicate safety glass.

8.2 Dimensions and number of test specimens

The dimensions of the test specimens shall be 360 mm × 1 100 mm, without holes, notches or cut-outs.

Five specimens shall be tested.

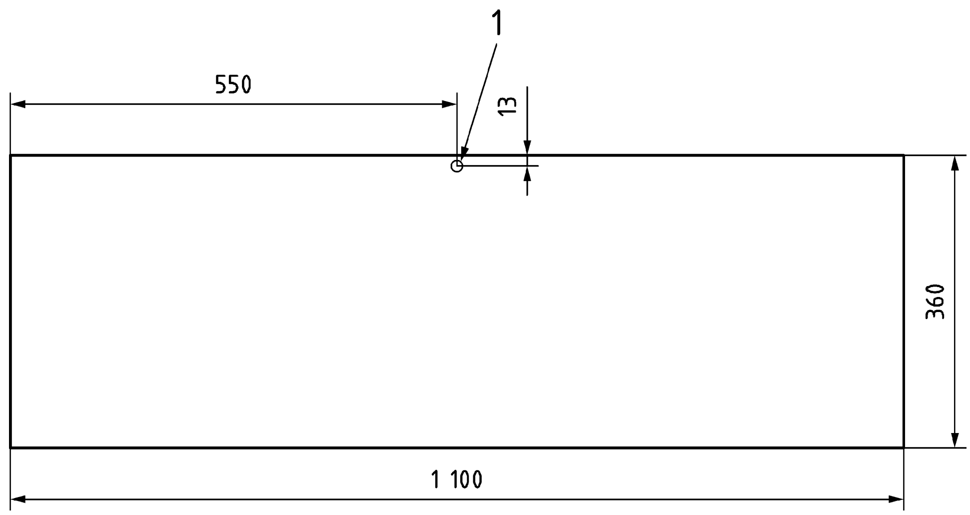
8.3 Test procedure

Each test specimen shall be impacted, using a pointed steel tool, at a position 13 mm in from the longest edge of the test specimen at the mid-point of that edge, until breakage occurs (see Figure 22).

Examples of steel tools are a hammer of about 75 g mass, a spring loaded centre punch, or other similar appliance with a hardened point. The radius of curvature of the point should be approximately 0,2 mm.

The test specimen shall be laid flat on a table without any mechanical constraint. In order to prevent scattering of the fragments, the specimen shall be simply held at the edges, e.g. by a small frame, adhesive tape etc., so that the fragments remain interlocked after breakage yet extension of the specimen is not hindered.

Dimensions in millimetres



Key

1 impact point

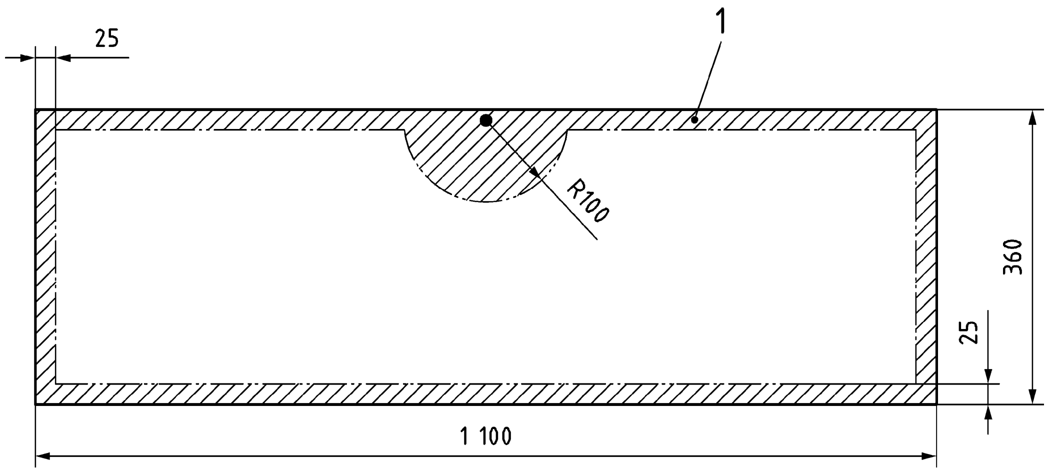
Figure 22 — Position of impact point

For thermally toughened soda lime silicate safety glass manufactured by vertical toughening, the impact point shall not be on the tong mark edge.

8.4 Assessment of fragmentation

The particle count and measuring of the dimensions of the largest particle shall be made between 3 min to 5 min after fracture. An area of radius 100 mm, centred on the impact point, and a border of 25 mm, round the edge of the test specimen (see Figure 23), shall be excluded from the assessment.

Dimensions in millimetres



Key

1 excluded area

Figure 23 — Area to be excluded from the particle count determination and largest particle measurement

The particle count shall be made in the region of coarsest fracture (the aim being to obtain the minimum value). The particle count shall be made by placing a mask of (50 ± 1) mm × (50 ± 1) mm on the test piece (see Annex C). The number of crack-free particles within the mask shall be counted. A particle is 'crack-free' if it does not contain any cracks which run from one edge to another (see Figure 24).

The examination shall be completed within 5 min of fracturing the glass.

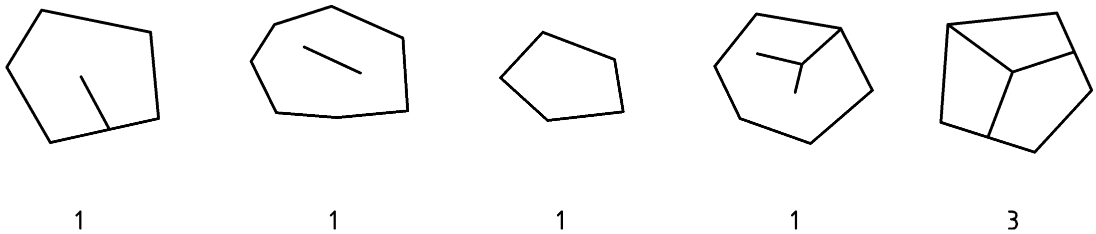


Figure 24 — Examples of crack-free particles and the assessment regarding the number

In the particle count, all particles wholly contained within the area of the mask shall be counted as one particle each and all the particles which are partially within the mask shall be counted as 1/2 particle each (see Annex C).

8.5 Minimum values from the particle count

In order to classify a glass as a thermally toughened soda lime silicate safety glass, the particle count of each test specimen shall not be less than the values given in Table 10.

Table 10 — Minimum particle count values

Glass type	**Nominal thickness,** *d* mm	**Minimum particle count** number	**Shower enclosures** **(see** EN 14428**)**
All glass types	2	15	not applicable
All glass types	3	15	40
All glass types	4 to 12	40	40
All glass types	15 to 25	30	30

8.6 Selection of the longest particle

The longest particle shall be chosen from the body of the test specimen. It shall not be in the excluded area (see 8.4).

8.7 Maximum length of longest particle

In order to classify the glass as thermally toughened soda lime silicate safety glass, the length of the longest particle shall not exceed 100 mm.

9 Other physical characteristics

9.1 Optical distortion

9.1.1 Thermally toughened soda lime silicate safety glass produced by vertical toughening

The tong marks can produce additional optical distortion which is generally in an area of radius 100 mm centred on the tong mark (see Figure 2).

9.1.2 Thermally toughened soda lime silicate safety glass produced by horizontal toughening

Roller waves create an optical distortion which is generally noticed in reflection. Glass which is thicker than 8 mm can show signs of small imprints in the surface (‘roller pick-up’).

9.2 Anisotropy (iridescence)

The thermal toughening process produces areas of different stress in the cross section of the glass. These areas of stress produce a bi-refringent effect in the glass, which is visible in polarized light.

When thermally toughened soda lime silicate safety glass is viewed in polarized light, the areas of stress show up as coloured zones, sometimes known as ‘leopard spots’.

Polarized light occurs in normal daylight. The amount of polarized light depends on the weather and the angle of the sun. The bi-refringent effect is more noticeable either at a glancing angle or through polarized spectacles.

Anisotropy is not a defect but a visible effect.

9.3 Thermal durability

The mechanical properties of thermally toughened soda lime silicate safety glass are unchanged for continuous service up to 250 °C and are unaffected by sub-zero temperatures. Thermally toughened soda lime silicate safety glass is capable of resisting both sudden temperature changes and temperature differentials up to 200 K.

NOTE This property does not have any relationship to the fire resistance performance.

9.4 Mechanical strength

The value of bending strength can only be given as a statistical value associated with a particular probability of breakage and with a particular type of loading. Table 11 gives the minimum characteristic bending strength (5 % Fractile for a confidence level of 95 %) for different types of glass when tested to EN 1288-3.

Table 11 — Minimum values for the mechanical strength of thermally toughened soda lime silicate safety glass

Type of glass	Minimum characteristic bending strength N/mm^2
Float: clear tinted coated	120
Enamelled glass (based on the enamelled surface in tension)	75
Others (according to Clause 4)	90

NOTE 1 The values in Table 11 represent the strength of thermally toughened soda lime silicate safety glass which meets the requirements of 8.5.

At least 10 specimens of thermally toughened soda lime silicate safety glass shall be tested according to EN 1288-3. The 5 % breakage probability, statistically evaluated at the lower limit of the 95 % confidence interval, shall be not less than the value in Table 11.

NOTE 2 A statistical evaluation of test results is not possible, at the time of the publication of this standard, for glass thicknesses <3 mm as usually those glasses will not break under the test conditions. EN 1288-3, [2], is being revised to allow glasses less than 3 mm to be tested to breakage.

9.5 Classification of performance under accidental human impact

Thermally toughened soda lime silicate safety glass can be classified, as to its performance under accidental human impact, by testing in accordance with EN 12600.

10 Marking

Thermally toughened soda lime silicate safety glass conforming to this European Standard shall be permanently marked. The marking shall give the following information:

— name or trademark of manufacturer;

— number of this European Standard: EN 12150-1.

For 3 mm thermally toughened soda lime silicate safety glass for use in showers i.e. glass conforming to the appropriate fragmentation level in Table 10, shall be marked as follows:

— name or trademark of manufacturer;

— number of this European Standard: EN 12150-1;

— the letter “S”.

Annex A
(informative)

Curved thermally toughened soda lime silicate safety glass

Curved (in the UK also called bent) thermally toughened soda lime silicate safety glass has been deliberately given a specific profile during the course of manufacture. It is not included in this European Standard. However, the information given in this European Standard on thickness, edge work and fragmentation is also applicable to curved thermally toughened soda lime silicate safety glass.

ISO/TC 160/SC 1/WG 8 has published Standards on curved glass, i.e. ISO 11485-1, ISO 11485-2 and ISO 11485-3. Part 3 deals with thermally tempered (toughened) safety glass. Specific reference is made to fragmentation testing, allowable particle counts and means of undertaking a pendulum impact test.

Annex B
(informative)

Alternative method for the measurement of roller wave distortion

B.1 Apparatus

This is a 350 mm long aluminium channel with a centrally mounted deflection gauge/dial gauge (Figure B.1).

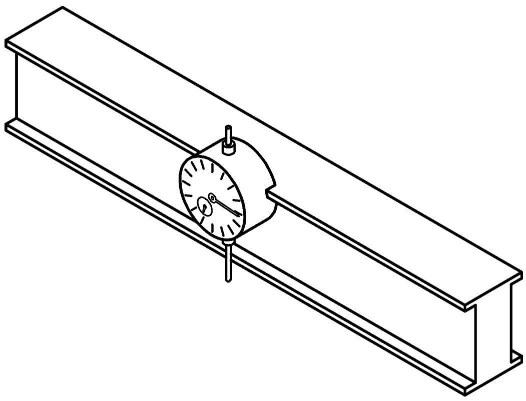


Figure B.1 — Roller wave measurement apparatus

B.2 Method

The apparatus is placed on the glass at right angles to the roller wave, so that it can bridge from peak to peak of the wave (Figure B.2).

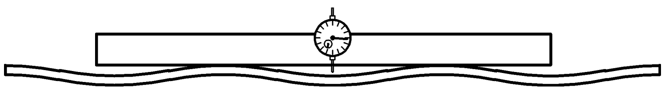


Figure B.2 — Place the apparatus across the roller wave

The apparatus is then moved along its axis until the dial gauge reads the highest value (Figure B.3).

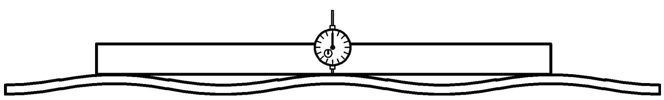


Figure B.3 — Set the zero of the gauge on a peak of the roller wave

At this point, the dial gauge is resting on a peak of the roller wave. The scale of the gauge is positioned (rotated) so that the needle points to 0 (zero) on the scale. The apparatus is then moved again along its axis until the gauge reads the lowest value (Figure B.4). At this point, the dial gauge is resting in the lowest point of the trough. The reading is then taken, and the depth of the roller wave is the difference between the zero point and the reading.

NOTE The dial gauge scale is usually arranged so that a positive value is obtained by raising the post. It is advised to take care to not misread the depth of the roller wave.

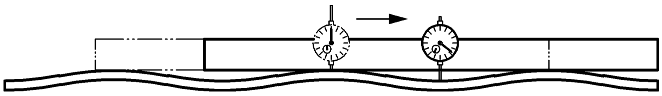


Figure B.4 — Move the gauge to a trough

The roller wave depth is recorded to the nearest 0,05 mm.

The above procedure can be performed several times on the same pane, giving a variety of answers, since the roller waves are unlikely to be consistent. The worst roller wave of those recorded is the value of the pane.

B.3 Limitations

The apparatus should only be used on panes with a dimension larger than 600 mm at right angles to the roller wave. There is an exclusion area, 150 mm from the edge of the pane, where the apparatus should not be used.

The deformation of the edges (up to 150 mm from the edge of the pane) can be different from the deformation of the rollers the surface out of this area of the glass.

A true measurement of roller wave can only be obtained on an otherwise flat pane of glass. If the pane has an overall bow, this will contribute to the value measured by the roller wave and shall be taken into account. This can be reduced by laying the pane of glass flat on a table, which will reduce the overall bow in the pane due to the self-weight of the pane, particularly with larger panes.

B.4 Alternative use of apparatus

If the dial gauge is mounted on the end of the aluminium channel rather than at the centre then it may be used for the measurement of edge lift.

Lay the test sample over the end of a table with the edge lift overhanging the edge of the support by between 50 mm and 100 mm so that the edge lift is as shown in Figure 5. Move the apparatus towards the edge of the sample. Measure the maximum deflection of the gauge from when sitting on a peak to touching the edge of the sample.

Annex C
(informative)

Examples of particle count

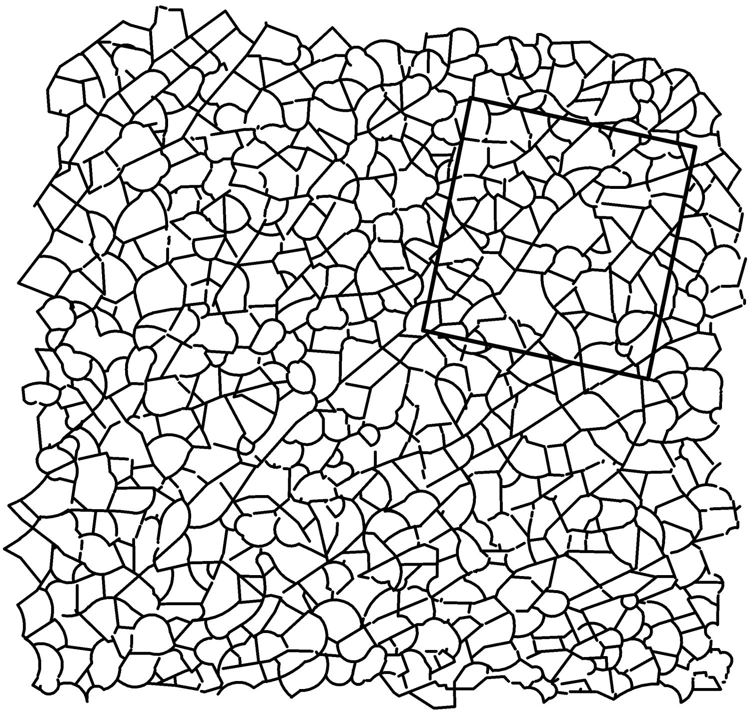
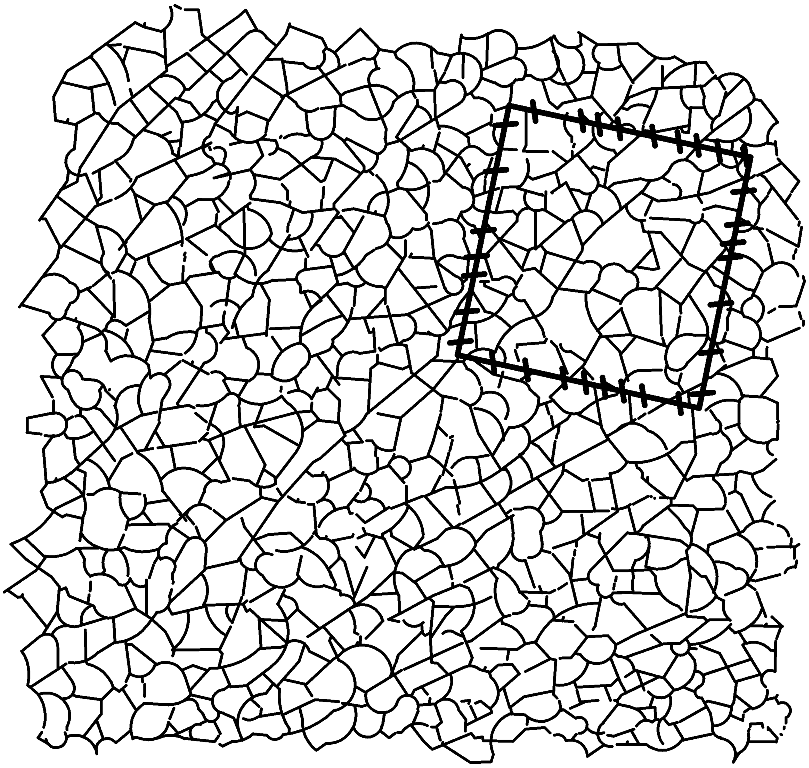


Figure C.1 — Example of selecting the area of coarsest fracture

Select the area of coarsest fracture, according to 8.4, place the template on the test specimen and draw round the template.

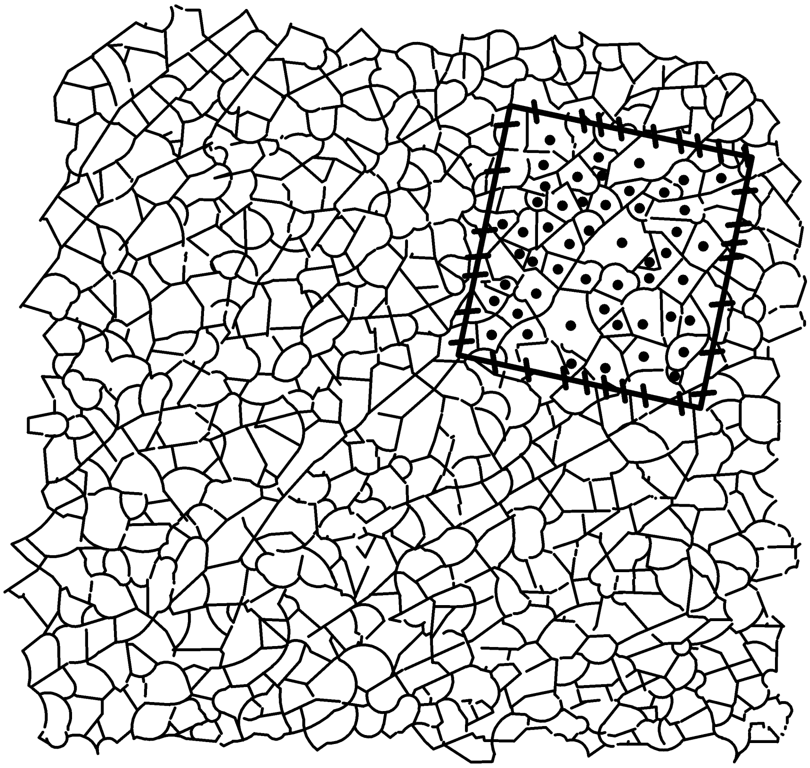


Key

Number of perimeter particles = 32/2 = 16

Figure C.2 — Example of marking and counting

Mark and count the perimeter fragments particles as 1/2 particle each.



Key

Number of central particles	= 53
Total number of particles	= 16 + 53 = 69

Figure C.3 — Example for marking and counting of overall particle count for the specimen

Mark and count the central particles and add these to the perimeter count to obtain the particle count for the specimen.

Annex D
(informative)

Risk of spontaneous breakage of toughened glass due to nickel sulfide inclusion

Nickel sulfide inclusion is a rare, but naturally occurring impurity present in all glass that can, in certain circumstances, lead to spontaneous breakage of thermally toughened glass in service.

To reduce the risk of toughened glass spontaneously breaking due to the presence of critical nickel sulfide (NiS) inclusions in the glass, it is advisable to put toughened glass through an additional heat treatment known as the heat-soak process (see EN 14179-1).

This is a destructive test which eliminates the majority of the glass that is at risk. While the technique cannot eliminate 100 % of the glass which is at risk, the risk of breakage is considerably reduced.

This treatment is recommended for all situations where the stability of the structure and the safety of users may be at risk from breakage of the toughened glass.

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[2] EN 12600, *Glass in building - Pendulum test - Impact test method and classification for flat glass*

[3] EN 14179-1, *Glass in building - Heat soaked thermally toughened soda lime silicate safety glass - Part 1: Definition and description*

[4] ISO 11485-1, *Glass in building — Curved glass — Part 1: Terminology and definitions*

[5] ISO 11485-2, *Glass in building — Curved glass — Part 2: Quality requirements*

[6] ISO 11485-3, *Glass in building — Curved glass — Part 3: Requirements for curved tempered and curved laminated safety glass*

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