Designation: D5109 – 12

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D374 Test Methods for Thickness of Solid Electrical Insulation (Withdrawn 2013)[3]

D618 Practice for Conditioning Plastics for Testing

D1531 Test Methods for Relative Permittivity (Dielectric Constant) and Dissipation Factor by Fluid Displacement Procedures (Withdrawn 2012)[3]

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Etching and Cleaning Copper-Clad Electrical Insulating Materials and Thermosetting Laminates for Electrical Testing (Withdrawn 2012)[3]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

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.

Current edition approved Nov. 1, 2012. Published November 2012. Originally approved in 1990. Last previous edition approved in 2004 as D5109 – 99(2004). DOI: 10.1520/D5109-12.

[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.

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

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 D618.

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. It is important that such exposure 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**—it is possible that some of the solvents used in the printed wiring board industry are 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. It is possible that such behavior will 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. Exercise care 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 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, it is acceptable to use the specimens that were exposed to solder dip 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 potentially exerted upon any trace on any circuit boards in service.

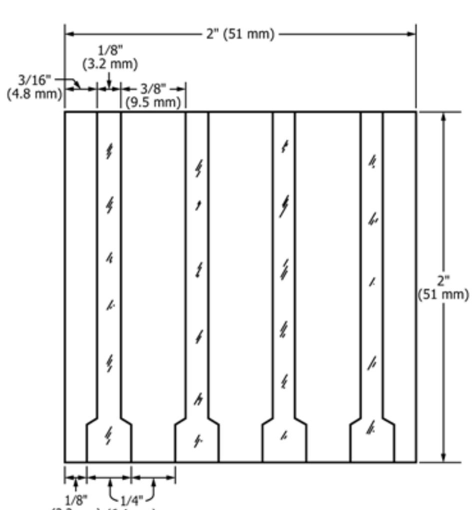

FIG. 1 Test Specimen for Peel Strength and Solder Float Tests

9.3 it is acceptable to use the specimens that passed the solder float test of 8.3.2 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. It is possible that such temperatures will 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 It is possible that either procedure will 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 glass transition temperature of the polymer resin system used to make the laminate.

10.3 *Apparatus*—The apparatus is described in NEMA Publication LI 1-1975.

10.4 *Specimens:*

10.4.1 The number of specimens will be dictated by the grade of copper-clad laminate being tested. Prepare at least two specimens for the lengthwise direction and two specimens for the crosswise direction. See Test Methods D229 for explanations of these terms. Laminate that is clad on two sides will require four additional specimens, two for each side. Laminate clad on one side will require only four specimens.

10.4.2 Prepare specimens for use with Procedure A in accordance with 8.2.1.

10.4.3 Prepare specimens for use with Procedure B in accordance with 8.2.1, except use a sample of unconditioned copper-clad laminate and etch a pattern on it which comprises four peel strength strips each having dimensions of 25 by 100 ± 5 mm.

10.5 *Procedure:*

10.5.1 Place the specimens in an oven in which the air is maintained at 150 ± 2°C, At the end of a 60–min exposure, remove each specimen and test in accordance with 9.4 and NEMA Publication LI 1-1975. The NEMA document calls for the testing to be performed at 150°C.

10.5.2 Record the test results of peel strength as N/mm width in accordance with Practice D3636. Alternatively, record the test results as lbf/in. of width in accordance with Practice D3636.

10.6 *Report*—Report the following information:

10.6.1 Identity of the laminate,

10.6.2 Which of the two procedures was used,

10.6.3 The test results and units for each direction tested,

10.6.4 The test results and units for each copper side tested, and

10.6.5 The number of strips that failed to peel across the entire width of strip.

10.7 *Precision and Bias:*

10.7.1 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.

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

11. Volume Resistivity and Surface Resistivity

11.1 *Significance and Use*—In printed wiring boards it is desirable to maintain high electrical resistance between traces on the surface of the board. Volume resistivity is one element that can affect the impedance of a circuit and often the impedance is critical. See also Test Methods D257 for more detailed information regarding significance of these properties.

11.2 *Specimens*—Both surface and volume resistivity can be measured on a laminate clad on two sides by etching appropriate electrodes on both surfaces. Single-sided laminate can be etched and the No. 3 electrode of Test Methods D257, Fig. 4, can be applied to the unclad surface using porous silver paint.

11.2.1 Use 100–mm by 100–mm pieces of laminate. Etch, using Practice D1825 procedures, to produce concentric electrodes as in Fig. 4 of Test Methods D257. The dimensions of the pattern shall be:

$$D_1 = 50 \text{ mm} \quad (1)$$

$$D_2 = 62.5 \text{ mm}$$

$$D_3 = 75 \text{ mm}$$

11.2.2 If necessary, it is acceptable to apply electrodes having the preceding dimensions to a laminate from which all of the copper has been etched, by coating or spraying with a porous conductive silver paint (see Test Methods D257, Section 6, on Electrode Systems).

11.2.3 Condition all specimens for 96 h at 35°C in a chamber maintained at 90 % relative humidity (see Practice D618). The specimens are to be tested in equilibrium with this environment.

11.3 *Procedure:*

11.3.1 **Warning**—*Lethal voltages are a potential hazard during the performance of this test. It is essential that the test apparatus, and all associated equipment electrically connected to it, be properly designed and installed for safe operation. Solidly ground all electrically conductive parts which it is possible for a person to contact during the test. Provide means for use at the completion of any test to ground any parts which were at high voltage during the test or have the potential for acquiring an induced charge during the test or retaining a charge even after disconnection of the voltage source. Thoroughly instruct all operators as to the correct procedures for performing tests safely. When making high voltage tests, particularly in compressed gas or in oil, it is possible for the energy released at breakdown to be sufficient to result in fire, explosion, or rupture of the test chamber. Design test equipment, test chambers, and test specimens so as to minimize the possibility of such occurrences and to eliminate the possibility of personal injury. If the potential for fire exists, have fire suppression equipment available.*

11.3.2 Test the specimens in the chamber which is at 35°C and 90 % relative humidity in accordance with the principles in Test Methods D257. Apply a direct voltage of 500 V for 60 s between electrodes 1 and 3 of Fig. 4 in Test Methods D257.

11.3.3 Measure the resistance between electrodes 1 and 3 of Fig. 4 in Test Methods D257. Compute the volume resistivity for the electrode dimensions of 11.2 using the equation in Table 2 of Test Methods D257 and the thickness of the etched laminate obtained in accordance with Section 17.

11.3.4 Move the leads so that the voltage is applied between electrodes 1 and 2 of Fig. 4 in Test Methods D257. Apply the voltage for 60 s. Measure the resistance between electrodes 1 and 2. Use the equation in Table 2 of Test Methods D257 to compute the surface resistivity of each specimen.

11.4 *Report*—Report the following information:

11.4.1 The identity of the laminate,

11.4.2 The volume resistivity, MΩ-cm,

11.4.3 The surface resistivity, Megohms per square, and

11.4.4 Whether silver paint was applied, and if so, where.

11.5 *Precision and Bias:*

11.5.1 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.

11.5.2 This test method has no bias because the value for resistivity is determined solely in terms of this test method itself.

12. Water Absorption

12.1 *Significance and Use*—This test method provides information about the amount of water absorbed in the laminate. Absorbed water can be detrimental to mechanical and to electrical insulating characteristics of the circuits produced from the laminate. Absorbed water in laminate can create problems during fabrication of circuit boards. The test is also useful in estimating the uniformity of quality of the laminate.

12.2 *Test Specimens*—Etch the copper from four pieces of laminate 75 by 25 ± 5 mm in accordance with Practice D1825.

12.3 *Procedure*—Determine the water absorption in accordance with Test Methods D229 using immersion time of 24 h at a temperature between 21 and 25°C.

12.4 Report the following information:

12.4.1 The average water absorption for all specimens tested, and

12.4.2 The identification of the laminate tested.

12.5 *Precision and Bias:*

12.5.1 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.

12.5.2 This test method has no bias because the value for water absorption is determined solely in terms of this test method itself.

13. Dielectric Breakdown Voltage Parallel to Laminations on Moisture-Conditioned Specimens

13.1 *Significance and Use:*

13.1.1 Industrial laminates used for the dielectric in copper-clad laminate were, and are still, used for electrical applications in which voltage stresses are exerted between conductors that are placed in holes in the unclad laminate. Use of unclad laminate in this configuration led to the development of this test method. There is debate as to the significance of this method.

13.1.2 Circuit boards are frequently used in service in applications such that the full thickness of the core insulation between the copper cladding is exposed to voltage stress parallel to the flat sides of the laminate between pin-type inserts. With the use of moisture-conditioned specimens this test method simulates the conditions likely to be found in service.

13.1.3 This test method is suitable as a quality control test for estimating continuity of quality.

13.2 *Specimens:*

13.2.1 From laminate pieces 50 by 75 mm, remove all of the copper by etching in accordance with Practice D1825.

13.2.2 Condition the specimens in accordance with Practice D618, Procedure E, which is immersion in distilled water for 48 h at 50°C followed by cooling submersed in distilled water for sufficient time to attain 23°C.

13.3 *Procedure*—Determine the dielectric breakdown voltage parallel to laminations on the moisture-conditioned specimens using the step by step test in accordance with the tapered pin method of Test Methods D229. Record the test result in accordance with Practice D3636.

13.4 *Report*—Report the following information:

13.4.1 The identity of the laminate tested,

13.4.2 The test result of the dielectric breakdown voltage, and

13.4.3 The nature of the surrounding medium used.

13.5 *Precision and Bias:*

13.5.1 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.

13.5.2 This test method has no bias because the value for dielectric breakdown voltage is determined solely in terms of this test method itself.

14. Permittivity and Dissipation Factor

14.1 *Significance and Use*—Circuit boards in some applications require the use of controlled impedance circuitry. Knowledge of the permittivity of the dielectric between the copper cladding is required for the design of such circuits. In circuits the dielectric losses of the dielectric between the copper cladding is one of the contributors to power loss in the circuit. Dielectric losses are affected by dissipation factor of the laminate.

14.2 *Specimens*—In some test apparatus arrangements, the capacitance of the test specimen influences the sensitivity of the null point determination with a resulting influence upon the precision of measurements of dissipation factor and permittivity. This fact often dictates the dimensions of specimens. (See Test Methods D150, and the instruction manuals provided by the manufacturer of the electrical test apparatus being used for a more comprehensive discussion of these effects.) If the two-fluid methods of Test Method D1531 are used, the size of the specimens will be dictated by the test cell geometry.

14.2.1 Select the size of the test specimens in accordance with thickness of the dielectric core of the laminate as shown in Table 1.

TABLE 1 Specimen Size for Permittivity Test[A]

Thickness	Specimen Size
1.2 mm and under	50 by 50 mm
over 1.2 mm to 2.4 mm	75 by 75 mm
over 2.4 mm to 6.5 mm	100 by 100 mm

[A] Metric conversion 0.001 in. = 0.0254 mm

14.2.2 If Test Methods D229 are to be used, print and etch an electrode pattern using the etch procedures of Practice D1825 if single or double sided copper-clad laminate is to be tested. Single sided laminate will require the application of porous conducting silver paint for the electrode on the unclad side of the laminate.

14.2.3 If Test Method D1531 methods are to be used, etch all copper from and clean the specimen in accordance with Practice D1825 so as to obtain a clean dielectric sheet for testing.

14.2.4 Condition all etched specimens in accordance with Practice D618, Procedure A, prior to testing.

14.3 *Procedure*—Determine the permittivity and the dissipation factor on the conditioned specimens in accordance with either Test Methods D1531 or Test Methods D229. Unless otherwise specified, make all tests at 1 MHz and room temperature.

14.4 *Report*—Report the following information:

14.4.1 The identity of the laminate tested,

14.4.2 The test results for permittivity,

14.4.3 The test results for dissipation factor,

14.4.4 The method used (Test Methods D1531 or Test Methods D229),

14.4.5 The temperature and the frequency used, and

14.4.6 Any deviation from the requirements of these test methods which were used to make the measurements.

14.5 *Precision and Bias:*

14.5.1 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.

14.5.2 This test method has no bias because the value for permittivity and dissipation factor is determined solely in terms of this test method itself.

15. Flexural Strength (flatwise)

15.1 *Significance and Use*—See Test Methods D229.

15.2 Some specifications or other purchase documents specify that flexural strength of copper-clad laminate be measured at room temperature or at some specific elevated temperature. Unless otherwise stated, all flexural properties, including strength, are to be measured at room temperature on specimens of copper-clad laminate from which all of the copper has been etched.

15.2.1 Grades G-11 and FR-5 are copper-clad laminates that are described as "temperature resistant types." Such laminates require testing for flexural strength at elevated temperatures of 150°C.

15.3 Measure flexural properties in accordance with Test Methods D229.

15.4 *Report*—Report the following information:

15.4.1 The identity of the copper-clad laminate tested,

15.4.2 The temperature of testing,

15.4.3 The time of exposure of specimens to elevated temperatures prior to testing,

15.4.4 The flexural strength test result, and

15.4.5 Any other flexural properties obtained from the test.

15.5 *Precision and Bias:*

15.5.1 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.

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

16. Flammability Rating

NOTE 2—Flammability rating was formerly called "rate of burning." This has been deprecated in preference to the expression "FR" which is defined in Terminology D1711.

16.1 *Significance and Use*—Many circuit boards are used in applications for which regulatory agencies demand decreased risks from fire hazards. It has been established that flammability rated laminates are preferred for use in such applications.

16.2 *Specimens*—From a sufficient area of copper-clad laminate, etch away the copper in accordance with Practice D1825. Cut the area into 20 pieces, each 13 by 127 ± 2 mm.

16.3 Procedure—Perform the tests in accordance with Method I of Test Methods D229.

16.4 *Report*—Report the following information:

16.4.1 The identity of the laminate tested,

16.4.2 The thickness of the laminate after etching, and

16.4.3 The classification (as in Table 1 of Test Methods D229) for the laminate with respect to its flammability rating.

16.5 *Precision and Bias:*

16.5.1 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.

16.5.2 This test method has no bias because the value for flammability rating is determined solely in terms of this test method itself.

17. Oven Blister Test

17.1 *Significance and Use:*

17.1.1 The processing of laminates into circuit boards often requires the exposure of laminate for short time periods (several minutes) to elevated temperatures as high as 180°C. This test provides some information regarding the suitability of the laminate for use at such process conditions.

17.1.2 The results of this test method are not to be used in any way to judge or infer the continuous use temperature of any copper-clad laminate.

17.2 *Specimens*—Cut four pieces of copper-clad laminate into 150 by 150 ± 10–mm specimens. Etch two of these pieces in accordance with Practice D1825 and leave the other two unetched.

17.3 *Procedure:*

17.3.1 Place the four specimens into a horizontal-flow air-circulating oven maintained at the temperature required by Table 7 of Specification D1867.

17.3.2 Support the specimens vertically in the oven on nonmetallic racks so that the plane of the specimen is parallel to the air flow.

17.3.3 At the end of the time specified in Table 7 of Specification D1867 remove the specimens and allow them to cool to room temperature.

17.3.4 Examine each specimen and note any sign of blistering.

NOTE 3—A blister formed between the copper foil and the dielectric substrate is called a "copper blister." If a blister forms within the dielectric substrate, it is called a "core blister." See 3.2.2.

17.4 *Report*—Report the following information:

17.4.1 The identity of the laminate,

17.4.2 The temperature of the oven,

17.4.3 The time of exposure to elevated temperature, and

17.4.4 A statement about the presence of blisters or lack thereof.

17.5 *Precision and Bias:*

17.5.1 No statement is made about either the precision or bias of this test method for determining blisters in copper-clad laminates since the result merely states whether there is conformance to the criteria for success specified in the procedure.

18. Thickness Dimensions and Thickness Variation

18.1 *Significance and Use:*

18.1.1 Precise imaging of printed circuits on copper-clad laminates can be affected by the actual laminate thickness and the variability of same.

18.1.2 Variation in thickness of copper-clad laminates is undesirable if the circuit boards are to be populated with components using automatic "pick-and-place" machinery.

18.2 *Apparatus*—See Test Methods D374 for apparatus description.

18.3 *Specimen*—A specimen shall be a single sheet of laminate having dimensions 300 by 300 ± 30 mm. The specimen shall be either copper-clad or it shall be a sheet from which all of the copper has been etched in accordance with Practice D1825.

18.4 *Procedure for Thickness:*

18.4.1 Take specimens that are in equilibrium with standard laboratory conditions (see Practice D618) and make at least one test measurement on each of at least ten different areas of each specimen using the apparatus described for Method A in the Apparatus section of Test Methods D374, (see Practice D3636 for meaning of "test measurement").

18.4.2 Record the value of each test measurement.

18.4.3 Compute the arithmetic mean of all of the test measurements. Record this mean value as the test result for the thickness of the specimen.

18.5 *Procedure for Thickness Variation:*

18.5.1 Refer to the purchase order, or a material specification, for a nominal thickness value for the laminate being examined. In the case of Specification D1867, nominal thickness values are shown in Table 4 in the column headed "Nominal Overall Laminate Thickness."

18.5.2 Calculate the absolute difference between the nominal thickness of the laminate and each of the individual test measurements recorded in 18.4.2.

18.5.3 Record the individual difference from the nominal thickness for each of the test measurements.

18.5.4 Compare each difference to the maximum thickness tolerance allowed by the material specification (see Specification D1867 or the purchase documents).

18.5.5 Record the greatest individual difference of 18.5.3 as the thickness variation for the laminate.

18.6 *Report*—Report the following information:

18.6.1 The complete identification of the laminate,

18.6.2 The date of testing,

18.6.3 The test result for the thickness of each specimen,

18.6.4 The thickness variation for each specimen, and

18.6.5 A statement describing any deviations from the requirements of these test methods used in the performance of the tests.

18.7 *Precision and Bias:*

18.7.1 The precision of this test method has not been determined. It is to be expected that with competent, trained operators in a reasonably well equipped laboratory using calibrated apparatus, the replication of thickness and thickness variation between two operators testing the same specimens from the same lot of copper-clad laminate will be within ±5 % of the mean value for thickness and within ±10 % for the thickness variation of the laminate.

18.7.2 This test method has no bias because the value for thickness is determined solely in terms of this test method itself.

19. Dimensional Instability

19.1 *Significance and Use:*

19.1.1 Precise registration of artwork and tooling holes is necessary during the processing of printed wiring boards. This requires a laminate which exhibits either minimal or predictable changes in dimensions during excursions to elevated temperatures or humidities, and exposure to aqueous liquids that are encountered during the fabrication of circuits.

19.1.2 Any copper-clad laminate will change dimensions if subjected to extreme conditions of temperature, pressure, or humidity. It is proper therefore, to refer to instability of dimensions rather than dimensional stability.

19.2 *Apparatus:*

19.2.1 An instrument, usually a mechanical, electronic, or an optical device graduated so as to differentiate between dimensions of 2.5 and 5.0 µm (0.0001 and 0.0002 in.) throughout a span of at least 0.6 m.

19.2.2 An oven capable of maintaining temperature control at 150 ± 2°C.

19.2.3 Etching facilities to etch laminate in accordance with Practice D1825.

19.3 *Specimens:*

19.3.1 Take a full size laminate sheet in the "as-received" condition. Mark this sheet with arrows and labels denoting lengthwise (LW) and crosswise (CW) directions. See Test Methods D229 for descriptions of these terms.

19.3.2 Cut from this sheet three specimens that are approximately 0.3 by 0.3 m each.

19.3.3 Mark each specimen with arrows denoting LW and CW.

19.3.4 Place the specimens in a standard laboratory atmosphere as described in Practice D618, Procedure A.

19.3.5 After conditioning, apply eight target marks on each specimen such that the target marks are placed in accordance with Fig. 2. All target marks shall be resistant to etching processes.

19.4 *Procedure:*

19.4.1 Using specimens that are in equilibrium with the standard atmosphere described in 19.3.4, measure the distance to the nearest 5 µm between the two target marks identified in Fig. 2 as 1 and 3. Record this distance as "O—LW." Repeat for the other two pairs of target marks in the lengthwise direction.

19.4.2 Using specimens that are in equilibrium with the standard atmosphere described in 19.3.4, measure the distance to the nearest 5 µm between the two target marks identified in Fig. 2 as 1 and 6. Record this distance as "O—CW." Repeat for the other two pairs of target marks in the crosswise direction.

19.4.3 Etch all copper from each specimen in accordance with Practice D1825.

19.4.4 Clean each specimen in accordance with Practice D1825. After cleaning, dry each specimen at 40°C for 16 h. After conditioning in accordance with 19.3.4, repeat the distance measurements of 19.4.1 and 19.4.2. Record the dimension for each direction either as "after etch LW" or "after etch CW."

19.4.5 Place each specimen into an oven which is controlled at 150 ± 2°C. Allow the specimens to bake for 30 ± 2 min. Remove specimens from the oven and allow them to come to equilibrium with the standard laboratory atmosphere of Practice D618, Procedure A.

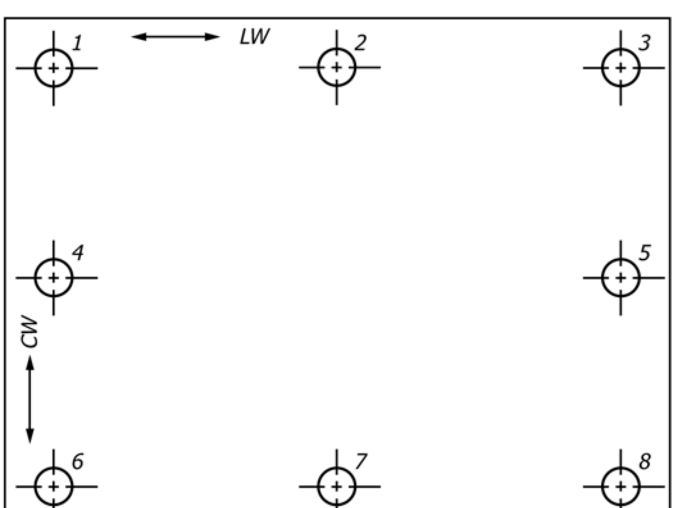

FIG. 2 Target Marks

19.4.6 Repeat the measurements of 19.4.1 and 19.4.2 and record each dimension either as "after bake LW" or "after bake CW."

19.5 *Calculation:*

19.5.1 Each specimen has three sets of distance measurements for the lengthwise dimensional instability determination. Calculate the percent change in each of the lengthwise dimensions due to etching by taking 100 times the ratio of "after etch LW" minus "O—LW" divided by "O—LW." A negative value is shrinkage; a positive value is growth.

$$100\left[\left(\text{after etch } LW\right) - \left(O - LW\right)\right] \div \left[\left(O - LW\right)\right] \quad (2)$$

19.5.2 Compute the arithmetic average from the three sets of "after etch" measurements. This average is the test measurement for dimensional instability due to etch on one specimen. Repeat the calculation for each specimen. The average of the three test measurements is the test result for dimensional change due to etch for the lengthwise direction.

19.5.3 For the crosswise direction dimensional instability after etch, repeat the calculations of 19.5.1 and 19.5.2 using appropriate crosswise direction dimensions.

19.5.4 For the after etch and bake dimensional instability values repeat the calculations of 19.5.1 and 19.5.2 using the dimensional data obtained after etch and bake on each specimen and in each of the two directions.

19.6 *Report*—Report the following information:

19.6.1 Complete identification of the laminate,

19.6.2 The lengthwise dimensional instability after etch, %,

19.6.3 The lengthwise dimensional instability after etch and bake, %,

19.6.4 The crosswise dimensional instability after etch, %,

19.6.5 The crosswise dimensional instability after etch and bake, %, and

19.6.6 Any deviations from the procedures set forth in these test methods.

19.7 *Precision and Bias:*

19.7.1 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.

19.7.2 This test method has no bias because the value for dimensional instability is determined solely in terms of this test method itself.

20. Keywords

20.1 copper-clad laminate; dielectric breakdown parallel to laminations; dimensional instability; dissipation factor; fiber reinforced; flexural strength; industrial laminate; laminate; oven blister; peel strength; permittivity; printed circuit boards; printed wiring boards; rigid laminate; solder float; surface resistivity; thermoset; thickness variation; trace; twist; volume resistivity; warp; water absorption

SUMMARY OF CHANGES

Committee D09 has identified the location of selected changes to this specification since the last issue, D5109 – 99R04, that may impact the use of this specification. (Approved November 1, 2012.)

(1) The conditioning standard D6054 has been replaced by the conditioning standard D618.

(2) Non mandatory terms have been eliminated.