Designation: ~~D5288 – 14~~ D5288 – 21

Standard Test Method for
Determining Tracking Index of Electrical Insulating Materials Using Various Electrode Materials (Excluding Platinum)[1]

This standard is issued under the fixed designation D5288; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This test method was developed using copper electrodes to evaluate the low-voltage (up to 600 V) tracking resistance of materials in the presence of aqueous contaminants.[2]

NOTE 1—At this time, only industrial laminates have been examined using this method, which was developed at the National Manufacturers Electrical Association (NEMA) laboratory located at the University of Cincinnati. It was found that a closer end point (less scatter) was obtained than with platinum electrodes, and materials tested tended to be ranked by resin system.

1.1.1 It is acceptable to consider other electrode materials for use with this test method depending upon the application of the insulating material.

1.2 This test method is similar to Test Method D3638, which determines the comparative tracking index of materials using platinum electrodes to produce the tracking on the specimen surface.

1.3 The values stated in metric (SI) units are the standard. The inch-pound equivalents of the metric units are approximate.

1.4 *This standard ~~is used to measure and describe the response of materials, products, or assemblies to heat and flame under controlled conditions, but does not by itself incorporate all factors required for fire hazard or fire risk assessment of the materials, products, or assemblies under actual fire conditions.~~does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *Fire testing is inherently hazardous. Adequate safeguards for personnel and property shall be employed in conducting these tests.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

*A Summary of Changes section appears at the end of this standard

2. Referenced Documents

2.1 *ASTM Standards:*[3]
D618 Practice for Conditioning Plastics for Testing
D1711 Terminology Relating to Electrical Insulation
D3636 Practice for Sampling and Judging Quality of Solid Electrical Insulating Materials
D3638 Test Method for Comparative Tracking Index of Electrical Insulating Materials
2.2 *IEC Publication:*[4]
IEC 60112 Standard Method for the Determination of the Proof and the Comparative Tracking Indices of Solid Insulating Materials, 2003

3. Terminology

3.1 *Definitions*—For definitions of terms used in this test method and associated with electrical and electronic insulating materials, use Terminology D1711.

3.2 *Definitions of Terms Specific to This Standard:*

~~3.2.1 *track, n*—a partially conducting path of localized deterioration on the surface of an insulating material.~~

~~3.2.2 *tracking, n*—the process that produces tracks as a result of the action of electric discharges on or close to an insulation surface.~~

~~3.2.3 *tracking, contamination, n*—tracking caused by scintillations that result from the increased surface conduction due to contamination.~~

3.2.1 *tracking index, TI, n*—an index for electrical insulating materials which is arbitrarily defined as the numerical value of that voltage which will cause failure by tracking when the number of drops of contaminant required to cause failure is equal to 50.
3.2.1.1 *Discussion—*
This value is obtained from a plot of the number of drops required to cause failure by tracking versus the applied voltage.

3.2.2 *tracking ~~index–copper~~index-copper electrodes, TI-Cu, n*—a tracking index test using copper electrodes.
3.2.2.1 *Discussion—*
This test is comparable to *comparative tracking index*, Test Method D3638, with the following exceptions: (*1*) copper electrodes are used instead of platinum, and (*2*) the electrodes may have to be re-ground after every test because of the softness of copper.

~~3.2.6 *tracking resistance, n*—the quantitative expression of the voltage and the time required to develop a track under specified conditions.~~

4. Summary of Test Method

4.1 The surface of a specimen of electrical insulating material is subjected to a low-voltage alternating stress combined with a low current which results from an aqueous contaminant (electrolyte) which is dropped between two opposing copper electrodes every 30 s. The voltage applied across these electrodes is maintained until the current flow between them exceeds a predetermined value which constitutes failure. Additional specimens are tested at other voltages so that a relationship between applied voltage and number of drops to failure can be established through graphical means. The numerical value of the voltage which causes failure with the application of ~~50 drops~~50 drops of the electrolyte is arbitrarily called the tracking index. This value provides an indication of the relative track resistance of the material.

5. Significance and Use

5.1 Electrical equipment has the potential to fail as a result of electrical tracking of insulating material that is exposed to various contaminating environments and surface conditions. A number of ASTM and other tests have been designed to quantify behavior

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[3] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[4] Available from International Electrotechnical Commission (IEC), ~~3 Rue~~3, rue de Varembé, ~~Case postale~~1st floor, P.O. Box 131, CH-1211, Geneva 20, Switzerland, ~~http://www.iec.ch.~~https://www.iec.ch.
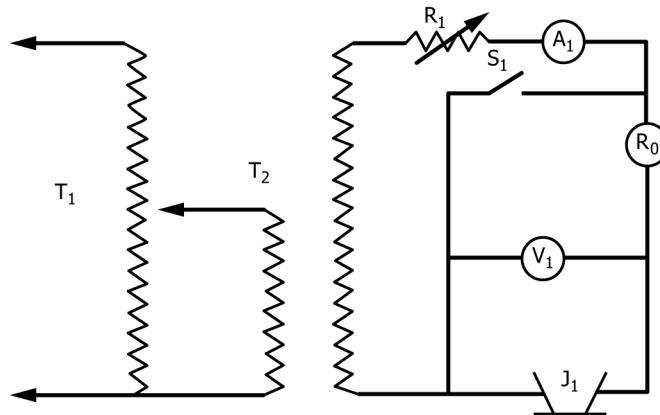
FIG. 1 Electrical Circuit Components

of materials, especially at relatively high voltages. This method is an accelerated test which, at relatively low test voltages, provides a comparison of the performance of insulating materials under wet and contaminated conditions. The Tracking ~~Index—Copper~~Index-Copper Electrodes test is not related directly to the suitable operating voltage in service.

5.2 When organic electrical insulating materials are subjected to conduction currents between electrodes on their surfaces, many minute tree-like carbonaceous paths or tracks are developed near the electrodes. These tracks are oriented randomly, but generally propagate between the electrodes under the influence of the applied potential difference. Eventually a series of tracks spans the electrode gap, and failure occurs by shorting of the electrodes.

5.3 As in other tracking test methods, for example, ~~IEC 112~~ IEC 60112 and Test Method D3638, this test method specifies test procedures that are intended to promote the formation of surface discharges which will produce carbon tracks in a reproducible manner. Since these conditions rarely reproduce the actual conditions encountered in service, the results of tracking tests cannot be used to infer either direct or relative service behavior of a material in a specific design application. Tracking tests can be used for screening purposes only. Suitability is verified through testing of the material in actual end use or under conditions that closely simulate actual end use.

5.4 The use of copper electrodes in this type of test was developed at the University of Cincinnati, NEMA laboratory. It is felt by the members of the Industrial Laminates Section of NEMA that using copper electrodes gives a more realistic value for a tracking index, related to the resin system used to reinforce the substrate of a laminate. In general, tracking tests made with copper electrodes tend to give lower values than platinum electrodes in the same type of test. It is a fact that copper is more widely used than platinum for electrical conductors.[5]

6. Apparatus

6.1 The simplified electrical circuitry used in this test is illustrated in Fig. 1. For necessary information on the cleanliness of apparatus, see Annex A1. The essential components are:

6.1.1 *Variable Power Source,* consisting of a transformer-type supply, such as the combination T_1 and T_2 in Fig. 1, with a variable output of 0 to 1000 V, 60 Hz capable of maintaining a current of 1 A (1 kVA).

6.1.2 *Voltmeter* (V_1), capable of measuring the varying ac output of the power source. A 0- to 600-V voltmeter with an accuracy of at least ±0.5 % of full scale.

6.1.3 *Ammeter* (A_1), with a range of 0 to 1 A ac and an accuracy of at least ±10 % of full scale.

6.1.4 *Current Limiting Resistor* (R_1), continuously variable, wire wound, rated at greater than 1 A.

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[5] ~~Middendorf, W. H. and Vemuri, R., "Report on Copper vs. Platinum Electrodes," 1990, available from National Electrical Manufacturer's Association, 2101 L St. N.W., Suite 300, Washington, D.C. 20037-8400.~~ Middendorf, W. H. and Vemuri, R., "Report on Copper vs. Platinum Electrodes," 1990. Available from National Electrical Manufacturers Association (NEMA), 1300 N. 17th St., Suite 900, Arlington, VA 22209, http://www.nema.org.
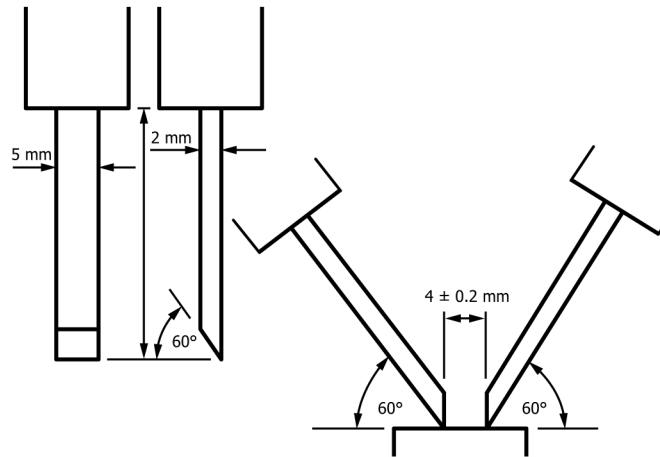
FIG. 2 Electrodes (Radius 0.05 to 0.1 mm)

6.1.5 *Shorting Switch* (S_1), single-pole single-throw rated at 1000 V and greater than 1 A.

NOTE 2—The need for a shorting switch is optional. It is possible to couple the variable resistor with the autotransformer which gives an automatic setting of the current throughout the range of the instrument. Then whenever it is necessary to check the calibration of the instrument, the shorting action can be accomplished by a jumper wire placed across the electrodes. This coupling of the autotransformer with the variable resistor is another option.

6.1.6 *Over-current Relay* (R_0), shall not trip at currents up to 0.1 A, and the tripping time on short circuit shall be a minimum of 0.5 s (the current shall be limited on short circuit to 1 A, with a tolerance of ± 10 % at a power factor of 0.9 to 1.0).

NOTE 3—Some instruments have used a Heinemann breaker, which is probably the closest standard commercial breaker to that described in the IEC Method.[6] Also the tripping action can be accomplished with electronic circuitry.

6.1.7 *Testing Fixture* (J_1)—adjustable platform which supports the specimen and electrode setup.

6.1.8 *Copper Electrodes,* of electrolytic copper having a rectangular cross section measuring 5 by 2 mm (0.2 by ~~0.08 in.),~~ 0.08 in.), extending 20 mm (0.8 in.) minimum from suitable mounting shanks (Fig. 2). The end of each electrode is machined to form a 30° chisel-point edge, having a radius from 0.05 to 0.10 mm, extending along the ~~5-mm~~5 mm (0.2-in.) side of the electrode. This is the radius that generally results from polishing a "0 mm" radius electrode. Since the direction of polish has the potential to influence the results, polish all electrodes in a direction perpendicular to the long dimension of the electrode face.

6.1.9 *Dropping Apparatus,* which shall drop the electrolyte precisely as specified. It is important to also include a means of electrically starting and stopping the dropping of the electrolyte as well as a counting device for monitoring the ~~numberof~~ number of drops. The orifice diameter of the drop mechanism is approximately 1.5 mm. However, if necessary, adjust this diameter somewhat so as to obtain the proper drop size in accordance with 9.2.

7. Reagents

7.1 *Electrolyte Solution of Ammonium Chloride in Water:*

7.1.1 Prepare a solution of ammonium chloride at an approximate concentration of 0.1 % by dissolving 1 g of reagent grade ammonium chloride in 1 L of water. The water used shall have a volume resistivity of no less than 0.5 MΩ-cm at ~~23°C.~~23 °C. Allow the solution to stand overnight in a covered, but not sealed, container.

7.1.2 Measure the resistivity of the solution using a conductivity's cell and an ac bridge, or meter, following the manufacturer's

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[6] The sole source of supply of the apparatus known to the committee at this time is ~~the~~ Heinemann Model Series JA, Curve 2. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

instructions. If the resistivity is 385 ± 5 Ω-cm at 23 ± ½ °C, °C, the solution is suitable for use in the test. If the resistivity is outside the above limits, adjust the concentration until these limits are observed. Adjustment is accomplished by adding water or NH_4Cl.

7.1.3 Calibrate the conductivity cell with 0.01 *N* potassium chloride calibrating solution which is available from the cell manufacturer.

8. Test Specimens

8.1 Select samples in accordance with Practice D3636.

8.2 Typical test specimens are 50 mm (2 in.) or 100 mm (4 in.) diameter disks or any other similar shape. The minimum thickness is 2.5 mm (0.100 in.). Test five specimens of each sample.

8.3 Variations in values can result from a lack of uniformity of dispersion of the material throughout the molded specimen or from surface imperfections. Take care to prepare specimens that are as uniform as possible, both within the particular specimen and from one specimen to another.

8.4 Condition samples in accordance with Procedure A of Practice D618.

8.5 Specimens must be clean of dust, dirt, oil, or other contaminants. The molded surface must be smooth and scratch-free.

9. Calibration and Standardization

9.1 Partially support the electrodes by adjustable pivot arms and rest on the test specimen as shown in Fig. 2, exerting a force of 100 g (3.5 oz).

9.2 The drop height for the electrolyte is a maximum of 40 mm (1.6 in.) above the electrode gap. The holding device is designed to store an aqueous solution and deliver periodically a measured drop to the specimen. The drop size is $20 + 5 − 0$ mm^3 (0.0015 in.^{3}) and the drop rate is 1 drop/30 ± 5 s. (The drop size can be measured by using a small calibrated graduate to accumulate a number of drops to obtain an accurate reading.)

9.3 Allow approximately 15 drops of electrolyte to drop from the apparatus into a beaker or other container so as to remove any solution with a high concentration of ammonium chloride.

9.4 Reform the electrodes after every test. Replace the electrodes when sharpening or machining reduces the length to cause instability of the electrode in the holder.

9.5 Reproducibility of results is improved by reforming, polishing, and washing the electrodes after each test. Wash using a stream of distilled water and dry with a clean paper based industrial towel.

10. Procedure

10.1 Conduct the test in a draft-free, clean environment at a temperature of 20 ± 5 °C. 5 °C.

10.2 Fill the dropping assembly with solution and set the counter to 0.

10.3 Set the power source to a voltage expected to be greater than the TI-Cu value and adjust in accordance with 10.6.

10.4 Place the test specimen on the supporting platform so that the electrodes can be placed on the specimen.

10.5 Position the electrodes as shown in Fig. 2 so that the chisel edges contact the specimen at a 60° angle between electrodes, and so that the chisel faces are parallel in the vertical plane and are separated by 4 ± 0.2 mm (0.16 in.).