
British Standard

Electrical insulating materials based on mica

Part 2. Methods of test

[IEC title: Specification for insulating materials based on mica. Part 2: Methods of test]

Matériaux isolants électriques à base de mica
Partie 2. Méthodes d'essais

Auf Glimmer basierte elektrische Isolierstoffe
Teil 2. Prüfverfahren

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National foreword

This Part of BS 6236, prepared under the direction of the General Electrotechnical Engineering Standards Committee, is identical with IEC Publication 371-2 : 1987 'Specification for insulating materials based on mica Part 2 Methods of test', published by the International Electrotechnical Commission (IEC).

No decision has yet been taken upon whether to publish a Part 3 containing requirements for individual materials.

Terminology and conventions. The text of the international standard has been approved as suitable for publication as a British Standard without deviation. Some terminology and certain conventions are not identical with those used in British Standards; attention is drawn especially to the following.

Wherever page numbers are quoted they are IEC page numbers.

Cross-references

International standard	Corresponding British Standard
ISO 67-1981	BS 3564 : 1986 Method for size-grading of muscovite mica blocks, thins and films (Identical)
ISO 178-1975	BS 2782 Methods of testing plastics Method 335A : 1978 Determination of flexural properties of rigid plastics (Identical)

The Technical Committee has reviewed the provisions of IEC 216-1 : 1987*, IEC 243 : 1967, IEC 250 : 1969 and IEC 371-3-1 : 1984, to which reference is made in the text, and has decided that they are acceptable for use in conjunction with this standard.

Additional information. Method 1 of clause 2 refers to the term 'caul plates' used in the assembly of stacks for preparing test laminates. Similar plates are illustrated in figure 1.

Figure 1 refers to the use of 'asbestos fabric' as one alternative for the pressing pad (item 2). Preferably the Kraft paper alternative should be adopted but if, for any reason, this is not practicable, attention is drawn to the Control of Asbestos at Work Regulations 1988.

Figure 6 should contain the legend '*Dimensions in millimetres*'.

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

* IEC 216, 3rd edition, is being published in five parts. Part 1 was published in September 1987. There will be no revision of BS 5691 (Part 1 : 1979 and Part 2 : 1979 being identical with IEC 216-1 : 1974 (2nd edition) and IEC 216-2 : 1974 (2nd edition) respectively) until all Parts have been published.

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Electrical insulating materials based on mica

Part 2. Methods of test

INTRODUCTION

This standard is one of a series which deals with insulating materials for use in electrical equipment built up from mica splittings or mica paper, with or without reinforcement, and with mica paper in its pure state.

The series consists of three parts:

1. Definitions and General Requirements.
2. Methods of Test.
3. Specifications for Individual Materials.

1. Scope

This Part 2 defines the methods of test which are applicable to built-up mica materials, products based on them and mica paper.

General notes on tests

Tests are carried out at ambient temperature (15 °C to 35 °C), unless a test temperature is specified either in the method or in the specification for individual materials.

2. Preparation of test specimens for curable materials

Test specimens are prepared in accordance with the following methods which are applicable only to curable materials.

Method 1

Clean off all loose particles and projecting fibres from sufficient material to provide the test pieces required for the particular test.

Cut and stack the pieces required to form the test laminate. For tape material, build up the laminate to the required thickness using half-lapped layers with successive layers at right angles, where necessary cutting the sides to obtain the required dimensions.

Adjust the press temperature to 160 ± 5 °C, unless otherwise specified.

Place the test laminate in the centre of two caul plates not exceeding 1.5 mm thick and at 15 °C to 35 °C.

Insert stops of a size to provide the required test laminate thickness.

Insert the assembly of plates and test piece in the centre of the preheated press.

Close the press immediately and apply sufficient pressure to reach stops. Cure the test piece for a minimum of 30 min.

Remove the test piece and post-cure for the length of time at the temperature given in Part 3 or according to the recommendation of the supplier.

Unless otherwise specified, condition the test piece for 24 h in a controlled atmosphere of $50 \pm 5\%$ r.h. and $23 \pm 2^\circ\text{C}$ before the test.

Method 2

Clean off all loose particles and projecting fibres from sufficient material to provide the test sheets required for the particular test.

For full-width and sheet material, cut and stack the sheets required to form the test laminate.

There are two suggested ways of producing a laminate from tape material:

- a) Cut the tape in pieces to the length of the laminate. Stack the pieces parallel and half-overlapped. The second and the following layers shall be moved sideways, so that the overlapping edges do not lie one upon another. In order to fix the pieces, the use of a hot iron is recommended.
- b) Take a metal sheet of the size of the required laminate and of a thickness of 2 mm to 3 mm. Wind the tape half-overlapped and always in the same direction around this sheet until the required thickness is reached. It is recommended to start each layer separately and to move the second and the following layers sideways, so that the overlapping edges do not lie one upon another. It is necessary to put an interleaving release material between the metal sheet and the tape. Two laminates with the same thickness are formed.

The prepared stacks, having a composition as shown in Figure 1, page 42, will be put in the press.

The following press procedure, illustrated by Figure 2, page 42, is an example. Other press procedures shall be subject to contract.

- Close the cold press and bring it to a pressure of 0.15 N/mm^2 .
- Heat the press to 70°C under pressure of 0.15 N/mm^2 .
- Reduce the pressure down to zero, open the press for a short time (ventilate).
- Heat the press to 90°C under pressure of 0.15 N/mm^2 .
- Reduce the pressure down to zero, open the press for a short time (ventilate).
- Heat the press to 110°C under pressure of 0.15 N/mm^2 .
- Reduce the pressure down to zero, open the press for a short time (ventilate).
- Heat the press to $160 \pm 5^\circ\text{C}$ under pressure of 0.15 N/mm^2 until the resin starts to gel. This point of time is visually controlled by a test rod. As soon as the resin starts to gel, bring the pressure up to 3 N/mm^2 .

- Cure under 3 N/mm² and 160 °C for 60 s or at a temperature otherwise specified.
- Specimen to be cooled under pressure.

After this press procedure, post-cure the laminate for the time and the temperature specified in Part 3 or according to the recommendation of the supplier.

3. Thickness

3.1 Test apparatus

Depending on the materials to be tested, the apparatus for measuring thickness is as follows:

- 3.1.1 A constant pressure measurement device having flat measuring faces of 6 mm to 8 mm diameter, the graduations being in divisions of 0.01 mm and permitting reading to within 0.005 mm. The pressure exerted on the specimen shall be 0.1 MPa $\pm$ 10%. The accuracy of measurement, when checked by a setting gauge, shall be within 0.005 mm.
- 3.1.2 A device as described in Sub-clause 3.1.1, but with a pressure of 0.7 MPa $\pm$ 10% exerted on the specimen.
- 3.1.3 A device as described in Sub-clause 3.1.1, but with a pressure of 7.0 MPa $\pm$ 10% exerted on the specimen.
- 3.1.4 Test apparatus capable of producing a constant pressure of 30 MPa $\pm$ 10% uniformly distributed over the faces of the test specimen. It consists of a press with parallel plates and a system permitting measurement within $\pm$ 0.02 mm.

3.2 Test specimen

- 3.2.1 Where the material is delivered in plates or in sheets, the test specimen consists of an entire plate or sheet.
- 3.2.2 Where the material is delivered in rolls, the test specimen consists of a strip taken across the full width of the roll to give an area of 0.2 m².
- 3.2.3 Where the material is delivered in the form of tapes, the test specimen consists of a strip 2 m long.
- 3.2.4 For commutator separators with a surface area of 10 cm² or less, the test specimen consists of five separators to be measured individually.
- 3.2.5 For commutator separators with a surface area greater than 10 cm², the test specimen depends on the method given in the specification for the individual material (see IEC Publication 371-3-1: Specification for Insulating Materials Based on Mica, Part 3: Specifications for Individual Materials, Sheet 1: Commutator Separators and Materials):
 - a) the test specimen consists of one separator;
 - b) the test specimen consists of one entire press-gauged stack of separators (separated if necessary by intermediate layers), the number of separators in the press-gauged stack to be specified by the purchaser.

- 3.2.6 For flat pieces cut to shape other than separators, the test specimen consists of one piece.

3.3 Procedure

The thickness shall be measured by one of the following procedures:

- 3.3.1 Where materials other than for commutator separators are delivered as sheets (including strips), rolls and tapes, the thickness on each test specimen is measured at ten points uniformly distributed along the diagonals for sheets and along a line which is approximately central for rolls and tapes (not at the edges); the measuring device is that described in Sub-clause 3.1.1 with a pressure of 0.1 MPa.

- 3.3.2 For commutator separators and for sheets and strips to be used in making commutator separators, one of the following procedures shall be adopted:

- 3.3.2.1 *Sheets*: the thickness is measured on each specimen as stated in Sub-clause 3.3.1 using the apparatus defined in Sub-clause 3.1.3 with a pressure of 7.0 MPa.

- 3.3.2.2 *Separators having a surface area of 10 cm² or less*: the thickness is measured at one single point chosen at random on each of the five separators using the apparatus defined in Sub-clause 3.1.3 with a pressure of 7.0 MPa.

- 3.3.2.3 *Separators having a surface area greater than 10 cm²*: the thickness is measured as in Item *a*) or Item *b*) below; the method used is indicated in the specification for the individual material:

- a*) in the case of separators delivered individually, the thickness is measured at three points uniformly distributed over the test specimen using the apparatus defined in Sub-clause 3.1.3 with a pressure of 7.0 MPa.
- b*) in the case of separators delivered in press-gauged packeted stacks, each test specimen, consisting of one stack, is measured under the conditions defined in Sub-clause 3.1.4 with a pressure of 30 MPa, ensuring that all the separators in the stack to be tested are properly aligned when the measurement is made.

Before each test the deformation of the press should be measured by carrying out a measurement with a steel block of known dimensions approximately equal to those of the test specimen.

In obtaining the thickness of the single test specimen (d_1), including that of any intermediate layers (d_2), the correction for the deformation of the test apparatus is added to or subtracted from the measured values.

The total thickness of a stack (d), of n separators with $(n - 1)$ intermediate layers is given by:

$$d = nd_1 + (n - 1)d_2$$

where:

- d = thickness of the whole stack composed of n separators and $(n - 1)$ intermediate layers
- d_1 = thickness of one separator
- n = number of separators
- d_2 = thickness of intermediate layers
- $n - 1$ = number of intermediate layers

3.4 *Statement of results*

For packeted stacks, report as the thickness of the stack the value of nd_1 and the number of separators per stack. For all other cases, report as the thickness of each test specimen the central value of the results and also report the maximum and minimum values.

4. **Density**

Determine the density by displacement of liquid. Use a liquid which will not affect the test specimen or be absorbed by it.

In the case of curable materials, use a laminate with trimmed edges of any convenient dimension, but prepared in accordance with Clause 2.

5. **Apparent density**

The apparent density (d) is calculated from the central values of the mass per unit area and thickness by means of the following equation:

$$d = \frac{m_a}{d_c \times 10^{-3}} \quad (\text{g/m}^3)$$

where:

m_a = mass per unit area (g/m^2)

d_c = thickness (mm)

6. **Composition**

6.1 *Test specimen*

The test specimen shall have a mass of approximately 5 g (for thin materials, two pieces of approximately 250 cm² are suitable). The entire thickness of material shall be included in the test specimen.

6.2 *Mass per unit area in the "as received" condition*

The test specimen shall be weighed with an accuracy of 1 mg within 4 h of removal from the original package and at a temperature of 23 ± 2 °C (mass m_1). The area (A) in square metres of the test specimen shall be determined with an accuracy of $\pm 1\%$.

The mass per unit area in the "as received" condition (m_t) is:

$$m_t = \frac{m_1}{A} \quad (\text{g/m}^2)$$

6.3 *Content of volatiles and mass per unit area of the dried material*

The test specimen (mass m_1) shall be heated for 1 h at 150 ± 3 °C, unless otherwise agreed upon between purchaser and supplier. After cooling in a desiccator, the test specimen is weighed (mass m_2).

The volatile content (T_v) is:

$$T_v = \frac{m_1 - m_2}{m_1} 100 \quad (\%)$$

The mass per unit area of the dried product (m'_t) is:

$$m'_t = \frac{m_2}{A} \quad (\text{g/m}^2)$$

6.4 Binder content

6.4.1 Material without reinforcement or with inorganic reinforcement

The test specimen, dried according to Sub-clause 6.3 (mass m_2), is heated in a muffle oven at a temperature of 500 ± 25 °C. Unless otherwise specified, the period of heating shall be 2 h. After cooling in a desiccator, the mass (m_3) is determined.

The binder content (C_b) is:

$$C_b = \frac{m_2 - m_3}{m_2} 100 \quad (\%)$$

Note. — In the case of dispute, the heating should be continued to constant mass, the mass being considered constant when consecutive weighings differ by not more than 0.1%.

The mass per unit area of binder (m'_b) is:

$$m'_b = \frac{m_2 - m_3}{A} \quad (\text{g/m}^2)$$

6.4.2 Material with organic reinforcement and soluble binder

The test specimen, dried according to Sub-clause 6.3 (mass m_2), is placed in the extraction thimble of a Soxhlet extraction apparatus with a capacity of 500 cm³.

The type of solvent as recommended by the supplier shall be capable of dissolving the binder completely, but shall not dissolve the reinforcement. The boiling under reflux is continued for 2 h or longer if necessary for the complete dissolution of the binder. The treated test specimen is taken out of the extraction thimble and shall be dried for half an hour at 135 °C. After cooling in a desiccator, the mass (m_4) is determined.

The binder content (C_b) is:

$$C_b = \frac{m_2 - m_4}{m_2} 100 \quad (\%)$$

The mass per unit area of binder (m'_b) is:

$$m'_b = \frac{m_2 - m_4}{A} \quad (\text{g/m}^2)$$

Note. — The normal extraction time is 2 h. For thicker materials, it may be of help to split the material carefully in order to facilitate penetration of the solvent.