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Specification for laminated pressboard –

Part 2:
Methods of test

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International Electrotechnical Commission, 3, rue de Varembé, PO Box 131, CH-1211 Geneva 20, Switzerland
Telephone: +41 22 919 02 11 Telefax: +41 22 919 03 00 E-mail: inmail@iec.ch Web: www.iec.ch

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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SPECIFICATION FOR LAMINATED PRESSBOARD –

Part 2: Methods of test

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 60763-2 has been prepared by IEC technical committee 15: Solid electrical insulating materials.

This second edition cancels and replaces the first edition published in 1991 and constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition.

a) The standard has generally been revised editorially and brought into line with IEC 60641-2.
b) The test method for the determination of the internal ply strength has been replaced with an alternative method.
c) The test method for the determination of the thermal resistance has been enlarged in its scope.

The text of this standard is based on the following documents:

FDIS	Report on voting
15/360/FDIS	15/373/RVD

Full information on the voting for the approval of this part can be found in the report on voting indicated in the above table.

The list of all parts of the IEC 60763 series, under the general title *Specification for laminated pressboard*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

INTRODUCTION

This International Standard deals with laminated pressboard as defined in Clause 2 of IEC 60763-1.

IEC 60641 applies to pressboard which is not laminated, and the material covered by this International Standard is made from sheets conforming to the requirements of that publication.

SPECIFICATION FOR LAMINATED PRESSBOARD –

Part 2: Methods of test

1 Scope

This part of IEC 60763 gives methods of test applicable for the material classified in IEC 60763-1.

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

IEC 60247:2004, *Insulating liquids – Measurement of relative permittivity, dielectric dissipation factor (tan δ) and d.c. resistivity*

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 60296:2003, *Fluids for electrotechnical applications – Unused mineral insulating oils for transformers and switchgear*

IEC 60641-2:2004, *Pressboard and presspaper for electrical purposes – Part 2: Methods of tests*

IEC 60763-1:1983, *Specification for laminated pressboard – Part 1: Definitions, classification and general requirements*

IEC 61125:1992, *Unused hydrocarbon-based insulating liquids – Test methods for evaluating the oxidation stability*

IEC 62021-1:2003, *Insulating liquids – Determination of acidity – Part 1: Automatic potentiometric titration*

ISO 287:1985, *Paper and board – Determination of moisture content – Oven-drying method*

ISO 2144:1997, *Paper, board and pulps – Determination of residue (ash) on ignition at 900 degrees C*

3 Conditioning of test specimens

Since the conditioning of laminated pressboard is very time-consuming, the material is tested either as received or dried. Only in case of dispute shall the material be conditioned according to the following procedure.

The conditioning shall be made at 23 °C ± 2 K and (50 ± 5) % relative humidity until the moisture content of the specimen reaches 5,5 % to 8 %. The conditioning shall be approached from the dry side after drying at 70 °C ± 5 K for a period sufficient to ensure that the conditioning atmosphere produces a mass increase in the specimen.

4 Drying of test specimens

4.1 Method A (preferable)

The test specimens shall be dried at 105 °C ± 2 K for (24 ± 1) h in an oven with forced air circulation and subsequently at 105 °C ± 2 K for (48 ± 2) h in a vacuum chamber at a residual pressure of not more than 1 kPa. The specimens shall then be removed and allowed to cool in a desiccator before the test.

4.2 Method B

Test specimens shall be dried in a ventilated oven at 105 °C ± 2 K for (168 ± 8) h at atmospheric pressure. When test pieces of the specified size are dried according to method B, test results similar to the test results obtained after drying according to method A may be expected.

5 Dimensions

5.1 Thickness

5.1.1 Test apparatus

An external screw-type micrometer having measuring faces of 6 mm to 8 mm diameter shall be used for testing. The measuring faces shall be flat to within 0,001 mm and parallel to within 0,003 mm. The micrometer shall be graduated in divisions of 0,01 mm and have an accuracy of ± 0,005 mm. The pressure exerted on the specimens shall be 0,1 MPa to 0,3 MPa.

5.1.2 Procedure

The thickness of the laminated pressboard sheet shall be measured to the nearest 0,01 mm in the as-received condition at eight points, two along each edge, but not less than 20 mm from the edge.

In case of dispute, a strip (40 ± 1) mm wide shall be cut across the full width of the sheet and, from this strip, at eight equally spaced positions eight test specimens shall be cut, each not less than 40 mm long. The test specimens shall be conditioned in accordance with Clause 3 and the thickness of each measured at a point near the centre of each test specimen.

5.1.3 Result

The central value of the eight measurements shall be taken as the result, and the minimum and maximum values obtained shall be reported.

5.1.4 Flatness

When any laminated pressboard sheet is placed without restraint, concave side up, on a flat surface, the departure at any point of the upper surface of the sheet from a light straight edge of (1000 ± 10) mm or (500 ± 5) mm, laid in any direction upon it, shall not exceed the value given in IEC 60763-3 appropriate to the material, its thickness and length of straight edge. The mass of the straight edge shall not exceed (500 ± 5) g.

6 Mechanical tests

6.1 Flexural strength and load to produce a standard deflection

6.1.1 General

The test shall be carried out with the load applied perpendicular to the laminations.

6.1.2 Test specimens

Rectangular strips (20 ± 1) mm wide and of a length of not less than 20 times the measured thickness shall be used. The thickness is that of the board under test except that, when the measured thickness of a test piece exceeds 20 mm, the thickness shall be reduced to (20 ± 1) mm, one face of the test piece being left intact.

Five tests shall be carried out on specimens cut in machine direction (direction A) and five in cross-machine direction (direction B). (See definitions of directions A and B given in Figure 1.)

If the machine direction is not known, five specimens shall be cut with their length parallel to one of the edges of the sheet and five specimens at right angle thereto. The set of test specimens giving the highest value of flexural strength is deemed to have been cut with the length in machine direction.

6.1.3 Test apparatus

Universal testing apparatus designed to bend a test piece of given dimensions at an appropriate constant rate of bending and to measure the force and the deflection at midpoint of the test piece. A test rig for the determination of the three-point bending strength.

6.1.4 Conditioning

Test specimens shall be dried in accordance with Clause 4.

6.1.5 Procedure

After cooling in a desiccator, the width of the test specimen shall be immediately measured with an accuracy of ± 0,1 mm and the thickness with an accuracy of ± 0,02 mm, and the test specimen shall be immediately placed lengthwise symmetrically across two parallel supports. Where one surface has been removed, the original, intact surface shall rest on the two supports.

Where they are in contact with the test specimen, the surfaces of the supports shall have a radius of (5 ± 0,2) mm. The distance between the supports shall be 16 times the nominal thickness of the test specimen and shall be measured with an accuracy of ± 0,5 %. The load shall be applied across the width of the test specimen by means of a loading member parallel with, and mid-way between, the supports. The radius of the end of the loading member shall be (5 ± 0,2) mm.

The load shall be increased steadily from zero to rupture by relative movement of the loading member and the supports at a constant rate. This rate of movement (which is the rate of deflexion of midpoint of the test specimen) shall be (5 ± 0,5) mm/min.

The load at a standard deflection of 0,4 mm shall be noted.

The maximum load shall be noted.

6.1.6 Results

The flexural strength σ_f in MPa of the test specimen shall be calculated as follows:

$$\sigma_f = \frac{1{,}5 \cdot F \cdot L}{bh^2}$$

where

F is the maximum load (in N);

L is the distance between the supports (in mm);

b is the width of the test specimen (in mm);

h is the thickness of the test specimen (mm).

The flexural strength and load to produce the standard deflection in the machine and cross-machine direction shall be reported, as the central value of the results from the five test specimens, cut in each direction.

6.2 Apparent modulus of elasticity in flexure

The apparent modulus of elasticity in flexure E in MPa can be calculated from the load at 0,4 mm deflection according to 6.1.4 using the following formula:

$$E_B = \frac{L^3}{4b \cdot h^3} \cdot \frac{F}{0{,}4}$$

where

L is the distance between the supports (in mm);

b is the width of the test specimen (in mm);

h is the thickness of the test specimen (in mm);

F is the load at deflection of 0,4 mm (in N).

The apparent modulus of elasticity in flexure in the machine and cross-machine direction shall be reported, as the central value of the results from the five test specimens, cut in each direction.

7 Compressibility

7.1 Principle

To determine the compressibility of laminated pressboard, a stack of test pieces shall be subjected to a low pressure (bedding pressure), followed by an increase of the pressure to a defined value (final pressure). The percentage change in the thickness of the pad is a measure of the compressibility of the material.

Subsequently, the pressure shall be decreased again to the bedding pressure. The percentage changes in the thickness of the pad allows the calculation of the reversible/residual compressibility of the material.

7.2 Test apparatus

Universal testing apparatus designed to compress a test piece of given dimensions at an appropriate constant rate of compression and to measure the compressive force and the deflection of the test piece. A test rig with parallel steel plates, parallel within 0,2 mm, and an area greater than the area of the test piece itself.

7.3 Test pieces

A sufficient number of square test pieces with an edge length of (25 ± 0,5) mm shall be cut. The number of test pieces shall be chosen so that three stacks of a height of 25 mm to 85 mm can be made. For materials of a thickness greater than 85 mm, the specimens shall be machined only on one face to a thickness of (85 ± 0,25) mm. All edges of the test specimens shall be free of burrs. The test pieces shall be dried in accordance with Clause 4.

7.4 Procedure

A stack of test pieces shall be placed between the plates of the test rig. A bedding pressure of (1 ± 0,1) MPa shall be applied for at least 5 min and then the height h_0 of the stack shall be measured with an accuracy of ± 0,1 mm.

The pressure shall be increased to (20 ± 0,1) MPa. During this operation, the rate of displacement of the moving plate shall be (5 ± 1) mm per minute. This pressure shall be maintained for 5 min minimum.

The difference in height Δh_1 from h_0 of the stack shall be measured with an accuracy of ±0,01 mm.

The pressure shall be reduced to (1 ± 0,1) MPa and kept for not less than 5 min.

The difference in height Δh_2 from h_0 of the stack shall be measured with an accuracy of ± 0,01 mm after the bedding pressure has been restored.

7.5 Results

The following calculated values shall be reported.

Compressibility (in %):

$$C = \frac{\Delta h_1}{h_0} \times 100$$

Residual amount of the compressibility (in %):

$$C_{\text{res}} = \frac{\Delta h_2}{\Delta h_1} \times 100$$

Reversible amount of the compressibility (in %):

$$C_{\text{rev}} = \frac{\Delta h_1 - \Delta h_2}{\Delta h_1} \times 100$$

All three values shall be reported. The central value shall be taken as the result.

8 Electric strength in oil

8.1 General and conditioning

Electric strength shall be determined by the method specified in IEC 60243-1. The test shall be carried out in mineral oil Class II (see IEC 60296) at 23 °C ± 2 K. The specimens shall be dried and oil-impregnated as described in the test for oil absorption (see Clause 13), except that the vacuum drying time shall be (48 ± 4) h. Drying and impregnation shall be carried out after machining. After drying and impregnation, the specimens shall be placed in position between the electrodes. At no time between impregnation and testing the specimens shall be exposed to the atmosphere.

8.2 Electric strength along laminate (edgewise electric strength)

8.2.1 Method 1 for materials with a thickness of more than 25 mm

Five specimens shall be tested. The size of the test specimens and the arrangements of the electrodes shall be as shown in Figure 2.

The cylindrical electrodes shall be (6 ± 0,1) mm in diameter and have hemispherical ends. Each hole shall be not more than 0,1 mm greater in diameter than each electrode diameter.

Alternative forms of vented electrodes are shown in Figure 3. When electrodes with slots are used, these slots shall be diametrically opposed to the gap between the electrodes.

The holes shall be pre-drilled by a normal point-ground drill down to the outermost glue-layer. By means of a specially ground, well-sharpened drill with a radius of (3 ± 0,1) mm, the final drilling shall be carried out so that the outermost glue layer is broken through. The drilling shall be done with great care so that the test specimen is not subjected to mechanical or thermal stresses and the drill does not break through the outermost layer. The application of voltage shall be in accordance with 9.1 of IEC 60243-1. The breakdown voltage shall be taken as the result. The central value of the five tests and the lowest value shall be reported.

8.2.2 Method 2 for materials with a thickness between 10 mm and 25 mm

Five specimens shall be tested. Test specimens of full thickness with a width of (10 ± 0,2) mm and a length of (50 ± 1) mm shall be cut so that exact parallel planes forming right angles to the surface of the material are produced. The electrodes shall be in accordance with Figure 6 of IEC 60243-1. The application of voltage shall be in accordance with 9.1 of IEC 60243-1. The breakdown voltage shall be taken as the result. The central value of the five tests and the lowest value shall be reported.

9 Internal ply strength, thermal resistance and oil compatibility

9.1 Principle

The test consists of determining the change of flexural strength of the material at room temperature and at 120 °C and before and after ageing in oil.

9.2 Test specimens

Rectangular strips (10 ± 1) mm wide and of a length of (10 ± 0,5) times the measured thickness shall be used. The thickness shall be that of the board under test except that, when the measured thickness of a test piece exceeds 15 mm, the thickness shall be reduced to (15 ± 0,5) mm, one face of the test piece being left intact.

Twenty test specimens cut in machine direction and 20 test specimens cut in cross- machine direction shall be prepared.

9.3 Test apparatus

Universal testing apparatus designed to bend a test piece of given dimensions at an appropriate constant rate of bending and to measure the force and the deflection at midpoint of the test piece. A test rig for the determination of the three-point bending strength.

9.4 Procedure

All the specimens shall be dried according to Clause 4, Method A. Twenty of the dried specimens shall be tested as indicated in Table 1.

The rest of the specimens shall be oil-impregnated according to 13.2. Ten oil-impregnated specimens shall be tested according to Table 1.

The oil vessel with the remaining 10 test specimens shall be placed in an oven with forced air circulation at 120 °C ± 2 K. The vessel shall be covered with aluminium foil. After (168 ± 4) h, the heating shall be switched off and the oil allowed to cool down to ambient temperature. Ten aged samples shall be tested according to Table 1.

Table 1 – Number of test specimens

Orientation of the board	Dried		Oil-impregnated	Oil-impregnated and aged
Test temperature	23 °C ± 2 K	120 °C ± 2 K	23 °C ± 2 K	23 °C ± 2 K
Machine direction	5	5	5	5
Cross-machine direction	5	5	5	5

9.5 Determination of the flexural strength

The test shall be carried out with the load applied perpendicular to the laminations. After cooling in a desiccator, the width of the test specimen shall be immediately measured with an accuracy of ± 0,1 mm and the thickness with an accuracy of to ± 0,02 mm; the test specimen shall be immediately placed symmetrically across two parallel supports. Where one surface has been removed, the original, intact surface should rest on the two supports.

The surfaces of the supports where they are in contact with the test specimen shall have a radius of (5 ± 0,2) mm. The distance between the supports shall be (6,6 ± 0,2) times the nominal thickness of the test specimen and shall be measured to within 0,5 %. The load shall be applied uniformly across the width of the test specimen by means of a loading member parallel with, and mid-way between, the supports. The radius of the end of the loading member shall be (5 ± 0,1) mm.

The load shall be increased steadily from zero by relative movement of the loading member and the supports at a constant rate. This rate of movement (which is the rate of deflexion of midpoint of the test specimen) shall be (5 ± 0,5) mm/min.

The maximum load shall be noted.

The location of the rupture – within pressboard, within glue line, interface board/glue – shall be noted.

9.6 Results

The flexural strength σ_f in MPa of the test specimen shall be calculated as follows:

$$\sigma_f = \frac{1{,}5 \cdot F \cdot L}{bh^2}$$

where

F is the maximum load (in N);

L is the distance between the supports (in mm);

b is the width of the test specimen (in mm);

h is the thickness of the test specimen (in mm).

The internal ply adhesion is indicated by the location of the rupture.

The thermal resistance is expressed in terms of percentage retention of the measured flexural strength of the dry samples tested at 120 °C relative to the strength at 23 °C.

The oil compatibility is expressed in terms of percentage retention of the measured properties of the oil-impregnated samples tested at 23 °C relative to the properties of the dry samples tested at 23 °C.

The resistance to ageing in oil is expressed in terms of percentage retention of the measured properties of the samples aged at 120 °C relative to the properties of the oil-impregnated, non-aged samples.

The central values of the thermal resistance, the oil compatibility and the resistance to ageing shall be taken as the results.

10 Apparent density

10.1 Test specimens

The test shall be carried out on three conditioned test pieces; one determination shall be made on each of the three test pieces.

Rectangular test pieces of an area not less than 100 cm^2 shall be used.

10.2 Procedure

The mass of the test specimen shall be measured to an accuracy of $10^{-4} \times$ the mass of the test piece.

Two measurements of the length and two of the width of each test piece to an accuracy of 0,1 mm shall be made at points at least 12 mm from the corners.

The thickness shall be determined by making eight measurements as indicated in 5.1 and the mean value of the measurements calculated.

10.3 Results

The apparent density ρ (the mass to volume ratio) shall be expressed as g/cm^3.

$$\rho = \frac{m}{s \times l \times w} \times 10^3$$

where

m is the mass, in g;

s is the mean of the eight thickness measurements (in mm);

l is the mean of the two length measurements (in mm);

w is the mean of the two width measurements (in mm)

All three values shall be reported. The central value shall be taken as the result.

11 Moisture content

The moisture content in the as-received condition shall be measured according to a method based on ISO 287.

Three test specimens of at least 50 g mass, preferably measuring 100 mm × 25 mm × original thickness in the as-received condition, shall be weighed with an accuracy of ±1 mg, then dried and cooled in accordance with Clause 3 and reweighed to the same accuracy as before. The moisture content is the loss of mass expressed as a percentage of the original mass. The central value of the three measurements shall be taken as the result; the other two values shall be reported.

12 Shrinkage in air after drying

12.1 Test specimens

Six specimens measuring approximatly 50 mm × 300 mm shall be cut, three being in machine direction A and three in cross-direction B (see Figure 1).

12.2 Procedure

After the specimens have been conditioned in accordance with Clause 3, their lengths and thicknesses shall be measured, one measurement being made of the length of each specimen and one of the thickness which shall be made at a point not less than 20 mm from an edge.

The specimens shall then be dried in accordance with Clause 4.

After cooling to room temperature in a desiccator, the length and thickness shall be measured again. The length before and after drying shall be measured with an accuracy of ± 0,05 mm; the thickness with an accuracy of ± 0,01 mm.

12.3 Results

The shrinkage in length shall be calculated for the directions A and B as the percentage change in dimensions of the original measurements of the conditioned test specimens. For each direction, the central value shall be taken as the result; the other two values shall be reported. For the shrinkage in thickness the central value shall be taken as the result; the highest and lowest values shall be reported.

13 Oil absorption

13.1 Test specimens

The test shall be carried out on three specimens each 100 mm × 25 mm and of the same thickness as the material under test.

13.2 Procedure

The specimens shall be dried in accordance with Clause 4, Method A, and the mass then determined to the nearest milligram.

The specimens shall be placed in a vacuum chamber, the temperature raised to 90 °C ± 2 K and the pressure reduced to not more than 1 kPa.

This temperature and pressure shall be maintained for 1 h. Then oil conforming to the requirements of Class II in IEC 60296, preheated to 90 °C ± 2 K, shall be admitted at a rate slow enough to ensure that the pressure does not rise above 2,5 kPa.

When the specimens are completely submerged, using sinkers if necessary, the pressure shall be allowed to rise slowly to atmospheric pressure and the heating switched off. The specimens shall be left under oil for (24 ± 1) h. The specimens shall then be taken from the oil and the surplus oil removed with blotting paper. The clean specimens shall then be weighed to the same accuracy as before and the mass of the absorbed oil determined.

13.3 Results

The results shall be expressed as the percentage of the mass of oil absorbed in relation to the original mass of the dried samples. The central value of the three determinations shall be taken as the result and the other two shall be reported.

14 Ash content

14.1 Procedure

The amount of residue of material left after incineration of the material in the as-received condition shall be determined according to the method described in ISO 2144. The mass of the specimen shall be at least 5 g and the sample shall be taken so that the glue/cellulose ratio is representative of the board under test. Three determinations shall be made.

14.2 Results

The central value obtained shall be taken as the result, based on oven-dry material (calculated from determination of moisture content according to 9.3); the highest and lowest values are reported.

15 Contamination of liquid dielectrics

15.1 Apparatus

– A conductivity cell according to IEC 60247.

– A cell for the determination of the dissipation factor of liquids according to IEC 60250.

– A vessel to contain oil, of neutral or borosilicate glass with a volume of at least 1 l in which an atmosphere of dry nitrogen may be maintained above the oil.

– An oven with forced air circulation, controllable to 100 °C ± 1 K.

– Clean metal tongs.

– Dry oil (Class II of IEC 60296) whose neutralization value and dissipation factor at 90 °C and 48 Hz to 62 Hz have been determined.

NOTE Cells of Figures 2 and 3 of IEC 60250 are also usable for resistivity measurement and accordingly described in IEC 60247.

15.2 Test specimens

A sufficient amount of material finely cut into pieces thinner than 1 mm and with a surface area of about 1 cm^2 and that has been dried at 105 °C ± 2 K for a period of at least 16 h. The specimens shall be handled by means of clean metal tongs.

15.3 Procedure

In the vessel (75 ± 0,1) g of the specimens shall be immersed in (750 ± 5) cm^3 of the oil. It is advisable to check the cleanliness of the vessel. An atmosphere of dry nitrogen shall be maintained above the oil. The vessel containing the oil with the specimens together with an identical vessel containing the same oil as blank shall be heated at 100 °C ± 1 K for a period of (168 ± 4) h.

After this period, the neutralization value according to IEC 62021-1, the sludge content according to IEC 61125 and the dissipation factor according to IEC 60247 at 90 °C ±1 K and 48 Hz to 62 Hz shall be measured for both the test oil and the blank.

15.4 Results

The difference between the two values obtained shall be taken as the result.

16 Conductivity of aqueous extract

16.1 Procedure

The test shall be carried out as described in IEC 60641-2 but specimens shall be taken so that the glue/cellulose ratio is representative of the whole thickness of the board. If strips are used, these should be not larger than 20 mm × 3 mm but smaller subdivisions may be used provided the glue/cellulose ratio is maintained.

16.2 Results

The conductivity shall be expressed in millisiemens per metre (mS/m).

17 pH of aqueous extract

The test shall be carried out as described in IEC 60641-2 but using an extract prepared as in 16.1.

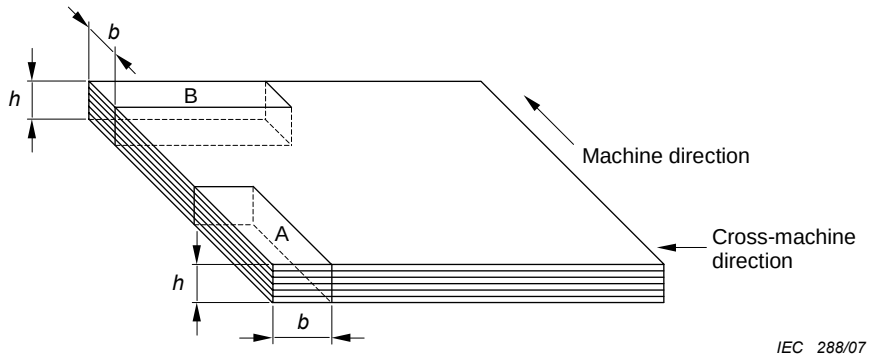


Figure 1 – Position of test specimen in relation to length, width and thickness of sheet

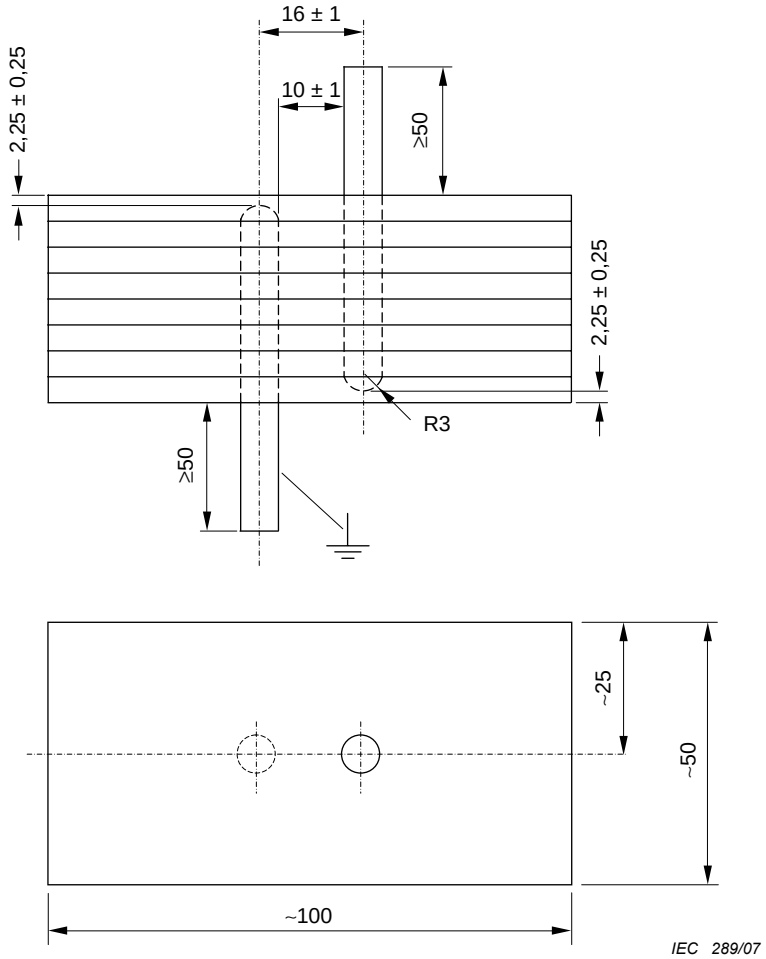
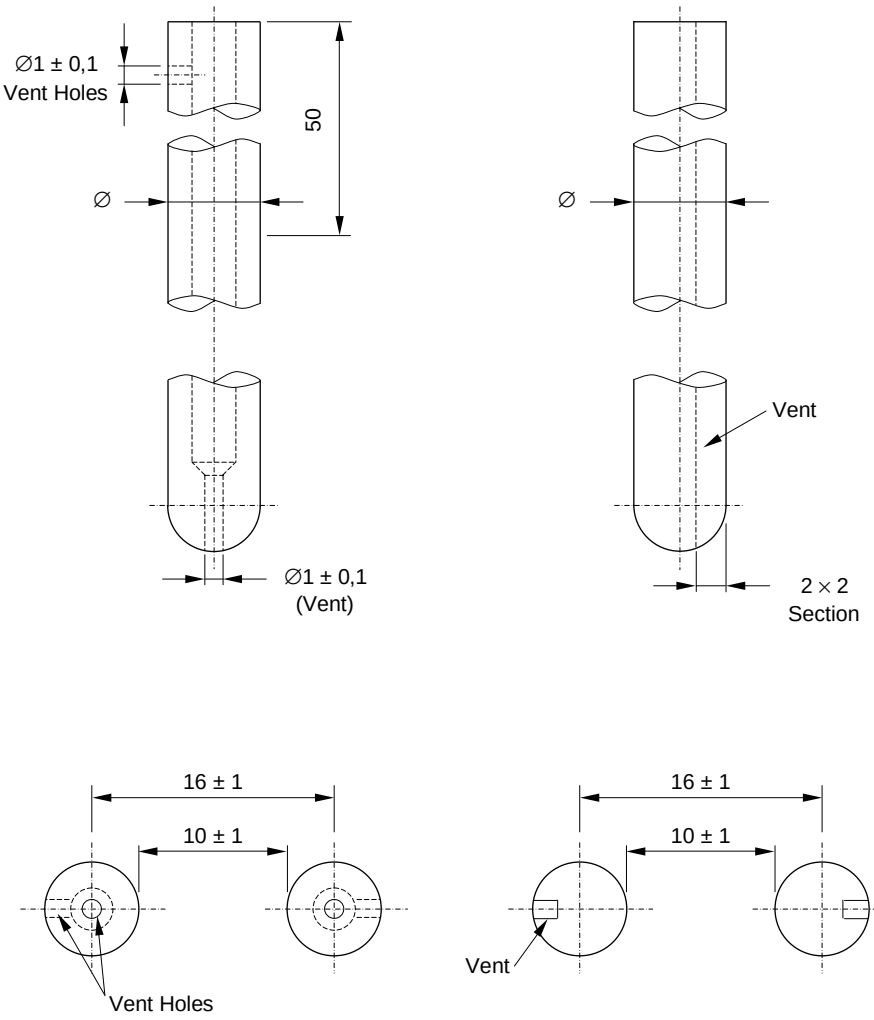


Figure 2 – Size of the test specimens and arrangement of the electrodes for testing the electric strength along laminae (edgewise electric strength)



Figures 3 and 4 – Alternative forms of vented electrodes

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