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**Dense and insulating shaped refractory  
products — Determination of modulus  
of rupture at ambient temperature**

*Produits réfractaires façonnés denses et isolants — Détermination  
du module de rupture par flexion à température ambiante*



## Foreword

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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.

International Standard ISO 5014 was prepared by Technical Committee ISO/TC 33, *Refractories*.

This second edition cancels and replaces the first edition (ISO 5014:1986), which has been technically revised.

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# Dense and insulating shaped refractory products — Determination of modulus of rupture at ambient temperature

## 1 Scope

This International Standard specifies a method for the determination of the modulus of rupture of dense and insulating shaped refractory products at ambient temperature, under conditions of a constant rate of increase of stress.

The method relates primarily to shaped and fired refractories. If it is to be applied to chemically bonded or tar-bonded bricks, they will usually require some form of preliminary heat treatment. This preliminary treatment, the details of which are outside the scope of this standard, is a matter of agreement between the interested parties and is described in the test report.

## 2 Definition

For the purposes of this International Standard, the following definition applies:

**2.1 modulus of rupture:** The maximum stress that a prismatic test piece of specified dimensions can withstand when it is bent in a three-point bending device.

## 3 Principle

Loading of test pieces of the product to be tested at a constant rate of increase of stress until failure occurs.

## 4 Apparatus

### 4.1 Loading device

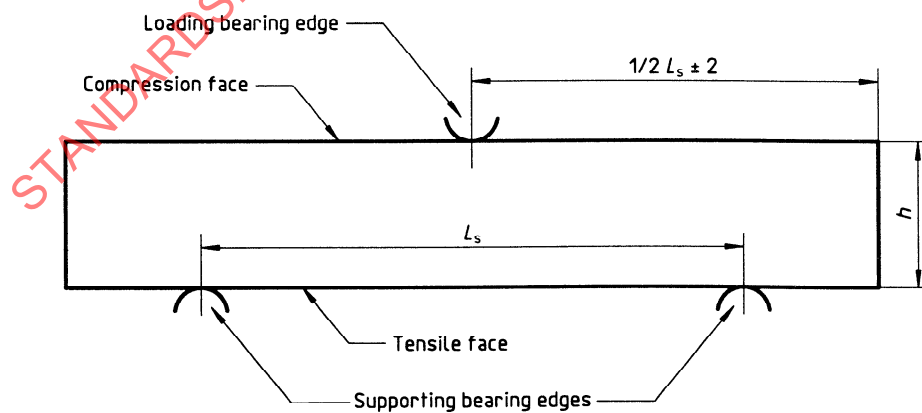
**4.1.1** The loading device shall have three bearing edges, two to support the test piece and one for the application of the load (see figure 1). The three edges shall have a radius of curvature in accordance with the requirements given in table 1 and shall be of length not less than 5 mm greater than the breadth ( $b$ ) of the test piece (see figure 2). The contact lines of the three edges shall be parallel to each other in a direction perpendicular to the length and the plane of the breadth of the test piece. Two supporting edges shall rest on an intermediate bearing piece, cylindrical on its lower surface, so that each edge may rotate independently in a vertical plane to accommodate any slight twist in the test piece (see figure 2). Alternatively, one supporting edge may be fixed, with the other supporting edge and the load-bearing edge being capable of rotation in a vertical plane. The distance between the two supporting edges shall be in accordance with table 1 and the load-bearing edge shall be positioned equidistantly, at  $L_s/2 \pm 2$  mm from each supporting edge.

**Table 1 — Dimensions and tolerances associated with the tests  
on test pieces of various sizes**

Dimensions in millimetres

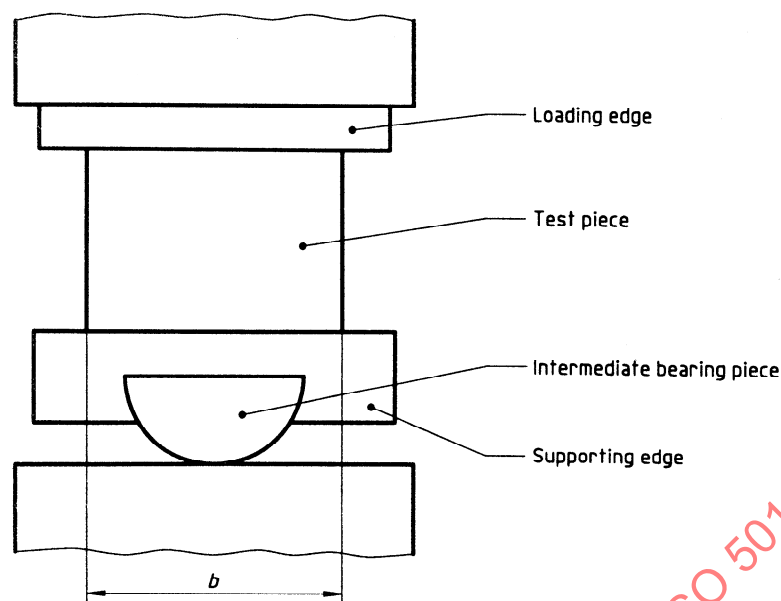
| Test piece size<br><br>$l \times b \times h$ | Tolerance<br>for the<br>breadth $b$<br>and height $h$ | Tolerance<br>for the<br>parallelism<br>of the cross-<br>section sides | Tolerance<br>for the<br>parallelism<br>of the top<br>and bottom<br>faces | Distance<br>between<br>supports<br><br>$L_s$ | Radius of curvature<br>for the loading edge<br>and bearing edges |
|----------------------------------------------|-------------------------------------------------------|-----------------------------------------------------------------------|--------------------------------------------------------------------------|----------------------------------------------|------------------------------------------------------------------|
| 230 x 114 x 76<br>230 x 114 x 64             | —                                                     | —                                                                     | —                                                                        | $180 \pm 1$                                  | $15 \pm 0,5$                                                     |
| 200 x 40 x 40                                | $\pm 1$                                               | $\pm 0,15$                                                            | $\pm 0,25$                                                               | $180 \pm 1$                                  | $15 \pm 0,5$                                                     |
| 150 x 25 x 25                                | $\pm 1$                                               | $\pm 0,1$                                                             | $\pm 0,2$                                                                | $125 \pm 1$                                  | $5 \pm 0,5$                                                      |

Dimensions in millimetres



NOTE — For tolerances see table 1.

**Figure 1 — Arrangements and dimensions of test piece and bearing edges  
of loading device**



**Figure 2 — Diagrammatic representation of loading device —  
Intermediate bearing piece**

**4.1.2** The loading device shall be capable of applying a load uniformly across the centre of the test piece and of increasing it at a uniform rate. A means shall be provided of recording or indicating the load at failure with an accuracy of  $\pm 2\%$ .

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

## **5 Preparation of test pieces**

### **5.1 Number**

**5.1.1** The number of items (for example, bricks, shapes, nozzles) to be tested shall be determined by agreement between the interested parties.

**5.1.2** If test pieces are cut out of bricks or blocks, the same number shall be cut from each one, in order to facilitate statistical analysis.

NOTE — The number of test pieces to be cut from each item (which detail is outside the scope of this International Standard) is a matter for agreement between the interested parties. It should be stated in the test report.

### **5.2 Shape and size**

Each test piece shall be a whole standard rectangular brick (230 mm x 114 mm x 76 mm or 230 mm x 114 mm x 64 mm) or one of the other sizes shown in table 1.

### **5.3 Preparation**

**5.3.1** Standard size bricks (see 5.2) shall be tested as received.

**5.3.2** If test pieces are cut out of bricks, it shall be done in such a way that, if the direction in which the brick was pressed is known, the upper longitudinal face in the testing position (the face in compression) is parallel to, or coincides with, one of the original faces of the brick perpendicular to the direction of pressing.

NOTE — Cutting with a continuous rim diamond wheel is recommended. If a serrated rim wheel is used, the edges of the cut where the wheel emerges are often frayed; it is therefore recommended that such a wheel should enter the face of the brick that is to form the tensile face of the test piece during the test.

**5.3.3** The direction of pressing, if known, shall be marked on the test piece.

## 6 Procedure

**6.1** Dry the test piece to constant mass in the oven (4.2), controlled at  $(110 \pm 5)^\circ\text{C}$ , cooling it each time away from moisture.

**6.2** Measure the breadth and height of each test piece at its mid-point with an accuracy of  $\pm 0,1$  mm and the distance between the supporting edges with an accuracy of  $\pm 0,5$  mm.

**6.3** Place the test piece on the lower bearing edges of the loading device (4.1) so that it rests symmetrically across them. When the test piece is a normal standard brick, the face bearing any brand mark, i.e. the upper face, shall be in compression. If the test pieces have been cut out of the brick, the face of the test piece which corresponds to the original face of the brick (if it has been preserved) shall be in compression.

**6.4** Apply the load vertically to the test piece until failure occurs. The rate of increase of stress shall be:

- a) for a dense shaped refractory product or material:

$$0,15 \text{ MPa/s} \pm 0,015 \text{ MPa/s.}$$

- b) for a shaped insulating refractory product or material:

$$0,05 \text{ MPa/s} \pm 0,005 \text{ MPa/s.}$$

**6.5** Record the load at which failure of the test piece occurs ( $F_{\text{max}}$ ) and the temperature at which the test was conducted.

## 7 Expression of results

**7.1** The modulus of rupture  $\sigma_F$  is the ratio of the bending moment at the point of failure  $M_{\text{max}}$  to the moment of resistance  $W$  (the section modulus), and is calculated from the following equation:

$$\sigma_F = \frac{M_{\text{max}}}{W} = \frac{3}{2} \times \frac{F_{\text{max}} L_s}{bh^2}$$