
**Glass in building — Curved glass —
Part 2:
Quality requirements**

*Verre dans la construction — Verre bombé — Partie 2: Exigences de
qualité*

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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

ISO 11485-2 was prepared by Technical Committee ISO/TC 160, *Glass in building*, Subcommittee SC 1, *Product considerations*.

ISO 11485 consists of the following parts, under the general title *Glass in building — Curved glass*:

- *Part 1: Terminology and definitions*
- *Part 2: Quality requirements*
- *Part 3: Requirements for tempered and laminated curved safety glass¹⁾*

1) Under preparation.

Glass in building — Curved glass —

Part 2: Quality requirements

1 Scope

This part of ISO 11485 specifies the quality requirements for curved glass used in general building construction, furniture, display and various other non-automotive applications.

2 Normative references

The following referenced documents are indispensable for the application 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 11485-1, *Glass in building — Curved glass — Part 1: Terminology and definitions*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 11485-1 apply.

4 Quality requirements

4.1 General

Curved glass can originate as annealed float glass, patterned glass or wired glass. Curved glass can be processed as tempered, laminated, heat strengthened, coated or frit enamelled. It can also be assembled into insulated glass units.

All of these various products shall conform to the corresponding ISO standard for flat products except for those unique characteristics covered by this part of ISO 11485 or when it can be demonstrated that a particular requirement of the corresponding standard cannot be applied to curved glass for any reason (i.e. testing flat samples vs. curved samples).

When there is no corresponding International Standard, any other national standard may be used instead.

When tested in accordance with Clause 5, the curved glass shall conform to the quality requirements given in Clause 4, summarized in Table 1.

The tolerance on thickness of curved glass panes shall conform to the tolerance on thickness stated in the corresponding basic product standard ISO 16293 (all parts), however minor changes to glass thickness may occur due to stretching during forming and/or shaping.

Table 1 — Quality requirements for curved glass

Quality requirement		Corresponding subclauses			
Classification	Sub-classification	Curved annealed glass, curved tempered glass, curved heat-soaked tempered glass	Curved laminated glass	Curved insulating glass	Test method
Shape and dimension	length tolerance	4.2	4.2	4.2	5.1
	girth tolerance	4.2	4.2	4.2	5.1
	shape accuracy tolerance	4.2	4.2	4.8	5.1
	thickness tolerance	—	4.7	4.8	—
	displacement	—	4.7	4.8	—
	edge straightness deviation	4.3	4.3	4.3	5.2
	maximum cross-curve deviation	4.4	4.4	4.4	5.3
	maximum twist deviation	4.5	4.5	4.5	5.4
Appearance	length and permissible number of appearance defects	4.6	4.6	4.6	5.5

4.2 Tolerances on the shape accuracy, girth and length

When measured in accordance with 5.1, the tolerances on shape accuracy, girth and length shall be as given in Table 2, illustrated in Figure 1.

Table 2 — Tolerances on the shape accuracy, girth and length

	Tolerance	
	Thickness < 10 mm	Thickness ≥ 10 mm
ΔP_C^a	$2/3 T$	$1/2 T$
ΔG	$\pm 2 \text{ mm/m}$	$\pm 3 \text{ mm/m}$
ΔL	$\pm 2 \text{ mm/m}$	$\pm 3 \text{ mm/m}$

^a Measured perpendicularly to the glass.

where

ΔP_C is the tolerance on the shape accuracy;

ΔG is the tolerance on the overall girth; and

ΔL is the tolerance on length.

T is the nominal thickness of the final product when the curved glass type is curved annealed glass, curved tempered glass, curved tempered heat-soaked glass or curved laminated glass, or the thickness of the glass components when assembled into a curved insulating glass.

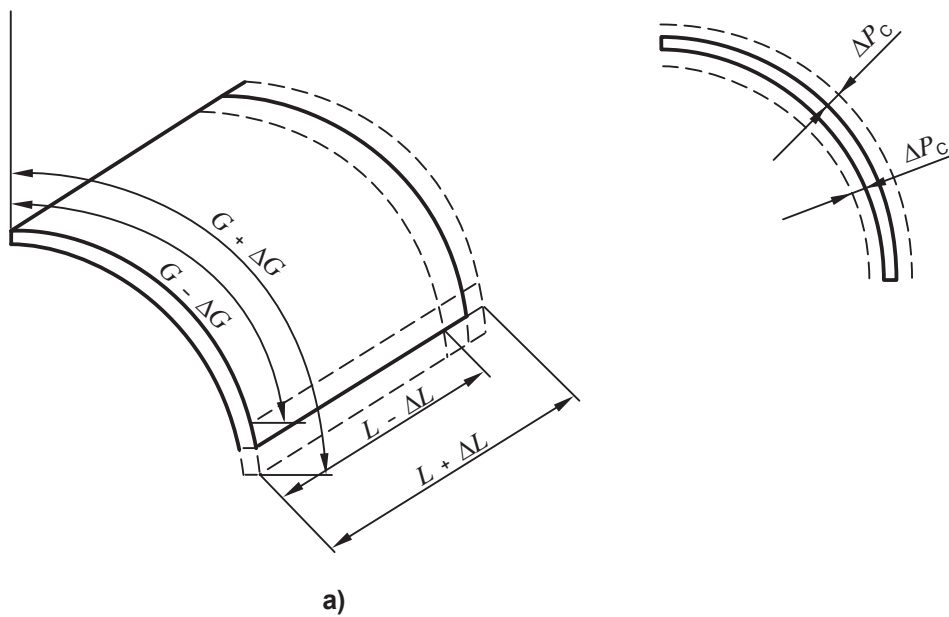


Figure 1 — Tolerances on shape accuracy, girth and length

4.3 Edge straightness deviation (ΔR_B)

When measured in accordance with 5.2, the acceptable limits for edge straightness deviation shall be:

$$\Delta R_B \leq 3 \text{ mm/m or } 2 \text{ mm, whichever is greater.}$$

NOTE An example of edge straightness deviation is shown in Figure 2.

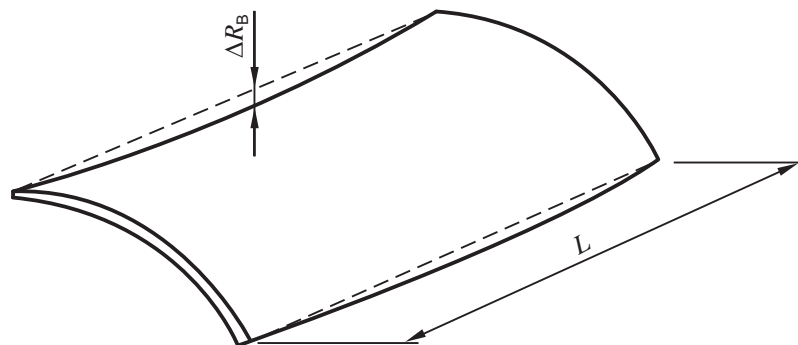


Figure 2 — Example of edge straightness deviation

4.4 Maximum cross-curve deviation

When measured in accordance with 5.3, the maximum cross-curve deviation shall not exceed 4 mm/m of the length (see Figure 9).

This maximum cross-curve deviation shall be distinguished from edge straightness deviation.

4.5 Maximum twist deviation (V)

When tested in accordance with 5.4, the twist deviation, as shown in Figure 3, shall not exceed the maximum tolerances for thicknesses of ≤ 12 mm. For other thicknesses, the manufacturer should be consulted.

Table 3 — Maximum tolerances for twist deviation

Length (mm)	Twist deviation (mm)
$L \leq 1\ 200$	$V < 4$
$1\ 200 < L \leq 1\ 500$	$V < 5$
$1\ 500 < L \leq 2\ 000$	$V < 6$
$2\ 000 < L \leq 2\ 400$	$V < 7$
$L > 2\ 400$	$V < 8$

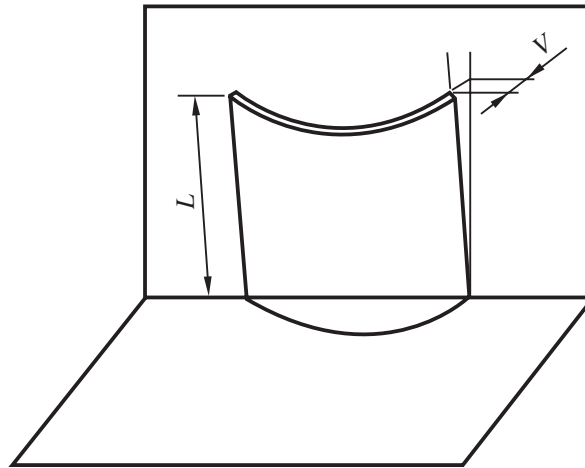


Figure 3 — Twist deviation

4.6 Appearance

When tested in accordance with 5.5, the appearance of curved glass shall conform to the acceptability criteria given in Table 4.

Table 4 — Appearance acceptability

Type of defect	Acceptability
cracking (cold crack)	None
chipping	Covered edge: No chipping of a width or length more than the nominal thickness of the glass. Exposed edge: No chipping that hinders serviceability.
tong marks	In cases where the nominal thickness of glass is 6 mm or less, tong marks shall only be allowed within 8 mm of the glass edge, as shown in Figure 4. In cases where the nominal thickness is over 6 mm, tong marks shall be allowed within the thickness of the glass + 2,0 mm, as shown in Figure 4.

Table 4 (continued)

Type of defect	Acceptability
pock marks	Pock marks shall not exceed 2,0 mm in diameter.
ring marks	In cases where the finished glass will be installed into a frame that conceals the edge(s), ring marks can be present inboard of the edge(s). In cases where the glass edge(s) are exposed in their final installation, ring marks inboard of the glass edge(s) are acceptable to the extent of glass thickness + 2,0 mm from the edge, only at the discretion of the concerned parties.

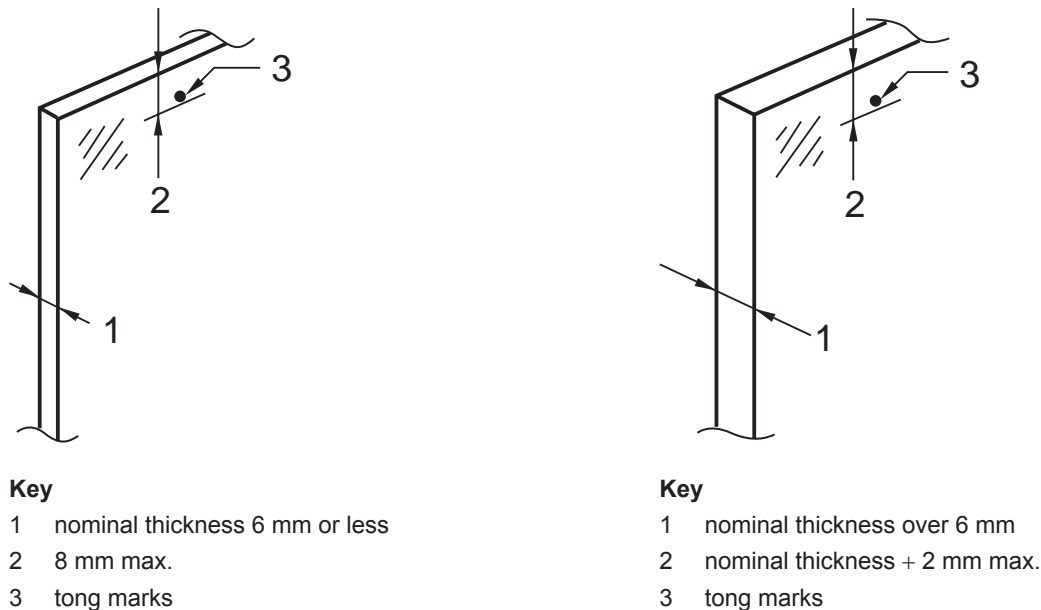


Figure 4 — Tong marks

4.7 Dimensional tolerances of curved laminated glass

4.7.1 Thickness

The total thickness of the laminated glass shall equal the sum of the nominal thickness of the components.

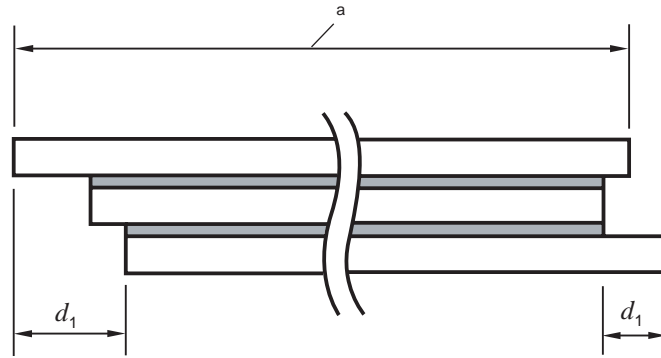
The tolerance in the total thickness shall equal the sum of the tolerances on the components given in the relevant product standard.

Thicknesses and tolerances on the interlayer and films shall be negligible when compared to the shape tolerances of the individual glass panes.

The accepted thickness tolerance of the interlayer in cast-in-place resins shall be $\pm 0,2$ mm per mm thickness of the interlayer (not including the thickness tolerance of the individual panes).

4.7.2 Displacement

The maximum displacement in the sliding " d_1 " of one of the glass edges, as shown in Figure 5, during the manufacturing of the curved laminated glass, shall be as given in Table 5, where G is the girth of the curved insulating glass unit.



Key
 a *L or G*

Figure 5 — Displacement for curved laminated glass

Table 5 — Maximum displacement of curved laminated glass

<i>L or G</i>	Maximum displacement
<i>L or G</i> ≤ 1 000 mm	<i>d</i> ₁ ≤ 2 mm
<i>L or G</i> > 1 000 mm	<i>d</i> ₁ ≤ 2 mm/m

4.8 Dimensional tolerances of curved insulating glass

4.8.1 Thickness

The tolerance on thickness of curved glass panes should conform to that required by the corresponding basic product standard ISO 16293 (all parts), however minor changes to glass thickness can occur due to stretching during forming and/or shaping.

The tolerance on the total thickness shall equal the sum of the tolerances on the components (see applicable standards) increased by 3 mm.

4.8.2 Tolerance on shape accuracy

The tolerance on shape accuracy, as shown in Figure 6, shall be given by:

$$\Delta P_C = \Delta P_{C1} + \Delta P_{C2} + 2 \text{ mm}$$

where

- ΔP_{C1} is the tolerance on the curvature of the first component of the curved insulating glass;
- ΔP_{C2} is the tolerance on the curvature of the second component of the curved insulating glass with ΔP_{C1} and ΔP_{C2} in accordance with limits given in Table 2.

NOTE The thickness deviation of curved insulating glass is partly the consequence of the tolerance on shape accuracy.

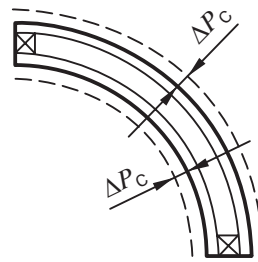


Figure 6 — Shape accuracy

4.8.3 Displacement

The maximum displacement in the sliding “ d_2 ” of one of the glass edges, as shown in Figure 7, during the manufacturing of the curved insulating glass, shall be as given in Table 6, where G is the girth of the curved insulating glass unit.

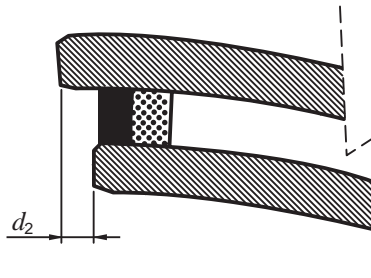


Figure 7 — Displacement for curved insulating glass

Table 6 — Maximum displacement of curved insulating glass

L or G	Maximum displacement
L or $G \leq 1\,000$ mm	$d_2 \leq 3$ mm
L or $G > 1\,000$ mm	$d_2 \leq 3$ mm/m

5 Test methods

5.1 Measurement of shape accuracy, girth and length

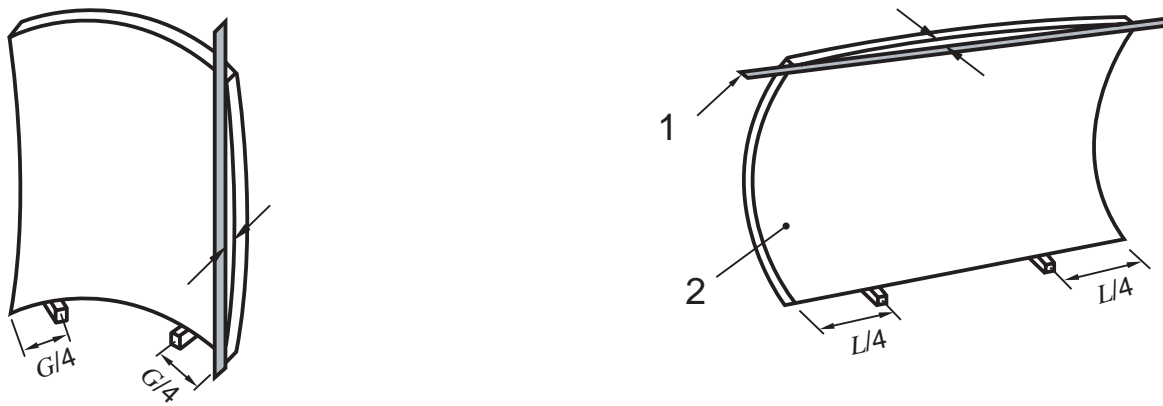
Measure the shape accuracy perpendicular to the glass using a gauge or a 1:1 scale template.

Measure the girth dimension on the convex surface using a flexible steel tape measure of 1 mm in scale interval.

Measure the length of the sides using a steel tape or a straightedge of 1 mm scale interval.

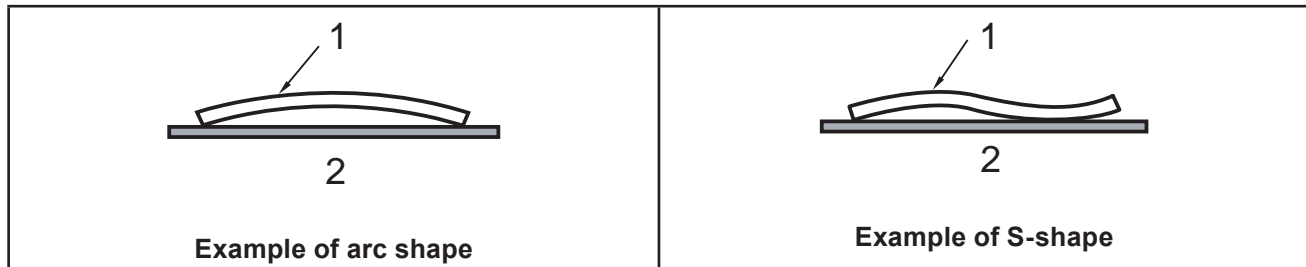
5.2 Edge straightness deviation

The edge straightness deviation should be measured with the glass in a vertical position as shown in Figure 8. Place a straightedge ruler, with 0,1 mm intervals, horizontally along the length of the glass to measure the gap between the glass specimen and the ruler.



Key

- 1 straightedge or a piece of thin and strong string can be used
- 2 glass concave surface or convex surface



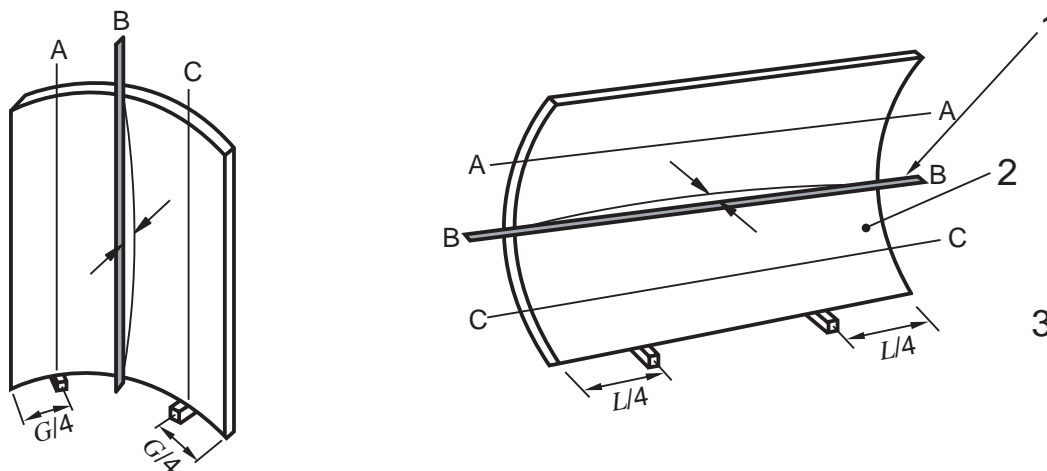
Key

- 1 glass edge
- 2 ruler

Figure 8 — Measurement of edge straightness deviation

5.3 Measurement of cross-curve deviation

Place a straightedge along the vertical edge (perpendicular to the arc) on the concave surface of glass, then measure the distance between the glass and the straightedge as shown in Figure 9.



Key

- 1 straightedge or a piece of thin strong string can be used. Measuring points: A-A, B-B, C-C
- 2 glass concave surface or convex surface
- 3 setting of the glass shall be either way as shown above

NOTE The cross-bend deviation shall be distinguished from warp of the height.

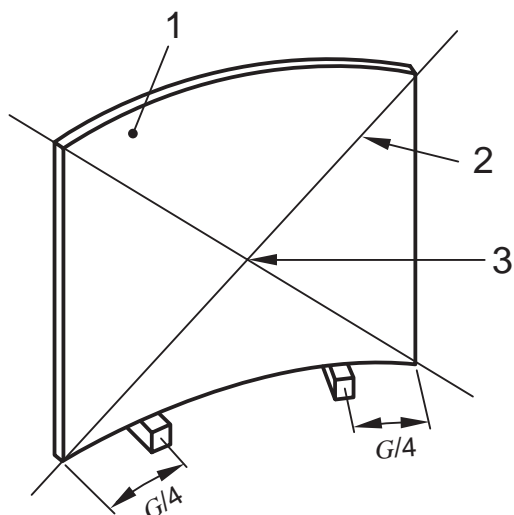
Figure 9 — Measurement of cross-curve deviation

5.4 Maximum twist deviation

Measure the maximum twist deviation as shown in Figure 10, using either the following method or any other technique that achieves a comparably accurate measurement.

- a) Stand a curved glass product vertically on the crossties (wooden blocks), preferably as it would be set in the actual building.
- b) Place two thin strong strings diagonally from the four corners on the concave side, which are theoretically on the same level.
- c) Pull the strings and move one of them at one corner so that they are straight and touch with each other at the crossing point.
- d) If the outer string at the crossing point parts from the glass at the corner, measure the distance, and its ΔV_1 (mm). If the diameter of the string is s (mm), the maximum twist deviation is $V(\text{mm}) = \Delta V_1 - 2s$.
- e) If the inner string parts from the glass, the distance is ΔV_2 (mm). Again, if the diameter of the strings is s (mm), the maximum deviation is $V(\text{mm}) = \Delta V_2 + 2s$.
- f) In either way, the V s are the same, which is the maximum twist deviation.

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Key

- 1 concave surface
- 2 thin strong string
- 3 crossing point

Figure 10 — Measurement of maximum twist deviation

5.5 Test method on appearance of curved glass

Conduct a visual inspection at 3,0 m from the glass product, in a vertical position, using daylight without direct sunlight, or using background lighting. To measure the length or diameter of the appearance defect, use a metal ruler with 0,5 mm intervals.

Bibliography

- [1] ASTM C1464-06, *Standard Specifications for Bent Glass*
- [2] ISO 16293 (all parts), *Glass in building — Basic soda lime silicate glass products*

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