Association Connecting Electronics Industries

3000 Lakeside Drive, Suite 309S
Bannockburn, IL 60015-1249

| Number | |
|---|---|
| **2.6.21** | |
| Subject | |
| **Service Temperature of Metal-Clad Flexible Laminate, Cover Material and Adhesive Bonding Films** | |
| Date | Revision |
| **6/11** | **B** |
| Originating Task Group | |
| **Flexible Circuits Test Methods Subcommittee (D-15)** | |

# IPC-TM-650
# TEST METHODS MANUAL

**1 Scope** This test method describes the procedure for establishing the service temperature for metal-clad flexible base material (laminate) as described in IPC-4204 as well as cover materials and adhesive bonding films (unsupported adhesive and supported bond plies) as described in IPC-4203. For purposes of this test method, cover material **shall** consist of coverlay and coverfilm but **shall not** include covercoat materials. Properties evaluated after thermal aging in this test are: visual, peel strength and dielectric strength.

**2 Applicable Documents**

**2.1 IPC[1]**

**IPC-T-50** Terms and Definitions for Interconnecting and Packaging Electronic Circuits

**IPC-TM-650** Test Methods Manual[2]

2.4.9 Peel Strength, Flexible Dielectric Materials

2.4.13 Solder Float Resistance Flexible Printed Wiring Materials

**IPC-4203** Adhesive Coated Dielectric Films for Use as Cover Sheets for Flexible Printed Circuitry and Flexible Adhesive Bonding Films

**IPC-4562** Metal Foil for Printed Board Applications

**2.2 ASTM International[3]**

**ASTM D-149** Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies

**3 Bond Strength Test Procedure**

**3.1 Specimen Preparation for Metal-Clad Flexible Base Material (Laminate)**

**3.1.1** Prepare twelve specimens according to the procedure outlined for method A of IPC TM-650, method 2.4.9, using appropriate photolithographic processes. Etch four conductors 3.2 mm [0.126 in] wide, 5.7 mm [0.224 in] pitch, 230 - 250 mm [9 - 10 in] long on a nominal 25 mm [1 in] wide strip of flexible base dielectric (see Figure 1).

Single-clad or double-clad flexible base material **shall** be tested in the format supplied. If the flexible base material under test is double-clad, prepare a separate set of specimens for each side. It is permissible to leave the unetched copper on the non-test side (see Notes 6.1 and 6.2).

**3.2 Specimen Preparation for Cover Material**

**3.2.1** Single-clad base material **shall** be produced from specimens of the cover materials. Cover material **shall** be bonded to the shiny side of 34.3 µm [1.35 mil] copper foil, type CU-E1-1S or CU-E7-1S per IPC-4562 (CU-E1-1S **shall** be the referee material). Copper foil cleaning **shall** be per the manufacturer's normal cleaning procedure. The referee cleaning procedure **shall** be per Table 1.

**3.2.2** Prepare twelve specimens according to the procedure outlined for method A of IPC TM-650, method 2.4.9, using appropriate photolithographic processes. Etch four conductors 3.2 mm [0.126 in] wide, 5.7 mm [0.224 in] pitch, 230 - 250 mm [9 - 10 in] long on a nominal 25 mm [1 in] wide strip of flexible base dielectric (see Figure 1).

**3.3 Specimen Preparation for Adhesive Bonding Film**

**3.3.1** Metal-clad flexible base material **shall** be produced from specimens of the adhesive bonding film being evaluated. Adhesive bonding film **shall** be bonded to the shiny side of 34.3 µm [1350 µin] ED copper foil, type CU-E1-1S or RA copper foil, CU-E7-1S per IPC-4562 (CU-E1-1S **shall** be the referee material). Adhesive bonding film **shall** be bonded between the copper foil and CU-E1-1S as support material as illustrated in Figure 2. Copper foil cleaning **shall** be per the manufacturer's normal cleaning procedure. The referee cleaning procedure **shall** be per Table 1, the same as detailed in IPC-4203.

Prepare specimens according to the procedure outlined for method A of IPC TM-650, method 2.4.9, using appropriate

1. www.ipc.org
2. Current and revised IPC Test Methods are available on the IPC Web site (www.ipc.org/html/testmethods.htm)
3. www.astm.org

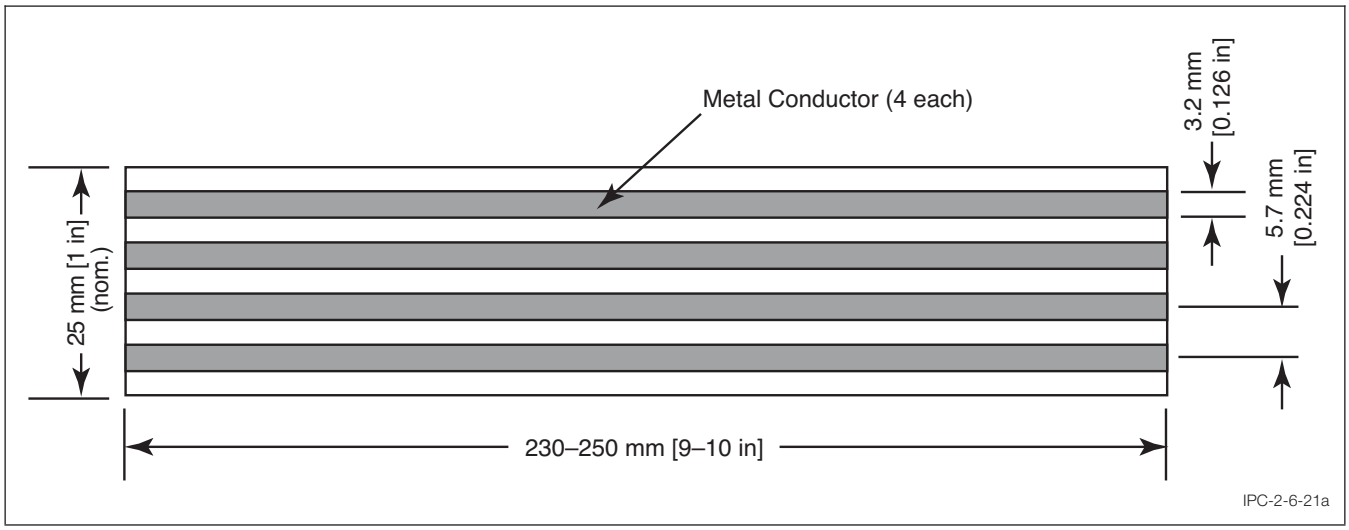


**Figure 1 Construction of Specimens for Peel Strength Testing**

**Table 1 Cleaning Process for Shiny Copper**

| Step | Process | Material | Temperature | Time |
|---|---|---|---|---|
| 1 | Soak Clean | Use commercially available acid or alkaline cleaners | Per supplier recommended temperature | Per supplier recommended time |
| 2 | Rinse | Running tap water | Room Temperature | 3 - 5 minutes |
| 3 | Microetch | Sodium persulfate: Two liters of deionized water, 280 grams of sodium persulfate, 25 cc sulfuric acid | Room Temperature | 1 - 2 minutes |
| 4 | Rinse | Running tap water | Room Temperature | 1 minute |
| 5 | Acid Dip | Sulfuric acid 10% by volume, dilution 1.8 liters deionized water, 200 cc sulfuric acid 96% assay | Room Temperature | 45 seconds |
| 6 | Rinse | Running tap water | Room Temperature | 1 minute |
| 7 | Rinse | Deionized water | Room Temperature | 1 minute |
| 8 | Dry | Force air dry or blot with paper towels | Room Temperature | 1 - 3 minutes |
| 9 | Bake | Bake in clean air-circulating oven | 110 ± 5 °C [230.0 ± 9.0 °F] | 10 to 15 minutes |
| 10 | Lamination | *Maximum delay between bake and lamination **shall** be 30 minutes | | |

*Lamination conditions (e.g., pressure, temperature, time, etc.) **shall** conform to suppliers' recommendations.

photolithographic processes such that a minimum of twelve good specimens are yielded at the end of 3.4.5. On the ''Test Surface,'' etch four conductors 3.2 mm [0.126 in] wide, 5.7 mm [0.224 in] pitch, 230 - 250 mm [9 - 10 in] long on a nominal 25 mm [1 in] wide strip of flexible base dielectric (see Figures 1 and 2).

### 3.4 Conditioning and Aging Procedure

**3.4.1** Twelve specimens, as described in section 3, **shall** be subjected to a stabilization period of a minimum of 24 hours at 23 °C ± 2 °C [73.4 °F ± 3.6 °F] and 50% ± 5% RH.

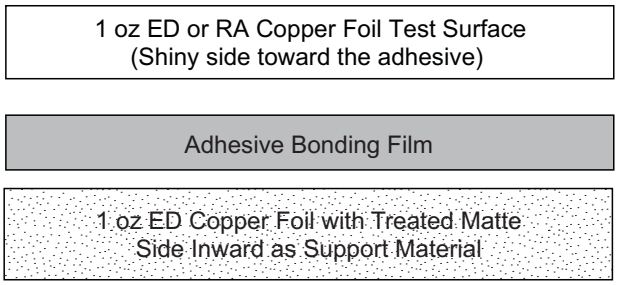


**Figure 2 Use of Adhesive Bonding Film to Form Test Specimen**

**3.4.2** Measure the flexible base dielectric thickness and the metal thickness of the twelve specimens by micrometer, caliper or similar following the stabilization period in 3.4.1. Nominal metal thickness to be tested is either 1 oz or 34.3 µm [1350 µin] thick (preferred) or ½ oz or 17.1 µm [680 µin] thick.

**3.4.3** On the specimens stabilized in 3.4.1, measure and verify that the conductor widths are 3.2 mm ± 0.15 mm [0.126 in ± 5.9 µin].

**3.4.4** Examine the twelve specimens measured in 3.4.3 using normal or corrected 20/20 (also termed 6/6 or 1.0) vision, and discard any peel strips showing the presence of any wrinkles, cracks, blisters, or loose conductors. Twelve specimens are required for the test, so any specimens not meeting this criterion **shall** be replaced.

**3.4.5** Per IPC-TM-650, TM 2.4.13, Method B, subject the specimens examined in 3.4.4 to pre-drying and then solder float.

**3.4.6** Examine the specimens subjected to solder float in 3.4.5 using normal or corrected 20/20 (also termed 6/6 or 1.0) vision. Discard any peel strips showing the presence of any wrinkles, cracks, blisters, or loose conductors. Verify that at least twelve good specimens remain.

**3.4.7** Place six specimens into an air-circulating oven at the desired Service Temperature value. The oven temperature **shall** be held at a tolerance of ± 3°C [5.4 °F]. The specimens are to continuously remain in the oven for 1000 hours, -0 hours / +12 hours.

**3.4.8** After being aged per 3.4.7, the test specimens **shall** be cooled to room temperature at standard ambient laboratory conditions. After being cooled to room temperature, the thermally aged (oven conditioned) specimens **shall** be subjected to a stabilization period of a minimum of 24 hours at 23 °C ± 2 °C [73.4 °F ± 3.6 °F] and 50% ± 5% RH.

**3.4.9** After the stabilization period in 3.4.8, examine the specimens using normal or corrected 20/20 (also termed 6/6 or 1.0) vision, and record the presence of any wrinkles, cracks, blisters, or loose conductors, or any delamination.

### 3.5 Measurement of Peel Strength

**3.5.1** AABUS, test specimens may have rigid reinforcement material attached to all twelve specimens that were subjected to the solder float in 3.4.5, including those six specimens that were additionally subjected to thermal aging in 3.4.7. The rigid reinforcement material **shall not** be attached prior to conditioning and aging. The attachment of the rigid reinforcement material depends on a number of factors, including the type of peel test apparatus as described in IPC-TM-650, Method 2.4.9. If the rigid reinforcement material is to be utilized, it should be adhered to the specimens using double-faced adhesive tape or appropriate adhesive system to the back side of the specimens.

If the test specimens are generated from double-clad flexible base materials with metal remaining on the non-test side, the additional rigid reinforcement material is unnecessary and should not be used.

**3.5.2** Measure the peel strength of the twelve conductors per the procedures outlined in IPC TM-650, Method 2.4.9. Specifically, peel the etched copper conductors away from the dielectric at a 90° angle and at a 50.8 mm [2 in] per minute crosshead speed.

### 3.6 Document and Report Results

**3.6.1** Calculate the average peel strength of the six specimens that were only exposed to the solder float (i.e., only as per 3.4.5 and *not* exposed to the thermal aging of 3.4.7). Do the same for the six thermally aged specimens per 3.4.7. Calculate the ratio of the ''thermally aged'' average peel strengths divided by the solder-floated only average peel strength to determine the percentage retention of peel strength. Record this number to ± 1% accuracy.

$$\frac{\text{[Ave. of Six (6) Peel Strengths of Thermally Aged Specimens]}}{\text{[Ave. of Six (6) Peel Strengths of Solder Floated-Only Specimens}} \times 100 = \%\ \text{of Peel Strength Retained}$$

**3.6.2** Report the results of the visual examination evaluation in 3.4.9.

**4 Dielectric Strength Using ASTM D-149 Test Procedure**

**4.1 Specimen Preparation**

**4.1.1** Prepare a specimen of the metal-clad flexible base material large enough [approximately 400 mm x 500 mm [approx. 16 in x 20 in]] to prepare at least twelve test specimens each of 80 mm x 80 mm [approx. 3.0 in x 3.0 in]. Cover materials **shall** be prepared per 3.2. Adhesive bonding films **shall** be prepared per 3.3 where copper foil is used on both sides of the adhesive bonding film.

**4.1.2** Remove (etch) all metal from both surfaces of the 400 mm x 500 mm [approx. 16 in x 20 in] specimen by standard industry practice. Rinse the etched material thoroughly. Cut the minimum of twelve test specimens to their nominal size of 80 mm x 80 mm [approx. 3.0 in x 3.0 in].

**4.2 Conditioning and Aging Procedure**

**4.2.1** After generating the minimum of twelve specimens as described in 4.1.1, all specimens **shall** be subjected to a stabilization period of a minimum of 24 hours at 23 °C ± 2 °C [73.4 °F ± 3.6 °F] and 50% RH ± 5% RH.

**4.2.2** Examine at least twelve specimens using normal or corrected 20/20 (also termed 6/6 or 1.0) vision, and record any presence of any wrinkles, cracks or blisters. Discard those specimens showing the presence of any wrinkles, cracks or blisters.

**4.2.3** Six specimens examined in 4.2.2 **shall** be placed into an air-circulating oven at the desired Service Temperature value. The oven temperature **shall** be held at a tolerance of ± 3 °C [± 5.4 °F]. The specimens are to continuously remain in the oven for 1000 hours, -0 hours / +12 hours.

**4.2.4** After being oven-conditioned as described in 4.2.3, the test specimens **shall** be cooled to room temperature at standard ambient laboratory conditions. After being cooled to room temperature, the oven-conditioned specimens **shall** be subjected to a stabilization period of a minimum of 24 hours at 23 °C ± 2° C [73.4 °F ± 3.6 °F] and 50% ± 5% RH.

**4.2.5** After the stabilization period in 4.2.4, examine the six specimens that had been subjected to the oven- conditioning using normal or corrected 20/20 (also termed 6/6 or 1.0) vision, and record the presence of any wrinkles, cracks or blisters.

**4.3 Measurement of Dielectric Strength**

**4.3.1** The six specimens that were not subjected to the oven-conditioning in 4.2.3 **shall** be subjected to the dielectric strength test per ASTM D-149. (These measurements **shall** be considered the ''as-received'' dielectric strength values.)

**4.3.2** The ''thermally aged'' (oven-conditioned) specimens examined in 4.2.5 **shall** be tested for dielectric strength according to the conditions outlined in 4.3.1. (These measurements **shall** be considered the ''thermally-aged'' dielectric strength values.)

**4.4 Evaluation of Results**

**4.4.1** Calculate the average dielectric strength of the six ''as-received'' specimens as measured in 4.3.1. Calculate the average dielectric strength of the six ''thermally aged'' specimens as measured in 4.3.2. Calculate the ratio of the average value of the ''thermally aged'' dielectric strength divided by the average value of the ''as-received'' dielectric strength to determine the percentage retention of dielectric strength. Record this number to ± 1% accuracy.

$$\frac{\text{[Ave. of Six (6) Diel. Strengths of ''Thermally Aged'' Specimens]}}{\text{[Ave. of Six (6) Diel. Strengths of ''As Received'' Specimens}} \times 100 = \% \text{ of Dielectric Strength Retained}$$

## 5 Data Reporting

**5.1** Report both percent values calculated in sections 3.6.1 and 4.4.1. The Service Temperature value, in units of °C, **shall** be based upon the lesser of the two reported percent values calculated in sections 3.6.1 and 4.4.1.

## 6 Notes

**6.1** For specimen preparation, test results may vary between specimens where the copper remains and those that have had the copper removed from the nontest side. If the flexible base material is supplied as single-clad and double-clad, both must be tested.

**6.2** For specimen preparation, test results may vary for the same flexible base material, depending whether it is tested as single- or double-clad.

**6.3** Suitable procedures must be used to ensure that solder does not remain on the test specimens after solder float.

**6.4** For flexible base materials other than polyimide, the temperature of the solder pot may be other than 288 °C [550 °F], AABUS.