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

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

**FOREWORD** ....................................................................................................................... 5

1 Scope........................................................................................................................................................................ 9
2 Normative references .................................................................................................................................................. 9
3 Terms and definitions .................................................................................................................................................. 11
4 Principle................................................................................................................................................................. 13
5 Test specimen .......................................................................................................................................................... 13
6 Test specimen conditioning ........................................................................................................................................ 15
   6.1 Environmental conditioning.............................................................................................................................. 15
   6.2 Test specimen surface state ............................................................................................................................ 15
7 Test apparatus ........................................................................................................................................................ 15
   7.1 Electrodes .......................................................................................................................................................... 15
   7.2 Test circuit ......................................................................................................................................................... 17
   7.3 Test solutions ..................................................................................................................................................... 17
   7.4 Dropping device ................................................................................................................................................ 19
   7.5 Test specimen support platform .................................................................................................................... 19
   7.6 Electrode assembly installation ....................................................................................................................... 19
8 Basic test procedure .................................................................................................................................................. 21
   8.1 General ............................................................................................................................................................. 21
   8.2 Preparation......................................................................................................................................................... 21
   8.3 Test procedure ................................................................................................................................................... 23
9 Determination of erosion ......................................................................................................................................... 23
10 Determination of proof tracking index (PTI) ........................................................................................................... 23
   10.1 Procedure......................................................................................................................................................... 23
   10.2 Report ............................................................................................................................................................. 25
11 Determination of comparative tracking index (CTI) ................................................................................................. 25
   11.1 General ............................................................................................................................................................. 25
   11.2 Determination of the 100 drop point ................................................................................................................ 25
   11.3 Determination of the maximum 50 drop withstand voltage ............................................................................ 27
   11.4 Report ............................................................................................................................................................. 29

Annex A (informative) List of factors that should be considered by product committees ........................................... 37
Annex B (informative) Electrode material selection ...................................................................................................... 39

Bibliography .............................................................................................................................................................. 41

Figure 1 – Electrode ....................................................................................................................................................... 33
Figure 2 – Electrode / specimen arrangement ............................................................................................................... 33
Figure 3 – Example of typical electrode mounting and specimen support .................................................................... 35
Figure 4 – Example of test circuit ................................................................................................................................ 35
INTERNATIONAL ELECTROTECHNICAL COMMISSION

METHOD FOR THE DETERMINATION OF THE PROOF
AND THE COMPARATIVE TRACKING INDICES
OF SOLID INSULATING MATERIALS

FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the 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, the IEC publishes International Standards. 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. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.

2) The formal decisions or agreements of the IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested National Committees.

3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical specifications, technical reports or guides and they are accepted by the National Committees in that sense.

4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.

5) The IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with one of its standards.

6) Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. The IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 60112 has been prepared by subcommittee 15E: Methods of test, of IEC technical committee 15: Insulating materials.

This fourth edition cancels and replaces the third edition, published in 1979, of which it constitutes a technical revision.

Major changes since the previous edition are the following:

The selection of a material for a specific application frequently involves compromises in the levels of the individual properties and test criteria. In the previous edition of IEC 60112 the test criteria required "no burning of the specimen", but this gave rise to two issues:

- difficulties in the identification of burning which includes all types of combustion, e.g. flaming, and smouldering in the situation where scintillations had occurred giving rise in many cases to carbon on the surface of the specimen, and
- a situation in which some product committees had found it necessary to dispense with the "no burning" criterion in the tracking tests which they replaced by flame tests on the final product, thereby giving rise to two types of CTI/PTI with different criteria.

This standard attempts to regularize this situation.

It has the status of a basic safety publication in accordance with IEC Guide 104.
The text of this standard is based on the following documents:

<table>
<thead>
<tr>
<th>FDIS</th>
<th>Report on voting</th>
</tr>
</thead>
<tbody>
<tr>
<td>15E/209/FDIS</td>
<td>15E/213/RVD</td>
</tr>
</tbody>
</table>

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until 2015. At this date, the publication will be

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

The contents of the corrigenda of June 2003 and October 2003 have been included in this copy.
1 Scope

This International standard 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 voltages.

The standard provides for the determination of erosion when required.

NOTE 1 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.

Test results cannot be used directly for the evaluation of safe creepage distances when designing electrical apparatus.

NOTE 2 This test discriminates between materials with relatively poor resistance to tracking, and those with moderate or good resistance, for use in equipment which can be used under moist conditions. More severe tests, of longer duration are required for the assessment of performance of materials for outdoor use, utilizing higher voltages and larger test specimens (see the inclined plane test of IEC 60587). Other test methods such as the inclined method may rank materials in a different order from the drop test given in this standard.

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 60589:1977, Methods of test for the determination of ionic impurities in electrical insulating materials by extraction with liquids


ISO 293:1986, Plastics – Compression moulding test specimens of thermoplastic materials


3 Terms and definitions

For the purposes of this International Standard, the following definitions apply:

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

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

NOTE In the present test, tracking is indicated by operation of an over-current device due to the passage of a current of at least 0.5 A for at least 2 s across the test surface and/or within the specimen.

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 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 11.4)

NOTE 1 The criteria for CTI may also require a statement concerning the degree of erosion.
NOTE 2 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.

3.6 persistent flame
in case of dispute – one which burns for more than 2 s

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

NOTE 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.
4 Principle

The upper surface of the test specimen is supported in an approximately 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 a.c. 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.

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 over the edges of the test specimen.

NOTE 1 Flat surfaces of not less than 20 mm × 20 mm are recommended to reduce the probability of electrolyte loss over the specimen edge although smaller sizes may be used, subject to no electrolyte loss, e.g. ISO 3167, 15 mm × 15 mm multi-purpose test specimens.

NOTE 2 It is preferable to use separate test specimens for each test. If several tests are to be made on the same test piece, care should be taken to ensure that the testing points are sufficiently far from each other so that splashes or fumes from the testing point will not contaminate 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 may not 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 allowed.

Test specimens shall have nominally 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 could 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 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 may be appropriate.

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

NOTE 5 Parts moulded using different flow directions may 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.

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.

6 Test specimen conditioning

6.1 Environmental conditioning

Unless otherwise specified, the test specimens shall be conditioned for a minimum of 24 h at 23 °C ± 5 K, with (50 ± 10) % RH.

6.2 Test specimen surface state

Unless otherwise specified,

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.

NOTE Dust, dirt, fingerprints, grease, oil, mould release or other contaminants may influence the results. Care should be taken when cleaning the test specimen to avoid swelling, softening, abrasion or other damage to the material.

7 Test apparatus

7.1 Electrodes

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

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

NOTE 2 It is recommended that 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.

At the start of the test, the electrodes shall be symmetrically arranged in a vertical plane, the total angle between them being \(60° \pm 5°\) 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 \(4,0 \text{ mm} \pm 0,1 \text{ mm}\).
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 N ± 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.

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 electrode/specimen contact points. The significance of these changes will probably be material dependent and has not been determined. Differences in design could 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 r.m.s. value and shall have a maximum error of 1,5 %. 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.

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 (see Figure 4). The instrument used to measure the value of the short-circuit current shall have a maximum error of ±3 %.

The input supply voltage to the apparatus shall be adequately stable.

The over-current device shall operate when a current with an r.m.s. value of 0,50 A with a relative tolerance of ±10 %, has persisted for 2,00 s with a relative tolerance of ±10 %.

7.3 Test solutions

Solution A:

Dissolve approximately 0,1 % by mass of analytical reagent grade anhydrous ammonium chloride \((\text{NH}_4\text{Cl})\), of a purity of not less than 99,8 %, in de-ionized water, having a conductivity of not greater than 1 mS/m to give a resistivity of \((3,95 \pm 0,05) \Omega\text{m}\) at \((23 \pm 1) ^\circ\text{C}\).

NOTE 1 Select the quantity of ammonium chloride to give a solution in the required range of resistivity.