Standard Test Methods for Flexible Composites of Copper Foil with Dielectric Film or Treated Fabrics[1]

This standard is issued under the fixed designation D 2861; 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 procedures for testing flexible materials consisting of copper foil combined with either dielectric film or with treated or impregnated fabric to form flexible composites used in the manufacture of flexible or multilayer circuitry, or both.

1.2 The procedures appear as follows:

Procedure	Section	ASTM Reference Method
Conditioning	5	
Flex Life of the Composite	20 to 25	
Peel Strength of the Composite	11 to 19	
Specimen Preparation	6	D 1825
Strain Relief Due to Etching	26 to 32	
Testing of the Dielectric Portion of the Composite	7 to 10	D 1825, D 2305, D 902

1.3 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for infomation 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.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 902 Test Methods for Flexible Resin-Coated Glass Fabrics and Glass Fabric Tapes Used for Electrical Insulation[2]

D 1711 Terminology Relating to Electrical Insulation[2]

D 1825 Practice for Etching and Cleaning Copper-Clad Electrical Insulating Materials and Thermosetting Laminates for Electrical Testing[2]

D 2305 Test Methods for Polymeric Films Used for Electrical Insulation[2]

D 6054 Practice for Conditioning Electrical Insulating Materials for Testing[3]

3. Terminology

3.1 *Definitions:* For definitions of terms used in this standard, refer to Terminology D 1711.

4. Selection of Test Specimens

4.1 Select specimens for test from portions of material that are free of obvious defects, unless the purpose of the test is to evaluate these defects.

5. Conditioning

5.1 Unless otherwise specified, conduct all conditioning and testing in the standard laboratory atmosphere specified in Practice D 6054. Condition specimens at least 18 h before testing.

6. Specimen Preparation

6.1 Prepare specimens by etching without scrubbing, using Practice D 1825. The etching reagents described in Practice D 1825 may be incompatible with some composite materials. The use of other reagents should be noted in the report for the test involved.

TESTING OF THE DIELECTRIC PORTION OF THE COMPOSITE

7. Significance and Use

7.1 The electrical and mechanical characteristics of circuits produced from flexible composites of copper foil with dielectric materials will to a large extent depend on the properties of the dielectric portion of the composite. Measurement of these properties is essential for predicting performance of the circuit.

[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] *Annual Book of ASTM Standards*, Vol 10.01.

[3] *Annual Book of ASTM Standards*, Vol 10.02.

8. Test Specimen

8.1 Take specimens as required from a sample that has been etched free of copper foil in accordance with Section 6. Take the thickness from the material that remains after etching.

9. Procedure

9.1 If the dielectric portion of the composite is a film, use the procedures described in Test Methods D 2305.

9.2 If the dielectric portion of the composite is a treated fabric, use the procedures described in Test Methods D 902.

10. Precision and Bias

10.1 This test method has been in use for many years, but no statement of precision has been available and no activity is planned to develop such a statement. A statement of bias is not applicable in view of the lack of a standard reference material for this property.

PEEL STRENGTH OF THE COMPOSITE

11. Significance and Use

11.1 The peel strength between copper foil and the dielectric material determines to what degree the composite can withstand processing and remain intact during service.

11.2 Flexible composites generally require more elaborate means for proper support during peel testing than do rigid, copper-clad laminates. The selection of the proper procedure will depend on the nature of the composite being tested, as shown by the following methods:

11.2.1 *Method A, Clamped Between Plates*— This test method is generally used when the material tested is not so flexible or slippery that it allows the substrate to deflect during the test.

11.2.2 *Method B, Using Adhesive Tape*— This test method is used principally for its convenience, but is limited to cases where the peel strength of the material is not so great as to allow lifting of the substrate from the plate during removal of the copper.

11.2.3 *Method C, Free-turning Drum*—This test method is also primarily used for its convenience, and is applicable where it is desired to prevent lifting of the dielectric material from the plate during removal of the copper.

12. Apparatus

12.1 *Force-Measuring Instrument*—A strain gage, dial-type force meter, or similar instrument sensitive to 0.05 lbf (0.2 N).

12.2 *Chart Recorder* (optional)—recording instrument capable of converting the force measured in 12.1 to a graphical record.

12.3 *Peeling Mechanism*—A device capable of peeling the copper from the dielectric at an angle of 90° to the specimen at a rate of 2 ± 0.1 in. (50 ± 3 mm)/min.

12.4 *Specimen Holder*—A device for clamping the specimen flat and in the correct position for testing with a minimum of the dielectric left unsupported. A device equivalent to that shown in Fig. 1 is required.

13. Test Specimen

13.1 Unless otherwise specified, prepare the test specimens to be a 2.5-in. (62-mm) square of the composite on which the pattern shown in Fig. 2 is etched in accordance with Section 6. The dielectric portion may be trimmed to conveniently fit the apparatus being used.

13.2 Orient the pattern so that the long direction of the copper strips is either machine direction or cross-machine direction as required.

14. Method A—Clamped Between Plates

14.1 Clamp the test specimen between the plates as shown in Fig. 1. Mount the plate horizontally.

14.2 Carefully initiate the removal of each of the copper strips by lifting the ½-in. (13-mm) land and peeling back to about 1 in. (25 mm).

14.3 Attach the free end of the strip to the force indicator by means of a clamp equipped with knurled jaws and a chain. Peel the strip the remaining 1-in. (25-mm) length at a rate of 2.0 ± 0.1 in. (50 ± 3 mm)/min. Repeat for each copper strip.

14.4 Determine the average peel force for each strip as follows:

14.4.1 If a recording instrument is used, determine the average peel force by the midpoint of a straight line that best fits the chart record.

14.4.2 If no recording instrument is used, take a visual reading every 5 s during the peeling and average the readings.

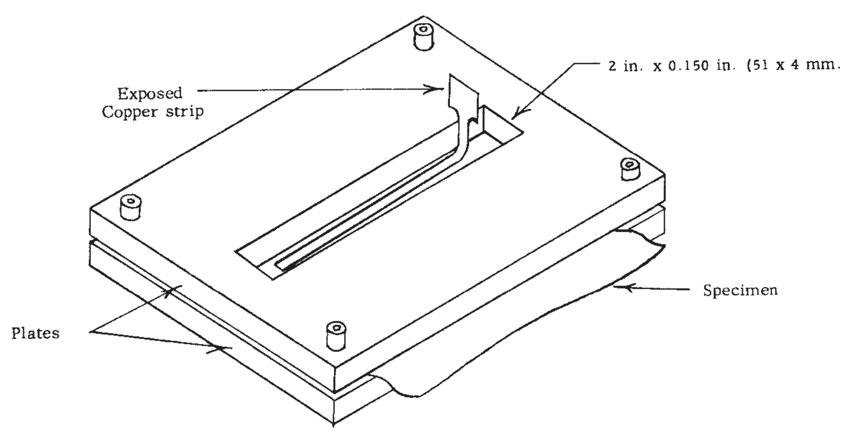


FIG. 1 Device for Holding Peel Specimen for Method A

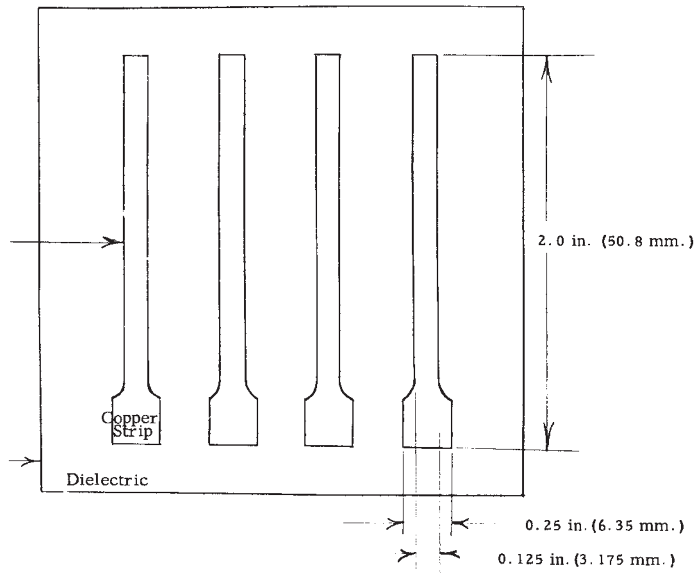


FIG. 2 Peel Strength Test Specimen

15. Method B—Using Adhesive Tape

15.1 Attach the test specimen to a flat surface using a suitably backed pressure-sensitive adhesive tape. Mount the surface horizontally. Apply the tape in such manner it extends at least 0.2 in. (5 mm) beyond the edges of the copper strip, taking care to avoid the inclusion of dirt or air bubbles.

15.2 Initiate removal of the copper strip and peel in accordance with the procedure of 14.3 and determine the average peel force in accordance with 14.4.

16. Method C—Free-Turning Drum

16.1 Select a test specimen 2.5 in. (62 mm) wide by 10 in. (250 mm) long. Wrap the specimen around a 3-in. (75-mm) diameter drum as shown in Fig. 3, with the longer dimension in the direction of winding. Position the tension bars and springs as indicated.

16.2 Initiate the removal of the copper strip and peel in accordance with the procedure of 14.3 and determine the average peel force in accordance with 14.4.

17. Calculation

17.1 Divide the average peel force in pounds-force (newtons) by the width of the peeled strip in inches (millimetres) to obtain the average peel strength for the strip in pounds-force per inch (newtons per millimetre) width.

18. Report

18.1 Report the following information:

18.1.1 Material identification and specimen orientation, whether machine- or cross-machine direction,

18.1.2 The nature of the etching material, if different than that specified in Practice D 1825,

18.1.3 Conditioning, if different from that specified in Section 5,

18.1.4 Method of recording the average peel force,

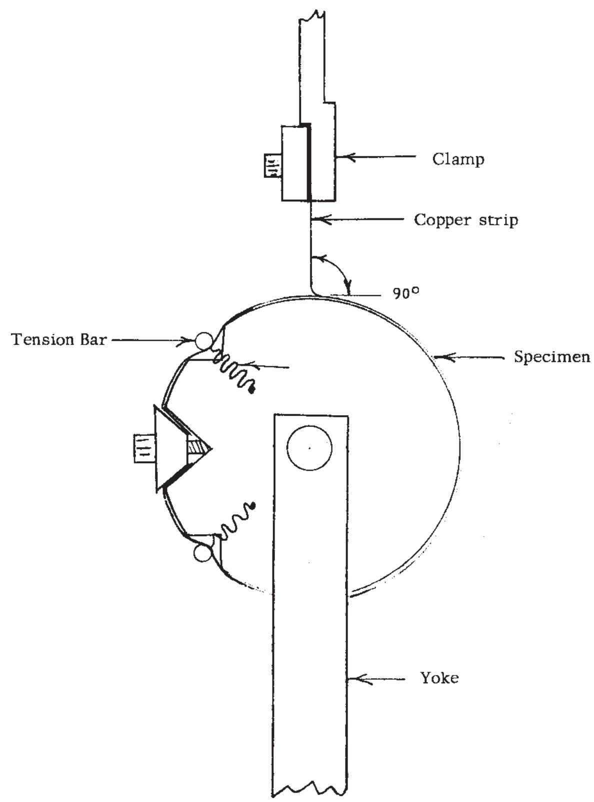


FIG. 3 Drum-Type Peel Strength Jig for Method C

18.1.5 Test method used, (A, B, or C), and

18.1.6 Peel strength values for each specimen.

19. Precision and Bias

19.1 This test method has been in use for many years, but no statement of precision has been available and no activity is planned to develop such a statement. A statement of bias is not applicable in view of the lack of a standard reference material for this property.

FLEX LIFE OF THE COMPOSITE

20. Significance and Use

20.1 Flexible copper foil composites are frequently used in applications where repeated flexing occurs during assembly, or during normal use, or both. The occurrence of a break in the copper foil would render the material useless.

21. Apparatus

21.1 *Flat Plates*, two parallel nonconducting, with clamps so arranged that a motor-driven crank and connecting rod will oscillate one of the plates parallel to the other at no more than 10 cpm with a 2-in. (50-mm) stroke.

21.2 *Mechanical Counter*, arranged to record total number of cycles.

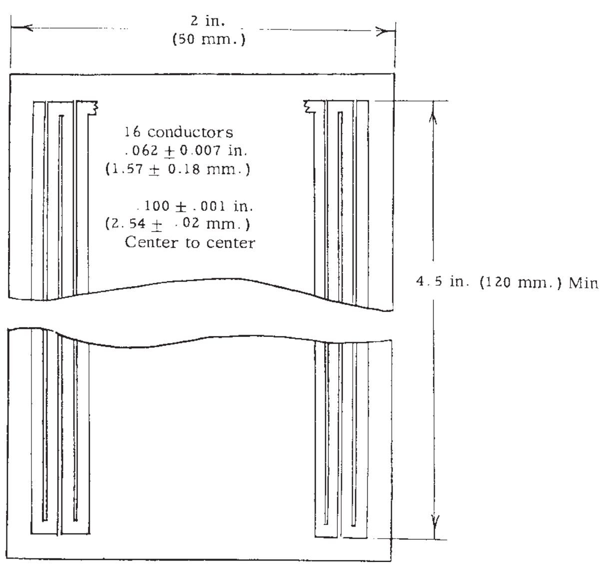
21.3 *Low-Voltage Relay Circuit* that will shut off the motor when a break occurs.

22. Test Specimen

22.1 Prepare rectangular specimens 2 by 5 in. (50 by 125 mm) then etch the pattern shown in Fig. 4 in accordance with Section 6. Cut the etched specimen lengthwise to provide a pair of specimens, each with 8 conductors.

23. Procedure

23.1 Attach leads to the lands in the test specimen and clamp the ends to opposite surfaces so that the conductors run parallel to the oscillation and a rolling loop is produced on the specimen without flexing it at the clamps. Adjust the apparatus so that the inside diameter of the rolling loop is ¼ ± 1⁄16 in. (6.4 ± 1.6 mm). Connect the leads into the lowvoltage circuit so that a break in the pattern will stop the test. Run the test until a discontinuity occurs. Unless otherwise specified, the copper pattern shall be on the concave side of one specimen and on the convex side of the other one in the pair. See Fig. 5.



NOTE 1—The dimensional tolerances apply to the negative or silk screen used to generate the pattern.

FIG. 4 Flexibility Test Pattern

24. Report

24.1 Report the following information:

24.1.1 Material identification and specimen orientation, whether machine- or cross-machine direction,

24.1.2 The nature of the etching material, if different than that specified in Practice D 1825,

24.1.3 Conditioning, if different than that specified in Section 5,

24.1.4 The number of cycles until a break occurs, and

24.1.5 Whether the copper pattern was on the concave or convex side.

25. Precision and Bias

25.1 This test method has been in use for many years, but no statement of precision has been available and no activity is planned to develop such a statement. A statement of bias is not applicable in view of the lack of a standard reference material for this property.

STRAIN RELIEF DUE TO ETCHING

26. Significance and Use

26.1 Strains in the composite caused by shrinkage of the dielectric or by mechanical or thermal stresses during manufacture of the composite may be relieved during etching away of the copper or during subsequent drying, solvent washing, or soldering steps. Such strain relief could lead to distortion and misregistration of etched circuit patterns, as well as wrinkling of the dielectric areas where the foil was removed.

27. Apparatus

27.1 Apparatus suitable for measuring distances of about 6 in. (150 mm) between markings without application of distorting force on a specimen that is held flat. An optical comparator is recommended. The degree of resolution of dimensional readings will largely determine the precision possible with this test method.

27.2 A means for maintaining the specimen in a flat position without interfering with the dimensional reading, and without applying distorting forces parallel to the plane of the specimen. A perforated vacuum plate or a pair of transparent plates may be used with success when an optical comparator is employed.

28. Test Specimens

28.1 Prepare 7-in. (175-mm) square test specimens of the composite to be tested.

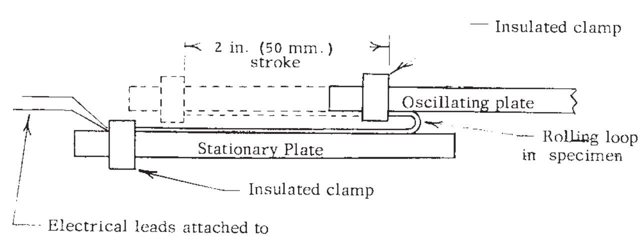


FIG. 5 Diagram of Specimen Arrangement for Flexibility Test

29. Procedure

29.1 On the copper side of the specimen make four marks, numbered 1 to 4 clockwise at the four corners of a 6-in. (150-mm) square pattern centered on the specimen, using a felt tip pen.

29.2 Use a sharp-needle point to make a pin prick about 0.005 in. (0.13 mm) in diameter at about the center of each of the marks in 29.1.

29.3 Mount the specimen using the apparatus of 27.2 and obtain distance measurements with the apparatus of 27.1. Record the distances between pin prick marks 1 and 2, 2 and 3, 3 and 4, and 4 and 1.

29.4 Use ¼-in. (6.4-mm) square pieces of etchant-resistant pressure-sensitive tape to mask the areas marked with the pin pricks. Add an extra square on the corner nearest the No. 1 position to identify this position after etching.

29.5 Etch the specimen free of copper except where masked, using the procedure in Section 5. Remove the masking materials without disturbing the pin prick marks.

29.6 Repeat the measurements described in 29.3, using the masked corner to identify Position 1.

29.7 Additional measurements may be obtained after various other conditionings of the specimen as desired.

30. Calculation

30.1 Calculate the strain relief coefficient for each pair of points as follows:

$$S = (D_2 - D_1)/D_1 \tag{1}$$

where:

S = strain relief, in./in. (mm/mm),
D_1 = distance measured before etching, and
D_2 = distance measured after etching and conditioning.

31. Report

31.1 Report the following information:

31.1.1 Material identification,

31.1.2 Conditioning, if other than specified in Section 4,

31.1.3 Strain relief coefficients obtained from each pair of points, and

31.1.4 Material direction in which each coefficient was measured; that, is, longitudinal or transverse direction with respect to the composite as supplied in coils or sheets.

32. Precision and Bias

32.1 This test method has been in use for many years, but no statement of precision has been available and no activity is planned to develop such a statement. A statement of bias is not applicable in view of the lack of a standard reference material for this property.

33. Keywords

33.1 copper foil; dielectric film; flex life; flexible composites; peel strength; strain relief (etching); treated fabric