The Institute for Interconnecting and Packaging Electronic Circuits
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IPC-TM-650
TEST METHODS MANUAL

Number	
2.5.17.1	
Subject	
Volume and Surface Resistivity of Dielectric Materials	
Date	Revision
12/94	**A**
Originating Task Group	
MIL-P-13949 Test Methods Task Group (7-11b)	

1.0 Scope This test method is designed to determine volume resistivity and surface resistivity of metallic-clad or unclad laminates under conditions of specified humidity and temperature and at elevated temperatures.

2.0 Applicable Documents

ASTM-D-257 D-C Resistance or Conductance of Insulating Materials

IPC-TM-650

Method 2.3.6, Etching, Ammonium Persulfate
Method, 2.3.7 Etching, Ferric Chloride
Method 2.3.7.1, Cupric Chloride Etching
Method 2.6.3, Moisture and Insulation Resistance, Rigid, Rigid/Flex and Flex Printed Wiring Boards

3.0 Test Specimens

3.1 Laminate thickness of 0.51 mm [0.020 in] or greater. Three specimens of dimensions 101.6 ± 3.2 mm x 101.6 ± 3.2 mm [4.0 ± 0.125 in x 4.0 ± 0.125 in] by thickness shall be prepared for each test condition, unless otherwise specified.

3.2 Laminate thickness of less than 0.51 mm [0.020 in]. Three specimens of dimensions 50.8 ± 1.6 mm x 50.8 ± 1.6 mm [2.0 ± 0.062 x 2.0 ± 0.062 in] by the thickness shall be prepared for each test condition, unless otherwise specified.

4.0 Equipment Apparatus

4.1 Conditioning chamber capable of maintaining 35 ± 2°C [95 ± 3.6°F] and 90 +5, –0% relative humidity.

4.2 Conditioning chamber capable of attaining the temperature and humidity conditions specified in IPC-TM-650, Method 2.6.3.

4.3 Air circulating oven capable of maintaining the specified test temperatures to within ± 2°C [±3.6°F].

4.4 Resistance measuring instrumentation capable of measuring to 10^{12} meg-ohms, minimum, with an accuracy of ± 5 percent at its highest scale setting. The equipment shall have the capability of applying 500 volts dc to the test specimen.

4.5 A system/fixture for electrical connections into the temperature and humidity chambers (see 4.1, 4.2, 4.3). Three separate cables shall be provided to make connections to each specimen being conditioned/tested. The center conductor of each cable shall be connected to one of the three electrodes applied to the test specimen. The opposite ends of the cables shall be brought outside the chamber and terminated at a convenient location for connection to the measuring instrument. Shields shall be trimmed back from the ends of the center conductor insulation and interconnected to the guard post of the measuring instrument. See 6.2 for additional information.

Support the specimen parallel to the air flow through the chamber during conditioning.

Special care should be taken to ensure that materials used in the fixture are such that resistance readings are that of the material being tested and not the fixture.

4.6 A measurement device capable of measuring laminate thickness to the nearest 0.0025 mm [0.0001 in].

4.7 Material and apparatus for formation of specimen conductors.

4.7.1 Conductor silver paint; composition 4817 by Dupont Company, or equivalent.

4.7.2 A system for applying the paint to the specimen, such as silk screening.

4.7.3 A mask, fixture, photoprinting system, or equivalent, for applying the applicable electrodes/test pattern to the specimen (See Dimension Table).

4.8 Etching system in accordance with IPC-TM-650, Method 2.3.6, 2.3.7, or 2.3.7.1.

5.0 Procedure

5.1 Specimen Preparation

5.1.1 Test patterns with the applicable dimensions shown in the Dimension Table, and in accordance with Figures 1, 2, and 3 shall be generated, as follows:

Dimension Table

Base Thickness	D_1 Diameter	D_2 Diameter	D_3 Diameter	D_4	D_5	A(cm^2)	P/D_4
Less than 0.51 mm (0.020 inches)	1.000 (2.540)	1.020 (2.591)	1.375 (3.493)	0.010 (0.025)	0.177 (0.460)	5.169	317.4
	±0.005 (0.013)	±0.005 (0.013)	±0.005 (0.013)	±0.001 (0.003)	±0.005 (0.013)		
0.51 mm (0.020 inches) and greater	2.000 (5.080)	2.500 (6.350)	3.000 (7.520)	0.250 (0.636)	0.250 (0.636)	25.652	28.27
	±0.015 (0.038)	±0.015 (0.038)	±0.015 (0.038)	±0.005 (0.038)	±0.015 (0.038)		

For the above: $Do = (D_1 + D_2)/2$

$A = \frac{\pi Do^2}{4}$

$P = \pi D_O$

Note: Dimensions are in inches with metric equivalents in parenthesis (1 inch = 2.54 cm).

5.1.1.1 Metallic-clad materials having a thickness of less than 0.51 mm [0.020 in] shall be photoprinted with a pattern of the outline of the conductors and etched in accordance with IPC-TM-650, Methods 2.3.6, 2.3.7, or 2.3.7.1. The electrodes shall then be completed (filled in) using silver conductive paint.

5.1.1.2 Metallic-clad laminates 0.51 mm [0.020 in] or thicker shall be etched in accordance with IPC-TM-650, Method 2.3.6, 2.3.7, or 2.3.7.1. A pattern of the outline of the conductors may be photoprinted before etching. Test electrodes shall be applied using silver conductive paint and an appropriate test pattern application system.

5.1.1.3 Solid metal foil electrodes shall not be acceptable in any case, except for the outer electrode for laminates less than 0.51 mm [0.020 in]. A small pad of retained cladding may be retained within the electrode borders to facilitate soldering of leads.

5.1.2 If soldering techniques are used to attach leads, suitable cleaning procedures shall be used to remove flux and other residue.

5.2 Conditioning

5.2.1 Humidity Conditioning

5.2.1.1 Specimens of a thickness less than 0.51 mm [0.020 in] shall be subjected to 90 + 5-0% relative humidity and 35 ± 2°C [95 ± 3.6°F] for a period of 96 +2, -0 hours prior to electrical measurement.

5.2.1.2 Specimens of a thickness greater than, or equal to, 0.51 mm [0.020 in] shall be subjected to the conditioning specified in IPC-TM-650, Method 2.6.3, paragraph 5.1.3. Following the tenth cycle, the conditioning chamber shall maintain a temperature of 25 ± 2°C [77 ± 3.6°F] and 90 +5, 0% relative humidity during the interval that electrical measurements are being made.

5.2.2 At Elevated Temperature Conditioning Specimens shall be subjected to the specified temperature (based on material type and specification requirements) for a period of 24 hours -0, +2 hours. Unless otherwise specified, the temperature shall be 125 ± 2°C [257 ± 3.6°F].

5.3 Electrical Measurements All electrical measurements shall be made inside the applicable conditioning chamber and at the conditions specified in 5.2.

5.3.1 Electrical measurements taken on specimens conditioned in accordance with paragraph 5.2.1 shall be completed within the 2 hour tolerance of the conditioning.

5.3.2 Electrical measurements taken on specimens conditioned in accordance with paragraph 5.2.2 shall be made after achieving 1.5 hours steady state of 25 ± 2°C [77 ± 3.6°F] and 90 +5, -0% relative humidity. All measurements shall be completed within 2 hours.

5.3.3 Electrical measurements taken on specimens conditioned in accordance with paragraph 5.3 shall be completed within the 2 hour tolerance of the conditioning.

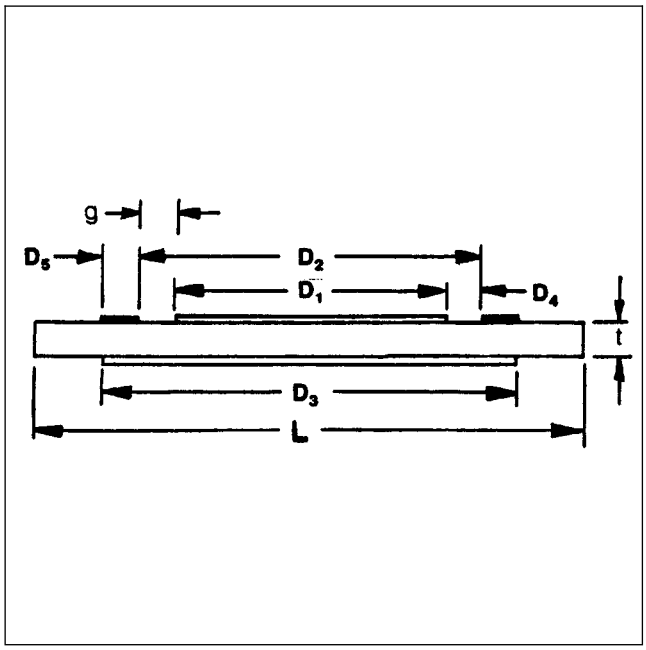

Figure 1 Test pattern dimensions (See table)

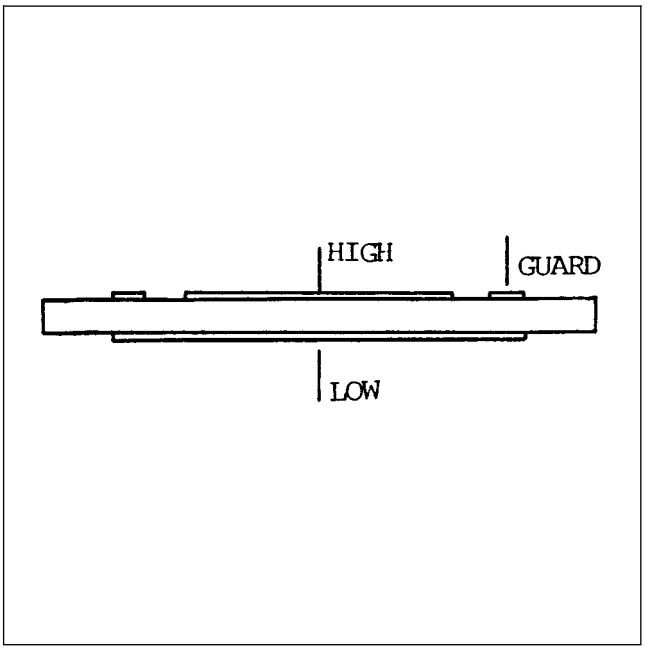

Figure 2

5.3.4 All electrical measurements shall be made using 500 volts direct current. The voltage shall be applied to the specimen for 60 +5, -0 seconds prior to taking the actual reading, for stabilization purposes.

5.3.5 Measure the volume resistance by connecting the resistance measuring device to the specimen electrodes through the fixture system as described in 4.5 in accordance with Figure 2.

5.3.6 Measure the surface resistance by interchanging the test cables connecting the solid back electrode and the outer ring to the instrument for the arrangement shown in Figure 3.

5.4 Specimen Thickness Each specimen shall be measured for its thickness without cladding. Specimens for each test condition shall have their thickness readings averaged.

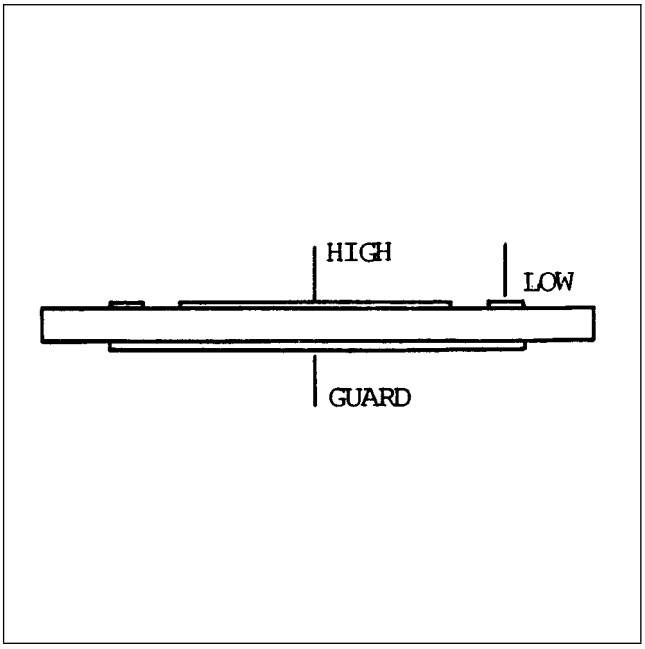

Figure 3

5.5 Calculations

5.5.1 The volume resistivity shall be calculated as follows:

$$r = \frac{RA}{T}$$

Where:

r = Volume resistivity in megohm-centimeters

R = Measured volume resistance in megohms

A = Effective area of the guarded electrode in square centimeters

T = Average thickness of specimen in centimeters
T = (t) x 2.54 [see 5.2.1]

t = Average thickness (t) in inches (from 5.4)

Note: The value of A may be obtained from the Dimension Table.

5.5.2 The surface resistivity shall be calculated as follows:

$$r^1 = \frac{R^1P}{D4}$$

Where:

r^1 = Surface resistivity in megohms

R^1 = Measured surface resistance in megohms

P = Effective perimeter of the guarded electrode in centimeters

D4 = Width of the test gap in centimeters

Note: The ratio of P/D4 for the electrode configuration being used may be obtained from the Dimension Table included in Figure 1.

5.6 Reporting

5.6.1 The volume resistivity of each specimen and the average shall be reported. Each condition tested shall be reported separately.

5.6.2 The surface resistivity of each specimen and the average shall be reported. Each condition shall be reported separately.

5.6.2.1 The surface resistance is the direct reading of the megohmeter scale and should be recorded in megohms.

6.0 Notes

6.1 For additional information see ASTM-D-257, D-C Resistance or Conductance of Insulating Materials.

6.2 The system of electrical connections to the specimens may benefit from a coaxial cable set-up designed to shield the measurement of volume or surface resistances from electrical interference.

6.3 Performance Specifications The following information should be reviewed within the applicable performance specification or product procurement document:

a. Specimen size, quantity, and configuration, if other than that specified in 3.0.

b. Conditioning parameters, such as temperature for Elevated Temperatures.

c. Any other changes to the specified procedures in this method.