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An American National Standard

Standard Test Methods for Copper-Clad Thermosetting Laminates for Printed Wiring Boards[1]

This standard is issued under the fixed designation D5109; 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.

1. Scope

1.1 These test methods cover the procedures for testing copper-clad laminates produced from fiber-reinforced, thermosetting polymeric materials intended for fabrication of printed wiring boards.

1.2 The procedures appear in the following sections:

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1.3 Metric units are the preferred units for these test methods. Inch-pound units, where shown, are presented for information only.

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.* For specific hazard statements, see 7.2.1, 8.1, and 11.3.1.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

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

D229 Test Methods for Rigid Sheet and Plate Materials Used for Electrical Insulation

D257 Test Methods for DC Resistance or Conductance of Insulating Materials

D374 Test Methods for Thickness of Solid Electrical Insulation

D1531 Test Methods for Relative Permittivity (Dielectric Constant) and Dissipation Factor by Fluid Displacement Procedures

D1711 Terminology Relating to Electrical Insulation

D1825 Practice for Etching and Cleaning Copper-Clad Electrical Insulating Materials and Thermosetting Laminates for Electrical Testing (Withdrawn 2012)[3]

D1867 Specification for Copper-Clad Thermosetting Laminates for Printed Wiring

D3636 Practice for Sampling and Judging Quality of Solid Electrical Insulating Materials

D6054 Practice for Conditioning Electrical Insulating Materials for Testing

E53 Test Method for Determination of Copper in Unalloyed Copper by Gravimetry

2.2 *Other Standard:*

NEMA Publication Number LI 1-1975 Test for Hot Peel Strength of Copper-Clad Industrial Laminates for Printed Circuits[4]

3. Terminology

3.1 *Definitions:* Definitions of terms used in these test methods are found in Terminology D1711.

3.2 *Definitions of Terms Specific to This Standard:*

[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 D09.07 on Flexible and Rigid Insulating Materials.

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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.

[4] Available from National Electronic Manufacturer's Association (NEMA), 2101 L St., NW, Washington, DC 20037.

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3.2.1 *blister, copper, n*—a gas pocket (a void) located at the interface of the dielectric and the copper foil in a copper-clad laminate.

3.2.2 *blister, core, n*—a gas pocket (a void) located between the laminations in the dielectric core of a copper-clad laminate.

3.2.3 *dimensional instability*—a characteristic of a solid material that is displayed by changes in the dimensions of a test specimen when the specimen is subjected to environments similar to those that the material may encounter during the manufacturing operations or use.

3.2.4 *peel strength, n*—a force required to separate copper foil from the surface of a copper-clad laminate using a specific test method. It is reported as a force per unit width.

3.2.5 *trace, n*—in the printed wiring board industry, an electrically conducting element of a printed circuit board that remains on the laminate surface after etching.

4. Conditioning

4.1 Unless otherwise stated in these test methods, condition test specimens in accordance with the provisions stated in Specification D1867 for the property of interest. If that standard does not specify conditioning requirements, use the conditioning requirements of Practice D6054.

5. Purity of Copper

5.1 *Significance and Use*—Since the electrical conductance of copper can be adversely affected by small amounts of impurities, this test provides assurance that the circuits fabricated from the laminate will provide sufficient conductance for signal transmission. The grain structure and the porosity of copper also affect conductance.

5.2 *Procedure*—Analyze the copper for purity in accordance with Test Methods E53.

5.3 Report the following information:

5.3.1 The amount of copper, %, and

5.3.2 The identity of the laminate sampled for testing.

5.4 *Precision and Bias:*

5.4.1 See Test Methods E53.

6. Warp or Twist

6.1 *Significance and Use*—Flat laminate material of large area per sheet is desirable for the most efficient fabrication of bare circuit boards. Lack of warp or twist is very necessary for efficient placement of components on the fabricated but unpopulated circuit boards particularly if automatic insertion machinery is used to install components on the circuit boards.

6.2 *Procedure*—Determine warp or twist on full size laminate sheets that are in the "as is" condition. Test and report the results in accordance with Test Methods D229.

7. Solvent Resistance

7.1 *Significance and Use*—Solvents are often used for processing or cleaning purposes in the fabrication of printed wiring boards. The solvents are used sometimes at elevated temperatures. Such exposure should not adversely affect the suitability of the dielectric portion of the laminate for its intended use.

7.2 *Procedure:*

7.2.1 Take a specimen of laminate of 10 to 40–cm ^{2} area. Etch all of the copper from the specimen in accordance with Practice D1825. (**Warning**—The solvents used in the printed wiring board industry may be physiologically hazardous substances. Such substances are to be used only where adequate ventilation is provided and in such a manner as to avoid absorption through the skin. Take precautions to condense any vapors and return them to the boiling liquid.)

7.2.2 Using appropriate apparatus to generate and maintain the vapor phase, suspend the specimen in solvent vapors for approximately 2 min.

NOTE 1—An appropriate apparatus consists of a vessel for heating liquid solvent and a reflux condenser in which the specimen can be placed so that it is in contact with the vapor phase of the boiling (condensing) solvent.

7.2.3 At the conclusion of this exposure, examine the surfaces of the specimen for any evidence of blistering or delamination.

7.3 *Report*—Report the following information:

7.3.1 Any visible evidence of blistering or delamination. Such behavior may be sufficient cause for judging that the laminate is not resistant to the solvent used.

7.3.2 The identification of the laminate tested.

7.3.3 The identification of the solvent used.

7.4 *Precision and Bias:*

7.4.1 No statement is made about the precision or bias of this test method for measuring resistance to solvents since the result merely states whether there is conformance to the criteria for acceptability specified in the procedure.

8. Solder Float Test

8.1 *Significance and Use*—Many printed wiring boards are populated with components followed by soldering either manually or with a wave soldering process. A popular circuit design uses a fabrication process known as soldermask over bare copper (SMOBC) in which the laminate is submerged in molten solder. In either of these two cases, the laminate is subjected to exposure to molten solder temperatures for short periods of time. This test method provides useful information about the suitability of both clad and unclad laminate to survive these exposures. (**Warning**—Molten solder can cause severe burns. Care should be exercised to prevent injury.)

8.2 *Unetched Laminate:*

8.2.1 Prepare test specimens of unetched laminate having dimensions 25 by 25 ± 1 mm by any thickness. For laminate clad on both sides, two specimens are required, one for each side. If specimens that survive the solder dip exposure are to be used for peel strength tests in accordance with Section 9, at least three specimens are required.

8.2.2 *Procedure*—Float an unfluxed, unetched specimen, copper side down, on clean molten tin/lead 60/40 solder that is at the temperature specified in Specification D1867 for the thickness of the laminate being tested. At the end of the time

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specified in Specification D1867, remove the specimen and examine the copper surface for evidence of blisters. For laminate clad on two sides, use a fresh specimen for testing each side.

8.3 *Etched Laminate:*

8.3.1 A specimen is unconditioned laminate of any thickness which is 50 by 50 ± 5 mm. Etch each specimen in accordance with Practice D1825 so as to have an etched pattern as in Fig. 1.

8.3.2 *Procedure:*

8.3.2.1 Float the unfluxed specimen with its etched copper trace side to be tested down on clean molten 60/40 tin/lead solder at the temperatures and for the times shown in Specification D1867.

8.3.2.2 At the end of the time specified for each grade, remove the specimen, allow it to cool to room temperature, and then examine it for evidence of: (*1*) blistering between layers of laminate, (*2*) blistering between copper and substrate, or (*3*) delamination of the copper foil.

8.3.2.3 For double-sided clad laminate, use a fresh specimen for examining each side. If no delamination or blistering is seen, the specimens that were exposed to solder dip may be used for the peel strength tests of Section 9.

8.3.3 *Report*—Report the following information:

8.3.3.1 Any evidence of blistering between laminate layers,

8.3.3.2 Any evidence of blistering between the copper and any substrate, and

8.3.3.3 Any delamination of the copper foil from the substrate.

9. Peel Strength Test

9.1 This test is performed at room temperature on specimens of laminate that have previously been subjected to the solder float test.

9.2 *Significance and Use*—This test method is useful for evaluating laminate for the detrimental effects, if any, due to soldering or other exposure to elevated temperature, upon the integrity of the bond interface between the dielectric substrate and the copper foil. There is no significance to this test in relation to the forces that may be exerted upon any trace on any circuit boards in service.

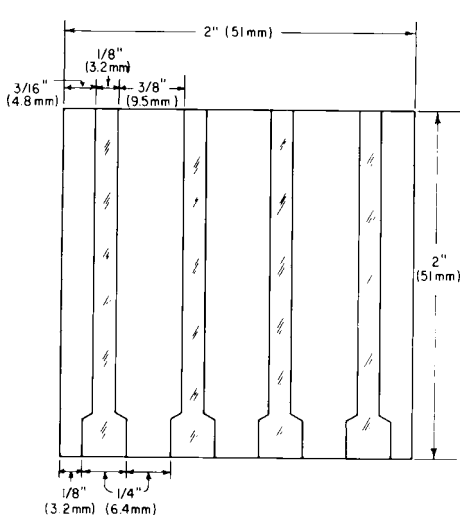

FIG. 1 Test Specimen for Peel Strength and Solder Float Tests

9.3 The specimens that passed the solder float test of 8.3.2 may be used for the room temperature peel strength tests since they contain the etched patterns required for peel tests. Otherwise, using the procedures of Practice D1825, etch patterns as in Fig. 1 on at least three specimens of copper-clad laminate.

9.4 *Procedure*—Peel back the copper foil from the 6-mm end of the copper strip for approximately 25 mm so that the line of peel is perpendicular to the surface of the substrate. Clamp each specimen, or hold it on a horizontal surface with the peeled copper strip up, providing a 25-mm span. Grip the end of the peeled strip between two knurled jaws of a clamp. Attach a flexible chain to a dial-indicating force indicator that has been adjusted to compensate for the weights of the chain and the clamp. Adjust the jaws to cover the full width of the copper strip and clamp them parallel to the line of peel. With the force indicator in a vertical plane, exert a steady vertical pull (approximately 50 mm/min) until the needle indicator shows a constant reading. If the full width of the copper strip does not peel, discard this specimen and repeat the procedure on another specimen. Make at least three tests and record the test result in accordance with Practice D3636.

9.5 *Report*—Report the following information:

9.5.1 The identity of the laminate,

9.5.2 The room temperature peel strength test result after solder float in N/mm of width, and

9.5.3 The total number of strips tested.

9.6 *Precision and Bias:*

9.6.1 This test has been in use for many years, but no information has been presented to ASTM upon which to base a statement of precision. No activity has been planned to develop such information.

9.6.2 This test method has no bias because the value for peel strength is determined solely in terms of this test method itself.

10. Peel Strength Test at Elevated Temperature

10.1 There are two procedures, identified as Procedure A and Procedure B. Only one is required. No preference is given here for either procedure. Procedure A uses the narrow (3.2–mm) peel strength strips etched using the pattern in Fig. 1. Procedure B uses an unconditioned copper-clad laminate for preparing specimens on which are etched 25 by 100–mm patterns for peel strength test strips. Procedure B is often used for quality control purposes.

10.2 *Significance and Use:*

10.2.1 Either procedure of this test method provides information that deals with the integrity of the adhesive bond between the copper foil and the dielectric while the laminate is at an elevated temperature. Such temperatures may be encountered in fabricating circuit boards or in assembly operations, but the forces exerted in this test are not related in any way to the manner in which forces are likely to be encountered by the laminate in service or during fabrication or assembly.

10.2.2 Either procedure may show a drastic reduction in the peel strength at elevated temperature compared to the peel strength at room temperature if the test temperature exceeds the

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