
**Shaped insulating refractory products —
Determination of permanent change in
dimensions on heating**

*Produits réfractaires isolants façonnés — Détermination de la variation
permanente de dimensions sous l'action de la chaleur*

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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 document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 2477 was prepared by Technical Committee ISO/TC 33, *Refractories*.

This third edition cancels and replaces the second edition (ISO 2477:1987), which has been technically revised to align it with EN 1094-6. The principal changes concern

- normative references,
- terms and definitions to bring the standard into line with ISO 836, and
- revisions to clauses concerning sampling, measuring equipment, test temperature and distribution, and heating.

Shaped insulating refractory products — Determination of permanent change in dimensions on heating

1 Scope

This International Standard describes a method for determining the permanent change in dimensions on heating of a shaped insulating refractory product.

2 Normative references

The following referenced documents are indispensable for the application 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 5016, *Shaped insulating refractory products — Determination of bulk density and true porosity*

3 Terms and definitions

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

3.1

permanent change in dimensions on heating

dimensional expansion or contraction that remains in a refractory that is heated with no externally applied force to a specified temperature for a specified time and then cooled to ambient temperature

3.2

insulating refractory product

shaped refractory having a true porosity of not less than 45 % (volume fraction) when determined in accordance with ISO 5016

4 Principle

Test pieces in the shape of rectangular prisms are cut from each brick or item, then dried and the distance between two opposite faces on each test piece is 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 test pieces are measured again, and the permanent change in dimensions is calculated.

5 Apparatus

5.1 Furnace, either electric or gas-fired, capable of heating the test pieces described in 6.2, in a continuously oxidizing atmosphere, at the specified rate (see 7.6), and of maintaining the test temperature for the required time.

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, minimum of three, to measure the temperature and the temperature distribution above the space occupied by the test pieces.

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

5.4 Length-measuring instrument, to enable measurements to be made of the distance between opposite faces of the test pieces to an accuracy of 0,1 mm.

EXAMPLES Vernier callipers, a dial-gauge comparator or electronic digital gauge.

5.5 Drying oven, preferably fan-assisted, having openings which permit efficient ventilation, and capable of being controlled at $110\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$.

6 Test pieces

6.1 Sampling

The number of items (e.g. bricks) to be tested shall be determined in accordance with a sampling plan agreed between the parties concerned. See for example ISO 5022.

6.2 Preparation of test pieces

6.2.1 One test piece, comprising a rectangular prism having approximate dimensions $100\text{ mm} \times 114\text{ mm} \times 76\text{ mm}$, or $100\text{ mm} \times 114\text{ mm} \times 64\text{ mm}$, shall be cut from each item.

NOTE Where the size of the item permits, more than one test piece may be taken.

6.2.2 If, because of the size of the item, a test piece cannot be cut having the dimensions specified in 6.2.1, a rectangular test prism shall be obtained by cutting a 100 mm length from the item, and the width and thickness of the test piece shall be measured and recorded.

NOTE Standard rectangular bricks in accordance with ISO 5019-1 have a width of 114 mm and a thickness of 76 mm or 64 mm.

6.2.3 The two opposite faces of the test piece (100 mm apart) shall be plane and parallel before the test.

7 Procedure

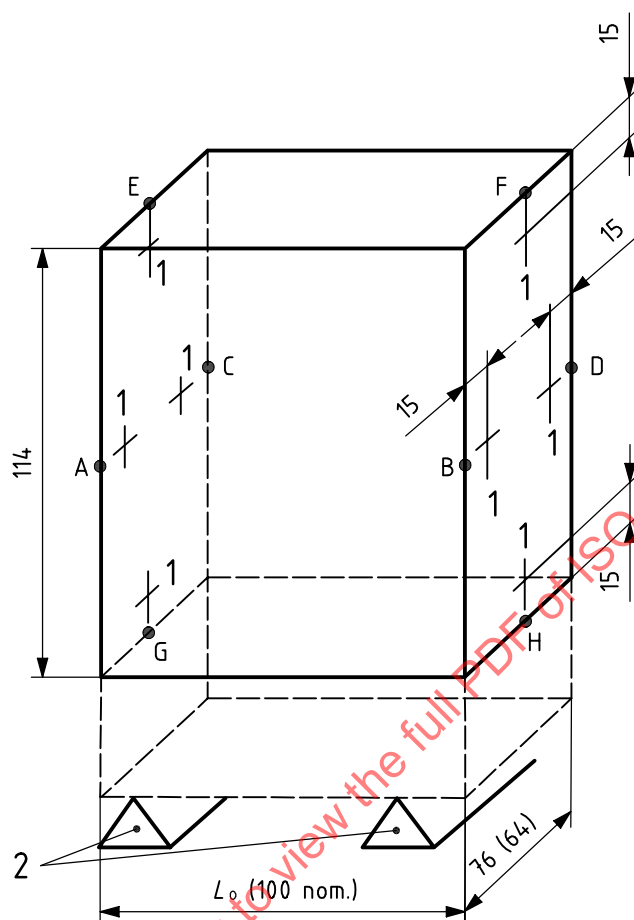
7.1 Drying of the test pieces

Dry each test piece in the drying oven (5.5) at $110\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$ to constant mass.

7.2 Measurement of test pieces

Make four measurements on each test piece, to the nearest 0,2 mm, of the distance, L_o , between the two opposite faces nominally 100 mm apart. Make two of these measurements parallel to the centrelines (EF and GH in Figure 1) of the top and bottom faces of the test pieces, approximately 15 mm in from the edges of those faces, and two parallel to the centrelines (AB and CD) of the front and rear faces of the test piece, approximately 15 mm in from the edges of those faces. Mark the measurement positions with refractory paint.

Dimensions in millimetres

**Key**

- 1 marked measurement positions, 15 mm from face of test piece
- 2 supporting piece (see 7.3)

Figure 1 — Position of measurements and mounting of the test pieces in the furnace

7.3 Mounting of test pieces in the furnace

Place the test pieces in the furnace (5.1), each one resting on a 100 mm × 76 mm (or 100 mm × 64 mm) face 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 50 mm, and shall be not nearer than 70 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, laid flat on the apices of two supports of triangular cross-section, 20 mm to 50 mm in height and about 80 mm apart, as shown in Figure 1.

7.4 Test temperature

A suitable test temperature, such as 750 °C or a higher temperature in multiples of 50 °C shall be used.

7.5 Temperature measurement and distribution

Using at least three thermocouples placed away from the walls of the furnace, away from the heaters and so as not to be in contact with any flames, measure and record the temperature distribution over the limits of the space occupied by the test pieces. The variation shown between the thermocouples shall not be greater than $\pm 10\text{ }^{\circ}\text{C}$.

7.6 Heating

Raise the temperature in the furnace at one of the following rates.

- a) For test temperatures up to $1\,250\text{ }^{\circ}\text{C}$:
 - from ambient temperature up to $50\text{ }^{\circ}\text{C}$ below the test temperature: between $5\text{ }^{\circ}\text{C/min}$ and $10\text{ }^{\circ}\text{C/min}$;
 - for the last $50\text{ }^{\circ}\text{C}$: between $1\text{ }^{\circ}\text{C/min}$ and $5\text{ }^{\circ}\text{C/min}$.
- b) For test temperatures above $1\,250\text{ }^{\circ}\text{C}$:
 - from ambient temperature up to $1\,200\text{ }^{\circ}\text{C}$: between $5\text{ }^{\circ}\text{C/min}$ and $10\text{ }^{\circ}\text{C/min}$;
 - from $1\,200\text{ }^{\circ}\text{C}$ up to $50\text{ }^{\circ}\text{C}$ below the test temperature: between $2\text{ }^{\circ}\text{C/min}$ and $5\text{ }^{\circ}\text{C/min}$;
 - for the last $50\text{ }^{\circ}\text{C}$: between $1\text{ }^{\circ}\text{C/min}$ and $2\text{ }^{\circ}\text{C/min}$.
- c) For gas-fired furnaces, for test temperatures greater than or equal to $1\,500\text{ }^{\circ}\text{C}$:
 - from ambient temperature up to $1\,200\text{ }^{\circ}\text{C}$: between $5\text{ }^{\circ}\text{C/min}$ and $20\text{ }^{\circ}\text{C/min}$;
 - from $1\,200\text{ }^{\circ}\text{C}$ up to $50\text{ }^{\circ}\text{C}$ below the test temperature: between $2\text{ }^{\circ}\text{C/min}$ and $5\text{ }^{\circ}\text{C/min}$;
 - for the last $50\text{ }^{\circ}\text{C}$: between $1\text{ }^{\circ}\text{C/min}$ and $2\text{ }^{\circ}\text{C/min}$.

For silica insulating products, the heating rate in the temperature range from ambient temperature up to $500\text{ }^{\circ}\text{C}$ shall not exceed $1\text{ }^{\circ}\text{C/min}$ to avoid cracking.

7.7 Maintenance of test temperature

Maintain the temperature recorded on each of the three thermocouples (5.2) to within $\pm 10\text{ }^{\circ}\text{C}$ of the test temperature for a period of 12 h. Record the mean of these three temperatures as the actual test temperature.

7.8 Sampling of furnace atmosphere

Sample the atmosphere of gas-fired furnaces in the vicinity of the test pieces at some time during the heating period specified in 7.6 and 7.7, and determine its oxygen content.

7.9 Cooling

Switch off the furnace and allow it to cool at its natural rate, with the test pieces being allowed to cool in the furnace.

7.10 Measurement of test pieces after firing

Record the appearance of the test pieces. Measure the distance between the two opposite faces of each test piece as described in 7.2. Where the measurements are made before the test pieces have cooled to ambient temperature, the temperature of the test pieces shall be reported.

8 Expression of results

Express the permanent change in dimensions as the change in dimension of the brick, ΔL , calculated as a percentage of the original length, L_0 , i.e. $100 \Delta L/L_0$. Calculate the change at each of the four measurement positions.

Report increases in length as positive (+), and decreases as negative (–).

Report the individual values calculated for each test piece, together with the mean value.

9 Test report

The test report shall include the following information:

- a) all information necessary for identification of the sample tested, i.e. description of the material tested (manufacturer and type, batch number);
- b) a reference to this International Standard (ISO 2477:2005);
- c) details of the method used, including
 - 1) the number of items tested (see 6.1),
 - 2) the number of test pieces per item or brick (see 6.2.1),
 - 3) the dimensions of the test pieces, their positions in the brick (see 6.2), and the presence and location of any fired surface,
 - 4) the type of furnace used (5.1),
 - 5) the oxygen content of the furnace atmosphere, if required (see 7.8),
 - 6) the heating schedule used (see 7.6),
 - 7) the nominal test temperature (see 7.4),
 - 8) the actual mean temperature (see 7.7), and
 - 9) the period at the actual mean temperature (see 7.7);
- d) the results of the test, including
 - 1) the appearance of the test pieces after heating (see 7.10),
 - 2) the results of the individual determinations and the mean value of the percentage linear change, indicating whether positive or negative, calculated as specified in Clause 8 for each test piece and each item, and
 - 3) the temperature of the test pieces if above ambient when remeasured;
- e) the name of the testing establishment;
- f) any deviations from the procedure specified;
- g) any unusual features (anomalies) observed during the test;
- h) the date of the test.