



# Standard Test Method for Dust-and-Fog Tracking and Erosion Resistance of Electrical Insulating Materials<sup>1</sup>

This standard is issued under the fixed designation D 2132; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 This test method is intended to differentiate solid electrical insulating materials with respect to their resistance to the action of electric arcs produced by conduction through surface films of a specified contaminant containing moisture. Test Methods D 2302 and D 2303 may also be used to evaluate materials.

1.2 The values stated in inch-pound units are the standard, except in cases where SI units are more appropriate. The values in parentheses are for information only.

1.3 *This standard 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 and health practices and determine the applicability of regulatory limitations prior to use.* Specific precautionary statements are given in 11.4.

NOTE 1—There is no equivalent ISO standard.

## 2. Referenced Documents

### 2.1 ASTM Standards:<sup>2</sup>

D 709 Specification for Laminated Thermosetting Materials

D 1711 Terminology Relating to Electrical Insulation

D 2302 Method of Test for Differential Wet Tracking Resistance of Electrical Insulating Materials with Controlled Water-to-Metal Discharges<sup>3</sup>

D 2303 Test Methods for Liquid-Contaminant, Inclined-Plane Tracking and Erosion of Insulating Materials

## 3. Terminology

### 3.1 Definitions:

3.1.1 For definitions pertinent to this test method see Terminology D 1711.

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee D09 on Electrical and Electronic Insulating Materials and is the direct responsibility of Subcommittee D09.18 on Solid Insulations, Non-Metallic Shieldings, and Coverings for Electrical and Telecommunications Wires and Cables.

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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

<sup>3</sup> Discontinued, see 1982 *Annual Book of ASTM Standards*, Part 39.

## 4. Summary of Test Method

4.1 With electrodes mounted as shown in Fig. 1, coat test specimens with a synthetic dust and test in a chamber shown in Fig. 2. Direct a water spray at the test specimen. After the surface has been wetted, apply a 60-Hz voltage between the electrodes. Arcing occurs across localized high-resistance areas produced by nonuniform evaporation of the water from the contaminant. These arcs produce high temperatures in the underlying insulation with resultant carbonization of most organic materials. The carbonization concentrates the electric field. Further carbonization may occur in the direction of the field. In such cases, a carbon track is formed which spans the distance between the electrodes and causes failure. Materials that do not track may erode under the action of the arcing. Such erosion usually progresses from an upper electrode through the thickness of the specimen towards the underlying electrode.

4.2 Rate materials that track in terms of the time required to form a track between the electrodes.

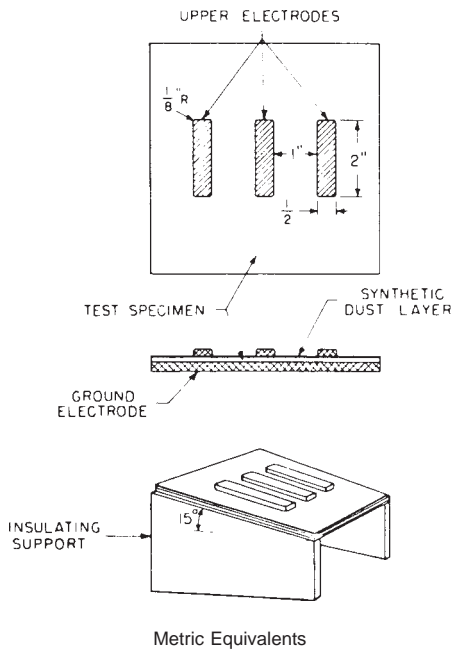
4.3 Rate materials that do not track in terms of the time required to erode to failure.

4.4 Failure will be indicated when the current increases sufficiently to actuate an overcurrent device.

NOTE 2—The conditions of this test favor the formation of a track for several possible reasons. Most important, the continuous renewal of the conducting properties of the contaminant by the water spray allows a track to grow progressively over long periods of time.

## 5. Significance and Use

5.1 *Method*—Electrical insulation in service may fail as a result of tracking, erosion, or a combination of both, if it is exposed to high relative humidity and contamination environments. This is particularly true of organic insulations in outdoor applications where the surface of the insulation becomes contaminated by deposits of moisture and dirt, for example, coal dust or salt spray. This test method is an accelerated test that simulates extremely severe outdoor contamination. It is believed that the most severe conditions likely to be encountered in outdoor service in the United States will be relatively mild compared to the conditions specified in this test method.



Metric Equivalents				
in.	1/8	1/2	1	2
mm	3.2	12.7	25.4	50.8

FIG. 1 Test Arrangement of Electrode System

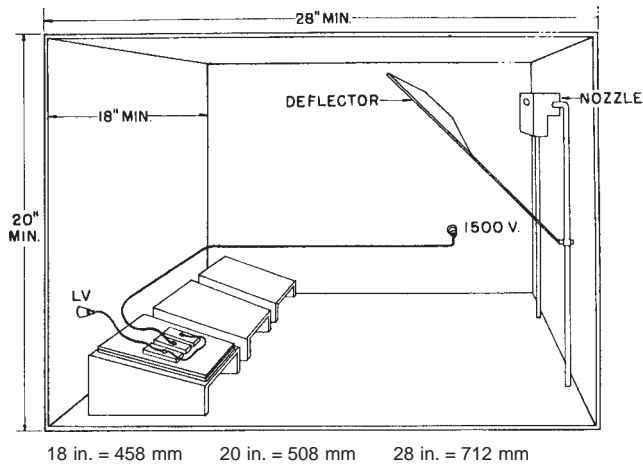


FIG. 2 Dust and Fog Test Chamber, Minimum Recommended Size

5.2 Test Results—Materials can be classified by this test method as tracking-resistant, tracking-affected, or tracking-susceptible. The exact test values for these categories as they apply to specific uses will be specified in the appropriate material specifications, but guideline figures are suggested in Note 3. Tracking-resistant materials, unless erosion failure occurs first, may last many hundreds of hours (Note 4). Erosion, though it may progress laterally, generally results in a failure perpendicular to the specimen surface. Therefore, only specimens of the same nominal thickness may be compared for resistance to tracking-induced erosion. The extent of erosion may be estimated from measurements of the depth of penetration of the erosion. Materials that are not tracking-susceptible may be placed in three broad categories—erosion-resistant, erosion-affected, and erosion-susceptible. When the standard

thickness specimen is tested, the following times to failure typify the categories (Note 5):

Erosion-susceptible	5 to 50 h
Erosion-affected	50 to 200 h
Erosion-resistant	over 200 h

NOTE 3—Tracking-susceptible materials usually fail within 5 h. Tracking-affected materials usually fail before about 100 h.

NOTE 4—This information is derived from the individual experiences of eight laboratories using this test method since its publication as a suggested test method in June 1957, and from the results of an organized test program among these laboratories.

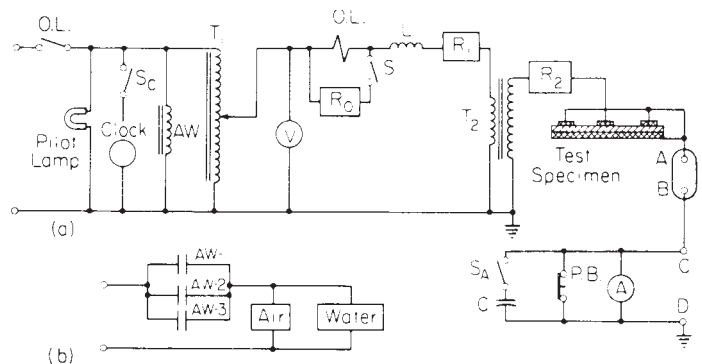
NOTE 5—In a normal distribution approximately 68 % of all test values are included within  $\pm 1$  standard deviation of the mean.

5.3 Interpretation of Test Results— This test method provides information that allows classification as described in 5.2. The comparison of materials within the same group is likely to be ambiguous unless three or more replicate specimens are tested. When the test method is used for specification purposes, simple minimum values should not be established without consideration of the large variance to be expected in test results. It is recommended that quality levels and specification minima be determined by statistical techniques.

## 6. Apparatus

6.1 General—A schematic diagram of the power supply and control apparatus for testing one specimen is shown in Fig. 3(a). It is generally desirable to test three or more specimens simultaneously. It is recommended but not mandatory that a separate power supply and control be used for each test specimen. This allows “breaking-in” and recording of time to failure separately for each specimen.

6.2 Circuit Breaker—The circuit breaker (current relay, OL) interrupts the power supply on failure and stops the timing meter. It may be used as an ON-OFF switch and as a device for interrupting air and water supply when all specimens fail. Fig. 3(b) illustrates the air and water supply circuit when three specimens are tested using one fog nozzle. The circuit breaker shall be rated at 2 to 3 A, inverse-time element type, for a 115-V supply. Use a resistance,  $R_0$ , to shunt the current coil during the break-in period so that the breaker will not actuate as a result of the bright-flash currents typical of this period. Adjust the resistance to produce an effective breaker action at approximately 6 A (115-V supply). Remove or switch out the shunt resistance after break-in.



(a) Power supply and control circuit of wet tracking tests.  
(b) Air and water supply circuit.

FIG. 3 Circuit Diagrams



FIG. 4 Clamping Arrangement for Test-Specimen Electrodes

6.3 *Supply Transformer*<sup>4</sup>—Use a supply transformer,  $T_2$ , capable of supplying 1500 V, 60 Hz, rms. A200-VA potential transformer is capable of supplying power for up to three specimens if desired. Use a transformer with a 20:1 ratio when used with a 115-V primary supply. Choose a transformer that offers an impedance between 600 and 1200  $\Omega$  resistance and 200 and 700  $\Omega$  reactance. Accomplish this by insertion of inductance  $L$  and resistance  $R_1$  in the low-voltage side and resistance  $R_2$  in the high-voltage side.

6.4 *Control Transformer*—Use a variable-ratio autotransformer,  $T_1$ , to adjust the voltage as required.

6.5 *Voltmeter*—A voltmeter,  $V$ , may be used in the primary side to determine the specimen test voltage. Alternatively a high-impedance voltmeter may be connected in the secondary, in which case precautions should be taken to prevent electric shock to an operator. If a voltmeter is used in the primary, calibrate it against secondary voltage with a secondary load of 10 mA.

6.6 *Monitoring Provisions*— Use an ac ammeter,  $A$ , to monitor specimen current. Use a separate ammeter for each test specimen. Alternatively make provisions to connect an ammeter into each test-specimen circuit. Shunt the ammeter with a normally closed contact,  $PB$ , and a capacitance,  $C$ , to protect the ammeter from the large intermittent currents that occur during break-in. Connect the capacitance, if used, by a switch,  $S_A$ . After the break-in period, open the switch unless the values of the capacitance and ammeter impedances are such as to produce negligible error in current measurement. Use terminals  $A$ ,  $B$  and  $C$ ,  $D$  for oscilloscope monitoring, for current measurement with a voltmeter in combination with a resistor,

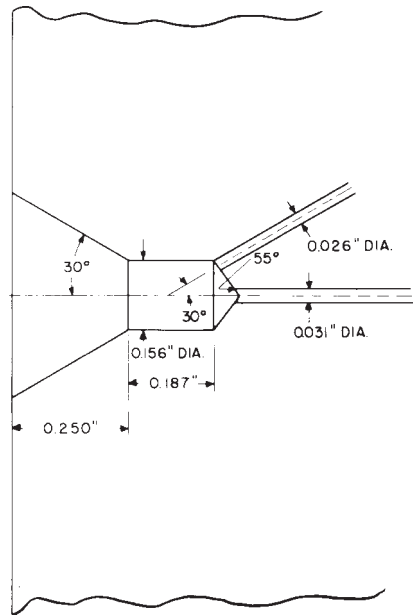
or for insertion of an undercurrent relay to be used to stop the clock if the scintillation current falls below the specified value.

6.7 *Electrodes*—Use three copper or brass electrodes  $\frac{1}{2}$  by 2 by  $\frac{1}{8}$  in. (13 by 51 by 3.2 mm), with corners rounded to a  $\frac{1}{8}$ -in. (3.2-mm) radius on the top surface of the specimen and spaced 1 in. (25 mm) apart as shown in Fig. 1. Use a ground plate of copper or brass and of the same size as the test specimen on the bottom surface and mounted on an insulating support inclined 15 deg to the horizontal as shown in Fig. 1. Clamp the electrodes firmly to the test specimen. A suggested arrangement is shown in Fig. 4.

6.8 *Test Chamber*—Use a cubicle test chamber, Fig. 2, made from plastic or metal. The front wall is made of glass or poly(methyl methacrylate), or contains viewing ports or doors made of these materials. Make the cubicle at least 20 in. (510 mm) high and 28 in. (710 mm) wide. Determine the depth by the number of specimens to be tested. Three specimens require a minimum depth of 18 in. (460 mm). Fit the chamber with means for venting near the bottom of the cubicle, preferably along the end of the chamber where the specimens are located. Limit the venting area to about 20 in.<sup>2</sup> (130 cm<sup>2</sup>) to eliminate dependence of test results on the ambient humidity.

6.8.1 Mount one or more fog nozzles (Fig. 5) to obtain the specified uniform moisture deposition on all test specimens. It is suggested that one fog nozzle, mounted approximately 25 in. (635 mm) straight line distance from the nozzle to the center specimen at a height of approximately 14 in. (360 mm) above these specimens, will, with a suitably adjusted deflector, produce the specified conditions for three test specimens in a single cubicle (see Fig. 2). When only one fog nozzle is used in the cubicle, it is recommended that additional air be introduced into the cubicle equal to about double that flowing

<sup>4</sup> General Electric Type JE41, Model KAR-3, and Westinghouse Type VS, Style No. 687588, have been found satisfactory for this purpose.



Metric Equivalents					
in.	0.026	0.031	0.156	0.187	4.75
mm	0.66	0.79	3.96	4.75	6.35

FIG. 5 Orifices of Fog Nozzle

through a standard fog nozzle connected to an air supply of 5 to 6 psig (34 to 41 kPa).

6.8.2 Connect the fog nozzle assembly,<sup>5</sup> Fig. 6, to an air and water supply. Provide means to adjust the air supply to 5 to 6 psig. Supply the water from a reservoir mounted below the nozzle so that the water level is approximately 5 in. (125 mm) below the nozzle. Use a needle valve in the water line to the nozzle to control the rate of fog deposition. To ensure uninterrupted flow of the water to the nozzle, filter the water to remove the dissolved air in the water.

## 7. Artificial Contaminant

7.1 Use synthetic dust of the following composition:

Material	Parts by Weight
Fling (SiO <sub>2</sub> floated), <sup>A</sup> 240-mesh	85
Clay, 325-mesh <sup>B</sup>	9
Salt (NaCl), technical grade	3
Paper, filter pulp <sup>C</sup>	3

<sup>A</sup> Fisher Scientific Co. Catalog No. S153-3 (SPD S-S3) is satisfactory for this purpose.

<sup>B</sup> R. E. Carroll, Inc., Trenton, NJ (1-800-257-9365) Suwanee Clay (325 mesh) is satisfactory for this purpose.

<sup>C</sup> International Paper Co., 2 Manhattenville Rd. (901-419-7307) Paper filter pulp is satisfactory for this purpose.

7.2 Mix the dust components in a ball mill with approximately 1-in. (25-mm) diameter flint pebbles to the consistency of a fine talcum. Milling for 72 h is usually sufficient.

7.3 Dispense the dust from an 8-oz. (265-cm<sup>3</sup>) wide-mouth bottle covered with 40-mesh screen. A few pebbles or marbles approximately 1/2 in. (13 mm) in diameter will help prevent screen clogging and keep the dust mixed.

<sup>5</sup> A suitable fog nozzle is a Lucite atomizer, Model 145-718 manufactured by Industrial Filter and Pump Manufacturing Co., 5916 Ogden Ave., Chicago, IL 60650. (708-656-7800)

7.4 Keep the dust dry prior to dispensing as well as in storage. The dust has not been found to deteriorate upon aging if kept dry.

## 8. Sampling

8.1 Refer to applicable material specification for sampling instructions.

## 9. Test Specimens

9.1 Prepare a test specimen between 5 by 5 in. (127 by 127 mm) and 6 by 6 in. (152 by 152 mm) and of the thickness specified.

9.2 The standard specimen thickness is 0.0625 ± 0.005 in. (1.6 ± 0.1 mm). Always use this thickness when it is desired to determine the erosion resistance of tracking-resistant materials.

9.3 The specimen may be up to 1/4 in. (6-mm) thick when it is desired to determine the tracking resistance of materials that are not tracking-susceptible.

NOTE 6—Some specimens may not track even when using a 1/4-in. thickness but may fail by erosion. In this event, report the tracking resistance as greater than the time required to produce erosion failure. Report the erosion resistance as the time to erosion failure of the standard specimen (0.0625 in., 1.6 mm).

## 10. Calibration

10.1 Periodically perform control tests on reference materials to demonstrate that the test equipment and procedure are in conformity with established standards. The following reference materials are recommended:

10.1.1 Polystyrene, failure by tracking in less than 1.5 h.

10.1.2 Melamine glass, Grade G-5 of Specification D 709, minimum thickness of 1/8 in. (3.2 mm), failure by tracking 1.5 to 5 h.

10.1.3 Poly(methyl methacrylate), 1/16 in. (1.6 mm) thick, failure by erosion 70 ± 30 h.

NOTE 7—In testing materials that do not fail by tracking in less than 5 h, it would be desirable to use a test procedure that is more severe than that described herein. However, until the changes in test-procedure details that are necessary to achieve greater severity can be specified and demonstrated by tests in several laboratories, the calibration figures stated above are to be taken as those obtainable with the procedure as now written.

## 11. Procedure

11.1 Mount the specimen together with the upper electrodes on the ground plate and place on the inclined insulating support.

11.2 Coat the specimen with the synthetic dust to a depth of 0.020 to 0.025 in. (0.5 to 0.6 mm) and place in the cubicle, or place in the cubicle first and then coat the specimen. Completely remove approximately 0.031 in. (0.8 mm) of dust from around the perimeter of the high-voltage electrode using a wire or tool with an approximate diameter 0.025 in.

11.3 Apply air pressure and water to the fog nozzle to produce a fog-deposition rate of 7 to 9 mg/in.<sup>2</sup>/min (0.01 to 0.014 mg/mm<sup>2</sup>/min) on the surfaces of the specimens. Determine the valve setting and deflector position necessary to produce the uniform specified deposition rate by previous experimentation, using water pans mounted on the inclined insulating supports.

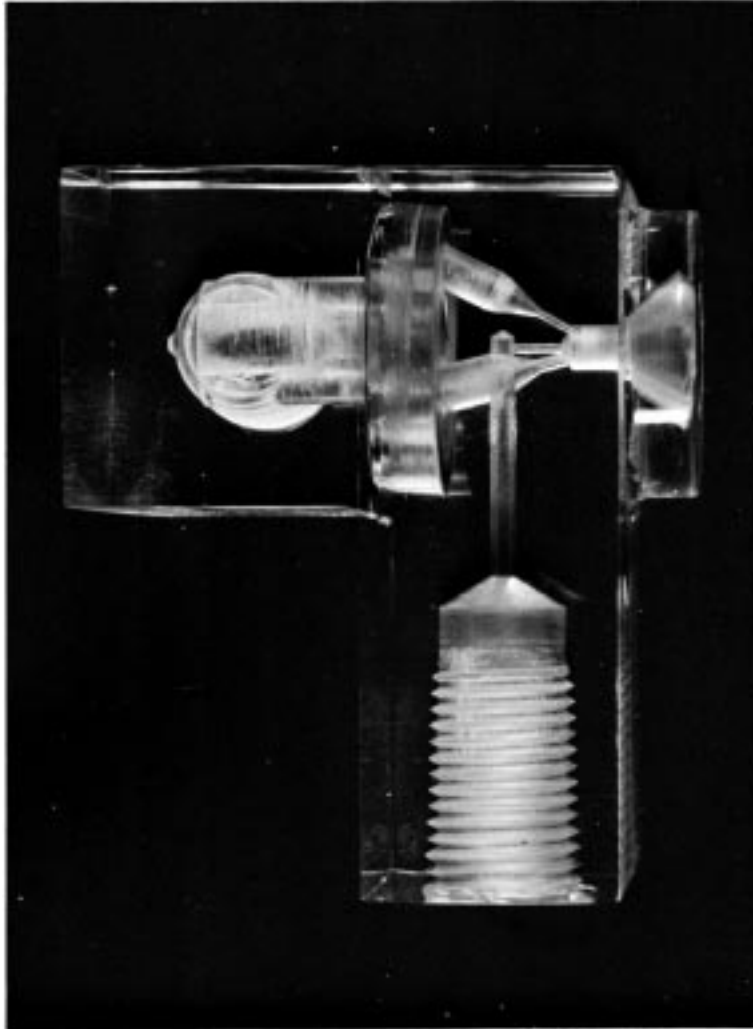


FIG. 6 Fog Nozzle Assembly

11.4 Wait 5 min after the start of fog application, then apply 500 V to the specimens and start the timer. Observe the specimens to determine the presence of scintillation around the high-voltage electrode. Scintillation consists of needlelike arcs up to  $\frac{1}{8}$  in. (3.2 mm) long which occur on the specimen surface. Scintillation must be present. If scintillation does not occur, check for the correct water rate and dust weight.

11.4.1 **Warning**—Lethal voltages may be present during this test. It is essential that the test apparatus and all associated equipment that may be electrically connected to it be properly designed and installed for safe operation. Solidly ground all metal parts that any person might come into contact with during the test. Thoroughly instruct all operators in the proper way to conduct the tests safely. When making tests at high voltages with electrodes, the energy released at breakdown may be sufficient to result in fire, explosion, or rupture of the test chamber. Design the test equipment, test chambers, and test specimens to minimize the possibility of such occurrences, and to eliminate the possibility of personal injury.

11.5 After scintillation is observed, raise the voltage either slowly or in steps until 1500 V is applied to the specimen. If bright arc flashes occur as the voltage is increased, lower the

voltage a little while the specimen breaks in at that voltage setting. Resume increasing the voltage until 1500 V is reached. Connect the timer when the applied voltage is 1000 or more and the scintillation current is 4 mA or more.

NOTE 8—During the break-in period, the fog-deposition rate may have to be lowered to 2 to 5 mg/in.<sup>2</sup> min (0.003 to 0.008 mg/mm<sup>2</sup>/min) in order to avoid excessive wetting of the test specimens.

11.6 If the current is not between 4 and 15 mA after reaching 1500 V, remove the specimen and repeat the procedure.

NOTE 9—If, after repeated trial, it is not possible to obtain scintillation at the specified conditions of voltage, current, and water-deposition rate, it is likely that the ac resistivity of the water supply is too high. The ac resistivity of the water should be between 2000 and 5000 $\Omega$ -cm. It may be necessary to add NaCl continuously to the water supply to maintain sufficient water conductivity.

11.7 Failure (Note 10) is indicated when the circuit breaker trips (after break-in) at the 2 or 3-A setting. If, before failure, the scintillation current falls substantially below 4 mA for a protracted period ( $\frac{1}{2}$  h or more), stop the test. Wash, but do not

scrub, the remaining dust off the specimen, re-dust, and repeat the procedure. Do this after each 100 h of test, if not required sooner.

NOTE 10—The circuit breaker may trip from causes other than failure; for example, malfunction or excessive moisture on the specimen. Therefore, the specimen should always be inspected for evidence of tracking or erosion before recording the failure time.

## 12. Report

12.1 Report the following information:

12.1.1 Description of the material tested,

12.1.2 Thickness of specimens,

12.1.3 Time to failure for each specimen tested,

12.1.4 Type of failure—tracking or erosion. If complete tracking failure is not obtained, note the extent of tracking and carbonization, and

12.1.5 AC resistivity in ohm-centimeters of the supply water (or of the reservoir water, if salt is added).

## 13. Precision and Bias

13.1 Experience indicates that the test result variance is large. The standard deviation,  $s$ , for tests on a given material in a given laboratory is nearly 40 % of the mean. (See Note 5 and Note 6.) Additional control of some of the test variables as described herein should reduce the variance.

## 14. Keywords

14.1 electrical insulation; erosion resistant insulation; resistance; tracking; wet tracking

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