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METHODS OF TEST FOR RIGID CELLULAR MATERIALS

Part 2. Methods 6-10

BRITISH STANDARDS INSTITUTION

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RIGID CELLULAR
MATERIALS**

Part 2. Methods 6-10

BS 4370 : Part 2 : April 1973

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, which may be purchased from BSI Sales Department. It may also be consulted in many public libraries and similar institutions.

This standard makes reference to the following British Standards:

- BS 874. Methods of determining thermal properties, with definitions of thermal insulating terms.
- BS 1610. Methods for the load verification of testing machines.
- BS 3718. Laboratory humidity ovens (non-injection type).
- BS 3898. Laboratory humidity ovens (injection type).
- BS 4370. Methods of test for rigid cellular materials.
Part 1. Methods 1-5.

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 reference PLC/RUC/5
Drafts for comment 68/30650 69/11251 70/19460 71/50226

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CO-OPERATING ORGANIZATIONS

The Plastics and Rubber Industry Standards Committees, under whose supervision this British Standard was prepared, consist of representatives from the following Government departments and scientific and industrial organizations:

British Association of Synthetic Rubber Manufacturers

*British Plastics Federation

British Resin Manufacturers' Association

*British Rubber Manufacturers' Association

Department of the Environment—Building Research Establishment

*Department of Trade and Industry

Electrical Installation Equipment Manufacturers' Association

Electrical Research Association

Engineering Equipment Users' Association

Institution of the Rubber Industry

*Ministry of Defence, Army Department

Ministry of Defence, Navy Department

Ministry of Defence, Procurement Executive

Natural Rubber Producers' Research Association

Oil Companies Materials Association

Plastics Institute

Post Office

*Royal Institute of British Architects

Royal Institute of Public Health and Hygiene

*Rubber and Plastics Research Association of Great Britain

Rubber Growers' Association

Society of Motor Manufacturers and Traders Limited

Tyre Manufacturers Conference Service Committee

The Government departments 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 Rigid Urethane Foam Manufacturers' Association

Expanded Polystyrene Product Manufacturers' Association

Ministry of Defence

PIRA—Research Association for the Paper and Board, Printing and Packaging Industries

Thermal Insulation Contractors' Association

BRITISH STANDARD METHODS OF TEST FOR RIGID CELLULAR MATERIALS

Part 2. Methods 6-10

FOREWORD

This British Standard has been prepared under the authority of the Plastics and Rubber Industry Standards Committees. It lists five methods of test for rigid cellular materials which are additional to the five methods already published as Part 1 of BS 4370.

The methods of test described here are intended to apply to cellular products of polymeric origin but they are not necessarily suitable for testing cellular materials of inorganic origin.

Many rigid cellular products and test specimens are not isotropic. This is usually ascribed to the fact that the cells in the material are elongated in a particular direction. This direction is referred to in this standard as the 'direction of anisotropy'. Tests carried out in this direction normally give results differing in magnitude from those carried out in other directions.

It should be noted that the direction of anisotropy may vary from place to place in a product. Hence the numbers of test specimens required in product specifications may be greater than those given herein.

The methods of test given in this standard are, in general, those which are being considered by Technical Committee TC 61 of the International Organization for Standardization (ISO). Method 9, however, differs from the corresponding ISO method and supersedes Part E4 of BS 903, 'Methods of testing vulcanized rubber', Parts E1 to E9, 'Methods of testing cellular ebonite'. Information concerning other related methods is given in a note under the title of each method.

METHODS

0. SCOPE

This second Part of BS 4370 describes five additional methods of test which are intended to apply to cellular products of polymeric origin.

Method 6. Determination of shear strength and shear modulus.

Method 7. Measurement of thermal conductivity (guarded hot plate method).

Method 8. Measurement of water vapour transmission.

Method 9. Determination of tensile strength.

Method 10. Determination of the volume percentage of closed cells.

NOTE. The titles of the British Standards referred to in this standard are listed on page 2.

1. METHOD 6. DETERMINATION OF SHEAR STRENGTH AND SHEAR MODULUS

NOTE. Contents are technically identical with ISO 1922.

1.1 Introduction. This method is for determining the shear strength and shear modulus of rigid cellular materials.

The test consists in subjecting a test specimen of a given shape to a shear stress transmitted to the test specimen through metal supports to which it is bonded, and in determining the corresponding stress-strain diagram.

1.2 Apparatus

1.2.1 Test machine. The test machine shall be such that:

(1) A test specimen having the form and dimensions shown in Fig. 1 can be held between two fixing devices each comprising a metal support, one of these devices being fixed and the other movable, and the stress being transmitted along the longitudinal axis of the test specimen.

(2) The movable grip can be moved away from the fixed grip at a constant rate, in a direction parallel to the longitudinal axis of the test specimen.

(3) The force exerted on the test specimen can be known with a maximum error of 1%, and the distance between the grips with a maximum error of 0.01 mm, by means of recording devices.

1.2.2 Metal supports. The apparatus also comprises two metal supports consisting of flat steel plates machined on one side, not less than 5 mm thick, the dimensions of which are shown in Fig. 1. The method of attaching the metal supports to the grips is shown in Fig. 1. The thickness of the adaptors which connect the metal supports to the testing machine grips shall be equal to the thickness of the test specimen.

1.2.3 Adhesive. The adhesive used to fix the metal supports to the test specimen shall be such that the shear strength of the adhesive film is greater than that of the cellular product in question, so as to avoid any slipping of the test specimen in the supports; preliminary tests should be made to ensure that the elongation of this film can be disregarded in the determination of the deformation of the test specimen. The adhesive shall be compatible with the material under test. (An epoxide resin based adhesive is likely to prove satisfactory.)

1.3 Test specimen

1.3.1 The test specimen shall be a right parallelepiped of the following dimensions:

length	250.0 ± 5 mm
width	50.0 ± 0.5 mm
thickness	25.0 ± 0.5 mm

The distance between two parallel surfaces shall not vary by more than 1%.

1.3.2 Test specimens shall be prepared without moulding skins; their surfaces shall be machined without modifying the original structure.

The two machined surfaces of the metal supports shall be bonded to the large surfaces of the test specimens as shown in Fig. 1.

1.4 **Number of test specimens.** A set of five test specimens shall be tested. When testing materials suspected of being anisotropic, sets of test specimens may be prepared having major axes parallel with, and normal to, the suspected direction of anisotropy.

Any test specimens of which the glueing surface breaks before the cellular material shall be rejected and if necessary the number of test specimens shall be increased so that the number of significant results is not less than five.

1.5 **Conditioning and temperature of test.** The test specimen shall be conditioned for a period of not less than 16 h at $23 \pm 2^\circ\text{C}$ and $50 \pm 5\%$ r.h. immediately before test.

The test shall be conducted at $23 \pm 2^\circ\text{C}$.

1.6 **Procedure.** The test specimen shall be attached to the grips of the testing machine and a force applied by the movable grip which shall be moved away from the fixed grip at a rate of from 1 mm to 2 mm per minute with a variation not greater than 10% during the test.

Record the force-deflection diagram.

1.7 Calculation and expression of results

1.7.1 *Shear strength.* The shear strength of the specimen shall be calculated, using the following expression:

$$q = 1000 \frac{F_m}{L \times b}$$

where q = the shear strength in kilopascals (kPa)*

L = initial length, in millimetres (mm), of the test specimen

b = initial width, in millimetres (mm), of the test specimen

F_m = maximum force, in newtons (N), applied to the test specimen.

1.7.2 *Shear modulus.* The shear modulus of the specimen shall be calculated, using the following expression:

$$G = 1000 \frac{t \times \theta}{L \times b}$$

where G = the shear modulus in kilopascals (kPa)*

L = initial length, in millimetres (mm), of the test specimen

b = initial width, in millimetres (mm), of the test specimen

t = thickness, in millimetres (mm), of the test specimen

θ = slope of the linear portion of the force-deflection diagram expressed as newtons per millimetre (N/mm).

* 1 kPa = 1 kN/m²

1.8 Report. The report shall state:

- (1) The description and identity of the material.
- (2) The direction of the application of the force in respect of any anisotropy.
- (3) The individual test results, reported as *a*. shear strength and *b*. shear modulus, for each direction of test.
- (4) The median test results, reported as *a*. shear strength and *b*. shear modulus, for each direction of test.
- (5) Any departure from the test method.
- (6) Date of test and date of report.

2. METHOD 7. MEASUREMENT OF THERMAL CONDUCTIVITY (GUARDED HOT PLATE METHOD)

NOTE. *Thermal conductance.* The insulation value for a non-homogeneous product is best characterized by thermal conductance obtained by neglecting the thickness factor in the determination of thermal conductivity, i.e.

$$\text{thermal conductivity} = \frac{Ht}{\Delta\theta} \text{ W/(m K)}$$

$$\text{thermal conductance} = \frac{H}{\Delta\theta} \text{ W/(m}^2 \text{ K)}$$

where *H* = the rate of heat flow per square metre in accordance with BS 874, Method 10A (W/m²)

$\Delta\theta$ = the temperature difference between the hot and the cold faces of the specimen (K)

t = mean specimen thickness (m).

A non-homogeneous product could be, for example, a cellular material with a natural skin or an adhered facing of some different material.

2.1 Introduction. This method is for determining the thermal conductivity of rigid cellular materials.

The method described refers to the guarded hot plate method described in BS 874. The equipment is suitable for homogeneous parallel sided slabs. The method requires the establishment of a steady state of heat flow.

The thermal conductivity will be influenced by factors such as water content, nature of cell structure, gas content and age of the test specimens.

2.2 Preparation of test specimens. Two similar flat test specimens are used, having the following dimensions:

length	300 ± 5 mm
width	300 ± 5 mm
thickness	30 – 50 mm

The difference in the mean thickness between the specimens shall not be greater than 1 mm.

The dimensions shall be measured in accordance with the requirements of BS 4370, Part 1.