

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

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

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National foreword

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Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 20, an inside back cover and a back cover.

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Verre dans la construction - Détermination de la résistance
du verre à la flexion - Partie 2: Essais avec doubles
anneaux concentriques sur éprouvettes planes, avec de
grandes surfaces de sollicitation

Glas im Bauwesen - Bestimmung der Biegefestigkeit von
Glas - Teil 2: Doppelring-Biegeversuch an plattenförmigen
Proben mit großen Prüfflächen

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

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Contents	Page
Foreword	3
1 Scope	4
2 Normative references	4
3 Definitions	4
4 Symbols	5
5 Principle of test method	6
6 Apparatus	7
7 Sample	9
8 Procedure	11
9 Evaluation	13
10 Test report	15
Annex A (informative) Example of a device for keeping the gas pressure, p, in line with the piston force, F	17
Annex B (informative) Bibliography	20

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of an identical text or by endorsement, at the latest by December 2000, and conflicting national standards shall be withdrawn at the latest by December 2000.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 2: Coaxial double ring test on flat specimens with large test surface areas.

There are four other parts to this standard:

- Part 1: Fundamentals of testing glass;
- 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 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 of glass for use in buildings, excluding the effects of the edges.

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 1288-1	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.
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

A	Effective surface area of quasi-uniform stress
E	Modulus of elasticity (Young's modulus) of the specimen.

NOTE: For soda lime silicate glass (see EN 572-1), a value of $70 \times 10^3 \text{ N/mm}^2$ is used.

F	Piston force
$F_{\max}$	Piston force upon breakage, "breaking force"
F_{ring}	Force transmitted by the loading ring to the specimen, "ring load"
h	Thickness or average thickness of specimen
L	Side length of the square specimens
μ	Poisson number of specimen

NOTE: For soda lime silicate glass (see EN 572-1), a value of 0,23 is used.

p	Gas pressure on the surface area defined by the loading ring
$p(F)$	Nominal gas pressure as a function of the piston force
$p_{\max}(F_{\max})$	Nominal gas pressure upon breakage
r	Location co-ordinate
r_1	Radius of loading ring
r_2	Radius of supporting ring
r_{3m}	Average specimen radius (for evaluation)
σ	Stress
σ_{bB}	Bending strength
σ_{beqB}	Equivalent bending strength
t	Time
$\Delta F/\Delta t$	Rate at which piston force rises
F^*, p^*, σ^*	Non-dimensional quantities corresponding to F , p and σ [see equations (1) to (5)]

5 Principle of test method

The square specimen, of side length, L , and having virtually plain parallel surfaces, is placed loosely on a supporting ring (a circular ring with a radius r_2). The specimen is subjected to a load, F_{ring} , by means of a loading ring (radius r_1), which is arranged concentrically to the supporting ring. In addition, the area, A , defined by the loading ring $0 < r < r_1$ is placed under gas pressure, p , which has a specific relationship with the ring load, F_{ring} (see Figure 1).

When the specimen is subjected to the ring load and the associated gas pressure, depending upon the dimensions r_1 , r_2 , L , and h , a radial tensile stress field, which is sufficiently homogeneous for the test purpose, is developed on the convexly bent surface over the area defined by the loading ring (see [1], [2], [3] of annex B). The tangential tensile stress is equal to the radial tensile stress at the central point ($r = 0$) of the specimen, but decreases as the radius, r , increases.

Outside the loading ring, the radial and tangential stresses fall sharply towards the edge of the specimen, so that the risk of breakage outside the loading ring is low. On the edge of the specimen itself, the radial stress is zero and the tangential stress is a compressive stress, this being the case on both the concavely and the convexly bent sides of the specimen. The edge of the specimen is thus always under tangential compressive stress (see EN 1288-1).

By increasing the force, F , and the gas pressure, p , the tensile stress in the central part of the specimen is increased at a constant rate [see (6.1b)] until breakage, so the origin of the break can be expected to occur in the surface area subjected to maximum tensile stress within the loading ring.

NOTE: With the test apparatus as shown in Figure 1, a force, pA , acts against the piston force, F , due to the gas pressure, p . The force transferred by the loading ring is $F_{\text{ring}} = F - pA$. Thus a distinction should be made between the piston force and the ring load.

The bending strength, σ_{bB} , or equivalent bending strength, σ_{beqB} , is calculated from the maximum value, F_{max} , of the piston force, measured at the time of breakage, and the thickness, h , of the specimen, taking into account the prescribed dimensions of the specimen and various characteristic material values. This assumes that the gas pressure, p , follows the piston force, F , according to the nominal function $p(F)$, (see Figure 3).