METHODS OF TESTING VULCANIZED RUBBER

PART A1. DETERMINATION OF DENSITY

BS 903 : Part A1 : 1971

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BRITISH STANDARDS INSTITUTION
Incorporated by Royal Charter
2 PARK STREET, LONDON W1A 2BS
Telex: 266933 Telephone: 01-629 9000

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The Institution desires to call attention to the fact that this British Standard does not purport to include all the necessary provisions of a contract.

In order to keep abreast of progress in the industries concerned, British Standards are subject to periodical review. Suggestions for improvements will be recorded and in due course brought to the notice of the committees charged with the revision of the standards to which they refer.

A complete list of British Standards, numbering over 5000, fully indexed and with a note of the contents of each, will be found in the British Standards Yearbook. The BS Yearbook may be consulted in many public libraries and similar institutions.

This standard makes reference to the following British Standards:

BS 733. Density bottles.

British Standards are revised, when necessary, by the issue either of amendment slips or of revised editions. It is important that users of British Standards should ascertain that they are in possession of the latest amendments or editions,

The following BSI references relate to the work on this standard:
Committee references RUC/10 and RUC/10/4
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CO-OPERATING ORGANIZATIONS

The Rubber Industry Standards Committee, under whose supervision this British Standard was prepared, consists of representatives from the following Government department and scientific and industrial organizations.

British Association of Synthetic Rubber Manufacturers
*British Rubber Manufacturers' Association Ltd.
*Department of Trade and Industry
*Institution of the Rubber Industry
*Natural Rubber Producers' Research Association
*Rubber and Plastics Research Association of Great Britain
Rubber Growers' Association
*Society of Motor Manufacturers and Traders Ltd.
Tyre Manufacturers' Conference

The Government department and scientific and industrial organizations marked with an asterisk in the above list, together with the following, were directly represented on the committee entrusted with the preparation of this British Standard:

British Railways Board
British Rubber and Resin Adhesive Manufacturers' Association
British Society of Rheology
Chemical Industries Association
Electrical Research Association
Institution of Mechanical Engineers
Institution of Mechanical Engineers (Automobile Division)
Institution of Municipal Engineers
Institution of Water Engineers
Ministry of Defence (Air Force Department)
Ministry of Defence (Army Department)
Ministry of Defence (Navy Department)
Ministry of Housing and Local Government
National College of Rubber Technology
National Physical Laboratory (Department of Trade and Industry)
Post Office
Royal Institute of Chemistry

BRITISH STANDARD

METHODS OF TESTING VULCANIZED RUBBER

Part A1. Determination of density

FOREWORD

This British Standard has been published under the authority of the Rubber Industry Standards Committee and is a revision of the 1956 edition.

The principal changes made in this revision are:

(1) the adoption of units in accordance with ISO Recommendation R 1000*, 'Rules for the use of units of the International System of units and a selection of the decimal multiples and sub-multiples of the SI units';

(2) the deletion of reference to 'specific gravity' (now termed 'relative density');

(3) the permitted use of single pan balances.

This Standard is technically identical with the document under consideration at the time of publication of this standard by Technical Committee 45—Rubber of the International Organization for Standardization.

In this standard the determination is made by observation of gravitational forces under different conditions, but for convenience these forces are expressed in mass units.

METHOD

1. SCOPE

This part of this British Standard describes two procedures for the determination of the density of rubber.

In Method A the weights of the test piece in air and in water are determined. The weight when immersed in water, is less than that in air by the weight of water displaced, the volume of water displaced being equal to that of the test piece. Method B, using a density bottle, is intended to be used only when it is necessary to cut up the test piece into small pieces to eliminate air spaces, as in the case of narrow bore tubing and electric cable insulant.

* The contents of ISO Recommendation R 1000 are more readily available in BSI publication PD 5686.

2. DEFINITION

Density. The mass per unit volume of the rubber at a stated temperature. It is expressed in Mg/m^3.

3. TEST PIECE

The test piece shall consist of a piece of the rubber with smooth surfaces, free from crevices and dust, and weighing at least 2·5 g.

4. APPARATUS

The apparatus shall consist of:

Balance, weighing to 1 mg, and for

METHOD A, *Balance straddle*. A pan straddle of convenient size to support the beaker and permit determination of the weight of the test piece in water.

Beaker, 250 ml capacity (or smaller if necessitated by the design of the balance).

METHOD B, *Density bottle*, complying with BS 733*.

5. PROCEDURE

5.1 Preparation of sample. If fabric is attached to or embedded in the rubber sample it shall be removed before cutting the test pieces. The method of removal shall preferably avoid the use of a swelling liquid, but a suitable non-toxic liquid of low boiling point may be used, if necessary, to wet the contacting surfaces. Care shall be taken to avoid stretching the rubber during the separation from the fabric, and the liquid, if used, shall be allowed to evaporate completely from the rubber surfaces after separation. Cloth-marked surfaces shall be made smooth by buffing.

5.2 Conditioning of samples and test pieces. Unless otherwise specified for technical reasons the following requirements shall be observed.

For all test purposes the minimum time between vulcanization and testing shall be 16 hours.

For non-product tests the maximum time between vulcanization and testing shall be 4 weeks and for evaluations intended to be comparable, the tests, as far as possible, shall be carried out after the same time interval.

For product tests, whenever possible, the time between vulcanization and testing shall not exceed 3 months. In other cases tests shall be made within 2 months of the date of receipt of the product by the customer.

Samples and test pieces shall be protected from light as completely as possible during the interval between vulcanization and testing.

* BS 733, ' Density bottles '.

Samples, after any necessary preparation, shall be conditioned at 20 ± 2 °C for at least 3 hours before the test pieces are cut. These test pieces may be tested immediately but, if not tested immediately, they shall be kept at 20 ± 2 °C until tested. If the preparation involves buffing, the interval between buffing and testing shall not exceed 72 hours.

5.3 Method A. The test piece shall be suspended from the hook on the balance using a suitable length of filament so that the bottom of the test piece is about 25 mm above the straddle. The filament shall either be counterbalanced or weighed; if weighed its weight shall be deducted from subsequent weighings of the test piece (see Note 1). The test piece shall be weighed to the nearest milligram. The weighing shall then be repeated with the test piece (and sinker, if required, see Note 2) immersed in freshly boiled and cooled distilled water at a temperature of 20 ± 2 °C contained in a beaker placed on the straddle. Air bubbles adhering to the test piece shall be removed (see Note 4) and the weight shall be determined to the nearest milligram, the pointer being watched for a few seconds to make sure that it does not drift gradually on account of convection.

Duplicate tests shall be made.

NOTE 1. Where the filament used is less than 0·010 g in weight, such as is the case with thin nylon filament, the correction to account for its weight is not necessary to ensure the stated accuracy of the final result.

NOTE 2. When this procedure is used for rubber having a density less than 1 Mg/m³, a sinker is necessary; a further weighing of the sinker alone in water is required.

NOTE 3. The main sources of error are (i) air bubbles adhering to the surfaces of the test piece during weighings in water; (ii) surface tension effects on the wire; (iii) convection currents in the water in which the test piece is suspended, to minimize which the temperature of the water and of the air in the balance case should be the same.

NOTE 4. In order to minimize the adherence of air bubbles to the test piece, it is permissible either to add a trace (say 1 part in 10 000) of surface active material such as a detergent to the distilled water, or to dip the test piece momentarily into a suitable liquid, such as methyl alcohol or industrial methylated spirits, miscible with water and having a negligible swelling or leaching action on rubber. If the latter procedure is adopted, precautions should be taken to minimize the carry over of alcohol.

5.4 Method B. The clean dry density bottle and stopper shall be weighed before and after the insertion of the test piece, which shall have been cut into suitable pieces. The bottle, containing the rubber, shall then be filled completely with freshly boiled and cooled distilled water at a temperature of 20 ± 2 °C. Air bubbles adhering to the rubber or to the walls of the bottle shall be removed (see Note 4 above). The stopper shall be inserted, care being taken that there is no air in the bottle or the capillary. The outside of the bottle shall be dried carefully. The bottle and contents shall then be weighed, and the bottle emptied completely and refilled with freshly boiled and cooled distilled water at 20 °C. After removing air bubbles, inserting the stopper and drying, the bottle and water shall be weighed. All the above weighings shall be made to the nearest milligram.

Duplicate tests shall be made.

NOTE. The main source of error is the presence of air bubbles inside the bottle. It may be necessary to heat the bottle and contents to dislodge bubbles, but in this case the bottle and contents should be cooled before weighing.

Another way of removing air bubbles is to stand the bottle in a vacuum desiccator and apply and release the vacuum several times until no more air comes off.

6. TEMPERATURE OF TEST

Unless otherwise required the test shall be carried out at 20 ± 2 °C.

7. EXPRESSION OF RESULTS

7.1 Method A.

If W_1 = is the net weight of the test piece in air,
W_2 = is its net weight in water at 20 °C, and
ρ = is the density of water at 20 °C in Mg/m³ then

$$\text{density of test piece} = \frac{W_1}{W_1 - W_2} \times \rho \text{ Mg/m}^3.$$

NOTE. This method is accurate to the nearest unit in the second place of decimals.

The density of water at 20 °C may be taken as 1·00 Mg/m³.

NOTE. When a sinker has been used, the calculation will be modified.
If W_1 = net weight of rubber in air,
W_2 = net weight of sinker in water, and
W_3 = net weight of rubber and sinker in water, then

$$\text{density of test piece} = \frac{W_1}{W_1 + W_2 - W_3} \times \rho \text{ Mg/m}^3.$$

7.2 Method B.

If W_1 = weight of density bottle
W_2 = weight of density bottle + test piece
W_3 = weight of density bottle + test piece + water
W_4 = weight of density bottle filled with water.

$$\text{density of test piece} = \frac{W_2 - W_1}{W_4 - W_3 + W_2 - W_1} \times \rho \text{ Mg/m}^3.$$

8. REPORT

The report shall state:

(1) mean density at 20 °C and
(2) method used.

BRITISH STANDARDS INSTITUTION

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The principal objects of the Institution as set out in the charter are to co-ordinate the efforts of producers and users for the improvement, standardization and simplification of engineering and industrial materials; to simplify production and distribution; to eliminate the waste of time and material involved in the production of an unnecessary variety of patterns and sizes of articles for one and the same purpose; to set up standards of quality and dimensions, and to promote the general adoption of British Standards.

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