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Method for the determination of the proof and the comparative tracking indices of solid insulating materials

Méthode de détermination des indices de résistance et de tenue au cheminement des matériaux isolants solides

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

Method for the determination of the proof and the comparative tracking indices of solid insulating materials

FOREWORD

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IEC 60112 has been prepared by IEC technical committee 112: Evaluation and qualification of electrical insulating materials and systems. It is an International Standard.

This sixth edition cancels and replaces the fifth edition published in 2020. This edition constitutes a technical revision.

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

a) In 7.3, the term "resistivity" has been replaced by "conductivity".

It has the status of a basic safety publication in accordance with IEC Guide 104.

The text of this International Standard is based on the following documents:

Draft	Report on voting
112/679/FDIS	112/686/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

1 Scope

This document specifies the method of test for the determination of the proof and comparative tracking indices of solid insulating materials on pieces taken from parts of equipment and on plaques of material using alternating voltage.

This document provides a procedure for the determination of erosion when required.

The proof tracking index is used as an acceptance criterion as well as a means for the quality control of materials and fabricated parts. The comparative tracking index is mainly used for the basic characterization and comparison of the properties of materials.

This test method evaluates the composition of the material as well as the surface of the material being evaluated. Both the composition and surface condition directly influence the results of the evaluation and are considered when using the results in material selection process.

The described test method is designed for a test voltage up to 600 V AC, because higher test voltages and DC voltage will lead to a reduced test severity.

Test results are not directly suitable for the evaluation of safe creepage distances when designing electrical apparatus.

The results of this method have been used for insulation coordination of equipment. It is important that use of these results also considers the overvoltage levels, creepage distances, and establishes the pollution degree to which the product insulation system will be expected to be subjected. This is in compliance with IEC 60664-1.

This basic safety publication focusing on a safety test method is primarily intended for use by technical committees in the preparation of safety publications in accordance with the principles laid down in IEC Guide 104 and ISO/IEC Guide 51.

One of the responsibilities of a technical committee is, wherever applicable, to make use of basic safety publications in the preparation of its publications.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

ISO 4287, *Geometrical Product Specification (GPS) – Surface texture: Profile method – Terms, definitions and surface texture parameters*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
tracking
progressive formation of conducting paths, which are produced on the surface or within a solid insulating material or both, due to the combined effects of electric stress and electrolytic contamination

3.2
tracking failure
failure of insulation due to tracking between conductive parts

Note 1 to entry: In the present test, tracking is indicated by operation of an over-current device due to the passage of a current across the test surface or within the specimen or both.

3.3
electrical erosion
wearing away of insulating material by the action of electrical discharges

3.4
air arc
arc between the electrodes above the surface of the specimen

3.5
comparative tracking index
CTI
numerical value of the maximum voltage (in V) at which five test specimens withstand the test period for 50 drops without tracking failure and without a persistent flame occurring and including also a statement relating to the behaviour of the material when tested using 100 drops (see 11.3)

Note 1 to entry: No tracking failure and no persistant flame are allowed at any lower test voltage.

Note 2 to entry: The criteria for CTI can also require a statement concerning the degree of erosion.

Note 3 to entry: Although a non-persistent flame is allowed in the test without constituting failure, materials which generate no flame at all are preferred unless other factors are considered to be more important. See also Annex A.

Note 4 to entry: Some materials can withstand high test voltages, but fail at lower test voltages. See also 11.2.

3.6
persistent flame
flame which burns for more than 2 s

Note 1 to entry: In the present test, persistent flame is indicated by a visual check.

3.7
proof tracking index
PTI
numerical value of the proof voltage (in V) at which five test specimens withstand the test period for 50 drops without tracking failure and without a persistent flame occurring

Note 1 to entry: Although a non-persistent flame is allowed in the test without constituting failure, materials which generate no flame at all are preferred unless other factors are considered to be more important. See also Annex A.

3.8
de-ionized water
water for analytical laboratory use in accordance with ISO 3696, grade 3, or equivalent quality

4 Principle

The upper surface of the test specimen is supported in a horizontal plane and subjected to an electrical stress via two electrodes. The surface between the electrodes is subjected to a succession of drops of electrolyte either until the over-current device operates, or until a persistent flame occurs, or until the test period has elapsed.

The individual tests are of short duration (less than 1 h) with up to 50 or 100 drops of about 20 mg of electrolyte falling at 30 s intervals between platinum electrodes, 4 mm apart on the test specimen surface.

An AC voltage between 100 V and 600 V is applied to the electrodes during the test.

During the test, specimens may also erode or soften, thereby allowing the electrodes to penetrate them. The formation of a hole through the test specimen during a test is to be reported together with the hole depth (test specimen thickness). Retests may be made using thicker test specimens, up to a maximum of 10 mm.

NOTE The number of drops needed to cause failure by tracking usually increases with decreasing applied voltage and, below a critical value, tracking ceases to occur. For some materials, tracking also ceases to occur above an upper critical value.

5 Test specimen

Any approximately flat surface may be used, provided that the area is sufficient to ensure that during the test no liquid flows away from the test electrodes.

NOTE 1 In general, flat surfaces of not less than 20 mm × 20 mm are used to reduce the probability of electrolyte flows away from the test electrodes although smaller sizes can be used, subject to no electrolyte loss, e.g. ISO 3167, 15 mm × 15 mm multi-purpose test specimens.

NOTE 2 In general separate test specimens for each test are used. If several tests are to be made on the same test piece, testing points can be sufficiently far from each other so that splashes, fumes, or erosion, from the testing point will not contaminate or influence the other areas to be tested.

The thickness of the test specimen shall be 3 mm or more. Individual pieces of material may be stacked to obtain the required thickness of at least 3 mm.

NOTE 3 The values of the CTI obtained on specimens with a thickness below 3 mm cannot be comparable with those obtained on thicker specimens because of greater heat transmission to the glass support through thinner test specimens. For this reason, stacked specimens are possible.

Test specimens shall have uniformly smooth and untextured surfaces which are free from surface imperfections such as scratches, blemishes, impurities, etc, unless otherwise stated in the product standard. If this is impossible, the results shall be reported together with a statement describing the surface of the specimen because certain characteristics on the surface of the specimen can add to the dispersion of the results.

For tests on parts of products, where it is impossible to cut a suitable test specimen from a part of a product, specimens cut from moulded plaques of the same insulating material may be used. In these cases, care should be taken to ensure that both the part and the plaque are produced by the same fabrication process, resulting in the same surface texture, wherever possible. Where the details of the final fabrication process are unknown, methods given in ISO 293, ISO 294-1 and ISO 294-3 and ISO 295 can be appropriate.

NOTE 4 The use of different fabrication conditions or processes can lead to different levels of performance in the PTI and CTI test.

NOTE 5 Parts moulded using different flow directions can also exhibit different levels of performance in the PTI and CTI test.

In special cases, the test specimen may be ground to obtain a flat surface. In this case, the surface texture according ISO 4287 (e.g. R_z values) shall be reported (see 10.2 and 11.5).

NOTE 6 Any grinding can damage the specimen. In this case, material surface made by grinding has higher or lower tracking value than the original surface.

Where the direction of the electrodes relative to any feature of the material is significant, measurements shall be made in the direction of the feature and orthogonal to it. The direction giving the lower CTI shall be reported, unless otherwise specified in a contract.

NOTE 7 Use of an aggressive electrolyte, such as solution C, is common, when the material has a hydrophobic surface.

6 Test specimen conditioning

6.1 Environmental conditioning

Unless otherwise specified in a contract, the test specimens shall be conditioned for a minimum of 24 h at (23 ± 2) °C, with (50 ± 10) % RH. Once the test specimen has been removed from the conditioning chamber (see 7.7), the test shall be started within 30 minutes.

6.2 Test specimen surface state

Unless otherwise specified in a contract,

a) tests shall be made on clean surfaces;

b) any cleaning procedure used shall be reported. Wherever possible, the details shall be agreed between supplier and customer.

Dust, dirt, fingerprints, grease, oil, mould release or other contaminants can influence the results. When cleaning the test specimen, swelling, softening, abrasion or other damage to the material shall be avoided.

7 Test apparatus

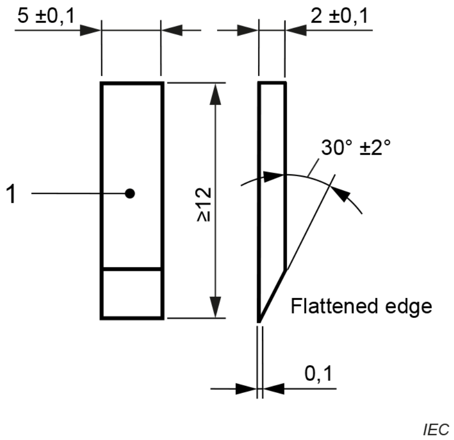
7.1 Electrodes

Two electrodes of platinum with a minimum purity of 99 % shall be used (see Annex C). The two electrodes shall have a rectangular cross-section of (5 ± 0,1) mm × (2 ± 0,1) mm, with one end chisel-edged with an angle of 30° ± 2° (see Figure 1). The sharp edge shall be removed to produce an approximately flat surface, 0,01 mm to 0,1 mm wide.

NOTE 1 A microscope with a calibrated eyepiece has been found suitable for checking the size of the end surface.

NOTE 2 In general, mechanical means are used to re-furbish the electrode shape after a test to ensure that the electrodes maintain the required tolerances, especially with respect to the edges and corners.

Dimensions in millimetres



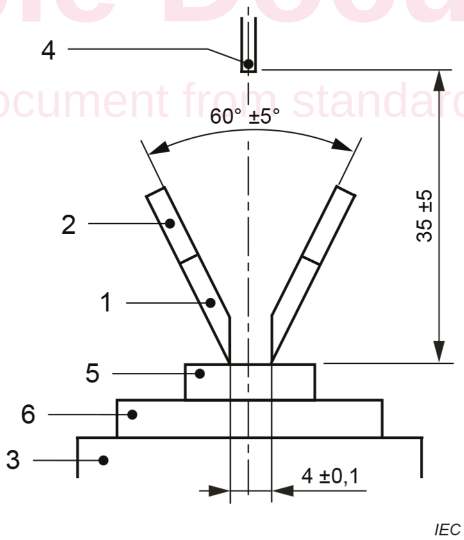
Key

1 platinum electrode

Figure 1 – Electrode

At the start of the test, the electrodes shall be symmetrically arranged in a vertical plane, the total angle between them being 60° ± 5° and with opposing electrode faces approximately vertical on a flat horizontal surface of the test specimen (see Figure 2). Their separation along the surface of the test specimen at the start of the test shall be (4,0 ± 0,1) mm.

Dimensions in millimetres



Key

1 platinum electrode

2 brass extension (optional)

3 table

4 tip of dropping device

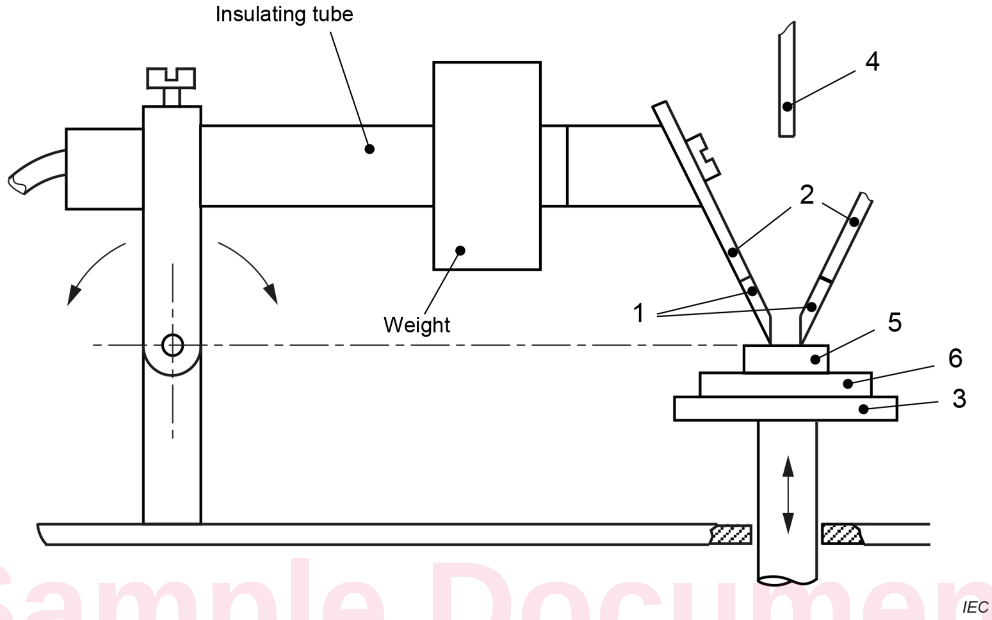
5 specimen

6 glass specimen support

Figure 2 – Electrode and specimen arrangement

A thin metal rectangular slip gauge shall be used to check the electrode separation. The electrodes shall move freely and the force exerted by each electrode on the surface of the test specimen at the start of the test shall be (1,00 ± 0,05) N. The design shall be such that the force can be expected to remain at the initial level during the test.

One typical type of arrangement for applying the electrodes to the test specimen is shown in Figure 3. The force shall be verified at appropriate intervals.



Key

1 platinum electrode

2 brass extension (optional)

3 table

4 tip of dropping device

5 specimen

6 glass specimen support

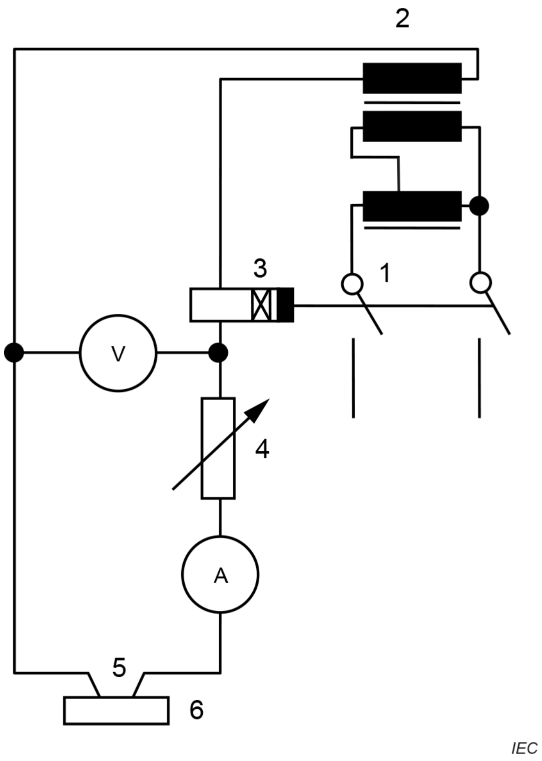
Figure 3 – Example of typical electrode mounting and specimen support

Where tests are made solely on those materials where the degree of electrode penetration is small, the electrode force may be generated by the use of springs. However, gravity should be used to generate the force on general purpose equipment (see Figure 3).

NOTE 3 With most, but not all designs of apparatus, if the electrodes move during a test due to softening or erosion of the specimen, their tips will prescribe an arc and the electrode gap will change. The magnitude and direction of the gap change will depend on the relative positions of the electrode pivots and the contact points between electrode and specimen. The significance of these changes will probably be material dependent and has not been determined. Differences in design can give rise to differences in inter-apparatus results.

7.2 Test circuit

The electrodes shall be supplied with a substantially sinusoidal voltage, variable between 100 V and 600 V at a frequency of 48 Hz to 62 Hz. The voltage measuring device shall indicate a true RMS value and shall have an accuracy of 1,5 % or better for the reading. The power of the source shall be not less than 0,6 kVA. An example of a suitable test circuit is shown in Figure 4.



Key

1 switch

2 AC source 100 V to 600 V

3 delay over-current device

4 variable resistor

5 electrodes

6 specimen

Figure 4 – Example of test circuit

A variable resistor shall be capable of adjusting the current between the short-circuited electrodes to (1,0 ± 0,1) A and the voltage indicated by the voltmeter shall not decrease by more than 10 % when this current flows. The instrument used to measure the value of the short-circuit current shall have an accuracy of ±3 % or better for the reading.

NOTE To achieve the tolerance requirement it can be necessary that the suppply voltage to the apparatus is sufficiently stable.

The over-current device shall operate when a current with an RMS value of (0,50 ± 0,05) A has persisted for (2,00 ± 0,20) s.

7.3 Test solutions

Solution A:

Dissolve approximately 0,1 % by mass of analytical reagent grade anhydrous ammonium chloride (NH_4Cl), of a purity of not less than 99,8 %, in de-ionized water to give a conductivity of (253 ± 4) mS/m at (23 ± 1) °C.

NOTE 1 The quantity of ammonium chloride is selected to give a solution in the required range of conductivity.

NOTE 2 The conductivity of the solution A at 25 °C is (264 ± 4) mS/m , and (238 ± 3) mS/m at 20 °C.