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Glazing in building — Determination of the bending strength of glass —

Part 3:
Test with specimen supported at two points (four-point bending)

Verre dans la construction — Détermination de la résistance du verre à la flexion —

Partie 3: Essais avec éprouvettes supportées en deux points (flexion quatre points)

ICS 81.040.20

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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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Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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

International Standard ISO (XYZ)-3 was prepared by Technical Committee ISO/TC 160, *Glazing in buildings*, Subcommittee SC 2,WG1.

ISO (XYZ) consists of the following parts, under the general title *Glazing in building — Determination of the bending strength of glass*:

— *Part 1: Fundamentals of testing glass*

— *Part 2: Coaxial double ring test on flat specimens with large test surface areas*

— *Part 3: Test with specimen supported at two points* ***(four point bending)***

— *Part 4: Testing of channel shaped glass*

— *Part 5: Coaxial double ring test on flat specimens with small or medium test surface areas*

This Standard has been based on 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)*** prepared by Technical Committee CEN/TC 129 "Glass in building"/WG8 "Mechanical Strength".

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

1 Scope

This International Standard specifies a method for determining the bending strength, including the effects of the edges, of flat glass for use in building. The method specified can also be used to determine the bending strength of the edges of glass separately.

The limitations of this part of this International Standard are described in ISO (XYZ)-1.

ISO (XYZ)-1 should be read in conjunction with this part of this International Standard.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO (XYZ). For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO (XYZ) are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 48, Rubber, vulcanised or thermoplastic—Determination of hardness (hardness between 10 IRHD and 100 IRHD)

ISO (XYZ)-1, Glass in building—Determination of the bending strength of glass—Part 1: Fundamentals of testing glass

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

NOTE: In the absence of ISO standards for basic and processed glass products for use in building reference is made to relevant CEN standards

3 Terms and definitions

For the purposes of this part of ISO (XYZ), the following terms and definitions apply.

3.1
bending stress
the tensile bending stress induced in the surface of a specimen

NOTE For testing purposes, the bending stress should be uniform over a specified part of the surface.

3.2
effective bending stress
a weighted average of the tensile bending stresses, calculated by applying a factor to take into account non-uniformity of the stress field

3.3
bending strength
the bending stress or effective bending stress which leads to breakage of the specimen

3.4
equivalent bending strength
the apparent bending strength of patterned glass, for which the irregularities in the thickness do not allow precise calculation of the bending stress

4 Symbols (and abbreviated terms)

B Specimen width

E Modulus of elasticity (Young's modulus) of the specimen

NOTE for soda lime silicate glass (see EN 572-1) a value of 70 x 10^3 N/mm^2 is used.

F_{max} Maximum force

NOTE Where the bending rollers are not firmly attached to the testing machine, but are laid on the specimen, the force resulting from their weight is added to the maximum measured force.

g Acceleration due to gravity

h Specimen thickness

k Dimensionless factor (see 6.2 of ISO (XYZ)-1 for explanation)

L Specimen length

L_s Distance between the centre lines of the supporting rollers

L_b Distance between the centre lines of the bending rollers

M_b Bending moment

y Central deflection of the specimen relative to the supporting rollers

Z Section modulus

σ_b Bending stress in the surface area defined by the bending rollers

σ_{beff} Effective bending stress

σ_{bB} Bending strength

σ_{bG} Bending stress imposed by the self-weight of the specimen

ρ Density of the specimen

5 Apparatus

5.1 Testing machine

The bending test shall be carried out using a suitable bending testing machine, which shall incorporate the following features:

a) The stressing of the specimen shall be capable of being applied from zero up to a maximum value in a manner which minimizes shock and is stepless;

b) The stressing device shall be capable of the specified rate of stressing;

c) The testing machine shall incorporate a load measuring device with a limit of error of ± 2,0 % within the measuring range;

d) The supporting rollers and the bending rollers (see figure 2) shall have a diameter of 50 mm and a length of not less than 365 mm. All the rollers shall be free to rotate.

5.2 Measuring instruments

The following measuring instruments are required:

- a measuring instrument enabling the width of the specimen to be measured to the nearest millimetre;

- a measuring instrument allowing the thickness of the specimen to be measured to the nearest 0,01 mm.

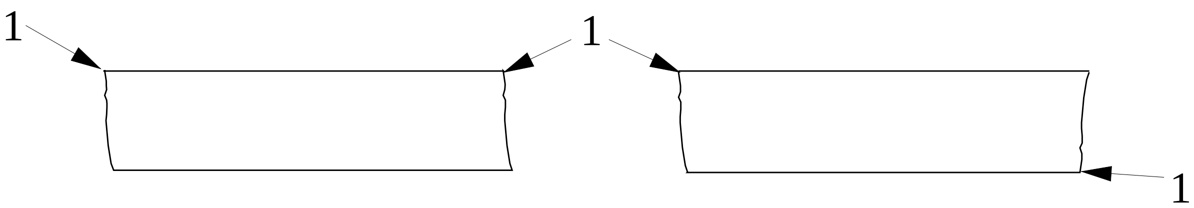
6 Sample

6.1 Number of specimens

The number of specimens to be tested shall be determined depending on the confidence limits required, especially with regard to estimating the extremes of the strength distribution (see ISO (XYZ)-1 for a discussion of numbers of specimens).

6.2 Specimen dimensions

Specimen length	*L*:	1100 mm ± 5 mm
Specimen width	*B*:	360 mm ± 5 mm
Specimen thickness	*h*:	thickness of the glass within the tolerance specified for the condition as supplied for test.



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1 Wheel cut edges.

NOTE The edges of cut glass are not the same on both corners, because wheel cut edges have the wheel applied to only one surface of the glass. In this instance the edge are asymmetrical with respect to the neutral axis of the specimen..

Figure 1 — Asymmetrical edges

6.3 Specimen condition and treatment

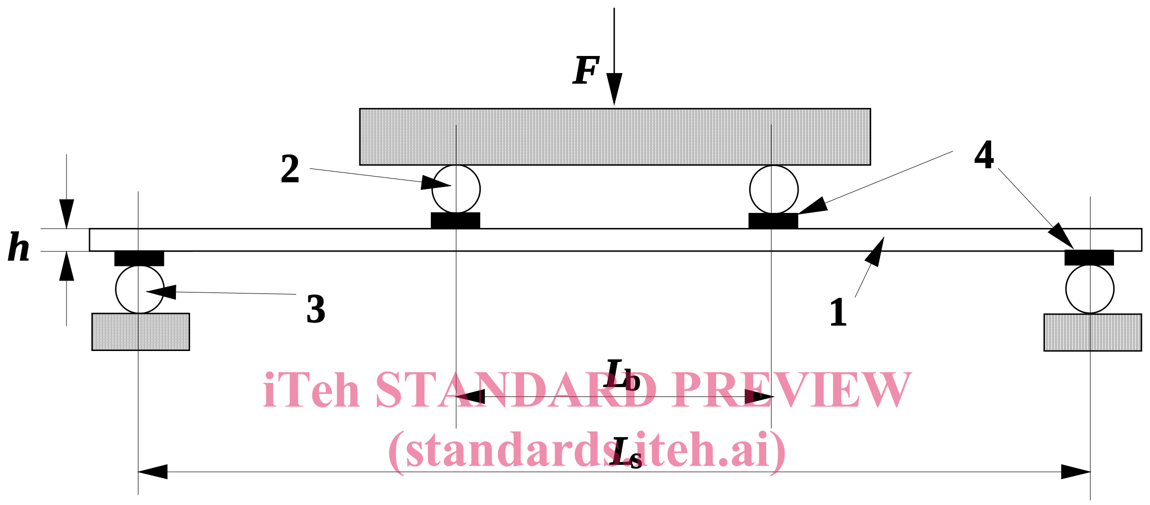
The specimens shall be flat and their edges shall be representative of the edge finish to be tested. If the edge is asymmetrical with respect to the neutral axis of the specimen, both stressed edges shall be in the same orientation (see figure 1) and all specimens in a sample shall be tested the same way up.

Any intended changes to the condition of the test piece by means of edge working, prior mechanical damage, etching, etc., shall be completed at least 24 h before testing the bending strength (see ISO (XYZ)-1). Similarly, protective coatings shall be removed at least 24 h before the test. The specimens shall be stored in the testing environment (see 7.2) for at least 4 h before being tested.

6.4 Adhesive film

To hold together the fragments, an adhesive film shall be fixed to the side of the specimens facing the bending rollers (see figure 2). This facilitates location of the fracture origin and measurement of the specimen thickness.

Dimensions in millimetres



1 Specimen

2 Bending roller

3 Supporting roller

4 Rubber strips

L_b = 200 ± 1

L_s = 1000 ± 2

Figure 2— Mounting of the test specimen

7 Procedure

7.1 Measuring width and thickness of each specimen

The width shall be determined as the arithmetic mean of at least three individual measurements.

The thickness shall be determined as the arithmetic mean of at least four individual measurements to the nearest 0,05 mm. The measured positions shall lie outside the two bending rollers, to avoid damaging the test surface, and shall be taken from both ends of the specimen. In the case of specimens with one or two ornamental surfaces, both the plate thickness and core thickness shall be measured. The average is taken from all these measured values.

Alternatively, the thickness shall be determined from at least four fragments taken from the area between the bending rollers after fracture, if the fracture pattern makes this feasible.

7.2 Bending test

The specimen shall be mounted as shown in figure 2. Strips of rubber, 3 mm thick and of hardness (40 ± 10) IRHD (in accordance with ISO 48), shall be placed between the specimen and the bending and supporting rollers.

The bending test shall be carried out at (23 ± 5) °C with the relative humidity between 40 % and 70 %. During the test the temperature shall be kept constant to 1 °C, in order to avoid the development of thermal stresses.

The specimen shall be bent with a uniformly increasing bending stress at a rate of (2 ± 0,4) N/(mm^2.s) until failure occurs. The maximum load, F_{max}, shall be measured and the time taken to reach this load shall be recorded.

8 Evaluation

8.1 General

For evaluation purposes, only those specimens shall be considered in which the origin of fracture lies between the bending rollers.

The bending strength, σ_{bB}, shall be calculated in accordance with equation (1) as follows.

For a rectangular cross section, where $Z = Bh^2/6$, and with the load applied as shown in figure 2, the bending strength is:

$$\sigma_{bB} = k\left[F_{max} \frac{3(L_s - L_b)}{2Bh^2} + \sigma_{bG} \right] \quad (1)$$

The bending stress, σ_{bG}, imposed by the self-weight of the specimen shall be calculated in accordance with equation (2)

$$\sigma_{bG} = \frac{3\rho g L_s^2}{4h} \quad (2)$$

8.2 Bending strength of the surface area, edges included

For calculating the overall bending strength or equivalent bending strength of the surface area, including the edges, defined by the bending rollers, the value $k = k_s = 1$ shall be used (see ISO (XYZ)-1).

8.3 Bending strength of the edges

For calculating the bending strength or equivalent bending strength of the free edges of the glass, only those specimens which fracture from the edge shall be taken into consideration.

NOTE When some of the specimens do not break from the edge, the set of edge strength results is not a true representation of the distribution of edge strengths. The edge strengths of those specimens which fracture from the test surface cannot be determined, but they are certainly higher than the measured values of bending strength of such specimens. There are, however, statistical techniques which can make an allowance for the unmeasured edge strength of those specimens.

The factor $k = k_e$ for use in equation (1) depends on the deflection of the specimen at its centre. The central deflection, y, can be determined by direct measurement, or calculated with sufficient accuracy from equation (3):

$$\frac{y}{h} = \frac{3F_{max}}{4EBh^4}\left[\frac{L_s^3}{3} + \frac{L_b^3}{6} + \frac{L_s L_b^2}{2} \right] \quad (3)$$