

Methods of test for dense shaped refractory products —

Part 5: Determination of cold crushing strength

The European Standard EN 993-5:1998 has the status of a
British Standard

ICS 81.080

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National foreword

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The UK participation in its preparation was entrusted by Technical Committee RPI/1, Refractory products and materials, to Subcommittee RPI/1/1, Sampling and physical testing of refractory materials, which has the responsibility to:

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

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 10, an inside back cover and a back cover.

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Methods of test for dense shaped refractory products – Part 5:
Determination of cold crushing strength

Méthodes d'essai pour produits réfractaires façonnés
denses – Partie 5: Détermination de la résistance à
l'écrasement à température ambiante

Prüfverfahren für dichte geformte feuerfeste Erzeugnisse –
Teil 5: Bestimmung der Kaltdruckfestigkeit

This European Standard was approved by CEN on 4 September 1998.

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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of an identical text or by endorsement, at the latest by March 1999, and conflicting national standards shall be withdrawn at the latest by March 1999.

It is closely based on the corresponding International Standard ISO 10059-1:1992, *Dense, shaped refractory products — Determination of cold compressive strength — Part 1: Referee test without packing*.

Reproducibility and repeatability data are not available, but can be given in a subsequent edition.

EN 993, *Methods of testing dense shaped refractory products*, consists of the following parts:

- *Part 1: Determination of bulk density, apparent porosity and true porosity,*
- *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 of rupture at ambient temperatures,*
- *Part 7: Determination of modulus of 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 (refractoriness);*
- *Part 13: Specification for pyrometric reference cones for laboratory use,*
- *Part 14: Determination of thermal conductivity by the hot-wire (cross-array) method;*
- *Part 15: Determination of thermal conductivity by the hot-wire (parallel) method;*
- *Part 16: Determination of resistance to sulphuric acids;*
- *Part 17: Determination of bulk density of granular materials by the mercury method with vacuum;*
- *Part 18: Determination of bulk density of granular materials by the water method with vacuum;*
- *Part 19: Determination of resistance to thermal expansion;*
- *Part 20: Determination of resistance to abrasion at ambient temperature.*

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 of determination of the cold crushing strength of dense shaped refractory products.

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 in 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 3599, *Vernier callipers reading to 0,1 and 0,05 mm.*

3 Definitions

For the purposes of this standard, the following definitions apply.

3.1

cold crushing strength

maximum load per unit area, applied under specified conditions at room temperature, that a refractory product will withstand before failure occurs

3.2

dense shaped refractory product

product having a true porosity of less than 45 % (V/V), when measured in accordance with EN 993-1

4 Principle

A test piece of known dimensions is subjected under specified conditions to a steadily increasing compressive load until its failure, when it cannot support a further increase in load. The cold crushing strength is calculated from the maximum load indicated at failure and the mean cross-sectional area over which the load is applied.

5 Apparatus

5.1 Mechanical or hydraulic compression testing machine, fitted with a measuring device capable of measuring the load exerted on the test piece to within $\pm 2\%$.

The machine shall be capable of increasing the stress at the rate of $1,0 \text{ MPa/s} \pm 0,1 \text{ MPa/s}$, until the test piece is unable to support the load.

The platens of the machine shall

- a) have a Rockwell hardness value between 58 HRC and 62 HRC;
- b) be ground plane to a flatness tolerance of 0,03 mm over the area to be in contact with the test piece;
- c) have a surface texture (mean roughness value R_a) between $0,8 \mu\text{m}$ and $3,2 \mu\text{m}$. This can be checked visually or by feeling with a "mean-roughness" reference standard such as is used for flat grinding.

The area of the upper platen shall not be greater than 100 cm^2 . The upper platen shall work on a seating that will compensate for small deviations from parallelism between the platen and test piece.

A testing machine whose upper platen does not comply with the above requirements for size can be used in conjunction with an ancillary adaptor, such as shown in Figure 1, placed centrally between the platens of the machine. The platens of the adaptor shall comply with the machine platen requirements for hardness and flatness given in this clause. They shall have a thickness of at least 10 mm.

NOTE The platens should be replaceable to allow re-machining and should not be matted.

5.2 Vernier callipers, in accordance with ISO 3599, for measurement of test pieces (see 6.3 and clause 7).

5.3 Set square.

5.4 Drying oven, capable of being controlled at $(110 \pm 5) ^\circ\text{C}$.

5.5 Feeler gauges.

5.6 Levelling plate.

6 Test pieces

6.1 The test pieces shall be either:

cylinders $50 \text{ mm} \pm 0,5 \text{ mm}$ in diameter and $50 \text{ mm} \pm 0,5 \text{ mm}$ in height; or

cubes $50 \text{ mm} \pm 0,5 \text{ mm}$ in edges length.

Where it is not possible to obtain this size from the test item, cylinders $36 \text{ mm} \pm 0,3 \text{ mm}$ in diameter and $36 \text{ mm} \pm 0,3 \text{ mm}$ in height shall be used. Only one test piece shall be taken from each item to be tested, unless otherwise agreed and reported (see clause 9).

6.2 Test pieces shall be cut from the item(s) so that the load applied during testing is in the same direction as the forming pressure during manufacture of the item, where this is known. The original position of the test pieces in the item(s) shall be reported. Test pieces containing cracks or visible defects shall be discarded and this shall also be reported. Both ends of the test piece shall be made plane and parallel, grinding the surfaces where required. Water sensitive material where hydration is expected during the time of test piece preparation and handling shall be machined dry or by using a non-reacting liquid.

To ensure that the top and bottom ends of the test pieces are plane over their entire surface, each end shall in turn be pressured with a load of $3 \text{ kN} \pm 1 \text{ kN}$ on to a levelling plate which is lined with carbon or blue paper and hard filter paper ($0,15 \text{ mm}$ in thickness). Test pieces that do not show two complete, clearly visible coloured impressions shall be reground (see Figures 2 to 5 for examples of cylindrical test pieces).

NOTE A steel straight edge can be used to assist in checking the surfaces. Mortar should not be used to plane the surfaces.

6.3 The parallelism of the test pieces shall be checked by four measurements of the height, at the extremities of two perpendicular diameters for a cylinder, or for a cube, along the four edges between the load-bearing faces. The difference between any two of these measurements of height shall not exceed $0,2 \text{ mm}$.

6.4 The perpendicularity shall be checked by placing the test piece on a plane surface and using a set square, placed against the side of the test piece, at four positions corresponding to the height measurements. No gap between the side of the test piece and the set square shall exceed $0,5 \text{ mm}$, measured with feeler gauges.

6.5 Drying of test pieces. The prepared test pieces shall be carefully dried by placing them in a drying oven at $(110 \pm 5) ^\circ\text{C}$ to constant mass. They are then cooled to room temperature and stored in a dry place until the test is begun.

7 Procedure

Measure two perpendicular diameters or medians of each surface to within 0,1 mm. From the arithmetic mean of these four measurements, calculate the initial cross-sectional area A_0 .

Place the test piece or the ancillary adaptor with the test piece in it centrally between the platens of the machine, without using any packing between the test piece and the platens.

Select the load range so that the expected load at failure is greater than 10 % of the load range. Apply the load smoothly and continuously, increasing the stress at the rate of $(1,0 \pm 0,1)$ MPa/s until the test piece fails, when it is unable to support the load. Record the maximum load indicated.

NOTE A graph of applied load against time is recommended for showing the result.

8 Expression of results

The cold crushing strength (σ) of the test piece (in MPa) is given by the expression:

$$\sigma = \frac{F_{\max}}{A_0}$$

where:

$F_{\max}$	is the maximum load recorded, in Newtons;
A_0	is the mean initial cross-sectional area of the test piece over which the load is applied, in square millimetres.

The result shall be given to three digits.

9 Test report

The test report shall include the following information:

- a) the name of the test laboratory;
- b) the date of the test;
- c) a reference to this European Standard, i.e. determined in accordance with EN 993-5;
- d) the designation of the material tested (manufacturer, size, quality, etc.);
- e) the number of items tested and the number of test pieces cut from each item if greater than one (see 6.1);
- f) the dimensions of the test pieces, their location in the item and the relationship to;
- g) the direction of pressing (see 6.1);
- h) the location of any defective test pieces (see 6.2);

- i) the individual value of cold crushing strength for each test piece and the mean value for each item, where different [see 6.1 and e)];
- j) the mean value for the batch sampled.

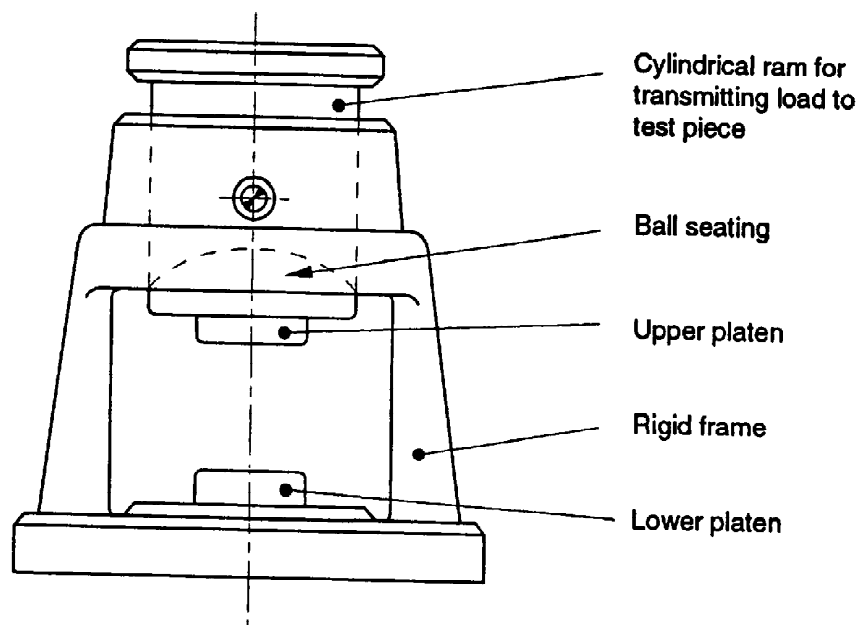
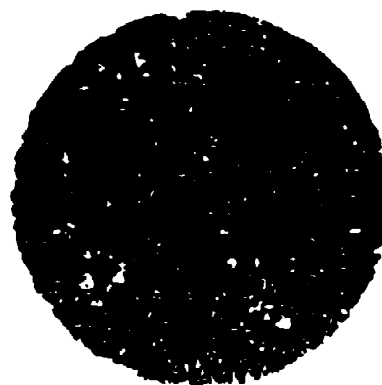


Figure 1 — Ancillary adaptor



a) coarse grained brick type

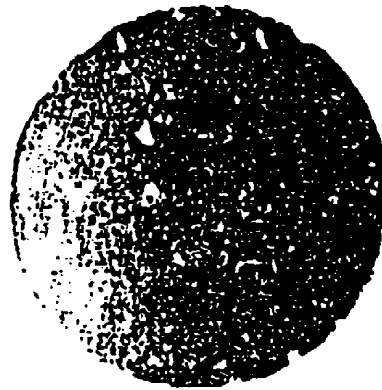


b) fine grained brick type

Figure 2 — Admissible carbon or blue paper replica



a) coarse grained brick type



b) fine grained brick type

Figure 3 — Carbon or blue paper replica still admissible



a) coarse grained brick type



b) fine grained brick type

Figure 4 — Carbon or blue paper replica not admissible



Figure 5 — Carbon or blue paper replica: not admissible because grooves after sawing or grinding are visible

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