



ASSOCIATION CONNECTING
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IPC-TM-650 TEST METHODS MANUAL

1.0 Scope This method describes a technique to determine the volume permittivity (dielectric constant) and loss tangent (dissipation factor) of insulating materials at 1 MHz using contacting electrodes. Several techniques are described using the actual thickness of the material measured, the geometry of the test specimen and values for capacitance and conductance of material to calculate the desired properties. The accuracy of this test is inherently limited by the ability to measure thickness accurately, however, use of an estimated value for effective electrode area, stray capacitance and equipment tolerances may also result in significant errors. Use of the preferred method (A) on metal clad materials should reduce errors on permittivity to those associated with thickness measurement (which should be under 2% for material over .005 inch), and an error (under 1%) associated with the effective area determination. Values determined with method B, C or D can be 5% or more from the actual value. Except for thickness determination, errors increase with specimen thickness due to the reduction in actual specimen capacitance. Method B and C are intended for thin materials while Method D is primarily for materials over .020 inch. For more accurate measurement of permittivity (dielectric constant) the two fluid method¹ easily permits measurement to better than 1%. For thin films under .005 inch, the two-fluid method IPC-TM-650, Method 2.5.5.3 is recommended.

2.0 Applicable Documents

ASTM-D-150 Standard Test Method for A-C Loss Characteristics and Permittivity (Dielectric Constant) of Solid Electrical Insulating Material

3.0 Test Specimens

3.1 Number Three specimens shall be prepared unless otherwise specified.

Method A Etched pattern silver painted with 1/2 inch soldered leads, see Figure 1.

Method B and C 2.0 inch diameter silver painted disks (from which 1.000 inch diameter disks are punched after painting).
Note: For thin films, samples may be cut into smaller specimens if capacitance exceeds instrument capacity.

1. Two Fluid Method, IPC-TM-650, Method 2.5.5.3

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Number 2.5.5.1	
Subject Permittivity (Dielectric Constant) and Loss Tangent (Dissipation Factor) of Insulating Material at 1 MHz (Contacting Electrode Systems)	
Date 5/86	Revision B
Originating Task Group N/A	

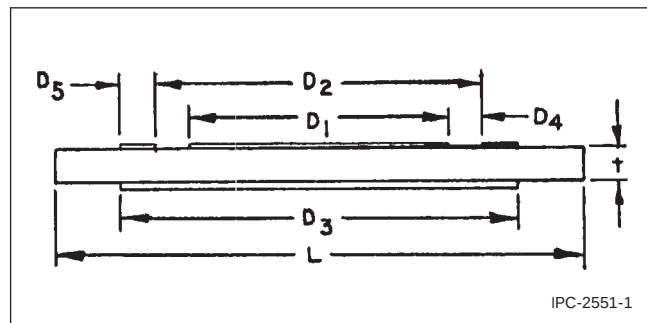


Figure 1 Electrode Configuration for Permittivity Tests Using a Three Terminal Bridge

Method D Silver painted disks or squares of the appropriate size with short leads attached by small residual copper pads or other means. (See Appendix 1 for appropriate size.)

3.3 Location One specimen from each edge and one from the center of a sheet. (This normally will provide the highest and lowest values of dielectric properties of a reinforced material.)

3.4 Metal Clad Materials Foil shall be removed by etching, leaving a metal outline for method "A".

3.5 Uncured Materials Materials which are not fully cured must be cured under normal conditions. Two ply minimum laminations are recommended for testing of bonding sheets while coverlays and similar materials may be tested in single ply or may be laminated together to produce a thicker specimen reducing the error induced by thickness measurement. Films coated on one side shall be laminated such that one coated side remains on the exterior.

4.0 Apparatus/Materials

4.1 All Methods Paper Cutter Silver Paint (DuPont 4929, or DuPont 4817 if material is attacked by cellosolve acetate) Micrometer with .00005 inch resolution Optical measuring device capable of measuring 1.0 inch to 1.2 inch with .001 inch resolution.



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4.2 Method A and Method D

1 MHz three terminal capacitance bridge with 100-1000 PF capacity

#20 tinned copper wire

Rosin flux solder

Soldering iron

Remote test fixture or binding post electrodes directly attached to the bridge

4.3 Method B 1 MHz capacitance bridge, two or three terminal Test fixture (Figure 2) Punch and die set, 1.0 inch diameter.

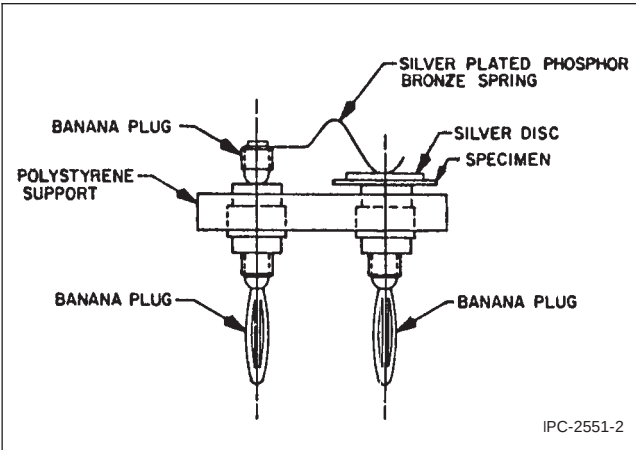


Figure 2 Test Fixture Permittivity and Loss Tangent of Thin Insulating Materials

4.4 Method C Q meter with 1 MHz capability Q Coils Test fixture (Figure 2) Punch and die set, 1.0 inch diameter.

5.0 Procedure

5.1 Preconditioning Unless otherwise specified the prepared painted sample shall be maintained at $23^{\circ}\text{C} \pm 5^{\circ}\text{C}$ and $50\% \text{ RH} \pm 10\% \text{ RH}$ for a minimum of 24 hours.

5.2 Test Conditions Unless otherwise specified specimens shall be tested at $23^{\circ}\text{C} \pm 2^{\circ}\text{C}$. Testing may be performed at $50\% \pm 10\% \text{ RH}$ or may be performed at ambient humidity within 5 minutes of removal from the 50% conditioning chamber.

5.3 Equipment Set Up

5.3.1 Warm up the capacitance measuring device in accordance with the manufacturer's recommendation.

5.3.2 Set the equipment to measure capacitance and conductance (or Q for Method C) at 1 MHz.

5.4 Test

5.4.1 Determine the thickness of the test specimen to the nearest .00005 inch or better at four locations (use corners for Figure 1 specimen used in Method A and make measurements prior to painting the specimen used for Methods B, C and D). *Note:* For films under .005 inch the known or measured density and the specimen weight and geometry may be used to determine effective thickness.

5.4.2 Measure the diameter (or length and width) of the electrode to the nearest .001 inch using a suitable device. For Figure 1 specimen record both the outer diameter of the inner electrode D_1 and inner diameter of the outer guard electrode D_2 .

5.4.3 Determine the capacitance and conductance or Q using Method A, B, C or D depending on equipment and test specimen type.

5.4.3.1 Method A capacitance bridge with Figure 1 specimen.

5.4.3.1.1 Connect the low terminal to the guarded (center) electrode shown as D_1 on the specimen.

5.4.3.1.2 Connect the guard electrode, shown as D_5 in Figure 1, to the bridge or fixture ground.

5.4.3.1.3 Zero the bridge for capacitance and conductance.

5.4.3.1.4 Connect the solid electrode shown as D_3 to the "high" terminal.

5.4.3.1.5 Determine and record the specimen capacitance as C_s and Conductance as G_s .²

5.4.3.2 Method B Capacitance Bridge with Fixture (Figure 2).

2. G_s —For many bridges the loss tangent (dissipation factor) may be read directly from the meter eliminating the need to calculate it from the conductance.