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

Number	
2.5.6.2	
Subject	
Electric Strength of Printed Wiring Material	
Date	Revision
8/97	**A**
Originating Task Group	
N/A	

1.0 Scope This method describes a technique for evaluating the ability of an insulating material to resist electrical breakdown perpendicular to the plane of the material when subjected to short term, high voltages at standard AC power frequencies of 50-60 Hz.

1.1 Applicability and Use of Data This method may be used on material of any thickness up to approximately 0.125 inch, however, for material over 0.020 inch, other methods such as dielectric breakdown are normally used to characterize a material's electrical integrity. Results of this test may be drastically affected by moisture content, and results obtained using different preconditioning may not be comparable.

This method uses an oil medium to prevent flashover on a small specimen and results may not be comparable to tests run in air. Values obtained using this method should not be used for predicting the insulating ability of ultra thin metal clad laminates.

The values determined by this method generally decrease with increasing specimen thickness for otherwise identical material. This method is based on the techniques described in ASTM D149.

2.0 Applicable Document

ASTM D149 Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies

3.0 Test Specimens

3.1 Number Three specimens shall be prepared unless otherwise specified.

3.2 Form Specimens should be 4.0 inch ± 1.0 inch X 4.0 ± 1.0 inch; however, size is not critical as long as no flashover occurs around the edges.

3.3 Location Specimens shall be cut by any convenient means from both edges[1] and the center of the laminate (except no specimen shall be taken closer than 1 inch from the edge of full size sheets).

3.4 Foil Clad Material Foil clad materials shall have all metal cladding removed by etching and should be thoroughly cleaned prior to conditioning or testing.

3.5 Uncured Material Uncured material must be fully cured. Under normal conditions, two ply lamination is recomrnended for comparison of prepreg material. Single ply laminates are recommended for cover lays and similar products designed for single ply usage.

4.0 Apparatus/Materials

4.1 High voltage breakdown tester, 25 KV, minimum with an adequate current rating[2], a motorized control capable of 500 volts per second rate of rise and a meter capable of indicating breakdown voltage within 5% over the entire range of actual breakdown voltages (generally 1 KV to 20 KV).

4.2 Oil tank filled with insulating oil[3].

4.3 Electrode test set 2 inch diameter electrodes with 1/4 inch radius on the edge of the electrodes and 50 g. ± 2 g. load applied by the weight of upper electrode (in air).

4.4 Two high voltage test leads (leads rated in excess of the tester voltage capability are recommended).

4.5 Micrometer capable of resolving at least 0.0001 inch. *Note:* For accurate measurement of material under 0.005 inch test accuracy may be severely limited by the ability to measure the specimen accurately.

4.6 Constant temperature water bath, capable of maintaining 50°C ± 2°C, filled with distilled water.

1. Edges: For a reinforced laminate the specimens shall be from opposite edges of the reinforcement.
2. Current capacity: 40 milliamps is normally satisfactory.
3. Insulating oil: Shell Dial AX Insulating Oil has been found suitable for breakdowns up to 100 KV.

4.7 Large beaker or pan filled with ambient temperature distilled water.

4.8 Rack for supporting and separating specimens in the 50°C water bath.

4.9 Lint free paper towels.

5.0 Procedure

5.1 Preconditioning Unless otherwise specified, the specimen shall be conditioned for 48 hours (+2 hours –0 hours) in distilled water maintained at 50°C ± 2°C.

Following this the specimen shall be immersed in the ambient temperature distilled water for 30 minutes minimum, 4 hours maximum, to achieve temperature equilibrium without significant changes in moisture content.

5.2 Test Conditions The test should be performed at ambient temperature, 23°C ± 5°C. Relative humidity is not significant as the tests are performed under oil.

5.3 Equipment Set Up

5.3.1 Set the high voltage tester in accordance with the manufacturer's instructions so that the voltage range will be adequate for the material being tested.

5.3.2 Set up the control for testing using a 500 volt per second rate of rise.

5.3.3 Attach the leads (if not permanently wired) such that the high lead is connected to one electrode and the ground lead is connected to the other electrode.

5.4 Test

5.4.1 Remove a preconditioned specimen from the ambient temperature water and wipe dry with a lint free paper towel.

5.4.2 Determine and record the thickness of the specimen at four locations 1 inch from the edge at the midpoint of each side.

5.4.3 Insert the specimen into the test fixture centering it to reduce chances of flashover.

5.4.4 Operate the tester such that the voltage is applied with a 500 volts per second increase and observe the point at which the tester indicates a breakdown.

5.4.5 Record the breakdown voltage to the nearest .1 KV for values over 10 KV and to at least the nearest 5% for all lower values.

5.4.6 Remove the specimen from the oil medium and verify that a breakdown has occurred. If none is apparent reinsert the specimen, carefully centering it, and retest as in 5.4.4 and 5.4.5. *Note:* If flashover occurs, either a larger specimen or new oil must be used.

4.7 Test the remaining two specimens as in 5.4.1 through 5.4.6.

6.0 Calculations

6.1 Calculate the average thickness for each specimen from the four individual values measured.

6.2 Determine the electric strength in volts per mil for each specimen by dividing the breakdown voltage expressed in kilovolts by the thickness express in inches.

$$ES = \frac{6.8\ KV}{.005\ inch} \times \frac{1000\ V}{KV} \times \frac{1\ inch}{1000\ mils} = 1360\ v/mil$$

6.3 Determine the average electric strength by averaging the individual values for each specimen. Round the average to the nearest 10 volts/mil.

6.4 If any specimen falls below the specification minimum, calculate the percentage of the requirement:

$$^{ES}min = \frac{Lowest\ Value}{Spec\ Value} \times 100\%$$

e.g. Value = 670 volts per mil

Specification = 750 volts per mil

$$^{ES}min = \frac{670}{750} \times 100\% = .893 \times 100\% = .89 \times 100\% = 89\%$$

7.0 Report

7.1 Report the average value for electric strength in volts per mil to the nearest 10 volts per mil.

7.2 Report the minimum value in percent of requirement if it is below the requirement for average electric strength.

7.3 Report the actual thickness range of the material tested including the minimum and maximum individual thickness measurements.

7.4 Report any anomalies in the test or any variations from the prescribed procedures or tolerances.

8.0 ***Notes***

8.1 This test method may be modified to an air medium to predict performance in normal environments more accurately, however, unless the electrode is effectively guarded, the breakdown will generally occur in air.

8.2 For testing the effect of copper foil on clad laminate under 0.005 inch it is suggested that two inch circular electrodes be left on the 4 inch X 4 inch specimen by etching. The ground electrode may be slightly larger to assure registration.

8.3 For materials which are compressible, a standard pressure of 25 PSI is to be used for determining specimen thickness.