**SLOVENSKI STANDARD**
**oSIST prEN ISO 1288-1:2014**

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**Steklo v stavbah - Ugotavljanje upogibne trdnosti stekla - 1. del: Uvodno preskušanje stekla (ISO/DIS 1288-1:2014)**

Glass in building - Determination of the bending strength of glass - Part 1: Fundamentals of testing glass (ISO/DIS 1288-1:2014)

Glas im Bauwesen - Bestimmung der Biegefestigkeit von Glas - Teil 1: Grundlagen der Glasprüfungen (ISO/DIS 1288-1:2014)



Verre dans la construction - Détermination de la résistance du verre à la flexion - Partie 1: Principes fondamentaux des essais sur le verre (ISO/DIS 1288-1:2014)



**Ta slovenski standard je istoveten z: prEN ISO 1288-1 rev**

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**ICS:**

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|---|---|---|
| 81.040.20 | Steklo v gradbeništvu | Glass in building |

**oSIST prEN ISO 1288-1:2014 en**

DRAFT INTERNATIONAL STANDARD
**ISO/DIS 1288-1**

ISO/TC **160**/SC **2** Secretariat: **ANSI**

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

## Part 1: **Fundamentals of testing glass**

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

*Partie 1: Principes fondamentaux des essais sur le verre*

ICS: 81.040.20



**ISO/CEN PARALLEL PROCESSING**

This draft has been developed within the International Organization for Standardization (ISO), and processed under the **ISO lead** mode of collaboration as defined in the Vienna Agreement.

This draft is hereby submitted to the ISO member bodies and to the CEN member bodies for a parallel five month enquiry.

Should this draft be accepted, a final draft, established on the basis of comments received, will be submitted to a parallel two-month approval vote in ISO and formal vote in CEN.



To expedite distribution, this document is circulated as received from the committee secretariat. ISO Central Secretariat work of editing and text composition will be undertaken at publication stage.

Reference number
ISO/DIS 1288-1:2013(E)

# Contents

# 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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

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 1288 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 1288-1 was prepared by Technical Committee ISO/TC 160, *Glass in building*, Subcommittee SC 2, *Use considerations*

ISO 1288 consists of the following parts, under the general title *Glass 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 test surface areas*

This Standard has been based on EN 1288-1 *Glass in building - Determination of the bending strength of glass" - Part 1: Fundamentals of testing glass* prepared by Technical Committee CEN/TC 129 "Glass in building"/WG8 "Mechanical Strength".

# Glass in building — Determination of the bending strength of glass — Part 1: Fundamentals of testing glass

## 1 Scope

This International Standard specifies the determination of the bending strength of monolithic glass for use in buildings. The testing of insulating units or laminated glass is excluded from this standard.

This standard describes:

- considerations to be taken into account when testing glass,

- explanations of the reasons for designing different test methods,

- limitations of the test methods,

and gives pointers to safety requirements for the personnel operating the test equipment.



ISO 1288-2, ISO 1288-3, ISO 1288-4 and ISO 1288-5 specify test methods in detail.



The test methods specified in this standard are intended to provide large numbers of bending strength values that can be used as the basis for statistical evaluation of glass strength.



## 2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 1288. 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 1288 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 1288-2, *Glass in building — Determination of the bending strength of glass — Part 2 : Coaxial double ring test on flat specimens with large test surface areas*

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

ISO 1288-4, *Glass in building — Determination of the bending strength of glass — Part 4 : Testing of channel shaped glass*

ISO 1288-5, *Glass in building — Determination of the bending strength of glass — Part 5 : Coaxial double ring test on flat specimens with small test surface areas*

ISO16293-1: *Glass in building – Basic soda lime silicate glass products – Part 1: Definitions and general physical and mechanical properties*

DIS 16293-2: *Glass in building – Basic soda lime silicate glass products – Part 2: Float glass*

NOTE 1: ISO TC160 SC1 WG1 is commencing work on standards for ‘polished wired glass’, ‘wired patterned glass’ and ‘patterned glass

NOTE 2: ISO TC160 SC1 WG2 is commencing work on standards for ‘thermally tempered soda lime silicate safety glass’, ‘heat strengthened soda lime silicate glass’ and ‘chemically strengthened glass’.

## 3 Terms and definitions

For the purposes of this part of ISO 1288, the following terms and definitions apply.

**3.1**
**flat glass**
any glass product conforming to ISO 162934or any transformed glass made from these products without deliberately inducing profile or curvature.

**3.2**
**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.

**3.3**
**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.



**3.4**
**bending strength**
the bending stress or effective bending stress which leads to breakage of the specimen.



**3.5**
**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.

**3.6**
**profile bending strength**
the quotient of the maximum bending moment and the section modulus of a channel shaped glass.

**3.7**
**stress intensity factor**
a measure of the stress at a crack tip.

**3.8**
**prestressed glass**
any glass product that has a surface prestress, i.e.. thermally tempered soda lime silicate safety glass, heat strengthened soda lime silicate glass and chemically strengthened glass.

## 4 Symbols (and abbreviated terms)

| | | |
|---|---|---|
| $F$ | Applied load | N |
| $h$ | Specimen thickness | m |
| $L$ | Length of side of square test sample | m |
| $k$ | Constant for calculation of bending stress in ISO 1288-3 | m |

| | | |
|---|---|---|
| $K_1,K_2$ | Constants for calculation of bending stress in ISO 1288-5 | |
| $M_{bB}$ | Maximum bending moment | Nm |
| $p$ | Gas pressure applied within loading ring in ISO 1288-2 | Pa |
| $P_{bB}$ | Profile bending strength (of channel shaped glass) = $M_{bB}/Z$ | Pa |
| $r_1$ | Radius of loading ring | m |
| $r_2$ | Radius of supporting ring | m |
| $r_3$ | Radius of circular specimen | m |
| $r_{3m}$ | Average specimen radius (for evaluation) | m |
| $y_0$ | Central deflection of specimen | m |
| $Z$ | Section modulus ( of channel shaped glass ) | $m^3$ |
| $\mu$ | Poisson number of specimen | |
| | NOTE : for soda lime silicate glass (see ISO 16293-1EN 572-1) a value of 0,23 is used. | |
| $\sigma_b$ | Bending stress | Pa |
| $\sigma_{beff}$ | Effective bending stress | Pa |
| $\sigma_{bB}$ | Bending strength | Pa |
| $\sigma_{beqB}$ | Equivalent bending strength | Pa |
| $\sigma_{rad}$ | Radial stress | Pa |
| $\sigma_T$ | Tangential stress | Pa |
| $\sigma_L$ | Stress in a direction along the length of the specimen | Pa |



# 5 Factors to be taken into account when testing glass

## 5.1 Glass as a material

### 5.1.1 General

Glass is a homogeneous isotropic material having almost perfect linear-elastic behaviour over its tensile strength range.

Glass has a very high compressive strength and theoretically a very high tensile strength, but the surface of the glass has many irregularities which act as weaknesses when glass is subjected to tensile stress. These irregularities are caused by attack from moisture and by contact with hard materials (e.g. grit) and are continually modified by moisture which is always present in the air.

Tensile strengths of around 10 000 MPa can be predicted from the molecular structure, but bulk glass normally fails at stresses considerably below 100 MPa.

The presence of the irregularities and their modification by moisture contributes to the properties of glass which need consideration when performing tests of strength.

Because of the very high compressive strength, glass always fails under tensile stress. Since glass in buildings is very rarely used in direct tension, the most important property for load resistance is the tensile bending strength. All the tests described in this standard are intended to evaluate the tensile bending strength of glass.

The bending strength is influenced by the following factors:

a) surface condition (see 5.1.2);

b) rate and duration of loading (see 5.1.3);

c) area of surface stressed in tension (see 5.1.4);

d) ambient medium, through stress corrosion cracking as well as healing of surface damage in the glass (see 5.1.5 and [1] in Bibliography));

e) age, i.e. time elapsing since the last mechanical surface treatment or modification to simulate damage (see 5.1.6);

f) temperature (see 5.1.7).

The influence exerted by factors b) to f) on bending strength has been taken into account in this standard.

### 5.1.2 Effect of surface condition



For the purpose of bending strength tests according to this standard, glass behaves as an almost ideally linear-elastic material that fails in a brittle manner. This brittleness means that contact with any hard object can lead to surface damage in the form of ultra-fine, partly submicroscopic cracks and chips. Surface damage of this kind, which is practically unavoidable during normal handling of glass, exerts a notch action which is a major factor in reducing mechanical strength, whereas the chemical composition of the glass has only a minor and in some cases entirely negligible, significance.



Hence it follows that the bending strength determined by the methods referred to in this standard is related largely to the surface condition of the specimen to be tested.

This surface condition is characterized by the following main features.

a) The surface condition imparted by a particular method of treatment, which produces a specific damage spectrum and thus results in a strength which is specific to the finished surface condition;

b) Residual stress, e.g. in the form of thermal or chemical prestress intentionally imparted, as well as unintended residual stresses.

### 5.1.3 Effect of rate of loading

For the interpretation of the bending strength values determined as described in this standard, the rate of loading is of special importance.

Cracks propagate in glass over a wide range of values of tensile stress (see [2] in Bibliography)). There is a lower limit to the stress intensity factor below which cracks do not propagate ( see [1] in Bibliography)). There is then some subcritical crack propagation at higher levels of stress intensity factor, which is influenced by humidity, temperature and chemical agents. Above a critical stress intensity factor crack propagation is very rapid and leads to (almost) instantaneous failure. The consequence of the subcritical crack propagation is, for example, that the rate of load increase and/or the duration of static loading influences the bending strength.

For prestressed glass, this time dependence does not manifest itself until the tensile stress induced in the surface exceeds the compressive stress permanently present there (see [3] in Bibliography)).

### 5.1.4 Effect of test surface area

The decrease in bending strength of glass with increasing size of the test area exposed to high stress is also of importance (see [4] in Bibliography)). This area effect is accounted for by the statistical distribution of surface defects varying in effectiveness; the larger the test area, the greater is the probability of its containing a large surface defect. Consequently, the influence of the area effect increases with decreasing incidence of defects in the surface, so that this influence is more pronounced in the case of undamaged, e.g. fire-finished glass surfaces (see [5] in Bibliography).

Differences are likely between the mean values of the bending strength as measured in accordance with ~~EN~~ ISO 1288-2 (maximally stressed area: 240 000 mm$^2$), or by using devices R105, R60, R45 and R30 in accordance with ~~EN~~ ISO 1288-5 (maximally stressed areas: 3850 mm$^2$, 1260 mm$^2$, 254 mm$^2$ and 113 mm$^2$ ), due to the size of the stressed area. Depending on surface damage, the results obtained from testing smaller surface areas may be significantly higher than those obtained from testing larger surface areas, as shown in table 1.

**Table 1 — Approximate effects of test surface area on the mean measured bending strength**

| Test Method | Device | Relative bending strength |
|---|---|---|
| ISO 1288-2 | -- | 100 % |
| ISO 1288-5 | R105 | 120 % to 180 % |
| ISO 1288-5 | R65 | 125 % to 210 % |
| ISO 1288-5 | R45 | 140 % to 270 % |
| ISO 1288-5 | R30 | 145 % to 300 % |



Since glass for use in buildings is often in large sizes, the test methods specified in ISO 1288-2 and ISO 1288-3 give values which are more appropriate as the basis for designing flat glass for use in buildings. The test method specified in ISO 1288-5 can be useful as a method of evaluating the comparative bending strength of flat glass.



### 5.1.5 Effect of ambient medium

The surrounding medium in which the glass is tested has an influence on the strength of the glass, particularly if the moisture level is very low. When glass is used in buildings, the relative humidity typically ranges from 30 % to 100 %. Within this range, the effect on the bending strength, as tested according to this standard, is not great. However, tests on glass for use in buildings shall be undertaken in test conditions with relative humidity levels in the range of 40 % to 70 %, in order to eliminate this effect when comparing bending strength results.

### 5.1.6 Effect of aging

If the glass surface is modified (by abrasion, etching, edge working etc.) before the testing, it is necessary to allow the fresh damage to heal before the test is undertaken. The continual surface modification by moisture affects the damage in a way that can reduce any weakening effect (see [1] of Bibliography). In practice, glass is highly unlikely to be stressed directly after it has been treated, so it shall be conditioned for at least 24 h before testing.

### 5.1.7 Effect of temperature

The bending strength of glass is affected by changes in temperature. Within the normal range of temperatures experienced by glass in buildings, this effect is not very significant, but, to avoid possible complications in the comparison of bending strength values, testing shall be undertaken in a restricted range of temperatures.

## 5.2 Bending stress and bending strength

### 5.2.1 General

The test methods described in ISO 1288-2, ISO 1288-3, ISO 1288-4 and ISO 1288-5 are designed to induce a uniform bending stress over an area (the test area) of the specimen. However, the tests are statically

 