**BRITISH STANDARD**

**BS 903-A1: 1996**
**ISO 2781:1988**
*(Incorporating Corrigendum 1:1996)*

# Physical testing of rubber —

## Part A1: Determination of density

ICS 83.060

# Committees responsible for this British Standard

The preparation of this British Standard was entrusted to Technical Committee PRI/22, Physical testing of rubber, upon which the following bodies were represented:

British Railways Board
British Rubber Manufacturers Association Ltd.
GAMBICA (BEAMA Ltd.)
Ministry of Defence
RAPRA Technology Ltd.
SATRA Footwear Technology Centre
Tun Abdul Razak Research Centre

This British Standard, having been prepared under the direction of the Sector Board for Materials and Chemicals, was published under the authority of the Standards Board and comes into effect on 15 November 1996



The following BSI references relate to the work on this standard:
Committee reference PRI/22
Draft announced in *BSI Update* October 1996

**ISBN 0 580 26769 5**

**Amendments issued since publication**

| Amd. No. | Date | Comments |
|---|---|---|
| | | |
| | | |
| | | |
| | | |

# Contents

# National foreword

This Part of BS 903 has been prepared by Technical Committee PRI/22, and is identical with ISO 2781:1988 *Rubber, vulcanized — Determination of density*, incorporating Corrigendum 1:1996, published by the International Organization for Standardization (ISO). It supersedes BS 903-A1:1980 which is withdrawn.

**Additional information**. Clauses **7** and **8** refer to a "standard temperature". In the UK the standard laboratory temperature is (23 ± 2) °C.

Although the international standard limits the scope of the method to solid vulcanized rubber, the method is also equally applicable to solid thermoplastics rubber.

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 3 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.

## 1 Scope

This International Standard specifies two methods of test for the determination of the density of solid vulcanized rubber.

Such determinations are of importance in the control of the quality of a rubber compound and in the calculation of the mass of rubber required to produce a given volume of vulcanizate.

This International Standard does not cover the determination of the relative density of rubber, which is the ratio of the mass of a given volume of the rubber to the mass of an equal volume of pure water at a given temperature.

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

## 2 Definition

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

**density**

the mass of unit volume of the rubber at a stated temperature. It is expressed in megagrams per cubic metre (Mg/m3)

## 3 Principle

Two methods, A and B, are given.

In method A the masses of the test piece in air and in water are determined using an analytical balance equipped with a pan straddle. The mass when immersed in water is less than that in air by the mass of water displaced, the volume of water displaced being equal to that of the test piece.

Method B 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 insulation. Measurements are made using a balance and a density bottle.

## 4 Apparatus

Ordinary laboratory apparatus and

**4.1** *Analytical balance*, accurate to 1 mg.

**4.2** *Balance pan straddle*, of convenient size to support the beaker and permit determination of the mass of the test piece in water (for method A).

**4.3** *Beaker*, 250 cm3 capacity (or smaller if necessitated by the design of the balance) (for method A).

**4.4** *Density bottle* (for method B).

## 5 Test piece

**5.1** The test piece shall consist of a piece of the rubber with smooth surfaces, free from crevices and dust, and having a mass of at least 2,5 g. For method B the shape of the test piece shall be such as to permit cutting into suitable pieces (see **9.3**).

**5.2** A minimum of two tests shall be made.

## 6 Time-interval between vulcanization and testing

Unless otherwise specified for technical reasons, the following requirements for time-intervals shall be observed.

**6.1** For all test purposes, the minimum time between vulcanization and testing shall be 16 h.

**6.2** 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.

**6.3** 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 by the customer of the product.

## 7 Conditioning of test pieces

**7.1** Samples and test pieces shall be protected from direct sunlight during the interval between vulcanization and testing.

**7.2** Samples, after such preparation as is necessary, shall be conditioned at a standard temperature (that is, 23 °C ± 2 °C or 27 °C ± 2 °C) for at least 3 h before the test pieces are cut. These test pieces may be tested immediately but, if not, they shall be kept at the standard temperature until tested. If the preparation involves buffing, the interval between buffing and testing shall not exceed 72 h.

## 8 Temperature of test

The test shall normally be carried out at a standard temperature (23 °C ± 2 °C or 27 °C ± 2 °C), the same temperature being used throughout one test or series of tests intended to be comparable.

## 9 Procedure

### 9.1 Preparation of sample

If fabric is attached to, or embedded in, the samples, it shall be removed before cutting the test pieces. The method of removal shall preferably avoid the use of a swelling liquid, but, if necessary, a suitable non-toxic liquid of low boiling point may be used 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.

### 9.2 Method A

Suspend the test piece (clause **5**) from the hook on the balance (**4.1**), using a suitable length of filament so that the bottom of the test piece is about 25 mm above the straddle (**4.2**). The filament shall be made from a material which is insoluble in water and which does not absorb a significant amount of water. It shall either be counterbalanced or be weighed and, if weighed, its mass shall be deducted from subsequent weighings of the test piece (see note 1).

Weigh the test piece to the nearest milligram in air. Repeat the weighing with the test piece (and sinker, if required, see note 2) immersed in freshly boiled and cooled distilled water at a standard temperature (23 °C ± 2 °C or 27 °C ± 2 °C) contained in the beaker (**4.3**), placed on the straddle. Remove air bubbles adhering to the test piece (see note 4) and determine the mass to the nearest milligram, watching the pointer for a few seconds to make sure that it does not drift gradually as a result of convection currents.

NOTE 1 Where the filament used has a mass less than 0,010 g, such as is the case with thin nylon filament, the correction to account for its mass is not necessary to ensure the stated accuracy of the final result. However, when the test piece is smaller than the one specified (e.g. when the density of small O-rings is to be measured), this can lead to inaccuracies and the mass of the filament needs to be taken into account in the final calculation. If a means of suspension other than a filament is used, the volume and mass of the suspension must be taken into account in making the final calculation.

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. Alternatively, a liquid of different density to water may be used in place of the water, in which case the formulae given in **10.1** are modified by the multiplication of the expression by the density of the liquid expressed in megagrams per cubic metre.

NOTE 3 The main sources of error are

a) air bubbles adhering to the surfaces of the test piece during weighings in water;

b) surface tension effects on the filament;

c) 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 denatured spirit, miscible with water and having a negligible swelling or leaching action on rubber. If the latter method is adopted, precautions should be taken to minimize the carry-over of alcohol.

### 9.3 Method B

Weigh the clean, dry density bottle and stopper (**4.4**) before and after the insertion of the test piece (clause **5**) cut into suitable pieces. The exact size and shape of the pieces will depend on the thickness of the original test piece. They should be such that no two dimensions are greater than 4 mm and the third not greater than 6 mm. Within these limitations the pieces should be as large as possible. All cut edges shall be smooth. Fill the bottle, containing the rubber, completely with freshly boiled and cooled distilled water at a standard temperature (23 °C ± 2 °C or 27 °C ± 2 °C). Remove air bubbles adhering to the rubber or to the walls of the bottle (see note 4 above).

Insert the stopper, taking care that there is no air in the bottle or the capillary. Dry the outside of the bottle carefully. Weigh the bottle and contents. Empty the bottle completely and refill with freshly boiled and cooled distilled water. After removing the air bubbles, inserting the stopper and drying, weigh the bottle and water.

All the above weighings shall be made to the nearest milligram.

NOTE The main source of error is air bubbles inside the bottle. It may be necessary to heat the bottle and contents to approximately 50 °C to dislodge bubbles, but in this case the bottle and contents must be cooled before weighing. Alternatively, the bottle may be placed in a vacuum desiccator and the vacuum applied and released several times until no more air is extracted.

## 10 Expression of results

### 10.1 Method A

The density ϱ, expressed in megagrams per cubic metre, is given by the formula

$$\frac{m_1}{m_1 - m_2}$$

where

$m1$ is the net mass of the rubber;

$m2$ is the mass of the rubber less the mass of an equal volume of water, determined by weighing in water, both at the standard temperature.

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

The density of water at standard laboratory temperature may be taken as 1,00 Mg/m3.

NOTE 1 When a sinker has been used, the calculation must be modified as follows:

$$\varrho = \frac{m_1}{m_1 + m_2 - m_3}$$

where

$m1$ is the net mass of the rubber;

$m2$ is the mass of the sinker less the mass of an equal volume of water, determined by weighing in water;

$m3$ is the mass of the sinker and rubber less the mass of a volume of water equal to their combined volumes, determined by weighing in water.

NOTE 2 For precise work, a factor to take account of the density of water at the test temperature should be used.

### 10.2 Method B

The density $\varrho$, expressed in megagrams per cubic metre, is given by the formula

$$\frac{m_2 - m_1}{m_4 - m_3 + m_2 - m_1}$$

where

$m1$ is the mass of the density bottle;

$m2$ is the mass of the density bottle plus test piece;

$m3$ is the mass of the density bottle plus test piece plus water;

$m4$ is the mass of the density bottle filled with water.

NOTE For precise work, a factor to take account of the density of water at the test temperature should be used.

## 11 Test report

The test report shall include the following particulars:

a) a reference to this International Standard;

b) the mean density;

c) the temperature of test;

d) the method used (method A or method B);

e) any deviations from the procedure specified in this International Standard.

# 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