BRITISH STANDARD

BS EN
1288-3:2000

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

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

The European Standard EN 1288-3:2000 has the status of a British Standard

ICS 81.040.20

National foreword

This British Standard is the official English language version of EN 1288-3:2000.

The UK participation in its preparation was entrusted by Technical Committee B/520, Glass and glazing in building, to Subcommittee B/520/4, Properties and glazing methods, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

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

Cross-references

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Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 11 and a back cover.

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EUROPEAN STANDARD

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English version

Glass 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)

Glas im Bauwesen - Bestimmung der Biegefestigkeit von Glas - Teil 3: Prüfung von Proben bei zweiseitiger Auflagerung (Vierschneiden-Verfahren)

This European Standard was approved by CEN on 5 September 1999.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

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

Central Secretariat: rue de Stassart, 36 B-1050 Brussels

Ref. No. EN 1288-3:2000 E

Contents

Foreword

This European Standard has been prepared by Technical Committee CEN/TC 129, Glass in building, the Secretariat of which is held by IBN.

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 December 2000, and conflicting national standards shall be withdrawn at the latest by December 2000.

CEN/TC 129/WG8, Mechanical Strength, prepared the draft, Glass in building - Determination of the bending strength of glass - Part 3: Test with specimen supported at two points (four point bending).

There are four other parts to this standard:

- Part 1: Fundamentals of testing glass;
- Part 2: Coaxial double ring test on flat specimens with large test surface areas;
- Part 4: Testing of channel shaped glass;
- Part 5: Coaxial double ring test on flat specimens with small test surface areas.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This European 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 standard are described in EN 1288-1.

EN 1288-1 should be read in conjunction with this standard.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references, the latest edition of the publication referred to applies.

EN 572-1	Glass in building - Basic soda lime silicate glass products - Part 1: Definitions and general physical and mechanical properties.
EN 1288-1	Glass in building - Determination of the bending strength of glass - Part 1: Fundamentals of testing glass.
ISO 48	Rubber, vulcanized or thermoplastic - Determination of hardness (hardness between 10 IRHD and 100 IRHD).

3 Definitions

For the purposes of this standard, the following 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

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 70×10^3 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 EN 1288-1 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

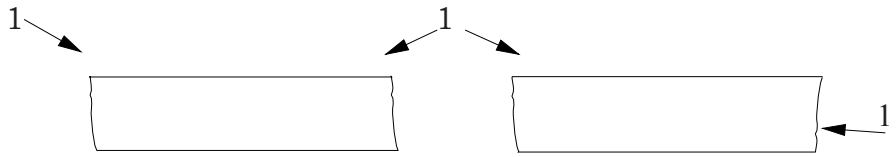
The number of specimens to be tested shall be determined depending on the confidence limits required, especially with regard to estimating the extremes of the strength distribution (see EN 1288-1 for a discussion of numbers of specimens).

6.2 Specimen dimensions

Specimen length, *L*:	1 100 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.

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.



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

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 EN 1288-1). 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.

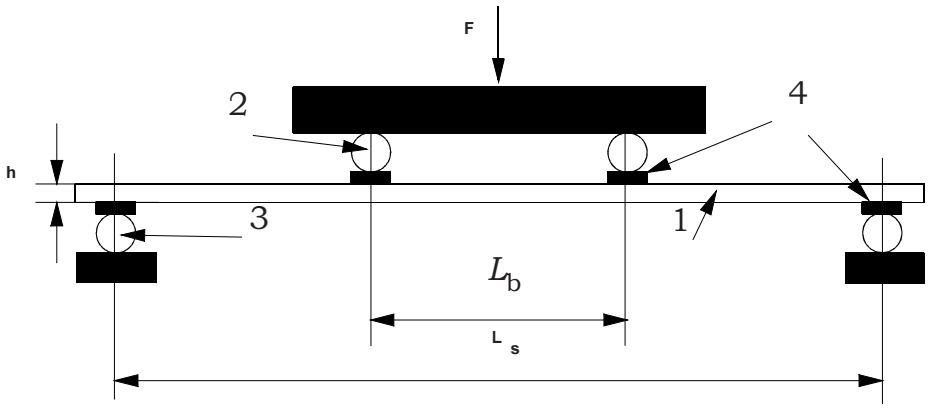
7 Procedure

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.



1 Specimen
2 Bending roller
3 Supporting roller
4 Rubber strips
L_b = 200 mm ± 1 mm
L_s = 1 000 mm ± 2 mm

Figure 2: Mounting of the test specimen

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) $N/mm^2 \cdot s$ 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:

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

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

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

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 EN 1288-1).

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):

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

The appropriate value of k_e, for use in equation (1), shall be obtained from Figure 3, which gives the value of k_e as a function of the value of y/h (see EN 1288-1).

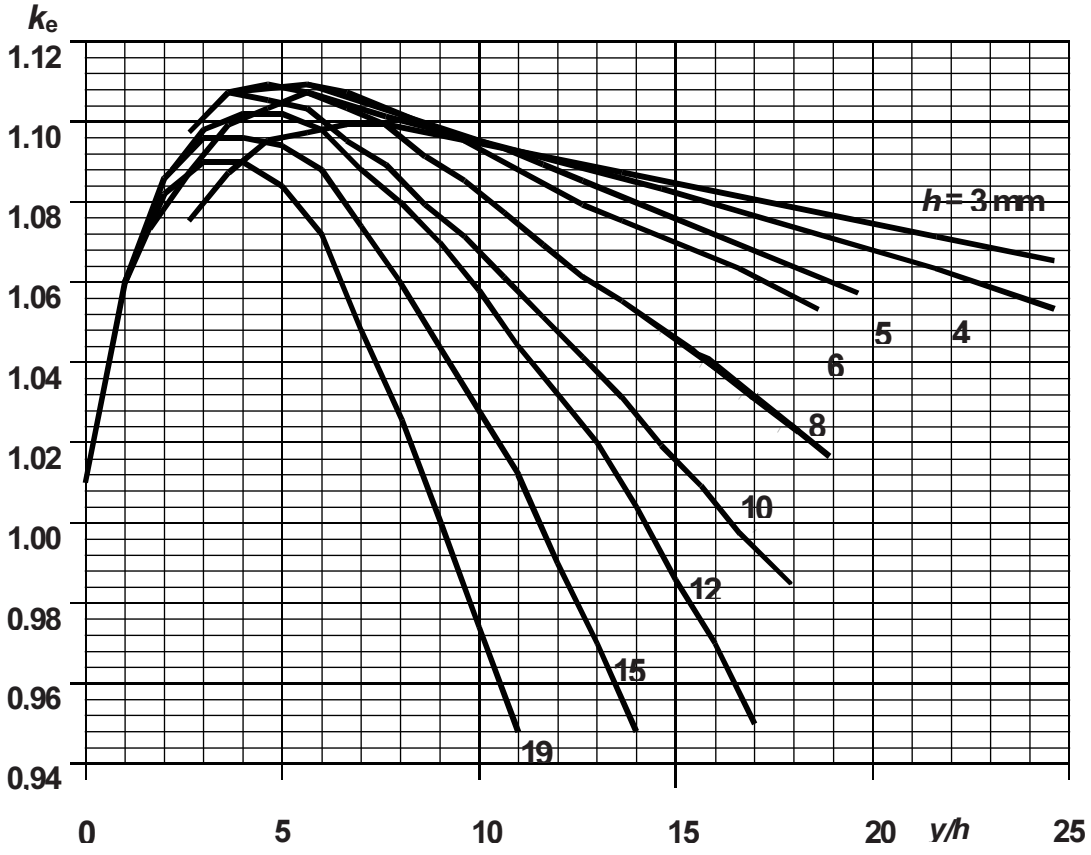


Figure 3: Dimensionless factor k_e as a function of y/h

9 Test report

With reference to this standard, the test report shall contain the following information:

a) Type and name of glass;

b) Pre-treatment and surface condition of the tested specimen surface including the sequence of treatment stages. In the case of specimens with one patterned surface, the surface which is placed under tensile stress (flat or patterned side) shall be indicated;

c) Description of the edge finish and which way up it was tested;

d) Inherent stress of the specimen, annealed or prestressed glass, including nature and if possible degree of prestressing;

e) Number of specimens;

f) For each specimen, the following information:

1) Thickness, h, in millimetres, to the nearest 0,05 mm, in the case of specimens with flat surfaces; maximum thickness (plate thickness), minimum thickness (core thickness) and average thickness, h, in millimetres, to the nearest 0,05 mm, in the case of specimens with one or two patterned surfaces;

2) Width in millimetres to the nearest millimetre;

3) Overall bending strength, σ_{bB}, or equivalent bending strength, σ_{beqB}, in N/mm^2 to the nearest 0,1 N/mm^2;

4) If desired, edge bending strength, σ_{bB}, or equivalent bending strength, σ_{beqB}, in N/mm^2 to the nearest 0,1 N/mm^2;

5) Time to breakage in seconds to the nearest 1 s;

6) Whether the specimen broke from the edge or the central part (body) of the specimen;

No average of the measured results shall be given;

g) Number of specimens not broken in accordance with clause 8;

h) Any deviation from this standard which may have affected the results.

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