SLOVENSKI STANDARD
SIST EN 1595:2000

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Pressure equipment made from borosilicate glass 3.3 - General rules for design, manufacture and testing

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Druckgeräte aus Borosilicatglas 3.3 - Allgemeine Grundsätze für Berechnung, Herstellung und Prüfung

Equipements sous pression réalisés en verre borosilicate 3.3 - Regles générales pour calculs, fabrication et essais

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ICS:

71.120.10	Reakcijske posode in njihovi deli	Reaction vessels and their components
81.040.30	Izdelki iz stekla	Glass products

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English version

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CEN

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

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Foreword

This European Standard has been prepared by CEN/CS.

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of an identical text or by endorsement, at the latest by July 1997, and conflicting national standards shall be withdrawn at the latest by July 1997.

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

Introduction

It has been assumed in the drafting of this European Standard that the execution of its provisions is entrusted to appropriately qualified and experienced people.

1 Scope

This European Standard specifies material, design, inspection, testing and marking requirements of pressure equipment (e. g. vessels, pipes, valves) made from borosilicate glass 3.3 with a coefficient of mean linear thermal expansion of $(3{,}3 \pm 0{,}1) \times 10^{-6}\ K^{-1}$.

It is not applicable to:

- circular, flat and tubular sight glasses;
- equipment made from borosilicate glass with another coefficient of thermal expansion.

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.

ISO 695
Glass – Resistance to attack by a boiling aqueous solution of mixed alkali – Method of test and classification

ISO 719
Glass – Hydrolytic resistance of glass grains at 98 degrees C – Method of test and classification

ISO 720
Glass – Hydrolytic resistance of glass grains at 121 degrees C – Method of test and classification

ISO 1776
Glass – Resistance to attack by hydrochloric acid at 100 degrees C – Flame emission or flame atomic absorption spectrometric method

ISO 7884-8
Glass – Viscosity and viscometric fixed points – Part 8: Determination of (dilatometric) transformation temperature

ISO 7991
Glass – Determination of coefficient of mean linear thermal expansion

3 Symbols and units

For the purposes of this European Standard the following symbols and their definitions apply:

c_p	specific heat capacity	$kJ \cdot kg^{-1} \cdot K^{-1}$
$c_{p20;100}$	mean specific heat capacity between 20 °C and 100 °C	$kJ \cdot kg^{-1} \cdot K^{-1}$
$c_{p20;200}$	mean specific heat capacity between 20 °C and 200 °C	$kJ \cdot kg^{-1} \cdot K^{-1}$
E	modulus of elasticity	$kN \cdot mm^{-2}$
K	strength characteristic	$N \cdot mm^{-2}$
S	safety factor	–

$\frac{K}{S}$	*permissible stress to be employed for calculations*	$N \cdot mm^{-2}$
ΔT	temperature difference between inner and outer surface of the wall	K
Θ_a	temperature of the medium around the pressure equipment	°C
Θ_B	maximum temperature of the medium in contact with glass	°C
Θ_g	transformation temperature	°C
Θ_i	temperature of the medium in the pressure equipment	°C
α	coefficient of linear thermal expansion	K^{-1}
$\alpha_{20/300}$	coefficient of mean linear thermal expansion over the range between 20 °C and 300 °C	K^{-1}
λ	thermal conductivity	$W \cdot m^{-1} \cdot K^{-1}$
$\lambda_{20/200}$	mean thermal conductivity between 20 °C and 200 °C	$W \cdot m^{-1} \cdot K^{-1}$
ν	Poisson's ratio (transverse contraction ratio)	–
ϱ	density	$g \cdot cm^{-3}$
σ_T	thermal wall stress, stress as a consequence of linear temperature gradient	$N \cdot mm^{-2}$
$\Delta\Theta$	temperature difference $\Theta_i - \Theta_a$	K

4 Material

4.1 Properties

For the construction of glass pressure equipment borosilicate glass 3.3 having the properties specified in table 1 shall be used.

Table 1: Characteristic values, application limits and chemical resistance of borosilicate glass 3.3

Coefficient of mean linear thermal expansion Test method: ISO 7991	$\alpha_{20/300} = (3,3 \pm 0,1)\ 10^{-6}\ K^{-1}$
Mean thermal conductivity between 20 °C and 200 °C	$\lambda_{20/200} = 1,2\ W \cdot m^{-1} \cdot K^{-1}$
Mean specific heat capacity between 20 and 100 °C	$c_{p20/100} = 0,8\ kJ \cdot kg^{-1} \cdot K^{-1}$
Mean specific heat capacity between 20 and 200 °C	$c_{p20/100} = 0,9\ kJ \cdot kg^{-1} \cdot K^{-1}$
Density at 20 °C	$\varrho = (2,23 \pm 0,02)\ g \cdot cm^{-3}$
Modulus of elasticity	$E = 64\ kN \cdot mm^{-2}$
Poisson's ratio (transverse contraction ratio)	$\nu = 0,2$
Transformation temperature Test method: ISO 7884-8	$\Theta_g = (525 \pm 15)$ °C
Maximum temperature of the medium in contact with glass*)	$\Theta_B \leq 300$ °C
Hydrolytic resistance at 98 °C Test method: ISO 719	Hydrolytic resistance grain class ISO 719-HGB1
Hydrolytic resistance at 121 °C Test method: ISO 720	Hydrolytic resistance grain class ISO 720-HGA1
Acid resistance Test method: ISO 1776	Sodium oxide (Na_2O) ≤ 100 μg per 1 dm^2 of glass when the glass "as a material" is tested (including preliminary acid treatment)
Resistance to attack by a boiling aqueous solution of mixed alkali Test method: ISO 695	Alkali resistance class ISO 695-A2 or better

*) With temperatures $\Theta_B \leq 200$ °C special precautions shall be taken for the prevention of abrupt temperature fluctuations.

4.2 Quality

The glass shall be annealed to commercially acceptable quality and shall be homogeneous enough to be free from imperfections, which can affect the mechanical strength.

Types of imperfections and criteria for acceptability shall be as given in table 2.

Table 2: Types of imperfections and criteria for acceptability

Types of imperfections	Description	Criteria for acceptability
Solid inclusions	Solid inclusions are non-transparent inclusions in the solidified glass. The solid inclusions may be both undissolved constituents of the glass batch, and also foreign bodies, e. g. particles from the refractory lining of the furnace or constitutents of glass that have crystallised out.	Solid inclusions which lie in the vicinity of the surface of the glass, and which therefore deform or interrupt the line of the surface and can thus be detected by touch, are not permissible. Solid inclusions from which cracks extend into the surrounding glass are not permissible. Solid inclusions within the glass wall are permissible. – if their diameter is no greater than 50 % of the wall thickness, but does not exceed 4 mm, – and if the distance between them is at least ten times the diameter of the smaller inclusion.
Bubbles	Bubbles are gaseous inclusions. They may be closed or open. Open bubbles are bubbles that have opened up at the surface of the glass wall, or bubbles sited at such a short distance beneath the surface that they can be made to collapse easily.	Open bubbles or bubbles which can be made to collapse easily are not permissible. Closed bubbles are permissible if the sum of their breadth and length is no greater than 30 mm, the breadth is no greater than 10 mm and the bubbles thickness is less than 50 % of the wall thickness but does not exceed 4 mm.
Knots	Knots are roundish integrated inhomogeneities within the glass. They have a different refractive index and are therefore visible.	Knots from which cracks extend into the surrounding glass are not permissible.
Cords	Cords are filamentary or thread-like inhomogeneities in the glass which for the most part follow a twisting path. They have a different refractive index and are therefore visible.	Cords from which cracks extend into the surrounding glass are not permissible.
Cracks	Cracks are breaks in the glass body which propagate right through or partly through the wall thickness.	Cracks are not permissible.

(continued)

Table 2: Types of imperfections and criteria for acceptability (concluded)

Types of imperfections	Description	Criteria for acceptability
Scratches	The term scratches is used to describe damage to the surface of the glass which follows a linear path, is rough and which as a rule has a dull appearance.	Scratches which can be detected clearly by touch, and those associated with cracking, are not permissible.
Knocks	Knocks are points at the surface of the glass which have been chipped as a consequence of impacts or blows.	Knocks are not permissible.

5 Certification of quality characteristics

By marking as defined in clause 8, the manufacturer certifies the following:

(1) that the type of glass designated through the application of his brand name has the specified physical and chemical properties or borosilicate glass 3.3;

(2) that the shape, dimensions and wall thickness requirements have been met.

6 Strength characteristics for design

6.1 If the surface is ground and polished or simply ground, or if an initially flame-polished undamaged surface is altered as a result of mechanical effects (e. g. scratches) when being utilised in the manner intended, or if it is possible for it to be altered under service conditions, the permissible tensile stress shall be

$$\frac{K}{S} = 7\ N \cdot mm^{-2}$$

6.2 If the flame-polished surface produced during the hot-forming process has neither been subjected to further mechanical processing, nor has been altered as a consequence of mechanical effects (e. g. scratches), and if this flame-polished state can be prevented from undergoing any alterations during the planned service period through the application of a protective surface finish firmly bonded to the glass, or through the adoption of other safety measures, the permissible tensile stress shall be

$$\frac{K}{S} = 10\ N \cdot mm^{-2}$$

6.3 The permissible compressive stress shall be:

$$\frac{K}{S} = 100\ N \cdot mm^{-2}$$

6.4 The characteristics given in 6.1 to 6.3 already embrace a safety factor S, for which no figure has been specified, which makes allowance for practical experience and for the theoretical finding relating to the strength behaviour of borosilicate glass 3.3 determined in experiments. Even with the application of a continuous maximum permissible load under unfavourable ambient conditions, a sufficiently low failure probability is ensured.