International Standard

ISO 10059-1

Third edition
2025-03

Dense shaped refractory products — Determination of cold compressive strength —

Part 1: Referee test without packing

Produits réfractaires façonnés denses — Détermination de la résistance à la compression à température ambiante —

Partie 1: Méthode d'essai de référence sans intercalaire

Reference number
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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 33, *Refractories*.

This third edition cancels and replaces the second edition (ISO 10059-1:1992), which has been technically revised.

The main changes are as follows:

— revised definitions;

— addition of the possibility to use cube shaped test piece;

— addition of an informative annex on precision and bias.

A list of all parts in the ISO 10059 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The ISO 10059 series comprises two parts. This document (ISO 10059-1) specifies a referee method for determination of the cold compressive strength, which does not use any packing material. ISO 10059-2 will specify an alternative test where packing material and alternative test piece sizes are permitted.

The test method for shaped insulating products is given in ISO 8895.

Dense shaped refractory products — Determination of cold compressive strength —

Part 1:
Referee test without packing

1 Scope

This document specifies a method for determination of the cold compressive strength of dense shaped refractory products.

Shaped refractories are those which have fixed geometry and dimensions when delivered to the user. This document is accordingly applicable to standard shape refractory bricks, but also special shapes refractory products and pre-cast products.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 13385-1, *Geometrical product specifications (GPS) — Dimensional measuring equipment — Part 1: Design and metrological characteristics of callipers*

ISO 7500-1, *Metallic materials — Calibration and verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Calibration and verification of the force-measuring system*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
cold compressive strength
σ_{CCS}
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 with specific dimensions, having a true porosity of less than 45 % by volume, when measured in accordance with ISO 5017

3.3
sample
representative collection of items that can be obtained by sampling according to a sampling plan agreed upon by the interested parties

Note 1 to entry: An example of an applicable sampling plan is given in ISO 5022.

3.4
item
refractory brick or shape

3.5
test piece
test specimen
piece of material extracted from an *item* (3.4) and suitably shaped and prepared for the test

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 compressive 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. The accuracy of the test machine shall be in accordance with ISO 7500-1, Grade 2 (accuracy 2 % of indicated load), or better.

The machine shall be capable of increasing the stress at a rate of (1,0 ± 0,1) MPa·s^{-1}, 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 µm and 3,2 µm 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, but shall have an area greater than the cross section of the test piece. The upper platen shall function on a seating that will compensate for small deviations from parallelism between the platens and test piece.

A testing machine whose platens do 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 platens requirements for hardness and flatness given in this subclause. They shall have a thickness of at least 10 mm.

Devices which measure the force directly in the pressing direction by a load cell and not conversion via the hydraulic pressure are more accurate and are recommended.

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

5.2 Calliper, which shall be in accordance with ISO 13385-1, for measurement of test pieces dimensions.

5.3 Set square.

5.4 Drying oven, capable of being controlled at (110 ± 5) °C, or other device which has an equivalent heating effect.

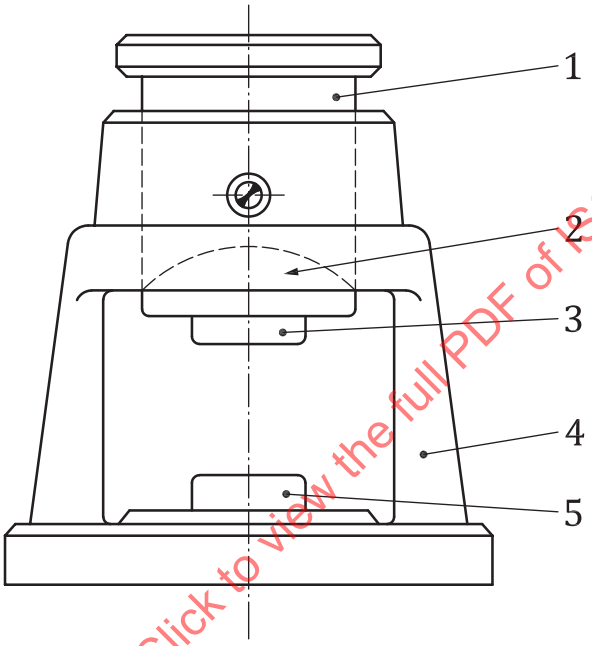
For MgO containing products, it is recommended to dry the test pieces to constant mass at (150 ± 10) °C.

NOTE A fan-assisted oven with ventilation and an exhaust air damper would assist in attaining an even temperature distribution and efficient drying of the test pieces.

5.5 Feeler gauges.

5.6 Levelling plate.

5.7 Ancillary adaptor, (see Figure 1) if needed (see 5.1).



Key

1 cylindrical element transmitting load onto the template
2 spherical testing
3 upper platen
4 stiff frame
5 lower platen

Figure 1 — Ancillary adaptor

6 Test pieces

6.1 Geometry of the test piece

The test pieces shall be either

a) cylinders (50 ± 0,5) mm in diameter and (50 ± 0,5) mm in height;

b) cubes (50 ± 0,5) mm in edges length.

When it is not possible to obtain this size from the test item, cylinders (36 ± 0,3) mm in diameter and (36 ± 0,3) mm in height shall be used.

It is not recommended to compare the tests results obtained using test pieces of different geometries or dimensions.

6.2 Number of test pieces

A sample consists of at least four items, obtained by sampling according to a sampling plan agreed upon by the interested parties, e.g. ISO 5022.

Only one test piece shall be taken from each item to be tested, unless otherwise agreed and reported (see Clause 9).

6.3 Test piece preparation and verification

6.3.1 The test piece shall be extracted from the middle of the item, unless otherwise agreed.

When more than one test piece is taken from an item, it is recommended to include at least one test piece taken from the centre, and one test piece adjacent to the hot face.

6.3.2 Test pieces shall be prepared by drilling cylinders 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, when 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 cylindrical 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 handing shall be machined dry or by using a non-reacting liquid.

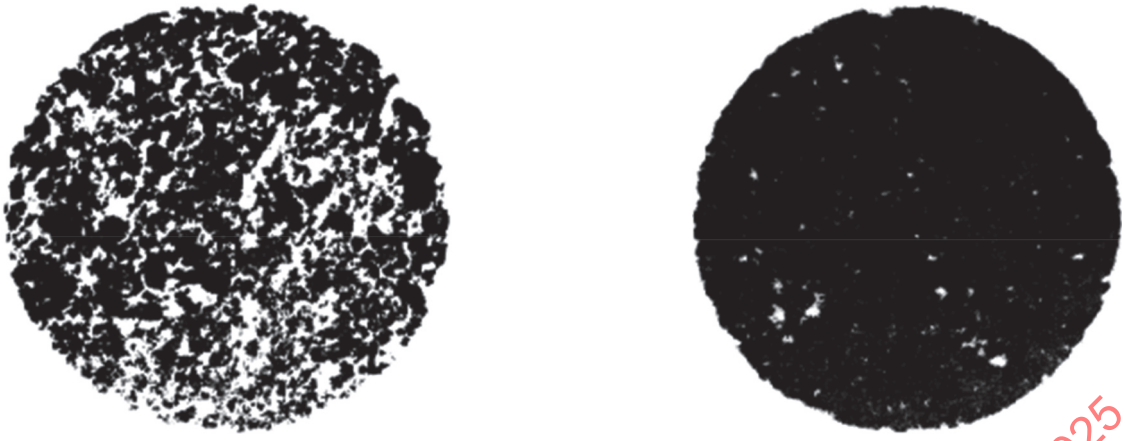
To ensure that the top and bottom ends of the test pieces are plane over their entire surface, each end shall in turn be pressed, with a load of (3 ± 1) kN, onto a levelling plate which is lined with carbon or blue paper and hard filter paper (0,15 mm in thickness). Test pieces that do not show two complete,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

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

NOTE Instead of a carbon or blue paper a pressure sensitive film can be used. An evaluation of the pressure distribution over the pressing surface is possible numerically.

6.3.3 The parallelism of the test pieces shall be checked by four measurements of the height, at the extremities of two perpendicular diameters. The difference between any two of these measurements shall not exceed 0,2 mm.

6.3.4 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. The gap between the side of the test piece and the set square shall not exceed 0,5 mm, measured with feeler gauges.



a) Coarse grained brick type b) Fine grained brick type

Figure 2 — Carbon or blue paper replica: good

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

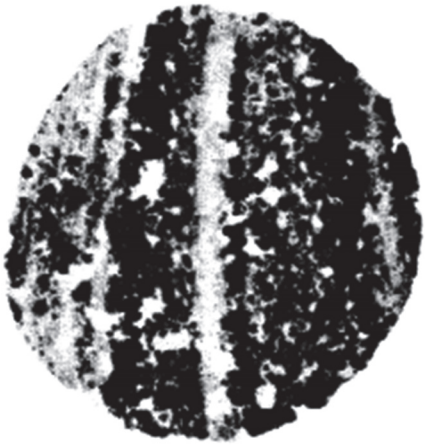


Figure 5 — Carbon or blue paper replica: not admissible because grooves are visible after sawing or grinding

7 Procedure

7.1 Dry the test piece to constant mass in the oven (5.3), controlled at (110 ± 5) °C, cooling it each time away from moisture. Store the test pieces under dry conditions till performing the test.

For MgO containing products, it is recommended dry the test pieces to constant mass at (150 ± 10) °C.

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

7.3 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.

7.4 Select the load range so that the expected load at failure is greater than 10 % of the load range.

NOTE For devices using load cells for measuring the force, the selected load range may be such that the expected failure corresponds to 5 % of this range.

7.5 Apply the load smoothly and continuously, increasing the stress at the rate of (1,0 ± 0,1) MPa·s–1 until the test piece fails, when it is unable to support the load.

7.6 Record the maximum load indicated.

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

8 Expression of results

The cold compressive strength (σ_{ccs}) of the test piece, expressed in MPa, is given by Formula (1):

$$\sigma_{ccs} = \frac{F_{max}}{A_0} \quad (1)$$

where

F_{max} is the maximum force, in Newtons (N);

A_0 is the mean initial cross-sectional area of the test piece over which the load is applied, in millimetres square (mm^2).

The result shall be given to three significant figures.

The precision that can be expected for the calculated values of cold compressive strength is discussed in Annex A.

9 Test report

The test report shall include the following information:

a) the name and address of the testing establishment;

b) the date of the test, unique identification of the report and of each page, the customer name and address, and signatory;

c) a reference to this document, i.e. "Determined in accordance with ISO 10059-1:2025";

d) the designation of the product tested (manufacturer, type, shape, batch number, etc.);

e) the number of items tested;

f) the size of the test pieces (see 6.1);

g) the number of test pieces cut from each item if greater than one (see 6.2);

h) the location of the test piece(s) in the item and the relationship to the direction of pressing (see 6.2);

i) the location of any defective test pieces (see 6.2);

j) either:

   1) the individual value of cold compressive strength for each test piece and the mean value and standard deviation for the sample;

   2) the individual value of cold compressive strength for each test piece, the mean value and standard deviation for each item, if more than one test piece was taken from each item (see 6.1) and the mean value and standard deviation for the sample;

k) details of any necessary deviations from this standard, and any useful comments about the test or the test results.

Annex A
(informative)

Precision and bias

A.1 Interlaboratory study

Two independent interlaboratory studies (ILS) were conducted:

a) The first ILS[5] was completed among 10 laboratories in 2014-2015.

Two different types of refractories were tested for cold compressive strength by each laboratory, a dense shaped refractory product (high alumina grade – HA75) and a carbon bonded refractory product (magnesia-carbon bonded grade – MC 95/10).

The test pieces were drilled from the bricks in two laboratories and then distributed to the other laboratories. Special sampling was applied to avoid the influence of extracting position on the obtained results in laboratories. Before testing sonic velocity were measured to ensure uniformity of bricks. The test pieces were in form of cylinders 50 mm high and 50 mm diameter.

b) The second ILS[6-8] was completed among 7 laboratories in 2021-2022.

Six different types of refractories were tested for cold compressive strength by each laboratory. Each laboratory performs 4-5 specimen of each brick compared to different parameters as shape (cylinder to cube), load rate (1,0 to 0,2 MPa·s^{-1}) and packing (with and without packing).

An overview of the conditions used is provided in Table A.1.

Table A.1 — Overview of the respective test conditions used

Method	Load rate [MPa/s]	Packing	Specimen geometry
ISO 10059-1	1,0	without	cylinder
ISO 10059-2	1,0	with	cylinder
ISO_cub	1,0	without	cube
ASTM_cyl	0,2	with	cylinder
ASTM_cub	0,2	with	cube
ASTM C133	0,2	with	cube

A.2 Precision data

A.2.1 General

The precision statistics for the cold compressive strength results on both ILS and all materials as well as all the parameters varied are reported in Table A.2.

The precision data as stated in ASTM C133 are also provided for comparison.

A.2.2 Repeatability

The maximum permissible difference due to test error between two test results obtained by one operator on the same material using the same test equipment is given by the repeatability interval (r) and the relative repeatability interval (% r). Two test results that do not differ by more than the repeatability interval are