BRITISH STANDARD

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Specification for insulating materials based on mica —

Part 2: Methods of test

The European Standard EN 60371-2:2004 has the status of a British Standard

ICS 17.220.99; 29.035.50

BSI
British Standards

National foreword

This British Standard is the official English language version of EN 60371-2:2004. It is identical with IEC 60371-2:2004. It supersedes BS EN 60371-2:1997, which is withdrawn.

The UK participation in its preparation was entrusted by Technical Committee GEL/15, Insulating material, to GEL/15/3, Material specifications, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

Cross-references

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EUROPEAN STANDARD **EN 60371-2**

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English version

Specification for insulating materials based on mica
Part 2: Methods of test
(IEC 60371-2:2004)

Spécification pour les matériaux isolants à base de mica
Partie 2: Méthodes d'essais
(CEI 60371-2:2004)

Bestimmung für Isoliermaterialien aus Glimmer
Teil 2: Prüfverfahren
(IEC 60371-2:2004)

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CENELEC
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Foreword

The text of document 15C/1610/FDIS, future edition 3 of IEC 60371-2, prepared by SC 15C, Specifications, of IEC TC 15, Insulating materials, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60371-2 on 2004-09-01.

This European Standard supersedes EN 60371-2:1997.

The main changes with respect to EN 60371-2:1997 are as follows:

a) All clauses re-numbered.

b) Relevant template of ISO 67 has been added to this standard as Annex A.

c) Clause 8: Tensile strength and elongation at break

Procedure modified to give "rate of movement" instead of "time limit". Different rate of movement for raw mica as opposed to reinforced and/or impregnated mica.

d) Clause 11: Stiffness

Size of test specimen revised. wording modified so that standard covers materials using carriers other than woven glass cloth and materials that are 3-ply. Revision of terms "machine direction" and "transverse direction".

e) Clause 13: Elastic compression and plastic compression

Tolerance on measurement of height of stack changed to within 0,01 mm.
Times for change in pressure in procedure changed to 1 min.

f) Clause 16: Electric strength

Modified in line with Amendment 1:1994 to IEC 60371-2:1987 (included in EN 60371-2:1997). Changes relate to latest edition of EN 60243-1.

g) Clause 19: Detection of defects and conductive particles

Revised subclause.

The following dates were fixed:

– latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2005-06-01
– latest date by which the national standards conflicting with the EN have to be withdrawn	(dow)	2007-09-01

Annex ZA has been added by CENELEC.

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Endorsement notice

The text of the International Standard IEC 60371-2:2004 was approved by CENELEC as a European Standard without any modification.

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CONTENTS

INTRODUCTION

This part of IEC 60371 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.

IEC 60371 consists of three parts under the main title *Specification for insulating materials based on mica:*

Part 1 Definitions and general requirements

Part 2 Methods of test

Part 3 Specifications for individual materials

SPECIFICATION FOR INSULATING MATERIALS BASED ON MICA –

Part 2: Methods of test

1 Scope

This part of IEC 60371 defines the methods of test which are applicable to built-up mica materials, products based on them and mica paper.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60216 (all parts), *Electrical insulating materials – Thermal endurance properties*

IEC 60243-1:1998, *Electrical strength of insulating materials – Part 1: Tests at power frequencies*

IEC 60250:1969, *Recommended methods for the determination of the permittivity and dielectric dissipation factor of electric insulating materials at power, audio and radio frequencies including metre wavelengths*

IEC.60371-3 (all parts), *Specification for insulating materials based on mica – Part 3: Specifications for individual materials*

ISO 178:2001, *Plastics – Determination of flexural properties*

3 Preparation methods of test specimens for curable materials

3.1 General

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

3.2 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 °C ± 5 K, unless otherwise specified.

Place the test laminate in the centre of two caul plates not exceeding 1,5 mm in thickness and at a temperature of 15 °C to 35 °C.

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

Insert the assembly of plates and the 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 and at the temperature given in IEC 60371-3 or according to the recommendation of the supplier.

Unless otherwise specified, condition the test piece for 24 h in a controlled atmosphere of (50 ± 5) % r.h. and at 23 °C ± 2 K before the test.

3.3 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 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, shall be put in the press.

The following press procedure, illustrated in Figure 2, provides an example:

– Close the cold press and bring it to a pressure of 0,15 MPa.
– Heat the press to 70 °C under pressure of 0,15 MPa.
– 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 MPa.
– 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 MPa.
– Reduce the pressure down to zero, open the press for a short time (ventilate).
– Heat the press to 160 °C ± 5 K under pressure of 0,15 MPa 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 MPa.

– Cure under 3 MPa and 160 °C for 60 min or at a temperature otherwise specified.
– Specimen to be cooled under pressure.

After this press procedure, post-cure the laminate for the time and temperature specified in the specification sheets of IEC 60371-3 or according to the recommendation of the supplier.

Other press procedures shall be subject to contract.

4 Thickness

4.1 Test apparatus

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

4.1.1 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 ± 10 %. The accuracy of measurement, when checked by a setting gauge, shall be within 0,005 mm. Measurement shall be made at ambient temperature and at least 5 s after the application of pressure.

4.1.2 A device as described in 4.1.1, but with a pressure of 0,7 MPa ± 10 % exerted on the specimen.

4.1.3 A device as described in 4.1.1, but with a pressure of 7,0 MPa ± 10 % exerted on the specimen.

4.1.4 Test apparatus capable of producing a constant pressure of 30 MPa ± 10 % uniformly distributed over the faces of the test specimen. It shall consist of a press with parallel plates and a system permitting measurement within ± 0,02 mm.

4.2 Test specimen

4.2.1 Where the material is delivered in plates or in sheets, the test specimen shall consist of an entire plate or sheet.

4.2.2 Where the material is delivered in rolls, the test specimen shall consist of a strip taken across the full width of the roll to give an area of 0,2 m^2.

4.2.3 Where the material is delivered in the form of tapes, the test specimen shall consist of a strip 2 m long.

4.2.4 For commutator separators with a surface area of 10 cm^2 or less, the test specimen shall consist of five separators to be measured individually.

4.2.5 For commutator separators with a surface area greater than 10 cm^2, the test specimen depends on the method given in the specification for the individual material (see relevant sheets of IEC 60371-3):

a) the test specimen shall consist of one separator;
b) the test specimen shall consist 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.

4.2.6 For flat pieces cut to shape other than separators, the test specimen shall consist of one piece.

4.3 Procedure

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

4.3.1 Where materials other than for commutator separators are delivered as sheets (including strips), rolls and tapes, the thickness on each test specimen shall be measured at ten points uniformly distributed along the diagonals for sheets and along a line which shall be approximately central for rolls and tapes (not at the edges); the measuring device shall be that described in 4.1.1 with a pressure of 0,1 MPa.

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

4.3.2.1 *Sheets:* the thickness shall be measured on each specimen as stated in 4.3.1 using the apparatus defined in 4.1.3 with a pressure of 7,0 MPa.

4.3.2.2 *Separators having a surface area of 10 cm^2 or less*: the thickness shall be measured at one single point chosen at random on each of the five separators using the apparatus defined in 4.1.3 with a pressure of 7,0 MPa.

4.3.2.3 *Separators having a surface area greater than 10 cm^2*: the thickness shall be measured as in item a) or item b) below; the method used shall be indicated in the specification for the individual materials:

a) in the case of separators delivered individually, the thickness shall be measured at three points uniformly distributed over the test specimen using the apparatus defined in 4.1.3 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, shall be measured under the conditions defined in 4.1.4 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 shall 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 shall be added to or subtracted from the measured values.

The total thickness of a stack (d), of n separators with (n – 1) intermediate layers shall be given by:

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

where

d is the thickness of the whole stack composed of n separators and (n – 1) intermediate layers;

d_1 is the thickness of one separator;

n is the number of separators;

d_2 is the thickness of intermediate layers;

n – 1 is the number of intermediate layers.

4.4 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 mean value of the results and also report the maximum and minimum values.

5 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 3.

6 Calculated density

The density can be calculated from the central values of the mass per unit area and thickness

$$\text{Density} = \frac{m_a}{d_e} \text{ x } 10^{-3} \ (\text{g}/\text{cm}^3) \qquad (2)$$

by means of the following equation

where

m_a is the mass per unit area, in g/m^2;

d_e is the thickness, in mm.

7 Composition

7.1 Test specimen

The test specimen shall have a mass of approximately 5 g (for thin materials, two pieces of approximately 250 cm^2 are suitable). The entire thickness of material shall be included in the test specimen.

7.2 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 °C ± 2 K (mass m_1). The area (A) in square metres of the test specimen shall be determined with an accuracy of ±1 %.

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

$$m_a = \frac{m_1}{A} \ (\text{g/m}^2) \qquad (3)$$

7.3 Content of volatiles and mass per unit area of dried material

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

The volatile content (T_v) is:

$$T_v = \frac{m_1 - m_2}{m_1} \times 100 \ (\%) \tag{4}$$

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

$$m'_a = \frac{m_2}{A} \ (g/m^2) \tag{5}$$

7.4 Binder content

7.4.1 Material without reinforcement or with inorganic reinforcement

The test specimen, dried according to 7.3 (mass m_2), shall be heated in a muffle oven at a temperature of 500 °C ± 25 K. Unless otherwise specified, the period of heating shall be 2 h. After cooling in a desiccator, the mass (m_3) shall be determined.

The binder content (C_b) is:

$$C_b = \frac{m_2 - m_3}{m_2} \times 100 \ (\%) \tag{6}$$

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:

$$m'_b = \frac{m_2 - m_3}{A} \ (g/m^2) \tag{7}$$

7.4.2 Material with organic reinforcement and soluble binder

The test specimen, dried according to 7.3 (mass m_2), shall be placed in the extraction thimble of a Soxhlet extraction apparatus with a capacity of 500 cm^3.

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 shall be continued for 2 h or longer if necessary for the complete dissolution of the binder. The treated test specimen shall be taken out of the extraction thimble and dried for 30 min at 135 °C. After cooling in a desiccator, the mass (m_4) shall be determined.

The binder content (C_b) is:

$$C_b = \frac{m_2 - m_4}{m_2} \times 100 \ (\%) \tag{8}$$

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

$$m'_b = \frac{m_2 - m_4}{A} \ (g/m^2) \tag{9}$$

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.

7.4.3 Material with organic reinforcement and insoluble binder

Using values of m_2 (see 7.3) and m_3 (see 7.4.1) and the mass of organic reinforcement (m_5) stated by the supplier, the binder content (C_b) is:

$$C_b = \frac{m_2 - (m_3 + m_5)}{m_2} \times 100 \ (\%) \tag{10}$$

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

$$m'_b = \frac{m_2 - (m_3 + m_5)}{A} \ (g/m^2) \tag{11}$$

7.4.4 Silicone binder content

The determination of the silicone content shall be subject to contract. An example of a possible method is given below.

7.4.4.1 Method of test

Weigh the test specimen in a previously dried and weighed extraction thimble to the nearest milligram. The difference in mass shall be taken as the mass of the specimen.

Put sufficient diethylamine (reagent grade) into a Soxhlet extraction flask to fill the siphon one and a half times. Extract the test specimen completely at a siphon rate of 6 to 10 times per hour (the minimum time of extraction is 4 h for thin materials, but may be much longer for thick materials).

Allow the apparatus to cool, then replace the diethylamine with acetone and extract as before for 1,5 h.

Remove the thimble, allow it to dry in air on a watchglass for 10 min, then heat for 30 min in an oven at 105 °C ± 2 K.

Cool the thimble in a desiccator, then weigh it to the nearest milligram. Subtract the weight of the thimble.

7.4.4.2 Statement of results

$$Silicone\ binder\ content = \frac{loss\ \ in\ \ mass}{mass} \times 100\ (\%) \tag{12}$$

Report the silicone binder content as a percentage to the first decimal place.

7.5 Mass per unit area of reinforcement material (m'_r)

The supplier shall state the mass per unit area of the reinforcement material used. The method for determining this property shall be subject to contract.

Alternatively, one of the following procedures may be used and stated in the contract:

a) For a material with inorganic reinforcement:

On completion of the heating period according to 7.4.1, carefully separate the reinforcement and weigh it (mass m_6).

The mass per unit area of reinforcement material (m'_r) is:

$$m'_r = \frac{m_6}{A} \ (g/m^2) \tag{13}$$

b) For a material with organic reinforcement and soluble binder:

On completion of the extraction according to 7.4.2, carefully separate the reinforcement and weigh it (mass m_7).

The mass per unit area of reinforcement material (m'_r) is:

$$m'_r = \frac{m_7}{A} \ (g/m^2) \tag{14}$$

7.6 Mica content

From the results of the previous tests, the mica content (C_m) and the mass per unit area of mica (m'_m) can be calculated.

For material without reinforcement or with organic reinforcement:

$$C_m = \frac{m_3}{m_2} \times 100 \ (\%) \tag{15}$$

$$m'_m = \frac{m_3}{A} \ (g/m^2) \tag{16}$$

For material with inorganic reinforcement:

$$C_m = \frac{\frac{m_3}{A} - m'_r}{m'_a} \times 100 \quad (\%) \tag{17}$$

$$m'_m = m'_a - m'_b - m'_r \quad (g/m^2) \tag{18}$$

7.7 Size of splittings

7.7.1 Test specimen

The size of the test specimen of sheet to be tested shall be 300 mm × 300 mm. The test specimen and special test conditions for tape materials are specified in the specification sheets of IEC 60371-3.

7.7.2 Method of test

To remove the bonding material, the test specimen shall be heated in a muffle oven until the binder is sufficiently degraded to permit examination of the splittings. Alternatively, the splittings may be removed mechanically provided no splitting is torn in the process.

The size of the splittings is determined with the template given in Annex A.

8 Tensile strength and elongation at break

8.1 Test apparatus

Either a constant rate-of-load machine or a constant rate-of-traverse machine may be used; the machine shall preferably be power-driven and graduated so that a reading of 1 % of the value required by the specification sheet is possible.

8.2 Test specimen

Five test specimens are used. The length of the test specimens shall be such that it allows a length of 200 mm between the jaws of the testing machine.

When testing full-width material or sheets, the width shall be 25 mm. Five test specimens shall be cut in the machine direction and five test specimens shall be cut perpendicular to that direction. Test specimens shall be cut so that no two test specimens cut in the same direction contain the same longitudinal threads if a woven reinforcement is used.

Tape material shall be tested in the machine direction and in the width as delivered up to a maximum of 25 mm.

8.3 Procedure

Fix a test specimen in the testing machine and apply the load at the relevant rate detailed below.

Rate of movement 10 mm/min for raw mica;
50 mm/min for reinforced and/or impregnated mica

Record the breaking force and the elongation at break or failure of one component in reinforced materials.

If the test specimen breaks in, or at a jaw, of the testing machine, discard the result and make a further test using another test specimen.

When the tensile strength of a join is to be determined, position the join approximately midway between the jaws.

NOTE With some materials, extra precautions may be required to prevent slippage in the jaws of the machine.

8.4 Statement of results

The tensile strength shall be reported in the two directions separately (where applicable). For each direction, take the central value of the five loads at break and calculate the tensile strength of the material in the relevant direction expressed in newtons (N) per 10 mm of width.

The elongation result shall be the central value of the five measurements expressed as percentages of the original length; the maximum and minimum values shall also be reported

9 Flexural strength and elastic modulus in bend

9.1 Test specimen

To determine the flexural strength, take five test pieces in the direction parallel to one edge and another five in a direction at right angles to this. Each test piece shall be of a length not less than 20 times the measured thickness, of a width 10 mm to 25 mm and of a thickness 4 mm ± 0,2 mm.

For the determination of the elastic modulus, two sets of two similar test pieces shall be taken

In the case of curable materials, cut the test pieces from a laminate prepared in accordance with Clause 3.

9.2 Procedure

Use the methods described in ISO 178. This determination shall be made at temperatures of 23 °C and 155 °C.

10 Folding

Make the test at a temperature of 23 °C ± 2 K after the test specimen has been maintained at this temperature for 1 h. Fold a test piece of any convenient size through 180° with the carrier-side surface inside. The creasing operation shall be made by finger and thumb as quickly as possible.

Examine the test piece for fracture or delamination.

11 Stiffness

11.1 Conditioning and test atmosphere

The test specimens shall be in equilibrium with the normal laboratory temperature 23 °C ± 2 K.

11.2 Test specimens

Full-width material: five test specimens in the machine direction and five test specimens in transverse direction, measuring 15 mm × 200 mm.

Tape material: five test specimens of 50 mm to 200 mm in length and the width of the tape greater than 10 mm. When testing the stiffness in the machine direction, the width of the tape will become the length of test specimens.

11.3 Procedure

The dimensions of test specimens shall be determined with an accuracy of ±0,5 mm. The test specimen is placed as shown in Figures 3 and 4 with the mica (or for 3-ply, the faced material) uppermost, symmetrically on the support platform, parallel to the slot and with its two edges overlapping the slot by equal amounts on each side. The penetrator bar shall be driven into the slot against the resistance of the test specimen until the maximum force of resistance is reached. The rate of movement shall be recorded.

The stiffness will be given in newtons per metre and is calculated as follows:

$$\text{Rigidity} = \frac{F_{max}}{l} \text{(N/m)} \quad (19)$$

where

F_{max} is the maximum flexural load (N);

l is the length of test specimen (m).

11.4 Statement of results

The mean values and the maximum and minimum values of the stiffness in machine and transverse direction shall be reported separately. Where the carrier is made of glass fabric, the machine direction means with deflection of warp yarns and the transverse direction means with deflection of weft yarns.

The test temperature shall be reported.

12 Resistance to exudation and displacement

This test, generally reserved for materials for commutator separators, determines the displacement of the mica, the binder (exudation), or both, under specific conditions of temperature and pressure.

The test shall be considered as being very subjective and great care shall be used in describing the test results.

12.1 Test apparatus

Test apparatus shall consist of a press capable of exerting a pressure of 60 MPa on the test specimens, flat steel plates 2 mm thick, and a block of steel 10 mm thick drilled to permit the insertion of a thermocouple for measuring the temperature.

12.2 Test specimen

The test specimen shall be between 12 mm and 15 mm in height and shall consist of a number of small plates of material having a surface area of about 20 cm^2 (small plates measuring 40 mm × 40 mm are recommended). When the test specimens are being prepared, care should be taken to ensure their reproducibility and all four edges of each plate are cleanly cut.

To undertake the test, an assembly is formed consisting of n small plates of material constituting the test specimen and (n + 1) steel plates having an identical surface area placed alternately, the drilled steel block being placed in the middle of the assembly and the best possible vertical alignment being ensured.

12.3 Procedure

An assembly prepared according to 12.2 shall be placed between the platens of the press which have been preheated to between 5 °C and 10 °C above the temperature specified in the specification sheets IEC 60371-3. The assembly shall then be subjected to a pressure of 60 MPa. Surround the assembly with thermal insulation. When the temperature indicated by the thermocouple (see 12.1) reaches the temperature specified in the specification sheets of IEC 60371-3, the two conditions (temperature and pressure) are maintained for 30 min, after which the edges of the test specimens shall be carefully inspected.

NOTE Other test conditions of time, temperature and pressure can be as stated in the contract.

12.4 Statement of results

The following observations shall be recorded:

– any displacement of the material;
– any exudation revealed by the presence of small droplets of the binder on the edges of the test specimens.

13 Elastic compression and plastic compression

This test is reserved for materials for commutator separators.

The elastic compression and plastic compression shall be determined from the variations in thickness of the material being tested when submitted to cyclic pressure variations between the limits of 7 MPa and 60 MPa, measured after dimensional stabilization (see 13.3) has been achieved. The temperature of the test is that stated for the individual material in the specification sheets of IEC 60371-3. The elastic compression and plastic compression shall be expressed as a percentage of the thickness measured at 7 MPa.

13.1 Test apparatus

The test apparatus shall be identical to that described in 12.1, with the addition of a measuring device enabling the height of the stack to be measured to within 0,01 mm.

13.2 Test specimen

The test specimen shall be identical to that described in 12.2.

13.3 Procedure

A stack made up according to 13.2 (see 12.2) shall be subjected to a pressure of 7 MPa at room temperature and its height d_0 shall be measured. Surround the assembly with thermal insulation. The platens shall then be heated to between 5 °C and 10 °C above the temperature indicated in the specification (t_{spec}) for individual materials. This temperature shall be maintained until the thermocouple indicates the temperature given in the specification sheets of IEC 60371-3 for the individual material. The pressure of 7 MPa shall be maintained. The total height of the stack d_1 shall then be determined.

The pressure on the stack shall then be increased to 60 MPa over a period of about 1 min and maintained for 15 min.

The total height of the stack d_2 shall then be determined.

The pressure shall then be decreased to 7 MPa over a period of about 1 min and the total height of the stack again measured.

The cycle shall be repeated, but with a dwell time of 5 min only and decreased to 7 MPa. The cycles shall be repeated until successive determinations of d_1 and d_2 are constant within 0,02 mm, the cycles then being considered as stabilized. The values d_1 and d_2 of the last stabilized cycle shall be recorded as D_1 and D_2. The stack shall then be allowed to cool to room temperature under a pressure of 7 MPa and the height d_5 is recorded.

To take account of any deformation of the apparatus and the intermediate steel plates, a stack shall be made of the steel plates and the drilled steel block used for the test. The stack heights, at the specified temperature for pressures of 7 MPa and 60 MPa, are recorded as d_3 and d_4 respectively. The stack height of the intermediate steel plates d_6 shall also be recorded at 7 MPa and room temperature.

13.4 Statement of results

The number of layers constituting the test specimen shall be recorded, as well as its height d_0.

The elastic compression of the material being tested is determined using the following formula:

$$\frac{(D_1 - d_3) - (D_2 - d_4)}{(D_1 - d_3)} \times 100\,(\%) \qquad (20)$$

The plastic compression of the material being tested is determined by the following formula:

$$\frac{d_0 - d_5}{d_0 - d_6} \times 100(\%) \qquad (21)$$

NOTE A typical illustration may be obtained by plotting the curves giving the percentages relative to D_1 at t_{spec} of the variations in thickness in relation to the pressure during the successive cycles of compression and decompression (see Figure 5).

14 Resin flow and consolidation

The temperature for this test shall be that noted in the specification sheets of IEC 60371-3 or as stated in the contract.

14.1 Test specimen

Using a template, cut sufficient squares of material 50 mm × 50 mm so that when stacked the aggregate of nominal thicknesses is about 2 mm. Clean off all loose particles and projecting fibres from the pieces to be tested and align the squares accurately.

For tape material, build up the stack to give a 2 mm nominal unpressed thickness by using sufficient layers of butted tape with successive layers at right angles. With certain widths of tape, it may be necessary to cut the sides to obtain 50 mm × 50 mm.

14.2 Procedure

Weigh the test piece to the nearest milligram (m_1).

Record the percentage resin content (C_b), determined in accordance with 7.4.

Measure the thickness of the stack (t_1) by the method given in 4.1.2 (0,7 MPa).

Place the test piece centrally between caul plates not exceeding 1,5 mm in thickness and at a temperature between 15 °C to 35 °C. Stops are not used.

Insert the assembly of plates and test piece in a press preheated to the temperature given in the specification sheets of IEC 60371-3.

Close the press immediately and apply a force of 1 MPa. Cure the test piece for (5 ± 1) min. Remove the test specimen from between the caul plates.

Remove the resin flash, being careful not to remove any mica or carrier. Re-weigh the test piece to the nearest milligram (m_2).

If difficulty is found in ensuring that only resin is removed, then alternative methods may be used, e.g. cut out a smaller section from pressed laminate and calculate accordingly.

Measure the thickness (t_2) using the method given in 4.1.2 (0,7 MPa).

14.3 Statement of results

The resin flow at the specified temperature, by weight, is as follows:

$$resin\ flow = \frac{m_1 - m_2}{m_1 C_b} \text{ x } 10^4\ (\%) \tag{22}$$

$$consolidation = \frac{t_1 - t_2}{t_1} \text{ x } 100\,(\%) \tag{23}$$

15 Gel time

Cut and stack ten pieces of material 100 mm × 25 mm. For tape less than 25 mm. wide, the test piece shall be the width of the tape under test.

Press the stack on a hot plate maintained at a surface temperature of 170 °C ± 2 K squeezing out the molten resin. A timer shall be started at the moment the resin comes into contact with the hot plate.

After the resin has melted and 75 % of the specified gel time has elapsed, the resin shall be stirred using a wooden stick 3 mm in diameter, holding the stick as near vertical as possible and mixing the centre as well as the edges of the molten resin. While stirring, the diameter of the pool of melted resin shall not exceed 25 mm.

Approaching the gel point, the resin becomes tacky and forms strings; the gel point is reached when it no longer forms strings and is no longer tacky, but is still elastic. At this point, the timer shall be stopped and the elapsed time, measured in seconds, shall be taken as the gel time. The subjectivity of this end point shall be born in mind when using this test.

16 Electric strength

This test shall be conducted in accordance with IEC 60243-1.

16.1 Electrodes

Each specification sheet of IEC 60371-3 shall specify whether the test electrodes used shall be in accordance with Figures 1a, 1b, or 2 of IEC 60243- 1.

16.2 Test specimen

The thickness of the test specimen shall be that of the product as received, unless otherwise specified in the specification sheets of IEC 60371-3.

The surface area of the test specimen shall be chosen in relation to the thickness of the product such as to avoid any superficial flashover between the electrodes.

In the case of curable materials, the test specimens shall be prepared in accordance with Clause 3. The test specimens shall be at least 250 mm × 250 mm. The test specimen thickness shall be 1 mm and shall consist of not less than three layers.

The number of tests shall be five and may be made on the same piece. The thickness shall be measured to ±0,1 mm.

16.3 Procedure

The pieces shall be tested in either air or oil after conditioning according to Clause 5 of IEC 60243-1. The testing medium shall be specified in the specification sheets of IEC 60371-3. The application of voltage shall be in accordance with 9.1 of IEC 60243-1. The criterion of breakdown shall be in accordance with Clause 10 of IEC 60243-1.

16.4 Statement of results

In accordance with Clause 12 of IEC 60243- 1.

17 Dissipation factor/temperature characteristics at frequencies of between 48 Hz and 62 Hz

17.1 Test specimen

The test specimen shall measure approximately 150 mm × 150 mm × 2 mm. In the case of curable materials, it shall be prepared in accordance with Clause 3.

17.2 Test conditions

Carry out the tests in air at temperature intervals of about 10 K, from 30 °C up to the temperature specified in the relevant specification sheets of IEC 60371-3.

17.3 Electrodes

Use electrodes as described in IEC 60250. A suitable arrangement shall be for the high voltage electrode to be 100 mm in diameter, the low voltage electrode shall be 75 mm in diameter and surrounded by a guard ring approximately 10 mm wide, with 1,5 mm to 2,0 mm clearance between electrode and guard ring. The electrodes shall be backed with brass electrodes from which the sharp edges shall be removed to a radius at the edge exceeding 0,8 mm.

17.4 Procedure

Make the test at a frequency of between 48 Hz and 62 Hz by means of a suitable apparatus in accordance with IEC 60250 and using a maximum stress of 1,5 kV/mm on the measured thickness.

Measure the dissipation factor on the test pieces at the temperatures given above and plot the dissipation factor against temperature.

17.5 Statement of results

In accordance with Clause 8 of IEC 60250.

18 Dissipation factor/voltage characteristics at frequencies of between 48 Hz and 62 Hz

18.1 Test specimen

The test specimen shall measure approximately 150 mm × 150 mm × 2 mm. In the case of curable materials, it shall be prepared in accordance with Clause 3.

18.2 Test conditions

Carry out the tests in air at voltages from 1 kV, in steps of 1 kV, up to 20 kV or to the deflection point of the curve, whichever comes first.

18.3 Electrodes

According to the instructions given in 17.3.

18.4 Procedure

Make the tests at a frequency of between 48 Hz and 62 Hz in air at 23 °C ± 2 K by means of a suitable apparatus in accordance with IEC 60250. Measure the dissipation factor at the voltages given above and plot the dissipation factor against voltage.

18.5 Statement of results

In accordance with Clause 8 of IEC 60250.

19 Detection of defects and conductive particles

Until a method of detection of defects has been agreed, the type and number of defects shall be subject to contract.

20 Penetration

20.1 Test apparatus

The apparatus shall be a Williams type penetrometer, with a test area of 6 cm ± 0,05 cm diameter (see Figure 6).

NOTE 1 The container for the test liquid can be heated and cooled and should be thermostatically controlled.

A system of time measurement, for example a stop-watch permitting the time to be measured with an accuracy of 0,1 s.

The test liquid shall be a mixture of 60 % volume of castor oil (double-refined) and 40 % volume of toluene.

Density at 25 °C: 0,917 g/cm^3.

Viscosity at 25 °C: 26 mPa·s.

NOTE 2 As toluene is volatile, the test liquid should be renewed every ten days. Furthermore, the ageing of the castor oil reduces the accuracy of the measurement. It is recommended not to use mixtures older than four months.

20.2 Test specimens

The test shall be carried out with test specimens 75 mm × 75 mm. Two sets of three test specimens shall be prepared.

20.3 Method of test

Measure the thickness of the test specimens by the method specified in the specification sheets of IEC 60371-3. All test specimens shall be numbered randomly from 1 to 6, on the same side of the mica paper, on an area not affected by the testing.

Test specimens 2, 4 and 6 shall be tested with the figures outside (not in contact with the test liquid). Test specimens 1, 3 and 5 shall be tested with the designated surface in contact with the liquid.

Fill the penetrometer so that the level on the test liquid shall be within 5 mm from the top. Fix the test specimen above the liquid by means of a clamping ring. Maintain the temperature of the test liquid at 25 °C ± 0,5 K (thermostatically controlled).

Start the timing device when the penetrometer is brought from horizontal into the inclined position.

Stop the time measurement when the circular test area is completely impregnated by the test liquid.

NOTE Losses of test liquid caused by testing should be replaced before the subsequent test.

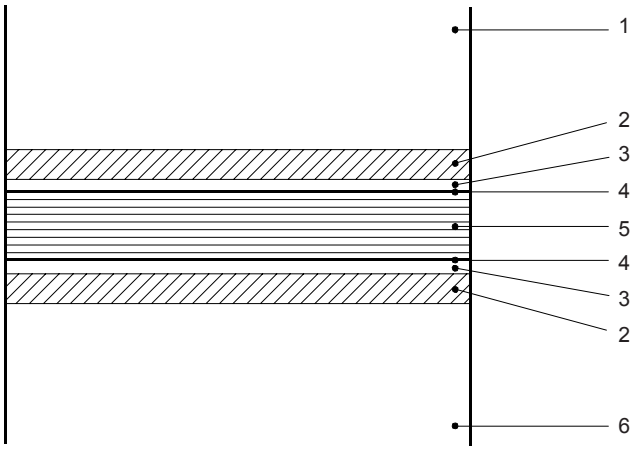
20.4 Statement of results

Report the central value and the minimum and maximum values of the time measurements for each set of the test specimens. Note the thickness.

21 Thermal endurance

The thermal endurance shall be determined in accordance with IEC 60216.

The property chosen for a particular material and the end point criterion will be given in the specification sheets of IEC 60371-3.



Key

1 upper heating plate
2 pressing pad (ten layers of Kraft paper or other materials such as aramid paper, aramid cloth or glass cloth. The pressing pad shall have a thickness of 1 mm to 2 mm.)
3 caul plate (chromium steel, 2 mm thick)
4 release material (e.g. triacetate film)
5 stack
6 lower heating plate

Figure 1 – Assembly of stacks for preparing test laminates

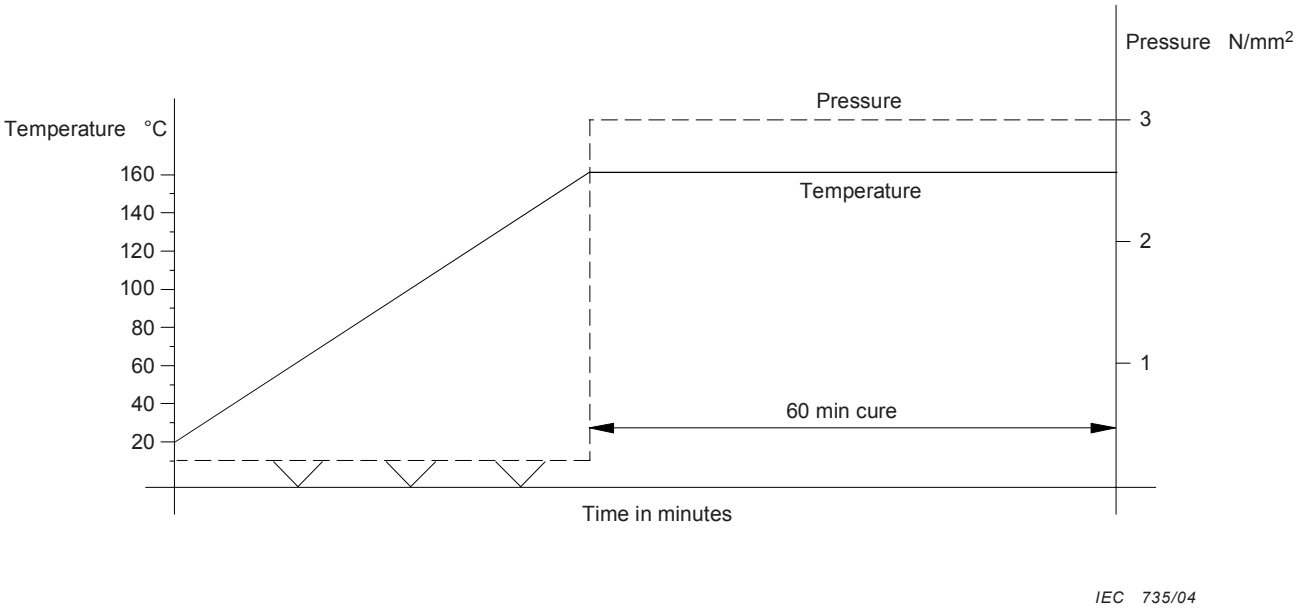
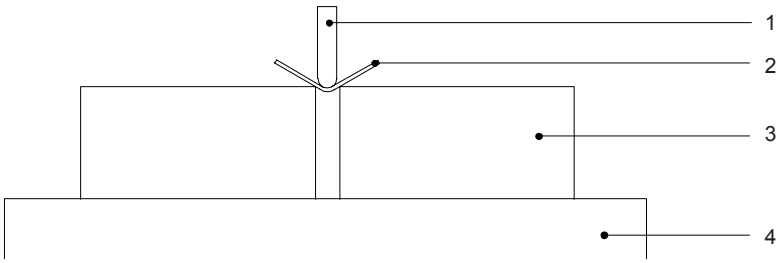


Figure 2 – Conditions for press procedure



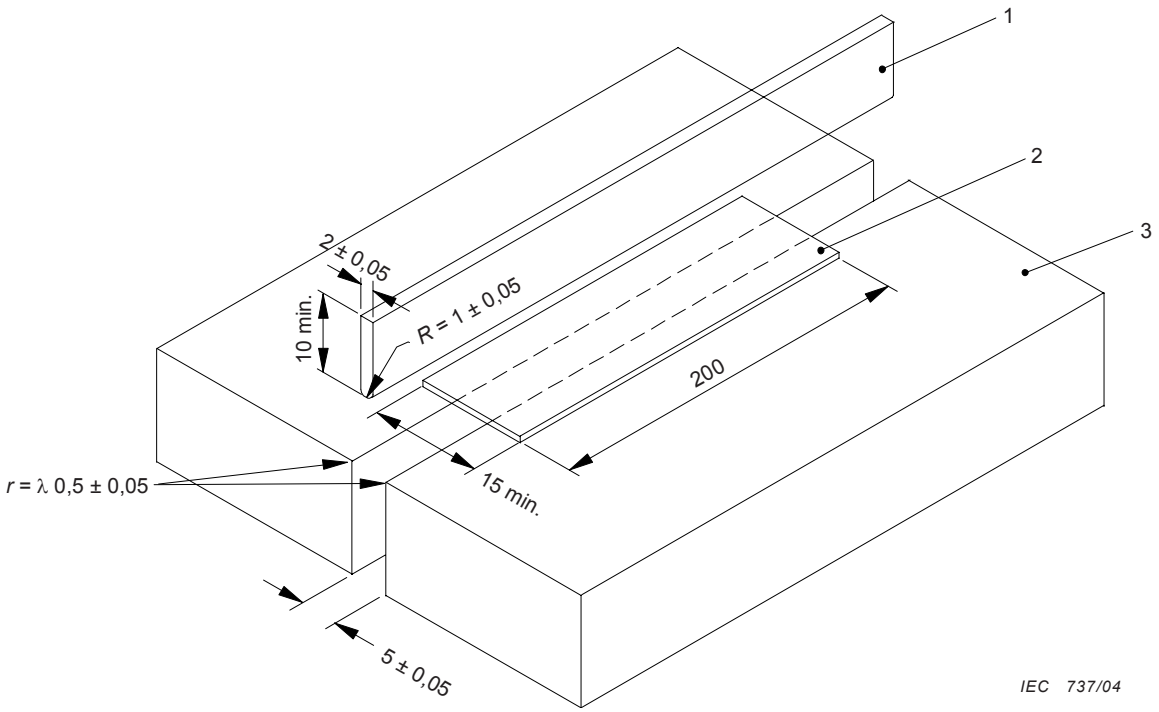
Key

1 penetration bar
2 test specimen
3 support platform
4 force-measuring device

IEC 736/04

Figure 3 – Apparatus for measurement of stiffness

Dimensions in millimetres



IEC 737/04

Key

1 penetration bar
2 test specimen
3 support platform

Figure 4 – Apparatus for measurement of stiffness

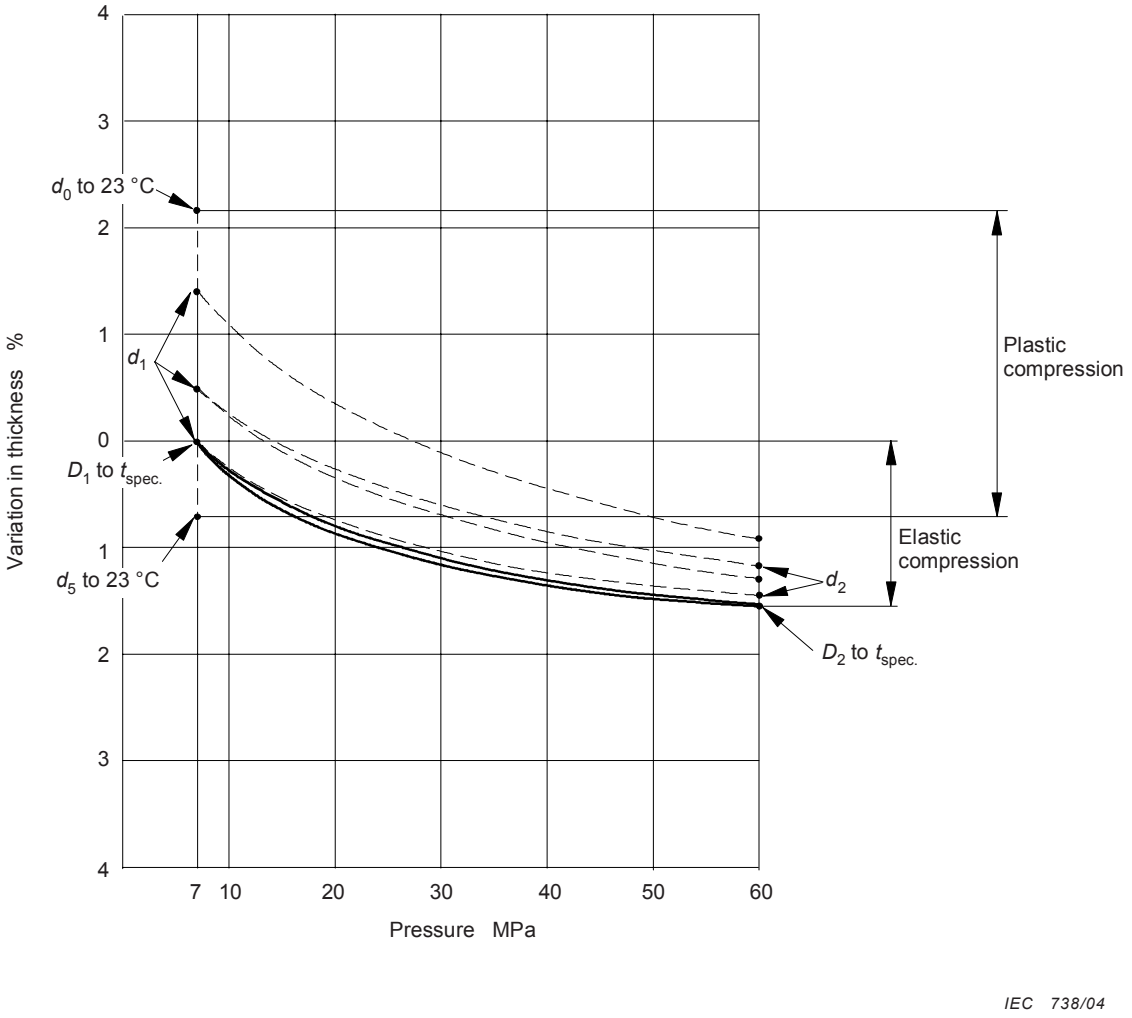


Figure 5 – Elastic compression, plastic compression

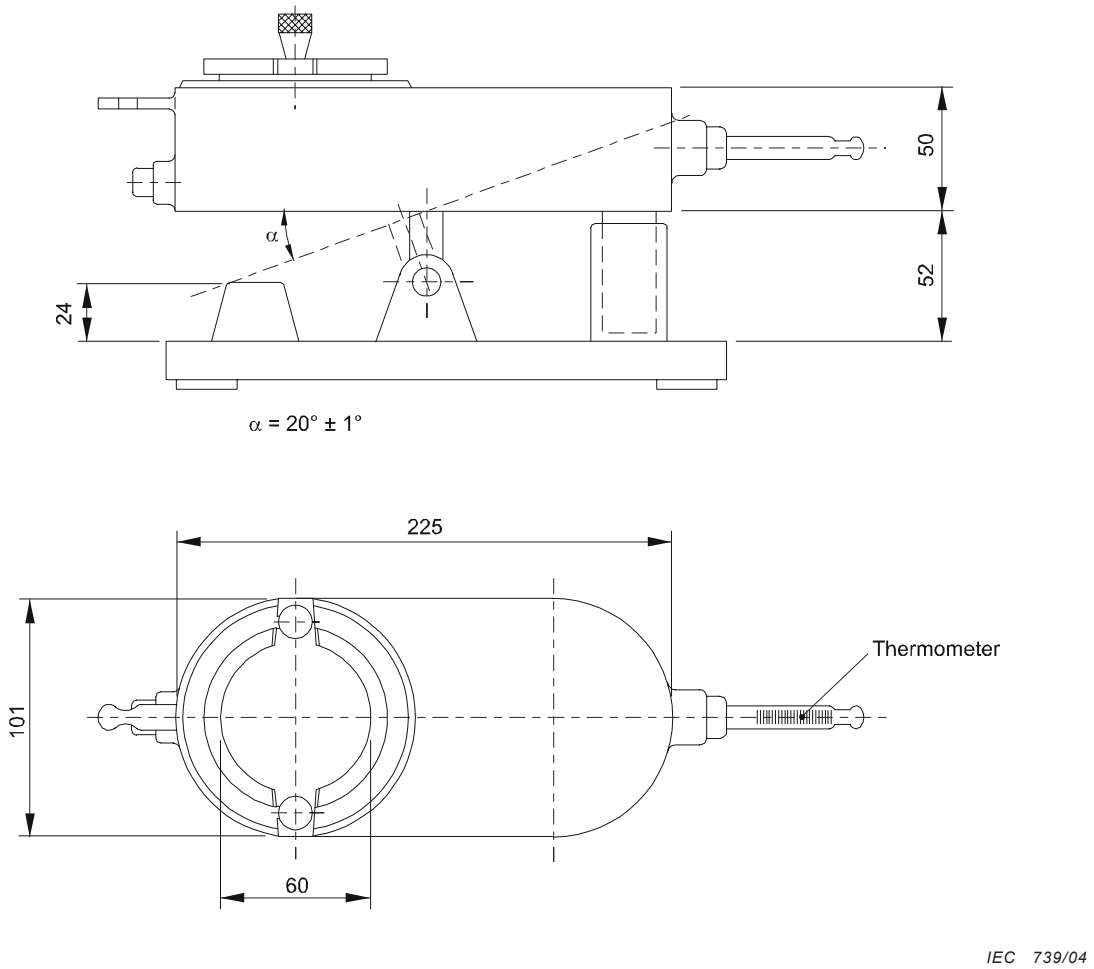


Figure 6 – Standard Williams type penetrometer. ?>>>>

Annex A
(normative)

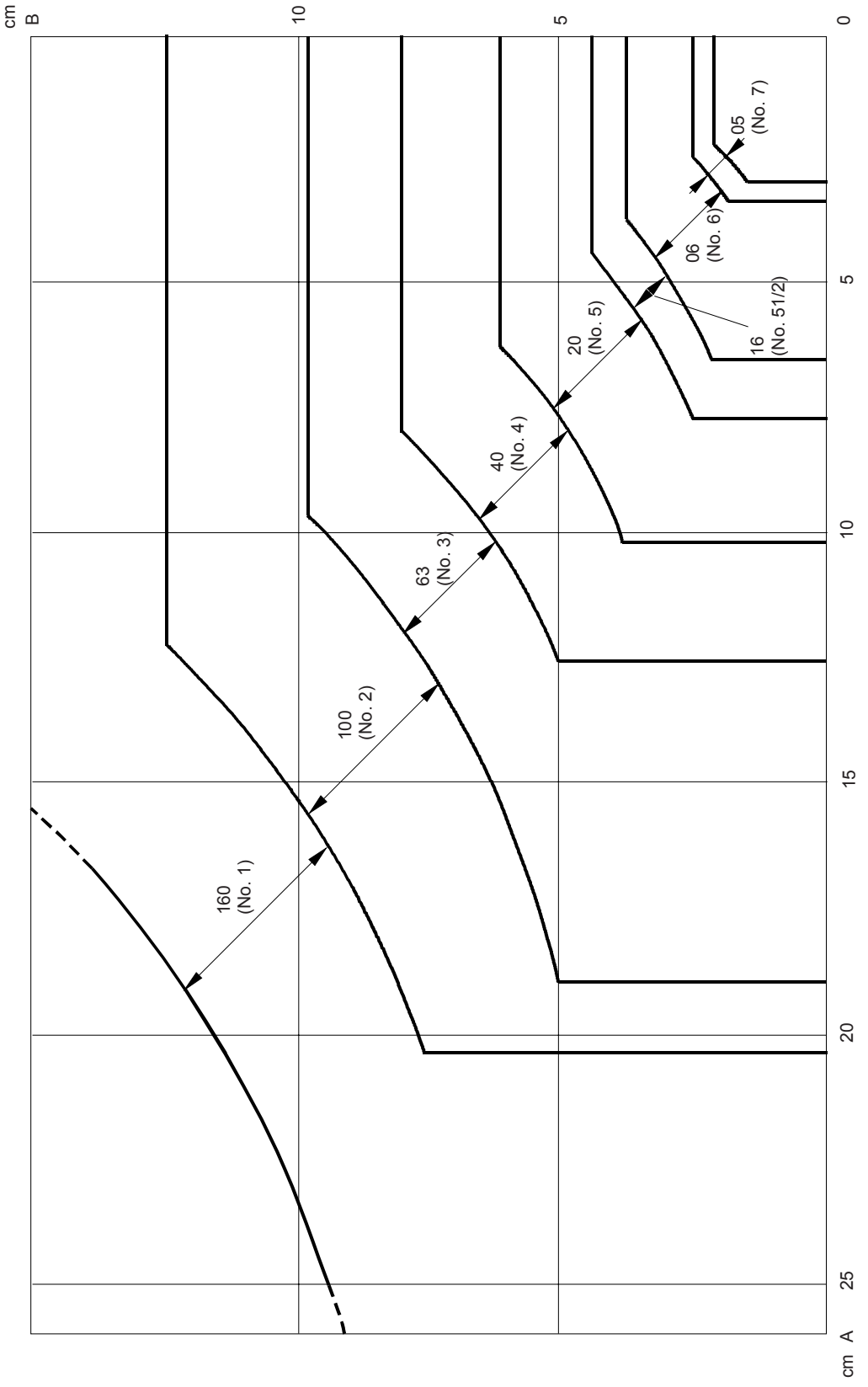


Figure A.1 – Grading chart for mica blocks, thins and splittings

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE Where an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 60216	Series	Electrical insulating materials - Thermal endurance properties	EN 60216	Series
IEC 60243-1	1998	Electrical strength of insulating materials - Test methods Part 1: Tests at power frequencies	EN 60243-1	1998
IEC 60250	1969	Recommended methods for the determination of the permittivity and dielectric dissipation factor of electrical insulating materials at power, audio and radio frequencies including metre wavelengths	-	-
IEC 60371-3	Series	Specifications for insulating materials based on mica Part 3: Specifications for individual materials	EN 60371-3	Series
ISO 178	- [1)]	Plastics - Determination of flexural properties	EN ISO 178	2003 [2)]

1) Undated reference.

2) Valid edition at date of issue.

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