

Insulating materials — Industrial rigid laminated sheets based on thermosetting resins for electrical purposes —

Part 2: Methods of test

The European Standard EN 60893-2:2004 has the status of a British Standard

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National foreword

This British Standard is the official English language version of EN 60893-2:2004. It is identical with IEC 60893-2:2003. It supersedes BS EN 60893-2:1995 which is withdrawn.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:

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**Insulating materials –
Industrial rigid laminated sheets
based on thermosetting resins for electrical purposes
Part 2: Methods of test
(IEC 60893-2:2003)**

Matériaux isolants –
Stratifiés industriels rigides en planches
à base de résines thermodurcissables
à usages électriques
Partie 2: Méthodes d'essai
(CEI 60893-2:2003)

Isolierstoffe –
Tafeln aus technischen
Schichtpressstoffen auf der Basis
warmehärtender Harze für
elektrotechnische Zwecke
Teil 2: Prüfverfahren
(IEC 60893-2:2003)

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CENELEC

European Committee for Electrotechnical Standardization
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Europäisches Komitee für Elektrotechnische Normung

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Foreword

The text of document 15C/1488/FDIS, future edition 2 of IEC 60893-2, 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 60893-2 on 2004-05-01.

This European Standard supersedes EN 60893-2:1994.

The major changes during the revision of the EN 60893 series are the following:

- a) new material types have been included;
- b) changes have been made to the property requirements of some existing types;
- c) a new method for testing permittivity and dissipation factor has been added;
- d) all non-specification data for each type has been moved to a new Part 4 document – IEC/TR 60893-4: Typical values.

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) 2005-02-01
- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) 2007-05-01

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60893-2:2003 was approved by CENELEC as a European Standard without any modification.

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INDUSTRIAL RIGID LAMINATED SHEETS BASED ON THERMOSETTING RESINS FOR ELECTRICAL PURPOSES –

Part 2: Methods of test

1 Scope

This part of IEC 60893 describes methods of test for the materials defined in IEC 60893-1 (referred to also as Part 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 60112, *Method for determining the comparative and the proof tracking indices of solid insulating materials under moist conditions*

IEC 60167:1964, *Methods of test for the determination of the insulation resistance of solid insulating materials*

IEC 60212:1971, *Standard conditions for use prior to and during the testing of solid electrical insulating materials*

IEC 60216-1:2001, *Electrical insulating materials – Properties of thermal endurance – Part 1: Ageing procedures and evaluation of test results*

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

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 60296:1982, *Specification for unused mineral insulating oils for transformers and switchgear*

IEC 60587:1984, *Test method for evaluating resistance to tracking and erosion of electrical insulating materials used under severe ambient conditions*

IEC 60695-11-10:1999, *Fire hazard testing – Part 11-10: Test flames – 50 W horizontal and vertical flame test methods*

IEC 60893-1, *Industrial rigid laminated sheets based on thermosetting resins for electrical purposes – Part 1: Definitions, designations and general requirements*¹

¹ Use edition 2 when published.

IEC 60893-3 (all parts 3), *Industrial rigid laminated sheets based on thermosetting resins for electrical purposes – Part 3: Specifications for individual materials*

IEC 60893-4:2003, *Industrial rigid laminated sheets based on thermosetting resins for electrical purposes – Part 4: Typical values*

ISO 62:1999, *Plastics – Determination of water absorption*

ISO 178:2001, *Determination of flexural properties*

ISO 179-1:2000, *Plastics – Determination of Charpy impact properties – Part 1: Non-instrumented impact test*

ISO 179-2:1997, *Plastics – Determination of Charpy impact properties – Part 2: Instrumented impact test*

ISO 180:2000, *Plastics – Determination of Izod impact strength*

ISO 527-1: 1993, *Plastics – Determination of tensile properties – Part 1: General principles*

ISO 527-4:1997, *Plastics – Determination of tensile properties – Part 4: Test conditions for isotropic and orthotropic fibre-reinforced plastic composites*

ISO 604:2002, *Plastics – Determination of compressive properties*

ISO 1183:1987, *Plastics – Methods for determining the density and relative density of non-cellular plastics*

ISO 3611:1978, *Micrometer callipers for external measurement*

3 Conditioning of test specimens

Unless otherwise specified, test specimens shall be conditioned for at least 24 h in standard atmosphere B according to IEC 60212 (temperature $23\text{ }^{\circ}\text{C} \pm 2\text{ K}$ relative humidity $(50 \pm 5)\%$).

Unless otherwise specified, each specimen shall be tested in the conditioning atmosphere and at the conditioning temperature, or the tests shall commence within 3 min of removal of each test specimen from the conditioning atmosphere.

Where testing at an elevated temperature is required in one of the specification sheets of IEC 60893-3, test specimens shall be conditioned for 1 h at that elevated temperature immediately before testing.

4 Dimensions

4.1 Thickness

4.1.1 General

Any method which enables the thickness of the laminated sheet to be measured at an appropriate number of points may be used, provided that the equipment used and the method of measurement are capable of a precision of 0,01 mm or better.

The following reference method has been shown to be suitable and shall be used in cases of dispute.

4.1.2 Test apparatus for reference method

In case of dispute, an external screw type micrometer according ISO 3611 having faces with diameters between 6 mm and 8 mm shall be used.

4.1.3 Procedure for reference method

Measure the thickness of the rigid laminated sheet as delivered to the nearest 0,01 mm at eight points, two along each edge but not less than 20 mm from the edge.

4.1.4 Results

Report the maximum and minimum measured values and the arithmetic mean of all measured values in mm.

4.2 Flatness

4.2.1 General

This test is applicable to all sheets having a thickness of 3 mm or greater.

4.2.2 Test specimens

The test specimen shall be the whole sheet or panel under test in the 'as received' condition.

4.2.3 Test method

When any sheet of nominal thickness 3,0 mm or more 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 1000 mm or 500 mm in length, laid in any direction upon it, shall not exceed the value given in the relevant sheet of IEC 60893-3 appropriate to the material, its thickness and length of straight edge. The mass of the 1000 mm straight edge shall not exceed 800 g, and the mass of the 500 mm straight edge shall not exceed 400 g.

4.2.4 Results

Report the maximum measured deviation from flatness in mm.

NOTE In cases where the sheet deviates from flatness in two directions, is saddle-shaped, measure both deviations and report the highest.

5 Mechanical tests

5.1 Flexural strength

5.1.1 General

The flexural strength is defined as the flexural stress at rupture. It shall be determined by the method specified in ISO 178.

5.1.2 Test specimens

Cut the test specimens from the sheet to be tested with their major axes parallel to the sides of the sheet. Test five test specimens in each direction, except for types with fibres aligned mainly in the same direction. In such cases, cut five specimens only, with their long axis parallel to the direction of the fibres.

If the nominal thickness of the sheet to be tested is more than 10 mm (20 mm in the case of types PF WV), reduce the thickness of the test specimens to 10 mm (20 mm in the case of PF WV).

When it is necessary to reduce the thickness of a test specimen, machine it, leaving one face of the sheet intact. In such cases, test specimens shall be tested with the original surface of the sheet in contact with the two supports.

5.1.3 Test method

The test shall be carried out with the load applied perpendicular to the plane of the laminations. The test speed shall be 5 mm/min with a tolerance of ± 20 %.

5.1.4 Results

Report the arithmetic mean of the results for each direction in MPa. Take the lower of the two mean values as the minimum flexural strength of the sheet under test, except in cases where the reinforcing fibres run mainly in one direction. In such cases, take the mean value obtained in this direction.

5.2 Modulus of elasticity in flexure

5.2.1 General

The following test method shall be used in order to determine the modulus of elasticity in flexure.

5.2.2 Test specimens

The specimens shall be in the same form as described for the flexural strength test described in 5.1.2 above.

5.2.3 Test method

Modulus of elasticity shall be determined by the method specified in ISO 178.

5.2.4 Results

Results shall be expressed in MPa.

5.3 Compressive strength

5.3.1 General

The following test method shall be used in order to determine the compressive strength.

5.3.2 Test specimens

Specimens shall be cut from the sheet under test as described in ISO 604.

5.3.3 Test method

Compressive strength shall be determined by the method specified in ISO 604 with the load applied perpendicular to the plane of the laminations.

5.3.4 Results

Results shall be expressed in MPa.

5.4 Impact strength

5.4.1 General

This test is only applicable to sheets of nominal thickness equal to or greater than 5 mm.

5.4.2 Charpy Impact strength

5.4.2.1 Test specimens

Test specimens shall be cut from the sheet under test in accordance with Figure 1a. Five specimens, with a thickness between 5 mm and 10 mm, shall be tested in each direction, except for types with fibres aligned mainly in the same direction. In such cases, cut five specimens only, with their longitudinal axis parallel to the direction of the fibres.

If the nominal thickness of the sheet to be tested is greater than 10 mm, reduce the thickness of the test specimen to 10 mm by machining equal amounts from both faces of the sheet.

5.4.2.2 Test method

The Charpy impact strength shall be determined in the edgewise direction as described by the method given in ISO 179-1 and ISO 179-2 except that the specimens shall be as described above, and the span shall be 70 mm. The material shall be tested with the major axes in each direction parallel to the sides of the sheet, except in the case of materials whose fibres lie mainly in the same direction. For these materials only specimens with their longitudinal axis parallel to the direction of the fibres shall be tested.

5.4.2.3 Results

Report the arithmetic mean of the results for each direction in kJ/m². Take the lower of the two mean values as the minimum Charpy impact strength of the sheet under test, except in cases where the reinforcing fibres run mainly in one direction. In such cases, take the mean value obtained in this direction.

5.4.3 Izod impact strength

5.4.3.1 Test specimens

The dimensions of the specimens shall be as described in Figure 1b. Five specimens, with a thickness between 5 mm and 10 mm, shall be tested in each direction, except for types with fibres aligned mainly in the same direction. In such cases, cut five specimens only, with their longitudinal axis parallel to the direction of the fibres.

If the nominal thickness of the sheet to be tested is greater than 10 mm, reduce the thickness of the test specimen to 10 mm by machining equal amounts from both faces of the sheet.

5.4.3.2 Test method

The Izod impact strength shall be determined in the edgewise direction as described by the method given in ISO 180. The material shall be tested with the major axes in each direction parallel to the sides of the sheet, except in the case of materials whose fibres lie mainly in the same direction. For these materials only, specimens with their longitudinal axis parallel to the direction of the fibres shall be tested.

5.4.3.3 Results

Report the arithmetic mean of the results for each direction in kJ/m^2 . Take the lower of the two mean values as the minimum Izod impact strength of the sheet under test, except in cases where the reinforcing fibres run mainly in one direction. In such cases, take the mean value obtained in this direction.

5.5 Shear strength parallel to laminations

5.5.1 General

The shear strength parallel to laminations test provides data that gives an indication of the degree of bonding or adhesion between laminations. The test is only applicable to sheets of nominal thickness greater than 5 mm.

5.5.2 Test specimens

Rectangular test specimens are cut with the following dimensions:

Length	20 mm $\pm$ 0,1 mm
Width and thickness	5 $\begin{smallmatrix} 0 \\ -0,15 \end{smallmatrix}$ mm

Cut the test specimens from the sheet to be tested with their major axes parallel to the sides of the sheet. Prepare five sets of test specimens for each direction, each set of specimens comprising two pieces.

The two specimens in each pair shall have widths (dimension along the laminations orthogonal to the length) identical within 0,01 mm.

5.5.3 Test method

Two test specimens are simultaneously subjected to shearing stress in the device shown in Figure 2.

The test specimens shall be arranged so that the shearing stress acts in a plane parallel to the laminations. The relative rate of movement of the cross head of the testing machine shall be 2 mm/min with a tolerance of $\pm 20\%$.

5.5.4 Results

Calculate the shear strength by dividing the shear force through the total shear plane area of $2 \times 100 \text{ mm}^2$.

Report the arithmetic mean value of the results for each direction in MPa and take the lower of the two mean values as the parallel shearing strength of the sheet under test.

5.6 Tensile strength

5.6.1 General

Tensile strength defined as tensile stress at maximum load shall be determined by the method specified in ISO 527-4, in conjunction with ISO 527-1.

5.6.2 Test specimens

Specimens shall be cut from the sheet under test with the major axis in each direction parallel to the sides of the sheet. Five specimens of nominal thickness between 1,5 mm and 10,0 mm shall be prepared from each direction according to type 1 of ISO 527-4, except in the case of materials whose fibres lie mainly in the same direction. For these materials only specimens with their longitudinal axis parallel to the direction of the fibres shall be tested.

If the sheet to be tested is more than 10 mm thick, reduce the thickness of the test specimens to 10 mm by machining equal amounts from each face.

5.6.3 Test method

Carry out the test as described in ISO 527-4. The rate of separation of the jaws of the testing machine shall be 5 mm/min with a tolerance of ± 20 %.

5.6.4 Results

Report the arithmetic mean of the results for each direction in MPa. Take the lower of the two mean values as the minimum tensile strength of the sheet under test, except in cases where the reinforcing fibres run mainly in one direction. In such cases, take the mean value obtained in this direction.

6 Electrical tests

6.1 Electric strength and breakdown voltage

6.1.1 General

Electric strength and breakdown voltage shall be determined by the methods specified in IEC 60243-1, which describes both the step-by-step and 60 s proof tests. Either test method may be used. Unless otherwise specified the test shall be carried out at $90\text{ }^{\circ}\text{C} \pm 2\text{ K}$ in mineral oil as described in IEC 60296, which is reasonably free from decomposition products. Immerse the specimens in oil maintained at that temperature for not less than 0,5 h and not more than 1 h immediately before test.

6.1.2 Test specimens

For electric strength, test three specimens normal to laminations. For breakdown voltage, test three specimens parallel to the laminations.

Test specimens shall be cut from the sheet under test. Specimen dimensions shall be as described in IEC 60243-1.

6.1.3 Test method

Test the material using either the 20 s step-by-step test as described in 9.2 of IEC 60243-1, or using the 60 s proof test as described in 9.6 of IEC 60243-1.

6.1.3.1 Electric strength perpendicular to laminations

For thicknesses not greater than 3 mm, the material shall be tested perpendicular to the laminations. The upper electrode shall be 25 mm in diameter and the lower electrode shall be 75 mm in diameter according to IEC 60243-1.