Designation: D257 – 14

Standard Test Methods for DC Resistance or Conductance of Insulating Materials[1]

This standard is issued under the fixed designation D257; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 These test methods cover direct-current procedures for the measurement of dc insulation resistance, volume resistance, and surface resistance. From such measurements and the geometric dimensions of specimen and electrodes, both volume and surface resistivity of electrical insulating materials can be calculated, as well as the corresponding conductances and conductivities.

1.2 These test methods are not suitable for use in measuring the electrical resistance/conductance of moderately conductive materials. Use Test Method D4496 to evaluate such materials.

1.3 This standard describes several general alternative methodologies for measuring resistance (or conductance). Specific materials can be tested most appropriately by using standard ASTM test methods applicable to the specific material that define both voltage stress limits and finite electrification times as well as specimen configuration and electrode geometry. These individual specific test methodologies would be better able to define the precision and bias for the determination.

1.4 *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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D150 Test Methods for AC Loss Characteristics and Permittivity (Dielectric Constant) of Solid Electrical Insulation

D374 Test Methods for Thickness of Solid Electrical Insulation (Withdrawn 2013)[3]

D1169 Test Method for Specific Resistance (Resistivity) of Electrical Insulating Liquids

D1711 Terminology Relating to Electrical Insulation

D4496 Test Method for D-C Resistance or Conductance of Moderately Conductive Materials

D5032 Practice for Maintaining Constant Relative Humidity by Means of Aqueous Glycerin Solutions

D6054 Practice for Conditioning Electrical Insulating Materials for Testing (Withdrawn 2012)[3]

E104 Practice for Maintaining Constant Relative Humidity by Means of Aqueous Solutions

3. Terminology

3.1 *Definitions:*

3.1.1 The following definitions are taken from Terminology D1711 and apply to the terms used in the text of this standard.

3.1.2 *conductance, insulation, n*—the ratio of the total volume and surface current between two electrodes (on or in a specimen) to the dc voltage applied to the two electrodes.

3.1.2.1 *Discussion*—Insulation conductance is the reciprocal of insulation resistance.

3.1.3 *conductance, surface, n*—the ratio of the current between two electrodes (on the surface of a specimen) to the dc voltage applied to the electrodes.

3.1.3.1 *Discussion*—(Some volume conductance is unavoidably included in the actual measurement.) Surface conductance is the reciprocal of surface resistance.

3.1.4 *conductance, volume, n*—the ratio of the current in the volume of a specimen between two electrodes (on or in the specimen) to the dc voltage applied to the two electrodes.

3.1.4.1 *Discussion*—Volume conductance is the reciprocal of volume resistance.

3.1.5 *conductivity, surface, n*—the surface conductance multiplied by that ratio of specimen surface dimensions (distance between electrodes divided by the width of electrodes defining the current path) which transforms the measured conductance to that obtained if the electrodes had formed the opposite sides of a square.

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[1] These test methods are under the jurisdiction of ASTM Committee D09 on Electrical and Electronic Insulating Materials and are the direct responsibility of Subcommittee D09.12 on Electrical Tests.

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[2] 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.

[3] The last approved version of this historical standard is referenced on www.astm.org.

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

3.1.5.1 *Discussion*—Surface conductivity is expressed in siemens. It is popularly expressed as siemens/square (the size of the square is immaterial). Surface conductivity is the reciprocal of surface resistivity.

3.1.6 *conductivity, volume, n*—the volume conductance multiplied by that ratio of specimen volume dimensions (distance between electrodes divided by the cross-sectional area of the electrodes) which transforms the measured conductance to that conductance obtained if the electrodes had formed the opposite sides of a unit cube.

3.1.6.1 *Discussion*—Volume conductivity is usually expressed in siemens/centimetre or in siemens/metre and is the reciprocal of volume resistivity.

3.1.7 *moderately conductive, adj*—describes a solid material having a volume resistivity between 1 and 10 000 000 Ω-cm.

3.1.8 *resistance, insulation, (R_i), n*—the ratio of the dc voltage applied to two electrodes (on or in a specimen) to the total volume and surface current between them.

3.1.8.1 *Discussion*—Insulation resistance is the reciprocal of insulation conductance.

3.1.9 *resistance, surface, (R_s), n*—the ratio of the dc voltage applied to two electrodes (on the surface of a specimen) to the current between them.

3.1.9.1 *Discussion*—(Some volume resistance is unavoidably included in the actual measurement.) Surface resistance is the reciprocal of surface conductance.

3.1.10 *resistance, volume, (R_v), n*—the ratio of the dc voltage applied to two electrodes (on or in a specimen) to the current in the volume of the specimen between the electrodes.

3.1.10.1 *Discussion*—Volume resistance is the reciprocal of volume conductance.

3.1.11 *resistivity, surface, (ρ_s), n*—the surface resistance multiplied by that ratio of specimen surface dimensions (width of electrodes defining the current path divided by the distance between electrodes) which transforms the measured resistance to that obtained if the electrodes had formed the opposite sides of a square.

3.1.11.1 *Discussion*—Surface resistivity is expressed in ohms. It is popularly expressed also as ohms/square (the size of the square is immaterial). Surface resistivity is the reciprocal of surface conductivity.

3.1.12 *resistivity, volume, (ρ_v), n*—the volume resistance multiplied by that ratio of specimen volume dimensions (cross-sectional area of the specimen between the electrodes divided by the distance between electrodes) which transforms the measured resistance to that resistance obtained if the electrodes had formed the opposite sides of a unit cube.

3.1.12.1 *Discussion*—Volume resistivity is usually expressed in ohm-centimetres (preferred) or in ohm-metres. Volume resistivity is the reciprocal of volume conductivity.

4. Summary of Test Methods

4.1 The resistance or conductance of a material specimen or of a capacitor is determined from a measurement of current or of voltage drop under specified conditions. By using the appropriate electrode systems, surface and volume resistance or conductance are measured separately. The resistivity or conductivity is calculated with the known specimen and electrode dimensions are known.

5. Significance and Use

5.1 Insulating materials are used to isolate components of an electrical system from each other and from ground, as well as to provide mechanical support for the components. For this purpose, it is generally desirable to have the insulation resistance as high as possible, consistent with acceptable mechanical, chemical, and heat-resisting properties. Since insulation resistance or conductance combines both volume and surface resistance or conductance, its measured value is most useful when the test specimen and electrodes have the same form as is required in actual use. Surface resistance or conductance changes rapidly with humidity, while volume resistance or conductance changes slowly with the total change being greater in some cases.

5.2 Resistivity or conductivity is used to predict, indirectly, the low-frequency dielectric breakdown and dissipation factor properties of some materials. Resistivity or conductivity is often used as an indirect measure of: moisture content, degree of cure, mechanical continuity, or deterioration of various types. The usefulness of these indirect measurements is dependent on the degree of correlation established by supporting theoretical or experimental investigations. A decrease of surface resistance results either in an increase of the dielectric breakdown voltage because the electric field intensity is reduced, or a decrease of the dielectric breakdown voltage because the area under stress is increased.

5.3 All the dielectric resistances or conductances depend on the length of time of electrification and on the value of applied voltage (in addition to the usual environmental variables). These must be known and reported to make the measured value of resistance or conductance meaningful. Within the electrical insulation materials industry, the adjective "apparent" is generally applied to resistivity values obtained under conditions of arbitrarily selected electrification time. See X1.4.

5.4 Volume resistivity or conductivity is calculated from resistance and dimensional data for use as an aid in designing an insulator for a specific application. Studies have shown changes of resistivity or conductivity with temperature and humidity (**1**, **2**, **3**, **4**).[4] These changes must be known when designing for operating conditions. Volume resistivity or conductivity determinations are often used in checking the uniformity of an insulating material, either with regard to processing or to detect conductive impurities that affect the quality of the material and that are not readily detectable by other methods.

5.5 Volume resistivities above 10^{21} Ω·cm (10^{19} Ω·m), calculated from data obtained on specimens tested under usual laboratory conditions, are of doubtful validity, considering the limitations of commonly used measuring equipment.

5.6 Surface resistance or conductance cannot be measured accurately, only approximated, because some degree of volume

[4] The boldface numbers in parentheses refer to the list of references appended to these test methods.

resistance or conductance is always involved in the measurement. The measured value is also affected by the surface contamination. Surface contamination, and its rate of accumulation, is affected by many factors including electrostatic charging and interfacial tension. These, in turn, affect the surface resistivity. Surface resistivity or conductivity is considered to be related to material properties when contamination is involved but is not a material property of electrical insulation material in the usual sense.

6. Electrode Systems

6.1 The electrodes for insulating materials are to allow intimate contact with the specimen surface, without introducing significant error because of electrode resistance or contamination of the specimen (**5**). The electrode material is to be corrosion-resistant under the conditions of the test. For tests of fabricated specimens such as feed-through bushings, cables, etc., the electrodes employed are a part of the specimen or its mounting. In such cases, measurements of insulation resistance or conductance include the contaminating effects of electrode or mounting materials and are generally related to the performance of the specimen in actual use.

6.1.1 *Binding-Post and Taper-Pin Electrodes,* Fig. 1 and Fig. 2, provide a means of applying voltage to rigid insulating materials to permit an evaluation of their resistive or conductive properties. These electrodes attempt to simulate the actual conditions of use, such as binding posts on instrument panels and terminal strips. In the case of laminated insulating materials having high-resin-content surfaces, lower insulation resistance values are obtained with taper-pin than with binding posts, due to more intimate contact with the body of the insulating material. Resistance or conductance values obtained are highly influenced by the individual contact between each pin and the dielectric material, the surface roughness of the pins, and the smoothness of the hole in the dielectric material. Reproducibility of results on different specimens is difficult to obtain.

6.1.2 *Metal Bars* in the arrangement of Fig. 3 were primarily devised to evaluate the insulation resistance or conductance of flexible tapes and thin, solid specimens as a fairly simple and convenient means of electrical quality control. This arrangement is more satisfactory for obtaining approximate values of surface resistance or conductance when the width of the insulating material is much greater than its thickness.

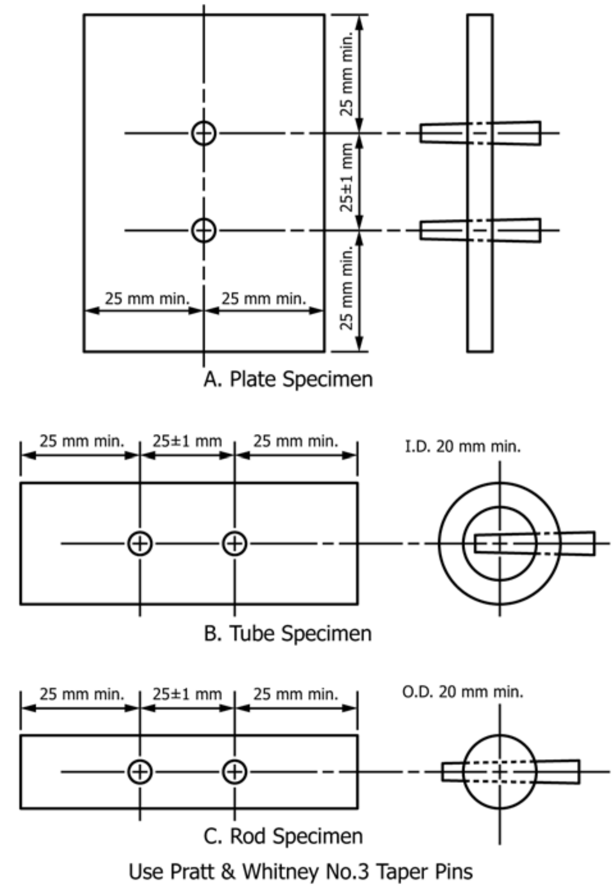

FIG. 2 Taper-Pin Electrodes

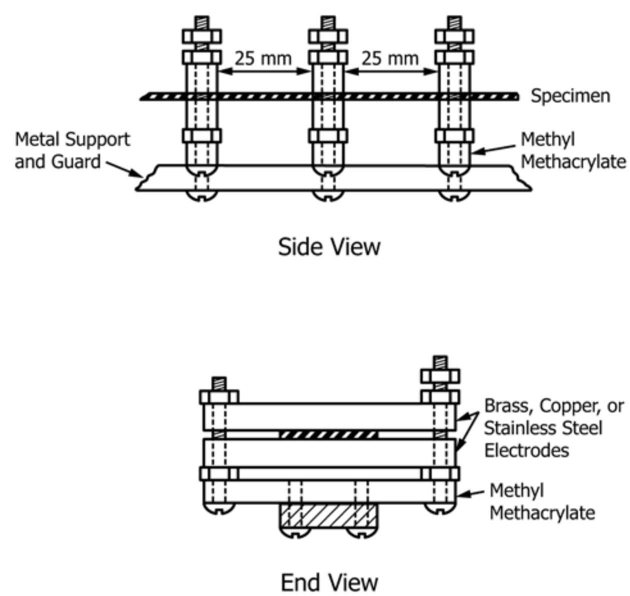

FIG. 3 Strip Electrodes for Tapes and Flat, Solid Specimens

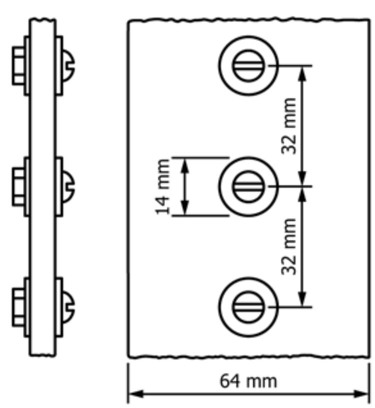

FIG. 1 Binding-Post Electrodes for Flat, Solid Specimens