BRITISH STANDARD

BS EN
60641-2:2004

Pressboard and presspaper for electrical purposes —

Part 2: Methods of tests

The European Standard EN 60641-2:2004 has the status of a British Standard

ICS 17.220.99; 29.935.10

National foreword

This British Standard is the official English language version of EN 60641-2:2004. It is identical with IEC 60641-2:2004. It supersedes BS EN 60641-2:1996 which is withdrawn.

The UK participation in its preparation was entrusted by Technical Committee GEL/15, Insulating material, to Subcommittee 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

The British Standards which implement international or European publications referred to in this document may be found in the *BSI Catalogue* under the section entitled "International Standards Correspondence Index", or by using the "Search" facility of the *BSI Electronic Catalogue* or of British Standards Online.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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

Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 25 and a back cover.

The BSI copyright notice displayed in this document indicates when the document was last issued.

Amendments issued since publication

Amd. No.	Date	Comments

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 2 November 2004

ISBN 0 580 44707 3

EUROPEAN STANDARD **EN 60641-2**

NORME EUROPÉENNE

EUROPÄISCHE NORM October 2004

ICS 17.220.99 ; 29.935.10 Supersedes EN 60641-2:1995

English version

Pressboard and presspaper for electrical purposes
Part 2: Methods of tests
(IEC 60641-2:2004)

Carton comprimé et papier comprimé
à usages électriques
Partie 2: Méthodes d'essai
(CEI 60641-2:2004)

Tafel- und Rollenpressspan
für elektrotechnische Anwendungen
Teil 2: Prüfverfahren
(IEC 60641-2:2004)

This European Standard was approved by CENELEC on 2004-09-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

CENELEC
European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

Ref. No. EN 60641-2:2004 E

Foreword

The text of document 15C/1609/FDIS, future edition 2 of IEC 60641-2, 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 60641-2 on 2004-09-01.

This European Standard supersedes EN 60641-2:1995.

The main changes with respect to EN 60641-2:1995 are listed below:

The following test methods have been cancelled:

– flexibility;

– conductivity of the organic extract;

– contamination of liquid dielectrics.

The following test methods have been rewritten:

– compressibility;

– conductivity of the aqueous extract;

– cohesion between plies.

The following test method has been introduced:

– determination of metallic particles with X-ray.

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.

———————

Endorsement notice

The text of the International Standard IEC 60641-2:2004 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 60247	NOTE	Harmonized as EN 60247:2004 (not modified).
ISO 186	NOTE	Harmonized as EN ISO 186:2002 (not modified).

———————

CONTENTS

PRESSBOARD AND PRESSPAPER FOR ELECTRICAL PURPOSES –

Part 2: Methods of tests

1 Scope

This part of IEC 60641 applies to pressboard and presspaper for electrical purposes.

The series does not apply to laminated material.

This part specifies the test methods to be used in testing pressboard and presspaper for electrical purposes to meet the requirements prescribed in the specification sheets of Part 3.

NOTE In this standard, reference is made in several places to ISO standards accompanied by a short description of the method used. It is to be understood that this short description is meant for identification purposes only and that all details should be taken from the ISO standard itself.

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

IEC 60554-2:2001, *Cellulosic papers for electrical purposes – Part 2: Methods of test*

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

ISO 534:1988, *Paper and board – Determination of thickness and apparent bulk density or apparent sheet density*

ISO 1924-2:1994, *Paper and board – Determination of tensile properties – Part 2: Constant rate of elongation method*

ISO 1974:1990, *Paper – Determination of tearing resistance (Elmendorf method)*

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

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
specimen
rectangle of paper or board cut to given dimensions from sheets or reels drawn from selected units

3.2
test piece
quantity of paper or board on which each single determination is carried out in accordance with the method of test.

NOTE The test piece may be taken from a specimen; in some instances, it may be the specimen itself.

4 General notes on tests

4.1 Conditioning

a) For materials with a thickness of <0,5 mm

Unless otherwise specified, the specimen after being cut, shall be conditioned for not less than 16 h in an atmosphere of 23 °C ± 2 K and (50 ± 5) % relative humidity. Test pieces shall be cut from the specimen and tested in this atmosphere.

b) For materials with a thickness of ≥0,5 mm

Unless otherwise specified, the specimen after being cut, shall be conditioned for not less than 16 h in an atmosphere of 23 °C ± 2 K and (50 ± 5) % relative humidity. Test pieces shall be cut from the specimen and tested in an atmosphere of 20 °C to 30 °C and 40 % to 60 % relative humidity.

In case of dispute, the conditioning shall be 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.

4.2 Drying

Unless otherwise specified, the following drying procedure shall be used.

Dry the test pieces in a ventilated oven at 105 °C ± 5 K.

The minimum drying time as a function of the thickness s expressed in millimetres shall be as follows:

Nominal thickness s (mm)	$\leq 0,5$	$0,5 < s \leq 1,5$	$1,5 < s \leq 5$	> 5
Time (h)	12	24	48	72

4.3 Tolerances

When tolerances are not specified for the dimensions of the test piece, it is understood that these dimensions are taken to the nearest millimetre.

4.4 Results

As a general rule, the central value is reported as the result. When agreed between parties, the mean value may be reported. This must be noted in the test report.

5 Thickness

For material with a grammage of less than 224 g/m^2, use the procedure as described in ISO 534. For materials with a grammage of 224 g/m^2 or more, use the following test:

5.1 Test apparatus

One of the test apparatus described below shall be used.

NOTE In case of dispute, the test apparatus should be the one described in 5.1.2.

5.1.1 Screw type micrometer

An external screw type micrometer having measuring faces of 6 mm to 8 mm diameter. The measuring faces shall be flat to within 0,001 mm and parallel to within 0,003 mm. The pitch of the screw shall be 0,5 mm and the graduations shall be 50 divisions 0,01 mm, enabling readings to be estimated to 0,002 mm. The pressure exerted on the test piece shall be 0,1 MPa to 0,3 MPa.

NOTE For thin, soft material (for instance, board type B.5.1, 1 mm) the error due to the pressure of the micrometer can be as great as 2 % of the measured value.

5.1.2 Dead weight micrometer

A dead weight dial type micrometer having two ground and lapped measuring concentric circular surfaces flat to within 0,001 mm and parallel to within 0,003 mm. The upper surface shall be 6 mm to 8 mm diameter. The lower surface shall be larger than the upper surface. The upper surface shall move on the axis perpendicular to the surfaces. The dial shall be graduated to read directly to 0,002 mm. The frame of the micrometer shall be of such rigidity that a force of 15 N applied to the dial housing, out of contact with either the weight or the presser foot spindle, will produce a deflection of frame not greater than 0,002 mm as indicated on the micrometer dial. The pressure exerted on the test piece shall be 0,1 MPa to 0,3 MPa.

5.1.3 Dial gauge micrometer

As an alternative to 5.1.2, a "Dial gauge type micrometer" with the following characteristics may be used:

Diameter of the upper measuring surface: (14,3 ± 0,5) mm.

Diameter of the lower measuring surface: bigger than the upper one.

Pressure exerted on the test piece: (0,055 ± 0,005) MPa.

The two measuring surfaces shall be parallel to within 0,005 mm or 1 %.

NOTE The values recorded with this apparatus could be significantly different from the ones recorded with the two other types.

5.2 Setting gauge

The setting gauge used to check the instruments shall be accurate to within ±0,001 mm of nominal thickness. The thickness indicated by the instruments shall not differ by more than 0,005 mm from the gauge block.

5.3 Procedure

Measure the thickness of the pressboard or the presspaper in the as received condition using one of the instruments described in 5.1 at points not less than 20 mm from the edges.

For the pressboard, the number of measurements shall be eight, two along each edge. For presspaper in reels, 5.1 of IEC 60554-2 must be followed. When measuring across the width of a reel, the number of measurements shall be five per metre.

In case of dispute, cut a strip 40 mm wide across the full width of the material and, from this strip, at eight equally spaced positions, cut eight test pieces, each not less than 40 mm long. Condition the test pieces in accordance with 4.1 and measure the thickness of each specimen at a point near the centre of each test piece using the instrument described in 5.1.2.

5.4 Results

The central value is taken as the result and reported together with the minimum and maximum values.

6 Apparent density

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

Use rectangular test pieces of an area not less than 100 cm^2 and determine the mass to an accuracy of $10^{-4} \times$ mass of test piece.

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

Determine the thickness by making eight measurements as indicated in 5.3 and calculate the mean value of the measurements.

Express the apparent density ρ (the mass to volume ratio) 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.

Report all three values. The central value shall be taken as the result.

7 Tensile strength and elongation

7.1 Principle

Measurement of the tensile force required under standardized test conditions to cause failure of test pieces 15 mm × 250 mm cut from both directions of the material.

The tensile strength, in MPa, is calculated by the formula:

$$\sigma = \frac{F}{w \times a}$$

where

F is the force, in N;

w is the width of the specimen, in mm;

a is the thickness of the specimen, in mm.

7.2 Determination with non-folded test pieces

Tensile strength and elongation shall be measured according to the method described in ISO 1924-2 with the following exceptions:

Nine measurements are made on test pieces cut in the machine direction and nine others on test pieces cut in the cross machine direction.

The central values are taken as the results and reported together with the maximum and minimum values.

7.3 Determination with folded test pieces

(This test applies to presspaper with a thickness ≤ 0,5 mm only.)

The test pieces are bent over by hand in the middle of their length and at right angles to the longitudinal edges of the test pieces as shown in Figure 1a. They are then fed through the rollers of the folding apparatus illustrated in Figure 2 with the longitudinal edge of the specimen lying against the guide. Following this, the folded specimen is bent by hand as shown in Figure 1b, and again passed through the rollers of the folding apparatus. After unfolding, the specimen is tested according to 7.2.

8 Internal tearing resistance

(This test applies to presspaper with a thickness ≤ 0,5 mm only.)

Measurement of the force required to tear rectangular specimens having a single cut leaving a 43 mm length to be torn.

The internal tearing resistance shall be measured according to the method described in ISO 1974 with the following exceptions:

A single tear tester shall be used.

Nine test pieces shall be taken from each direction of the presspaper.

The central values are taken as the results and reported together with the maximum and minimum values obtained.

9 Edge tearing resistance

(This test applies to presspaper with a thickness ≤ 0,5 mm only.)

9.1 Procedure

This test shall be made as prescribed in Clause 10 of IEC 60554-2, with the following exception:

Test pieces shall be conditioned as described in 4.1.

9.2 Results

The results shall be reported as prescribed in 10.4 of IEC 60554-2.

10 Compressibility

(This test applies to pressboard with a thickness ≥ 0,5 mm only.)

10.1 Principle

To determine the compressibility of pressboard, a stack of test pieces is subjected to a low pressure (bedding pressure), followed by an increase of the pressure to a defined value (final pressure). The percentage change in 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 change in thickness of the pad allows calculation of the reversible/residual compressibility of the material.

10.2 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.

10.3 Test pieces

Cut a sufficient number of square test pieces with an edge length of (25 ± 0,5) mm. The number of test pieces shall be chosen so that three stacks of a height of 25 mm to 50 mm can be made. All edges of the test specimen shall be free of burrs. The test pieces shall be dried in an oven at 105 °C ± 5 K for 4 h to 24 h. Subsequently the oven shall be evacuated at approximately 1 kPa. The complete drying period shall be 24 h to 48 h.

10.4 Procedure

Place a stack of test pieces between the plates of the test rig. Apply a bedding pressure of 1 MPa for at least 5 min and then measure the height h_0 of the stack with an accuracy of ±0,1 mm.

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

Measure the difference in height Δh_1 from h_0 of the stack with an accuracy of ± 0,01 mm.

Reduce the pressure to 1 MPa and keep it for not less than 5 min.

Measure the difference in height Δh_2 from h_0 of the test piece with an accuracy of ± 0,01 mm after the bedding pressure has been restored.

10.5 Results

Report the following calculated values:

Compressibility (in %):

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

Residual part of compressibility (in %):

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

Reversible amount of compressibility (in %):

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

Report all three values. The central value shall be taken as the result.

11 Shrinkage

(This test applies to pressboard with a thickness ≥ 0,5 mm only.)

11.1 Test apparatus

Thickness measuring device as described in Clause 5.

Double prick punch with a distance between the pricks of (200 ± 1) mm as shown in Figure 3.

Measuring calliper with an accuracy of 0,01 mm as shown in Figure 4.

Setting gauge with a hole distance of (200 ± 1) mm.

Clamping device designed to hold the test piece flat during punching and measuring.

11.2 Test pieces

Cut six test pieces measuring 50 mm × 300 mm, three being in the machine direction and three in the cross machine direction.

11.3 Procedure

Condition the test pieces according to 4.1. Determine the moisture content of the conditioned test piece according to Clause 13.

Clamp the test piece in the clamping device and apply two holes along the middle line of the test piece with the double prick punch. Measure the distance between the holes with the calliper to an accuracy of 0,01 mm.

Measure the thickness of the test piece at three equally spaced, marked positions according to Clause 5.

Dry the test pieces as described in 4.2.

After cooling at room temperature in a desiccator, the distance between the holes and the thickness are measured again.

Alternatively, the overall length of the test specimen can be measured with a calliper gauge.

11.4 Results

The shrinkage in length for both directions and the shrinkage in thickness is calculated as the difference in dimension before and after drying, taken as a percentage of the dimension before drying of the conditioned test piece.

Report all three values for each three directions together with the moisture content of the test pieces before drying. The central value shall be taken as the result.

12 Plybond resistance

12.1 Principle

Measure the force perpendicular to the plane of the plies which is necessary to tear a test piece in two parts parallel to the plies.

12.2 Test pieces

Cut six test pieces 30 mm × 30 mm to an accuracy of ±0,3 mm out of a sample taken not less than 25 mm from the edge of the sheet. Both machine direction and cross direction shall be noted on the test pieces.

Condition the test pieces according to 4.1.

12.3 Test apparatus

A tensile machine equipped with a special testing device as described Figure 5.

12.4 Test method

The conditioned test pieces are removed from the conditioning atmosphere just prior to the test.

Coat both jaws of the testing device with a double-sided adhesive tape of a suitable type. Insert the test piece exactly between the jaws, the front edge being in line with the front edge of the jaws to 0,5 mm.

Insert the jaws under the plates of a press and apply a compressive force of 10 kN for materials with a thickness of < 0,5 mm and (25 ± 1) kN for materials with a thickness of ≥0,5 mm for 3 min to 4 min. The force shall be applied perpendicular to the test piece surface in order to ensure a correct adhesion of the test piece to the jaws of the testing device.

Within 30 s, insert the testing device equipped with the test piece between the jaws of the tensile testing machine and start the machine immediately. The speed of the driven jaw of the testing machine shall be 5 mm/min to 10 mm/min.

Three tests shall be made with the cross direction parallel to the front edge of the testing device and three tests shall be made with the machine direction parallel to the front edge of the testing device.

The plybond resistance is defined as the topmost value of the force applied.

The three first tests give the plybond resistance in the machine direction; the three others give the plybond resistance in the cross machine direction.

NOTE The double-sided adhesive tape should be such that the splitting occurs between the plies of the test piece. This can be easily checked by ensuring that at least one ply remains stuck to either jaw of the special testing device after splitting. If this is not the case, the double-sided adhesive tape is not of the so-called suitable type.

12.5 Results

Report as plybond resistance the central value in both directions expressed in N per 30 mm of width. Report all three values obtained.

13 Moisture content

The moisture content of material, as received, shall be measured in accordance with ISO 287 (oven drying method).

The method consists of weighing the test pieces at the time of sampling and again after a drying period, which led to a constant mass of the test piece. The drying shall be carried out as described in 4.2.

The mass of the test piece shall be at least 20 g and its area at least 100 cm^2. Three test pieces shall be taken.

Report all three values. The central value shall be taken as the result.

In case of dispute, the test shall be carried out on 10 test pieces taken at random on different portions of the consignment.

14 Ash content

The amount of residue of material left after incineration of the material shall be determined according to the method described in ISO 2144. The mass of the test piece shall be about 5 g. Three determinations shall be made and the result expressed in per cent of the initial mass of incinerated oven dry material, dried as described in 4.2.

Report all three values. The central value shall be taken as the result.

15 Conductivity of aqueous extract

NOTE Most standard conductivity meters give the conductivity in μS/cm and mS/cm. Therefore, for easy calculation, μS/cm will be used throughout this clause.

15.1 Test apparatus

A conductivity meter, capable of measuring the conductivity in a range of 0 μS/cm to 500 μS/cm and an accuracy of ±1 % of the relevant range.

A conductivity cell with a measurement range of 0 μS/cm to 500 μS/cm.

Wide-mouth 250 cm^3 conical flasks with reflux condensers in acid- and alkali-resistant glass.

15.2 Procedure

The determination shall be made on the material as received. First, a blank test shall be carried out in water, which has been boiled for (60 ± 5) min in the flask to be used. If the conductivity of this water is not more than 2 μS/cm, the flask may be used. If the conductivity is more than this value, then the flask shall be boiled with a fresh portion of water. If the conductivity of the second test exceeds 2 μS/cm then another flask shall be used.

The test on the material shall then be carried out as follows:

Cut a specimen weighing approximately, but not less than 20 g, from the entire thickness of the material under test into pieces of about 10 mm × 10 mm and of a thickness not greater than 1 mm. Weigh (5 ± 0,1) g of the material into a 250 cm^3 glass flask with a reflux condenser and add (100 ± 0,75) cm^3 water having a conductivity of not more than 2 μS/cm. The water shall be boiled gently for (60 ± 5) min, and then cooled in the flask to room temperature. It is necessary to take precautions against the absorption of carbon dioxide from the air.

The extract is then decanted into the measuring vessel for the conductivity to be measured immediately. The measuring vessel shall be rinsed twice with the extract. The measurement of the conductivity shall be made at 20 °C ± 0,5 K. If the measuring instrument is capable of calculating a temperature compensation, the measurement can be made at 20 °C to 25 °C. The value shall then be reduced to a temperature of 20 °C.

Three extracts shall be prepared and measured.

NOTE It is essential to ensure during the sampling, storing and manipulation of test pieces and test portions intended for tests for conductivity and pH of aqueous extract, that they are not contaminated either by the atmosphere, particularly the atmosphere of a chemical laboratory, or by handling with bare hands.

15.3 Results

Calculate the conductivity of the extract solution as follows:

$$\gamma = \frac{\gamma_1 - \gamma_0}{10}$$

where

γ is the conductivity of the extract solution, in mS/m;

γ_1 is the measured value of the conductivity of the extract solution, in μS/cm;

γ_0 is the measured value of the conductivity of the blank, in μS/cm.

Report all three values. The central value shall be taken as the result.

16 pH of aqueous extract

16.1 Test apparatus

A pH meter having a sensitivity of at least 0,05 pH units.

pH electrodes capable of measuring the pH value in water with a low ion content.

Wide-mouth 250 cm^3 conical flasks with reflux condensers in acid- and alkali-resistant glass.

16.2 Procedure

Prepare three extracts as described in 15.2.

The extract shall be decanted only for immediate use, avoiding unnecessary exposure to the atmosphere.

Calibrate the pH meter with a buffer solution having a pH value within ±2 pH units of that of the extract. Remove the electrodes from the buffer solution and wash them thoroughly by rinsing several times in distilled water and once in a small quantity of extract.

Immerse the electrodes in the unfiltered extract and measure the pH value of the extract at 20 °C to 25 °C.

NOTE 1 If the extract is to be used for the determination of conductivity, the sample for this determination should be drawn from the aqueous extract prior to the pH determination. This is because the potassium chloride, which diffuses from the combined glass electrode, would otherwise affect the result.

NOTE 2 See Note to 15.2.

16.3 Results

Report all three values. The central value shall be taken as the result.

17 Oil absorption

17.1 Test pieces

Cut three rectangular test pieces of an area not less than 100 cm^2 from the material to be tested.

17.2 Procedure

Suspend the test pieces for 24 h in a vacuum cabinet having a pressure of about 1 kPa and at a temperature of 105 °C ± 5 K. After lifting the vacuum slowly, allow the test pieces to cool in a desiccator, and weigh each test piece to determine its mass m_1 to an accuracy of $10^{-4} \times m_1$.

After the mass has been determined, the test piece shall be suspended in the vacuum cabinet again, the temperature shall be raised to 70 °C to 90 °C and the pressure reduced to <1 kPa. The temperature and the pressure shall be maintained for at least 1 h. Then oil conforming with the requirements of Class II in IEC 60296, preheated to 70 °C to 90 °C, shall be admitted at a rate slow enough to ensure that the pressure is maintained at not more than 1,5 kPa.

When the test pieces are completely submerged, lift the vacuum and switch off the heating. The specimens are left in the oil for 6 h. The test pieces are then taken out of the oil and the surplus of oil removed with blotting paper. The clean test pieces are weighed and their new mass m_2, is determined with an accuracy of $10^{-4} \times m_2$.

17.3 Results

The oil absorption in % of the mass of the material is given by the formula:

$$A = \frac{m_2 - m_1}{m_1} \times 100$$

where

A is the oil absorption in % of the mass of the test piece before impregnation;

m_1 is the mass in g of the test piece before impregnation;

m_2 is the mass in g of the impregnated test piece.

The central value is taken as the result, the two others are reported.

18 Conducting paths

(This test is applicable to presspaper with a thickness < 0,5 mm only.)

The test shall be carried out according to 26.1 of IEC 60554-2.

19 Presence of metallic particles

NOTE Any of the methods described below can be used for the determination.

19.1 Chemical methods

NOTE 1 The three chemical methods described below will only show ferrous particles as well as copper, brass and bronze particles.

NOTE 2 In all three methods, the purity of the chemicals is important. The quality should be at least p.a. (per analysis).

19.1.1 Test piece

A square with sides of approximately 100 mm.

19.1.2 Procedure – Method 1

Immerse the test piece completely in a 1 % (volume) solution of acetic acid for a period of at least 5 min. Remove the test piece from the solution and dry it in a dust-free atmosphere on an ash-less filter paper. When dry, immerse the test piece for a period of 5 min in a solution containing 1 cm^3 acetic acid and 1 g potassium ferrocyanide per litre. Remove the test piece from the solution, rinse it with distilled water and dry it in an oven at about 50 °C.

19.1.3 Procedure – Method 2

NOTE This method is to be used for a quick determination of metallic particles on the surface of the material.

Impregnate a pad of tissue paper with hydrochloric acid with a concentration of 10 % and dab regularly both sides of the test piece in order to wet them uniformly with hydrochloric acid.

Dry it in an oven without forced air circulation for about 5 min at about 105 °C until the surface appears dry.

Recommence the same operation with a pad of tissue impregnated with potassium ferrocyanide (50 g/l).

19.1.4 Procedure – Method 3

Hang a test piece of about 300 mm × 600 mm or of an equivalent area in clean dust-free air .

Use a vaporizer to spray the test piece with a solution of 10 % of nitric acid to which one drop of 5 % potassium permanganate per 100 ml has been added.

Allow to dry and further spray a solution of 5 % potassium ferrocyanide in the same way.

19.1.5 Results

Examine the test piece for coloured stains. Zones faintly coloured in blue or in red shall be disregarded. Blue stains indicate the presence of iron, red stains indicate the presence of copper, brass or bronze.

Report for each side of the test piece the number of coloured stains and their colour.

Method 1 allows, when checking the different layers of the test piece, the detection of metal particles embedded in the material itself. The number and colour of the embedded particles shall be reported.

NOTE 1 Because these methods are extremely sensitive, it is not easy to derive a conclusion from the tests. The mere fact of cutting the test sample will cause blue traces to appear on the edges and at every point which have been in contact with iron tools.

NOTE 2 The oven used for the drying must be very clean; otherwise the ventilation can transport particles to the surface of the test pieces.

NOTE 3 The test specimen must be inspected immediately after drying, because even after a short period of time the potassium ferrocyanide will react with the oxygen from the air and the whole test piece will become bluish.

19.2 X-ray method

19.2.1 Test piece

A rectangular piece of material size A4 (210 mm × 297 mm) or bigger is taken from the consignment and thoroughly blown on both sides with dry clean air to remove any dust which could lie on or cling to the surface.

19.2.2 Test apparatus

An X-ray apparatus (Roengten tube) with adjustable exposure time, current, voltage and film-to-source-distance (FTSD), capable of housing a test piece of the required size.

NOTE 1 An X-ray apparatus with the following characteristics has been found to be suitable:

Exposure time	0 min to ≥2 min
Voltage	10 kV to 110 kV
Film-to-source-distance (FTSD)	> 600 mm
Focal spot	0,5 mm to 0,7 mm
Tube current	3 A to 5 A

An X-ray film with extra fine grain and a very high resolution.

Adequate means necessary to develop X-ray films.

A device to enable reading X-ray photographs.

NOTE 2 The X-ray equipment must meet the local radiation safety regulations.

19.2.3 Test method

Place the test piece directly onto the X-ray film. Adjust the settings of the Roengten tube (time, voltage and current). Make one full size photograph of the test piece (scale 1:1).

NOTE A sufficient resolution is obtained with long exposure times and rather low voltages.

After developing the film, insert the photograph in the photograph reader and check for bright spots on the film.

Heavy metal particles will appear as shiny spots. Other embedded particles, including aluminium, appear as a light spot against a greyish background.

19.2.4 Results

Count the total number of shiny spots and classify them in a table according to their apparent diameter Ø:

- Ø < 0,1 mm
- ≤ 0,1 mm Ø ≤ 0,25 mm
- Ø > 0,25 mm

Count the number of other impurities (light spots).

Calculate the number of shiny spots within each diameter range per dm^2 and report these values.

Calculate the number of other impurities per dm^2 and report this value.

20 Electric strength

The test shall be carried out at 23 °C ± 3 K in air and in oil in accordance with IEC 60243-1 .

20.1 Test apparatus

The apparatus shall be in accordance with Clause 7 of IEC 60243-1. The electrodes shall be in accordance with 4.1.1 of that standard. The faces of the electrodes shall be parallel and free from pits or other imperfections.

20.2 Test pieces for test in air

Test pieces 300 mm × 300 mm, shall be dried as described in 4.2.

After the drying period has passed, the test pieces shall be cooled in a desiccator and tested within 3 min of removal from the desiccator.

20.3 Test pieces for test in oil

Test pieces 300 mm × 300 mm, shall be suspended for 24 h in a vacuum cabinet at 105 °C ± 5 K and under a pressure of less than 100 Pa. Then oil, complying with the requirements of Class II of IEC 60296, preheated at 80 °C ± 10 K shall be admitted at a rate slow enough to ensure that the pressure is maintained at no more than 250 Pa.

When the test pieces are completely submerged, the vacuum is released and the test pieces allowed to stand immersed in oil at atmospheric pressure and at a temperature of 80 °C ± 10 K for not less than 24 h. The test pieces are then cooled to 23 °C ± 5 K while completely immersed in oil and the electrodes placed in position.

NOTE 1 Materials with a thickness above 3 mm must be milled to a thickness of 3 mm.

NOTE 2 If impregnated test pieces are exposed to air, there is a risk of air bubble adsorption at the material surface.

20.4 Test pieces for testing after folding

(This test applies to presspaper with a thickness ≤0,5 mm only.)

Test pieces (300 × 300) mm, shall be dried in accordance with 4.2. Make one fold parallel to each of the four edges and about 40 mm from the edge.

The folds are made as follows. The test piece is inserted as far as it will go into the slit of the device illustrated in Figure 6, bent by hand through 90° to one side and then through a further 90° to the other side.

The folded test pieces are then fed through the rollers of the folding apparatus shown in Figure 7, the fold lying against the guide. Next, the fold of the test pieces is bent back by hand through 360° and the test piece again passed through the rollers of the folding apparatus. This double folding action is performed on all four edges of the test pieces.

The test piece is unfolded before testing.

The folding and subsequent testing after unfolding shall be carried out as quickly as possible. If necessary the "3 min-limit" in 20.2 may be exceeded but in any case testing shall be completed in no more than 10 min.

20.5 Number of tests

For tests in air and in oil, nine measurements shall be made.

For the tests after folding, five measurements are made along each of the two longitudinal folds and five measurements along each of the two transverse folds avoiding the four points at which the folds cross each other.

20.6 Procedure

The application of voltage shall be in accordance with 9.1 of IEC 60243-1.

For criterion of breakdown, see Clause 10 of IEC 60243-1.

20.7 Results

The report shall be in accordance with Clause 12 of IEC 60243-1.

The central value, expressed as kV/mm, based on the measured thickness is taken as the result for each set of measurements; the lowest value of each set is also reported. The sets consist of nine measurements each in the case of tests in air and in oil, and 10 measurements each in tests on longitudinal and on transverse folds.

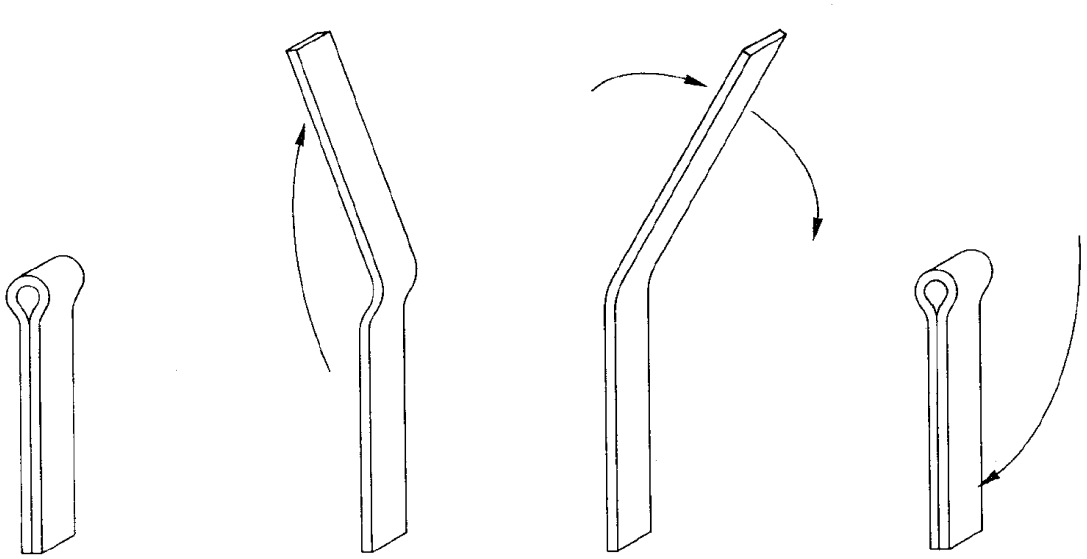


Figure 1a Figure 1b

IEC 741/04

Figure 1 – Folding sequence

Dimensions in millimetres

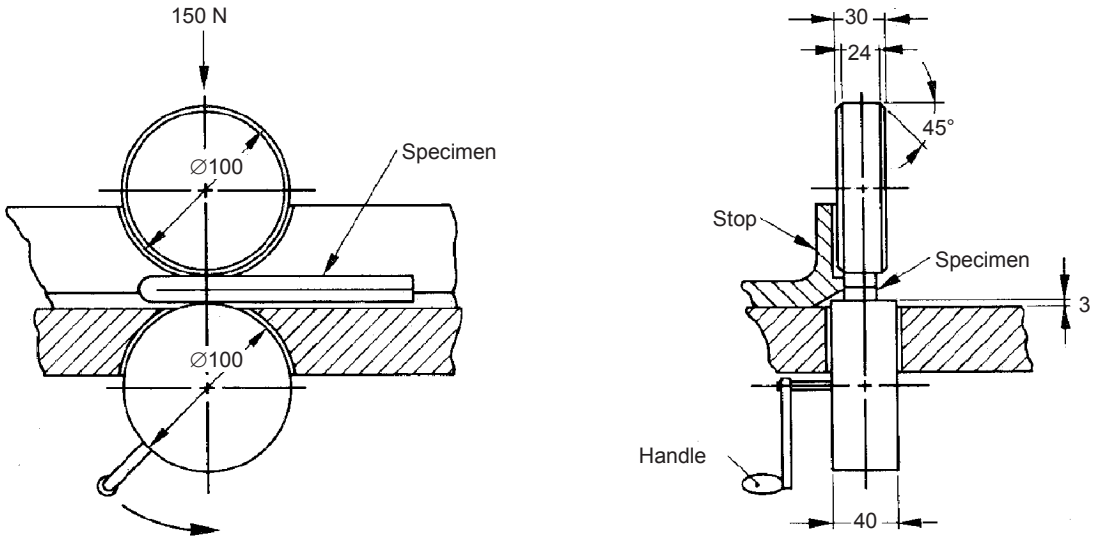
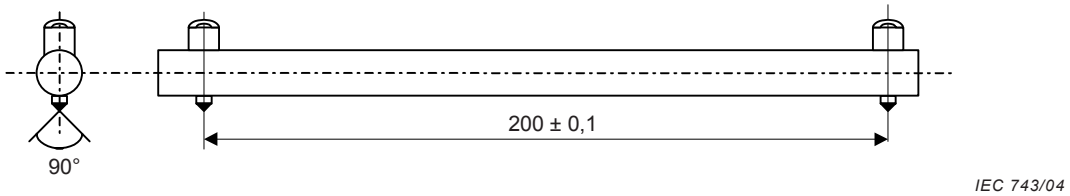


Figure 2 – Folding apparatus

IEC 742/04

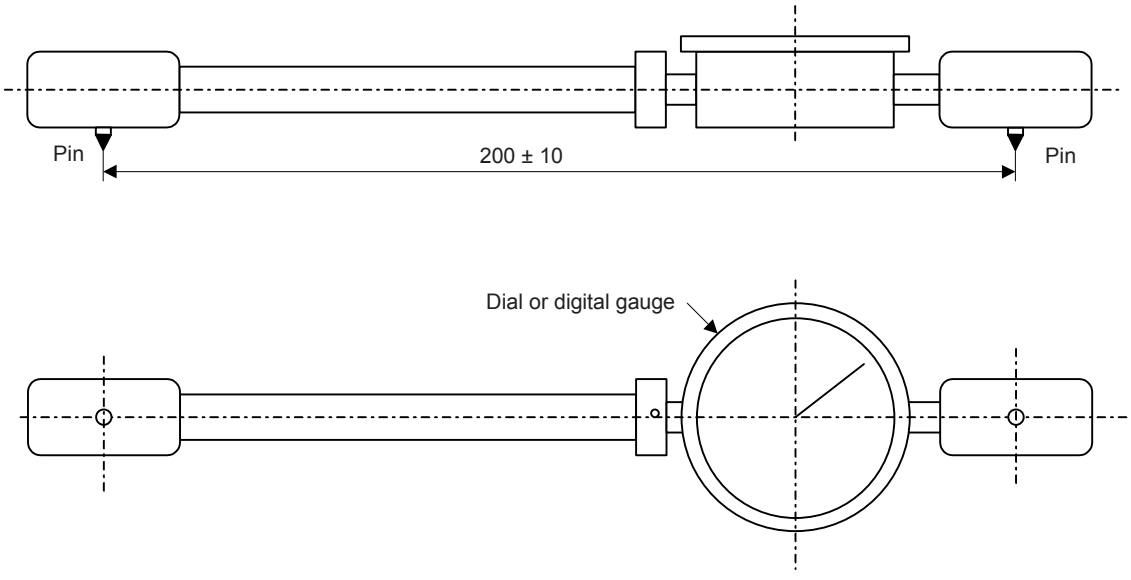
Dimensions in millimetres



IEC 743/04

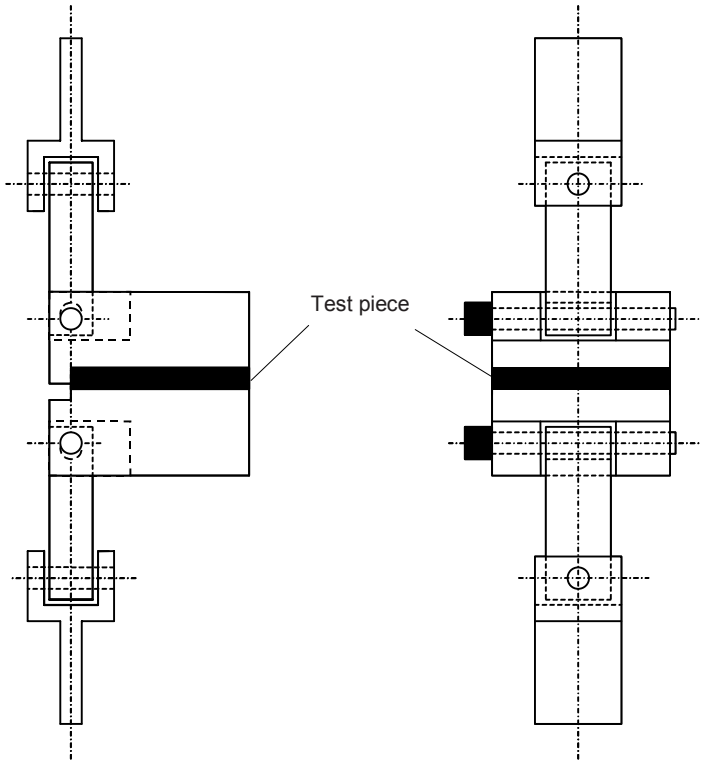
Figure 3 – Double prick punch

Dimensions in millimetres



IEC 744/04

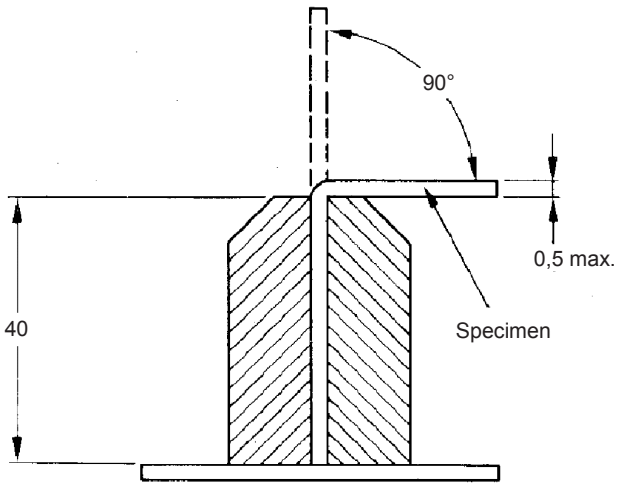
Figure 4 – Measuring calliper



IEC 745/04

Figure 5 – Plybond resistance tester

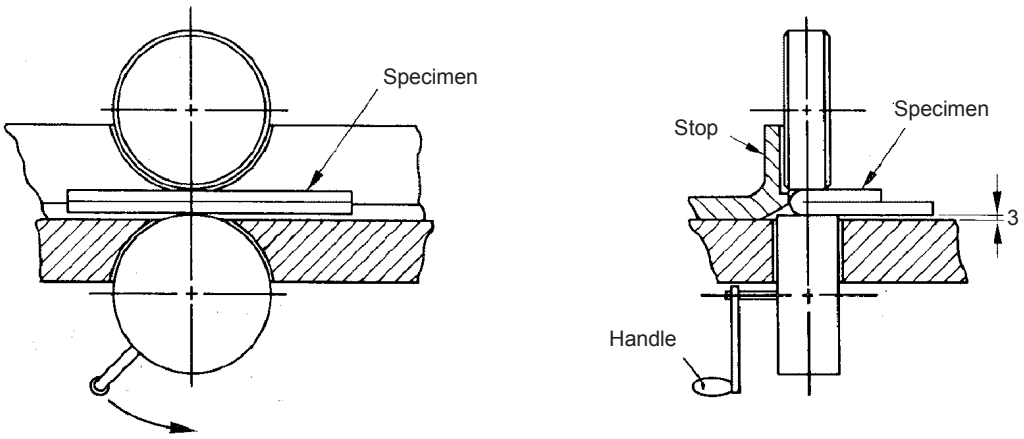
Dimensions in millimetres



IEC 746/04

Figure 6 – Folding device

Dimensions in millimetres



IEC 747/04

Figure 7 – Folding apparatus
(For dimensions, see Figure 2)

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 60243-1	1998	Electrical strength of insulating materials - Test methods Part 1: Tests at power frequencies	EN 60243-1	1998
IEC 60296	2003	Fluids for electrotechnical applications - Unused mineral insulating oils for transformers and switchgear	EN 60296 + corr. September	2004 2004
IEC 60554-2	2001	Cellulosic papers for electrical purposes Part 2: Methods of test	EN 60554-2	2002
ISO 287	1985	Paper and board - Determination of moisture content - Oven-drying method	EN 20287	1994
ISO 534	1988	Paper and board - Determination of thickness and apparent bulk density or apparent sheet density	EN 20534	1993
ISO 1924-2	1994	Paper and board - Determination of tensile properties Part 2: Constant rate of elongation method	EN ISO 1924-2	1995
ISO 1974	1990	Paper - Determination of tearing resistance (Elmendorf method)	EN 21974	1994
ISO 2144	1997	Paper, board and pulps - Determination of residue (ash) on ignition at 900 degrees C	-	-

Bibliography

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

ISO 186:2002, *Paper and board – Sampling to determine average quality*

———————

BSI — British Standards Institution

BSI is the independent national body responsible for preparing British Standards. It presents the UK view on standards in Europe and at the international level. It is incorporated by Royal Charter.

Revisions

British Standards are updated by amendment or revision. Users of British Standards should make sure that they possess the latest amendments or editions.

It is the constant aim of BSI to improve the quality of our products and services. We would be grateful if anyone finding an inaccuracy or ambiguity while using this British Standard would inform the Secretary of the technical committee responsible, the identity of which can be found on the inside front cover. Tel: +44 (0)20 8996 9000. Fax: +44 (0)20 8996 7400.

BSI offers members an individual updating service called PLUS which ensures that subscribers automatically receive the latest editions of standards.

Buying standards

Orders for all BSI, international and foreign standards publications should be addressed to Customer Services. Tel: +44 (0)20 8996 9001. Fax: +44 (0)20 8996 7001. Email: orders@bsi-global.com. Standards are also available from the BSI website at http://www.bsi-global.com.

In response to orders for international standards, it is BSI policy to supply the BSI implementation of those that have been published as British Standards, unless otherwise requested.

Information on standards

BSI provides a wide range of information on national, European and international standards through its Library and its Technical Help to Exporters Service. Various BSI electronic information services are also available which give details on all its products and services. Contact the Information Centre. Tel: +44 (0)20 8996 7111. Fax: +44 (0)20 8996 7048. Email: info@bsi-global.com.

Subscribing members of BSI are kept up to date with standards developments and receive substantial discounts on the purchase price of standards. For details of these and other benefits contact Membership Administration. Tel: +44 (0)20 8996 7002. Fax: +44 (0)20 8996 7001. Email: membership@bsi-global.com.

Information regarding online access to British Standards via British Standards Online can be found at http://www.bsi-global.com/bsonline.

Further information about BSI is available on the BSI website at http://www.bsi-global.com.

Copyright

BSI
389 Chiswick High Road
London
W4 4AL