BRITISH STANDARD

BS 1902-3.17: 1990

Methods of testing

Refractory materials —

Part 3: General and textural properties —

Section 3.17 Determination of volume and bulk density of dense shaped products (methods 1902-317)

Confirmed February 2011

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Refractory Products Standards Policy Committee (RPM/-) to Technical Committee RPM/1, upon which the following bodies were represented:

British Ceramic Research Ltd.
British Steel Industry
Electricity Supply Industry in England and Wales
Engineering Equipment and Materials Users' Association
Refractories Association of Great Britain
Refractory Contractors' Association
Society of Glass Technology

This British Standard, having been prepared under the direction of the Refractory Products Standards Policy Committee, was published under the authority of the Board of BSI and comes into effect on
30 November 1990

The following BSI references relate to the work on this standard:
Committee reference RPM/1
Draft for comment 88/43674 DC

ISBN 0 580 18363 7

Amendments issued since publication

Amd. No.	Date	Comments

Contents

Foreword

This Section of BS 1902 was prepared under the direction of the Refractory Products Standards Policy Committee.

A method for measuring the bulk density and apparent porosity of dense shaped products is given in BS 1902-3.8:1989, which is identical to ISO 5017:1988, published by the International Organization for Standardization (ISO). Bulk density may also be calculated from measurement of the volume, which may be obtained either from measurement by mercury balance or from the dimensions of a shaped item, as described in this Section.

These methods were originally included in BS 1902-3.8:1981, which has been withdrawn.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 4, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

NOTE This Section is to be used in conjunction with BS 1902-3.0 "*Introduction*" and BS 1902-3.1 "*Guidance on sampling*". Section 3.0 sets out the general arrangement of BS 1902 and lists the Sections of Part 3.

1 Scope

This Section of BS 1902 describes methods for the determination of the volume and bulk density of dense shaped refractory products, by the mercury balance, and by measurement of the dimensions of a shaped item.

Appendix A describes the construction and calibration of the mercury balance.

NOTE The titles of the publications referred to in this standard are listed on the inside back cover.

2 Designations

The methods for the determination of volume and bulk density are referred to by the following designations.

Method 1902-317/1 (mercury balance)

Method 1902-317/2 (dimensions of a shaped item)

3 Principle

The volume and bulk density of a test piece are determined by one of the following methods:

a) measurement of the apparent mass when immersed in mercury;

b) measurement of the linear dimensions of a shaped item.

NOTE The volume of a rectangular test piece is determined by calculation from the measurement of its dimensions.

WARNING. It is important that proper precautions for the protection of laboratory personnel are taken when mercury is used. The use of a fume cupboard is strongly recommended. Attention is drawn to **4.3.4** and to the relevant regulations and guidance documents which include the Department of Employment Technical Data Note No. 21, published by HMSO[1)].

4 Determination of volume and bulk density of dense shaped products by measurement of the apparent mass when immersed in mercury (method 1902-317/1)

4.1 Apparatus

4.1.1 *Mercury balance*, an example of which is shown in Figure 1. The balance operates on the principle of a hydrometer, but since mercury is denser than metals used for construction of the balance, it is necessary to add weights to a position below the centre of buoyancy, so that the instrument will float in a vertical position. This is achieved by placing the vessel containing the mercury on a bridge or shelf, and providing a scale pan below the level of support.

NOTE The recommended construction material for the frame is aluminium strip, protected with a mercury-resistant coating such as shellac or varnish. See Appendix A.

4.1.2 *Weights*, to load the scale in increments of 0.01 g.

4.2 Test pieces

The dimensions of the test piece shall be such as to fit the test piece holder used. (An example of a test piece holder is shown in Figure 1.)

4.3 Procedure

4.3.1 Dry the test piece at 110 ± 5 °C to constant mass. Cool to room temperature and weigh to 0.01 g (W).

4.3.2 Immerse the test piece holder in the mercury and add weights (**4.1.2**) to the scale pan to sink the apparatus to the mark shown in Figure 1. Record the total mass of the weights added (W_1). If the mark sinks below the surface of the mercury without the addition of the weights use the calibration procedure given in **A.2**.

4.3.3 Raise the test piece holder above the surface of the mercury, push the test piece under the surface of the mercury and place the holder over the test piece to prevent it breaking the surface. Take care to ensure that air is not entrapped between the holder and the test piece. Add weights (**4.1.2**) to overcome the increased upthrust, until the instrument again sinks to the mark. Record the total mass of the weights added (W_2).

NOTE If the test piece contains large pores or fissure defects, these can be penetrated by the mercury causing the instrument to sink during the final adjustment towards the balance point. If this occurs, the test should be abandoned and an alternative method used.

[1)] Available from HMSO, 49 High Holborn, London WC1 for personal callers, or by post from HMSO, P.O. Box 276 London SW8 5DT.

4.3.4 Remove the test piece from the apparatus and place it in an impervious bag or container to prevent the spread of droplets of mercury. Dispose of the bags in accordance with the requirements of the local authority.

4.4 Calculation of results

4.4.1 The bulk volume (V) is calculated from the following equations.

With no test piece in the holder:

$$W_1 + W_0 = V_0 D + X \quad (1)$$

where

W_0 is the mass of the hydrometer (in g);

V_0 is the volume of mercury displaced by the hydrometer (in cm^3);

D is the density of mercury at the temperature of test (in g/cm^3);

X is the small upthrust due to the action of surface tension on the stem (in g);

V is the bulk volume of the specimen (in cm^3);

W_1 is the mass of the weights added to the pan to sink the apparatus to the mark (in g).

With the test piece in the holder and the hydrometer sunk to the mark:

$$W + W_1 + W_2 + W_0 = V_0 D + X + VD \quad (2)$$

where

W is the mass of the test piece (in g);

W_2 is the mass of the additional weights to overcome the increased upthrust (in g).

Subtracting (1) from (2):

$$W + W_2 = VD \quad (3)$$

whence

$$V = \frac{W + W_2}{D} \quad (4)$$

4.4.2 The bulk density ρ (in g/cm^3) is then calculated from the following equation:

$$\rho = \frac{W}{V} \quad (5)$$

4.5 Test report

The test report shall include the following information:

a) the name of the testing establishment;

b) the date of the test;

c) a description of the refractory product tested (manufacturer, type, batch number, etc.);

d) a reference to these methods of test, e.g. determined in accordance with method 1902-317/1 (see clause **2**);

e) the number of test pieces;

f) the results for the volume and bulk density of each test piece.

5 Determination of volume and bulk density of dense shaped products by measurement of the linear dimensions of a shaped item (method 1902-317/2)

5.1 Principle

The volume of a rectangular test piece is determined by calculation, from the measurement of its dimensions.

5.2 Apparatus

5.2.1 *Measuring equipment*, in accordance with method 1902-302.

5.2.2 *Drying oven*

5.2.3 *Balance*, to weigh to 0.05 % of the smallest test piece measured.

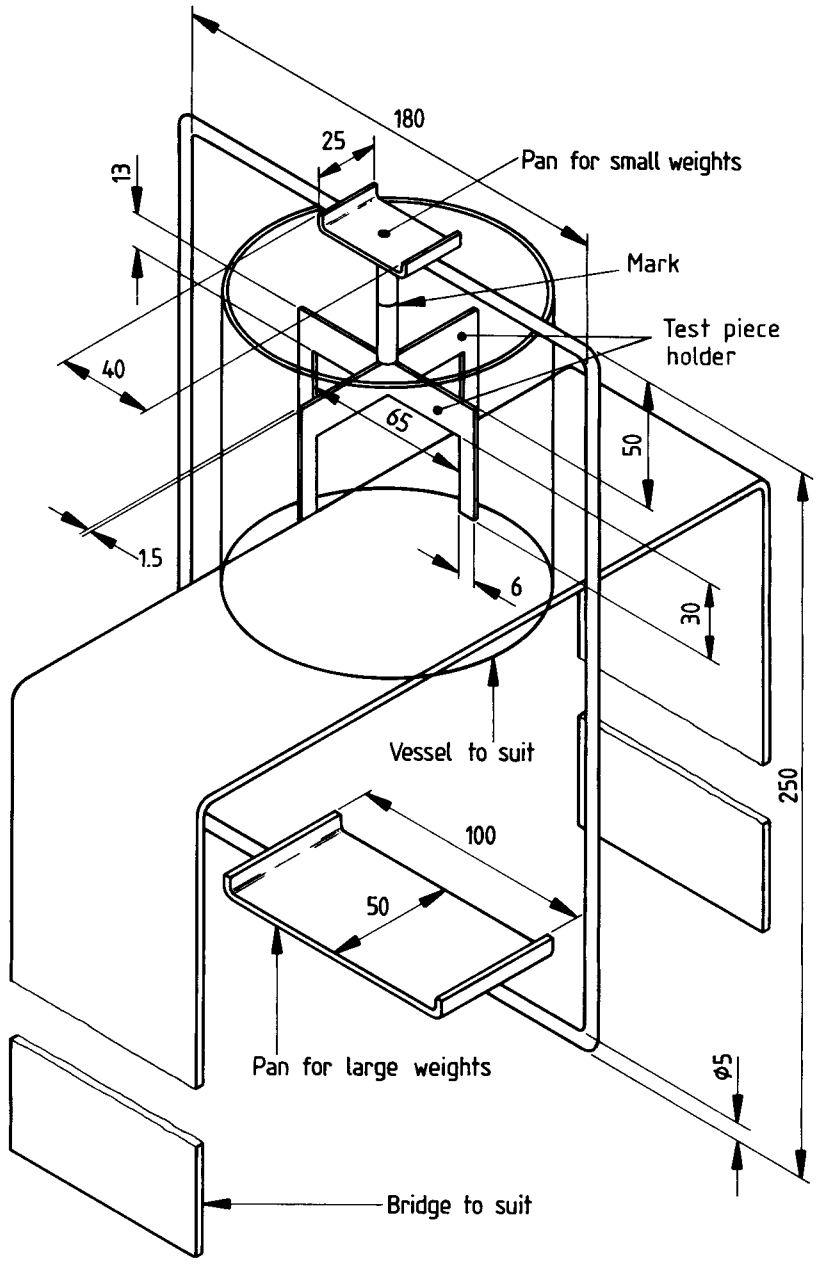
5.3 Preparation of test pieces

5.3.1 The bricks or blocks used as test pieces shall have plane and parallel surfaces and be nominally either rectangular or cylindrical. No one dimension of a test piece shall be less than 50 mm.

5.3.2 A test piece shall be excluded if its departure from squareness is such that, for any pair of opposite faces, four measurements to the nearest 0.5 mm made along the centrelines of the faces differ amongst themselves by more than 1.0 mm. A test piece shall also be excluded if it has any appreciable edge defects.

5.4 Procedure

Measure the length a, width b and depth c for rectangular test pieces or diameter d and height h for cylindrical test pieces, to the nearest 0.5 mm, in accordance with method 1902-302. Dry in the oven to constant mass and weigh to 0.05 % of its mass.



All dimensions are in millimetres.

Figure 1 — Typical example of a mercury balance

5.5 Expression of results

The bulk volume V (in cm^3) is calculated from the expressions:

$$V = \frac{a \times b \times c}{1000} \quad (6)$$

where a, b, c are the dimensions (in mm) for rectangular test pieces.

$$V = \frac{\pi d^2 h}{4 \times 1000} \quad (7)$$

where d, h are the dimensions (in mm) for cylindrical test pieces.

The bulk density ρ (in g/cm^3) is calculated from the expression:

$$\rho = \frac{W}{V} \quad (8)$$

where W is the dry mass (in g).

5.6 Test report

The test report shall be in accordance with **4.5**.

Appendix A Construction and calibration of the mercury balance

A.1 Construction material

The recommended construction material for the frame of the mercury balance is aluminium strip, protected with a mercury-resistant coating. This material is light enough to require weights on the scale pan to sink the instrument to the mark on the stem with the test piece holder empty.

If the frame is constructed of denser material and does not float in the mercury it may be calibrated in accordance with **A.2**.

A.2 Calibration

Place a dry, machined steel block of accurately known volume and mass W' in the instrument so that the four prongs keep it vertical when immersed in the mercury. Add weights W'_1 to the scale pan until the instrument just sinks to the mark on the neck. The apparent volume of the steel block holder is then

$$\frac{W' + W'_1}{D} \qquad (9)$$

where

W' is the mass of the steel block (in g);

W'_1 is the mass of the weights added to the scale pan (in g);

D is the density of mercury at the temperature of the test (in g/cm^3).

The difference between the value so obtained and the true volume of the steel block is the volume calibration figure for the apparatus (V_0), as in **4.4**.

Publications referred to

BS 1902, *Methods of testing refractory materials.*
BS 1902-3, *General and textural properties.*
BS 1902-3.0, *Introduction.*
BS 1902-3.1, *Guidance on sampling.*
BS 1902-3.2, *Measurements of dimensions of specimens for testing.*
BS 1902-3.8, *Determination of bulk density, true porosity and apparent porosity of dense shaped products.*

BSI — British Standards Institution

BSI is the independent national body responsible for preparing British Standards. It presents the UK view on standards in Europe and at the international level. It is incorporated by Royal Charter.

Revisions

British Standards are updated by amendment or revision. Users of British Standards should make sure that they possess the latest amendments or editions.

It is the constant aim of BSI to improve the quality of our products and services. We would be grateful if anyone finding an inaccuracy or ambiguity while using this British Standard would inform the Secretary of the technical committee responsible, the identity of which can be found on the inside front cover. Tel: 020 8996 9000. Fax: 020 8996 7400.

BSI offers members an individual updating service called PLUS which ensures that subscribers automatically receive the latest editions of standards.

Buying standards

Orders for all BSI, international and foreign standards publications should be addressed to Customer Services. Tel: 020 8996 9001. Fax: 020 8996 7001.

In response to orders for international standards, it is BSI policy to supply the BSI implementation of those that have been published as British Standards, unless otherwise requested.

Information on standards

BSI provides a wide range of information on national, European and international standards through its Library and its Technical Help to Exporters Service. Various BSI electronic information services are also available which give details on all its products and services. Contact the Information Centre. Tel: 020 8996 7111. Fax: 020 8996 7048.

Subscribing members of BSI are kept up to date with standards developments and receive substantial discounts on the purchase price of standards. For details of these and other benefits contact Membership Administration. Tel: 020 8996 7002. Fax: 020 8996 7001.

Copyright

BSI
389 Chiswick High Road
London
W4 4AL