



**SLOVENSKI STANDARD
SIST EN 993-10:1998**

01-april-1998

**Metode za preskušanje gostih oblikovanih ognjevzdržnih izdelkov - 10. del:
Ugotavljanje trajnih sprememb mer pri segrevanju**

Methods of test for dense shaped refractory products - Part 10: Determination of permanent change in dimensions on heating

Prüfverfahren für dichte geformte feuerfeste Erzeugnisse - Teil 10: Bestimmung der bleibenden Längenänderung nach Temperatureinwirkung

Méthodes d'essai pour produits réfractaires façonnés denses - Partie 10: Détermination de la variation permanente de dimensions sous l'action de la chaleur

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Ta slovenski standard je istoveten z: EN 993-10:1997

ICS:

81.080 Ognjevzdržni materiali Refractories

SIST EN 993-10:1998 **en**

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EUROPEAN STANDARD

EN 993-10

NORME EUROPÉENNE

EUROPÄISCHE NORM

November 1997

ICS 81.080

Descriptors: refractory materials, shaped refractories, dense shaped refractory products, tests, thermal tests, determination, dimensional stability, procedure

English version

Methods of test for dense shaped refractory products - Part 10: Determination of permanent change in dimensions on heating

Méthodes d'essai pour produits réfractaires façonnés
denses - Partie 10: Détermination de la variation
permanente de dimensions sous l'action de la chaleur

Prüfverfahren für dichte geformte feuerfeste Erzeugnisse -
Teil 10: Bestimmung der bleibenden Längenänderung nach
Temperatureinwirkung

This European Standard was approved by CEN on 16 October 1997.

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.

CEN members are the national standards bodies of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.



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

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Contents

	Page
Foreword	3
1 Scope	4
2 Normative references	4
3 Definitions	4
4 Principle	4
5 Apparatus	5
6 Test pieces	6
7 Procedure	6
8 Expression of results	9
9 Test report	10

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Foreword

This European standard has been prepared by Technical Committee CEN/TC 187 "Refractory products and materials", the secretariat of which is held by BSI.

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 May 1998, and conflicting national standards shall be withdrawn at the latest by May 1998.

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.

It is closely based on the corresponding International Standard, ISO 2478 'Dense shaped refractory products - Determination of permanent change in dimensions on heating', published by the International Organization for Standardization (ISO).

Reproducibility and repeatability data are not available at present but may be included in a subsequent edition.

EN 993 Methods of test for dense shaped refractory products consists of 18 Parts:

- Part 1 : Determination of bulk density and porosity of dense shaped products
 Part 2 : Determination of true density
 Part 3 : Test methods for carbon-containing refractories
 Part 4 : Determination of permeability to gases
 Part 5 : Determination of cold crushing strength
 Part 6 : Determination of modulus rupture at ambient temperature
 Part 7 : Determination of modulus rupture at elevated temperatures
 Part 8 : Determination of refractoriness-under-load
 Part 9 : Determination of creep in compression
 Part 10 : Determination of permanent change in dimensions on heating
 Part 11 : Determination of resistance to thermal shock (ENV)
 Part 12 : Determination of pyrometric cone equivalent
 Part 13 : Specification for pyrometric cones
 Part 14 : Determination of thermal conductivity (hot wire, cross-array)
 Part 15 : Determination of thermal conductivity (hot wire, parallel)
 Part 16 : Determination of resistance to acids
 Part 17 : Determination of bulk density of granular material (mercury method)
 Part 18 : Determination of bulk density of granular material (water method)

1 Scope

This European Standard describes three methods for the determination of the permanent change in dimensions on heating of dense shaped refractory products.

NOTE : The method can be applied to materials sensitive to oxidation. However, some of these materials can be affected during the test in such a way as to make the measurement of the dimensional changes impossible to carry out to the required accuracy.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at appropriate places in the text and the publications 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 993-1 : Methods of test for dense shaped refractory products - Part 1 : Determination of bulk density, apparent porosity and true porosity.

ISO 3611 : Micrometer callipers for external measurement.

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3 Definitions

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For the purposes of this European Standard, the following definitions apply.

3.1 permanent change in dimensions on heating: The expansion or contraction that remains in a shaped refractory product that is heated to a specified temperature for a specified time and then cooled to ambient temperature.

3.2 dense shaped refractory products: A refractory product having a true porosity of less than 45 % (v/v) when measured in accordance with EN 993-1.

4 Principle

Test pieces in the shape of rectangular prisms or cylinders are cut from each brick or item, then dried, and their linear dimensions (Methods 1 and 2) or volume (Method 3) measured. The test pieces are heated in a furnace having an oxidizing atmosphere at a prescribed rate to a specified temperature, which is maintained for a specified time. After cooling to ambient temperature, the measurements on the test pieces are repeated, and the permanent change in dimensions or volume is calculated.

5 Apparatus

5.1 Furnace, either electric or gas-fired, capable of heating the test pieces described in clause 6, in a continuously oxidizing atmosphere, at the specified rate (see 7.6), and of maintaining the test temperature for the required time.

NOTE : The use of an electric furnace is recommended, but a gas-fired furnace may be used provided that the furnace atmosphere is continuously oxidizing and there is provision for monitoring this condition.

5.2 Thermocouples, a minimum of three, to measure the temperature and the temperature distribution over the space occupied by the test pieces.

5.3 Temperature/time registration device, for use in conjunction with the thermocouples (see 5.2), so that a continuous record of the temperature is obtained.

5.4 Length measuring device

5.4.1 General. Two measuring devices may be used, either the dial gauge apparatus (method 1) or Vernier callipers (method 2).

Method 1 shall be used as a reference method.

5.4.2 Dial gauge apparatus, (Method 1), consisting of a dial gauge or micrometer with an accuracy of 0,01 mm, mounted on a stand which has a surface ground base plate (see figure 1), and a test piece carrier (see figure 2), with three studs to support the test piece and two pins to locate it. The dimensions of the locating pins shall be as shown in figure 2. The under surface of the carrier shall be ground flat. A diagonal mark shall be inscribed at one corner to enable a rectangular test piece to be placed symmetrically on the studs. A cylinder of known length shall be used to calibrate the device.

The carrier shall be used to support and locate the test piece so that measurements with the dial gauge or micrometer before and after firing are made at the same points on the test piece surface.

5.4.3 Vernier callipers, (Method 2), in accordance with ISO 3611.

5.5 Volume measuring device, (Method 3), of the water displacement type, the bulk volume being determined in accordance with the method specified in EN 993-1.

5.6 Drying oven, capable of being controlled at $(110 \pm 5) ^\circ\text{C}$, which shall be fan-assisted and shall have openings which permit efficient ventilation.

6 Test pieces

The number of items tested and the number of test pieces per item, shall be by agreement between the parties.

NOTE 1: It is recommended that only one test piece should be taken from each item.

Test pieces shall be in the form of either:

- a) rectangular prisms, 50 mm x 50 mm x 60 mm or
- b) cylinders, 50 mm diameter and 60 mm long.

Tolerances on all dimensions shall be ± 2 mm.

NOTE 2: The 60 mm dimension should coincide with the direction of the forming pressure during manufacture if this direction is known.

The position of each test piece in the brick shall be recorded. The 50 mm x 50 mm faces of the prism, or the ends of the cylinder, shall be ground plane and parallel before the test. Each test piece shall be identified by appropriate marking.

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7 Procedure

7.1 Drying of the test pieces

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Dry each test piece in the drying oven (see 5.6) at (110 ± 5) °C to constant mass.

7.2 Measurement of test pieces

7.2.1 Linear measurement by dial gauge apparatus (Method 1)

Calibrate the length-measuring device (see 5.4) using the cylinder of known length. Place the test piece on the carrier, with the 60 mm dimension vertical. For rectangular test pieces, align one corner with the diagonal mark on the carrier, and mark this corner so that the test piece may be placed in the same position for measurement after firing. Mark cylindrical test pieces adjacent to the diagonal mark.

Measure the length of the test piece in four positions, to an accuracy of 0,01 mm, by moving the carrier with the test piece over the base plate. For rectangular test pieces, the four positions are located on the diagonals, between 20 mm and 25 mm from each corner. For cylindrical test pieces, the positions are 10 mm to 15 mm from the perimeter, on two diameters at right angles.

Record each measuring point.

7.2.2 Linear measurement by Vernier callipers (Method 2)

Measure the length of the test piece using the Vernier callipers (see 5.4.3) to an accuracy of $\pm 0,02$ mm. Measure the length at three positions using the measuring points shown in figure 3. Mark the positions at which the measurements are made, either with refractory paint or by cutting small grooves across the edges of the test pieces (see figure 3).

NOTE : Sliding test pieces in and out of the jaws of callipers can lead to wear of the surface of the jaws, although such an effect will be reduced because the length change is calculated by the difference of two measurements made with the same callipers. To minimize such wear, the test pieces should be placed carefully in the open jaws in contact with the upper fixed jaw, and the lower jaw moved up until contact is made.

7.2.3 Volume measurement (Method 3)

Determine the bulk density of the test piece in accordance with EN 993-1.

Calculate the bulk volume, V_B , in cubic centimetres, from the measurements taken, using the following equation:

$$V_B = \frac{m_2 - m_1}{\rho_{liq}}$$

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where

- m_1 is the apparent mass of the immersed test piece in grams;
- m_2 is the mass of the soaked test piece in grams;
- ρ_{liq} is the density of the immersion liquid in grams per cubic centimetre.

7.3 Mounting of test pieces in the furnace

Place the test pieces in the furnace (see 5.1), each one resting on one of its 50 mm x 50 mm faces (for prisms) or on end (for cylinders), and protected from direct radiation in an electrically heated furnace or from the flame of the gas burner in a gas-fired furnace. Do not superimpose test pieces one on another. To allow free circulation of the hot gases, the test pieces shall be separated from each other by a distance of not less than 20 mm, and shall be not nearer than 50 mm to the walls of the furnace.

The test pieces shall be placed in the furnace on bricks, 30 mm to 65 mm thick, of the same material as the test pieces, the bricks being laid flat on the apices of two supports of triangular cross-section, 20 mm to 50 mm in height and about 80 mm apart.