12.1.2.2 ASTM D 5423 – Standard Specification for Forced-Convection Laboratory Ovens for Evaluation of Electrical Insulation.

Exception: Compliance with the maximum allowable thermal lag time of 660 seconds for an oven operating at 200 ±5 °C is not required, since the maximum allowable thermal lag time exceeds, in orders of magnitude, the maximum allowable thermal lag time criteria.

12.1.3 Samples

12.1.3.1 General

12.1.3.1.1 Samples shall be tested without imbedded or attached components, such as capacitors, resistors, or integrated circuits.

12.1.3.1.2 FMIC test samples fabricated from the representative production processes shall be provided in the minimum and maximum construction build-up thickness, as specified in the applicable test method.

12.1.3.1.3 The sample thickness shall be measured and tested in accordance with ASTM D 374, Method A or C. The deviation from the sample thickness shall be within the allowable range or tolerance specified in Table 12.1.

Table 12.1
Sample Thickness Tolerance

Material nominal thickness		Thickness tolerance	
mm	**(in)**	**mm**	**(in)**
Less than 0.025	Less than (0.001)	± 0.005	± (0.0002)
0.025 – 0.074	(0.001 – 0.003)	± 0.008	± (0.0003)
0.075 – 0.099	(0.003 – 0.004)	± 0.01	± (0.0004)
0.10 – 0.19	(0.004 – 0.007)	± 0.02	± (0.0008)
0.20 – 0.37	(0.008 – 0.014)	± 0.03	± (0.001)
0.38 – 0.62	(0.015 – 0.024)	± 0.05	± (0.002)
0.63 – 1.59	(0.025 – 0.061)	± 0.08	± (0.003)
1.60 – 2.54	(0.062 – 0.100)	± 0.10	± (0.004)
Greater than 2.55	Greater than (0.100)	± 0.13	± (0.005)
NOTE: The measured minimum build-up thickness and minimum film thickness shall not be less than the minimum calculated thickness, when employing the tolerance.			

12.1.3.1.4 The minimum and maximum individual material component thickness shall be determined from the measured average material thickness and shall compare to the calculated minimum and maximum material thickness, when employing the tolerance.

12.1.3.1.5 The minimum and maximum construction build-up thickness shall be determined from the measured average minimum and maximum thickness, and shall compare to the calculated minimum and maximum build-up thickness, respectively when employing the tolerance shown in Table 12.1. The minimum and maximum build-up thickness tolerance should be as shown in Table 12.1 and should not be the sum of tolerance of individual sheet.

12.1.3.1.6 In addition to the sample specifications for the particular test methods described in 12.4 – 12.11, the following sample specifications in Singlelayer, 12.1.3.2, and Multilayer, 12.1.3.3, shall apply.

12.1.3.1.7 Occasionally, a production sample shall be tested. When a production sample is tested in lieu of the representative samples, the FMIC type shall be limited by the production board construction tested including but not limited to materials, material thickness, build-up thickness, conductor line widths, and conductor weights.

12.1.3.2 Singlelayer

12.1.3.2.1 Each combination of material components or constructions shall be provided for test, except as indicated or described in Materials, Section 8; FMIC Constructions, Section 9; Processes, Section 10; and Parameter Profile Indices, Section 11; or, the Standard for Polymeric Materials – Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials Used in Printed Wiring Boards, UL 746E.

12.1.3.2.2 Representative singlelayer construction samples shall be provided. The representative minimum build-up construction shall include but not be limited to the thinnest individual film, adhesive, base material, and conductors, and shall be the thinnest production construction having one or two patterned conductor layers.

12.1.3.2.3 Representative maximum build-up singlelayer construction samples shall be provided. The representative maximum build-up construction shall include but not be limited to the thickest individual film, adhesive, base material, and corresponding maximum thickness conductors, and shall be the thickest production construction having one or two patterned conductor layers.

Exception: If the film, adhesive, base material, and conductor materials have been evaluated to the compliance requirements in accordance with the Standard for Polymeric Materials – Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials Used in Printed Wiring Boards, UL 746E, and if the same materials are used in the candidate construction, within the parameter profile indices established from testing in accordance with UL 746E, then testing of the representative maximum build-up construction shall not be repeated.

12.1.3.2.4 The conductor pattern shall be included on both sides of the samples and conductor patterns are to be positioned directly opposite each other, as mirror images, if double-sided constructions are intended for production; or, or the conductor pattern shall be included on one side if only single-sided constructions are intended for production.

12.1.3.2.5 A double-sided construction with conductor patterns on both sides of the singlelayer dielectric is to be considered representative of identical materials of construction with a representative conductor pattern on only one side of the same singlelayer dielectric, if the single-sided construction has the same film, adhesive, base material, conductor material, material thicknesses, and parameter profile indices. A single-sided construction is not considered representative of a double-sided construction.

12.1.3.3 Multilayer

12.1.3.3.1 Each combination of material layers or constructions shall be provided for test, except as indicated, or described in Materials, Section 8; FMIC Constructions, Section 9; Processes, Section 10; and Parameter Profile Indices, Section 11; or the Standard for Polymeric Materials – Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials Used in Printed Wiring Boards, UL 746E.

12.1.3.3.2 Representative multilayer construction samples shall include but not be limited to the thinnest thickness individual lamination(s) of film, adhesive, base material, conductor material, bonding film, cover material, dielectric material, laminate, prepreg, and other insulation material. The representative multilayer construction shall be the thinnest complete production multilayer construction having two or the minimum number of internal patterned conductor layers, whichever is greater.

12.1.3.3.3 Representative multilayer construction samples shall include but not be limited to the thickest thickness individual lamination(s) of base material, film, adhesive, a maximum conductor thickness, bonding film, cover material, dielectric material, laminate, prepreg, and other insulation material. The representative multilayer construction shall be a complete production multilayer construction having two or the minimum number of internal patterned conductor layers, whichever is greater.

Exception: If the film, adhesive, base material, conductor material, bonding film, cover material, dielectric material, laminate, prepreg, and/or other insulation material, have been evaluated to the compliance requirements in accordance with the Standard for Polymeric Materials – Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials Used in Printed Wiring Boards, UL 746E, and if the same materials are used in the candidate construction, within the parameter profile indices established from testing in accordance with UL 746E, then testing of the representative maximum build-up construction samples shall not be repeated.

12.1.3.3.4 The conductor pattern shall be included in the internal patterned conductor layers, and on both of the external patterned conductor layers of multilayer construction samples. The internal and external patterns shall be positioned directly opposite each other, as mirror images.

12.1.3.3.5 An interior conductor layer of the maximum conductor weight corresponding to the minimum build-up construction shall be included in multilayer construction samples. The internal patterned conductors shall mirror the external patterned conductors.

12.1.4 Apparatus

12.1.4.1 A measuring device used to perform the tests in this standard shall be capable of measuring the specified parameter with an accuracy within 10 percent of the measured parameter.

12.1.4.2 A ceramic plate or tile to hold or retain the samples during cooling.

12.1.5 Procedure

12.1.5.1 Prior to all tests, subject all samples to a stabilization period in accordance with the Standard Practice for Conditioning Plastics for Testing, ASTM D618, and the Standard for Plastics – Standard Atmospheres for Conditioning and Testing, ISO 291, for a minimum of 40 hours at 23 ±2 °C (73.4 ±3.6 °F) and 50 ±10 percent RH, unless otherwise specified in the individual test method.

12.1.5.2 Examine all the samples prior to test using normal or corrected 20/20 (also termed 6/6 or 1.0) vision, and record any presence of any wrinkles, cracks, blisters, delamination or loose conductors or film, adhesive, base material, bonding film, cover material, dielectric material, laminate, prepreg, or other insulation material.

12.1.5.3 During the test, the standard atmospheric conditions surrounding the samples shall be 25 °C ±10 °C (77 °F ±18 °F) and 50 ±10 percent relative humidity, unless otherwise specified in the individual test method.

12.1.5.4 Oven conditioning temperatures based on the desired or established MOT for the FMIC type shall correspond to the temperatures in Table 12.2. The following tests require oven conditioning based on the MOT: Delamination, 12.4; Bond Strength, 12.6; Ambient Bend, 12.9; and Stiffener Bond Strength, 12.12.

Table 12.2
Corresponding Oven Conditioning Temperatures for the Desired (or Established) MOT

t_1, Desired (or established) MOT (°C)	t_2, Oven temperature (°C) for 240-hour oven conditioning	t_3, Oven temperature (°C) for 1344-hour oven conditioning
75	118	98
80	123	103
85	129	108
90	134	113
105	150	128
120	167	144
125	172	149
130	177	154
150	199	174
155	204	179
160	210	184
170	220	195
175	226	200
180	231	205
Note – The temperatures represented by t_2 and t_3 are calculated based on the formulas in 12.4.4.2 and 12.4.4.3, with the conditioning values rounded up to the next whole integer.		

12.1.5.5 Samples shall be racked, hung, or placed in a fixture such that the mechanism used to hold or retain the samples position does not adversely affect the samples or impede the conditioning during pre-conditioning, thermal stress, and oven conditioning.

12.1.5.6 Cool the test samples to room temperature at standard ambient laboratory conditions. The samples shall be placed on a ceramic plate or tile, hung, or racked such that the samples are not adversely affected by the mechanism used to hold or retain the samples during cooling.

12.1.6 Data collection

12.1.6.1 The conductor average width shall be determined and reported by measuring the average contact or interface area of the materials (i.e., conductor material to base material). If possible, the interface area of the materials shall be used to measure the conductor trace average width from a top-view as seen from above the sample. See Figure 12.1 and Figure 12.2. Each of the following conductor widths shall be determined:

a) A midboard conductor having the minimum average width on the sample;

b) A 1.6 mm (0.062 inch) width conductor;

c) An edge conductor having the minimum average width within 0.40 mm (0.015 inch) of the board edge and not sheared at the board edge, except as described in 8.4.17. If the edge conductor does not meet the criteria and/or is not included on the sample, a conductor of other width (d) specified by the fabricator shall be tested; and

d) A midboard/non-edge conductor of "other" width (optional) specified by the fabricator. The "other" width conductor is optional unless the edge conductor does not meet the criteria in Conductors and conductor adhesives, 8.4 and/or is not included on the sample test pattern.

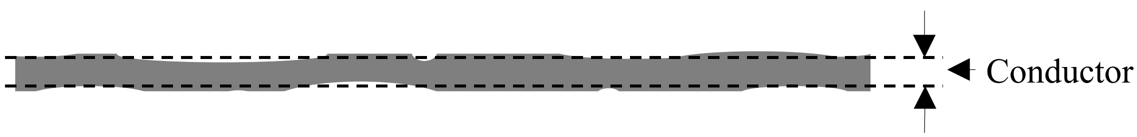
Figure 12.1

Measuring Conductor Trace Average Width (Side-View)

S5082

Figure 12.2

Measuring Conductor Trace Average Width (Top-View)

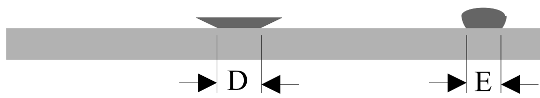


S5083

12.1.6.2 In cases where the contact or interface area of the materials cannot be viewed from a top-view as seen from above the sample (see Figure 12.3), the average contact or interface area of the separated materials shall be used to measure the conductor trace average width.

Figure 12.3

Measuring Conductor Trace Average Width (Side-View)

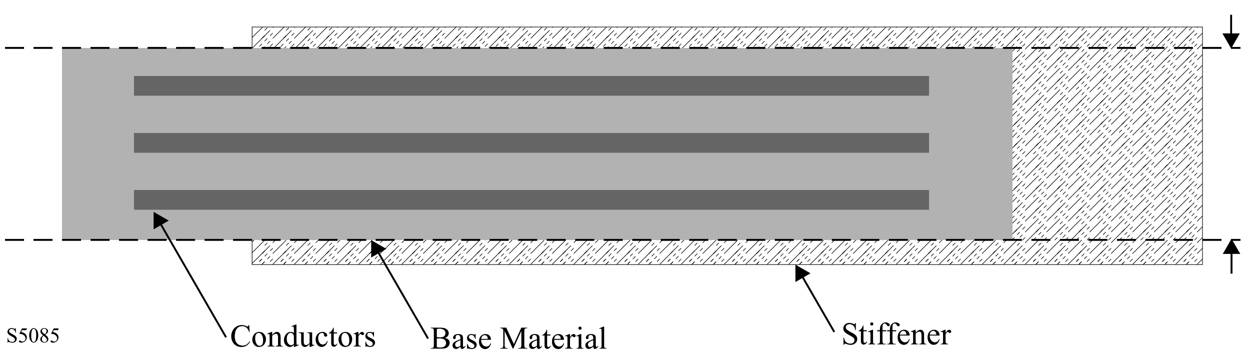


S5084

12.1.6.3 The construction average width shall be determined and reported by measuring the average contact or interface area of the materials (i.e., construction to stiffener). If possible, the interface area of the materials shall be used to measure the construction average width from a top-view as seen from above the sample. See Figure 12.4.

Figure 12.4

Measuring Construction Average Width (Top-View)

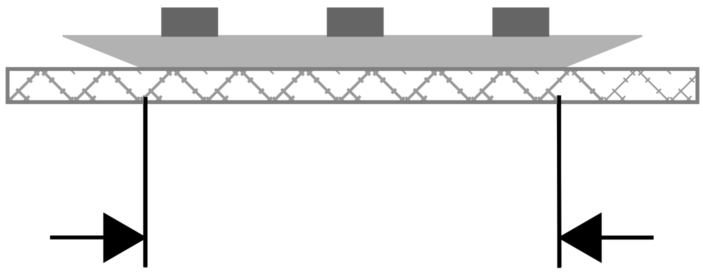


S5085

12.1.6.4 In cases where the contact or interface area of the construction and stiffener materials cannot be viewed from a top-view as seen from above the sample (see Figure 12.5), the average contact or interface area of the separated materials shall be used to measure the construction average width.

Figure 12.5

Measuring Construction Average Width (Side-View)

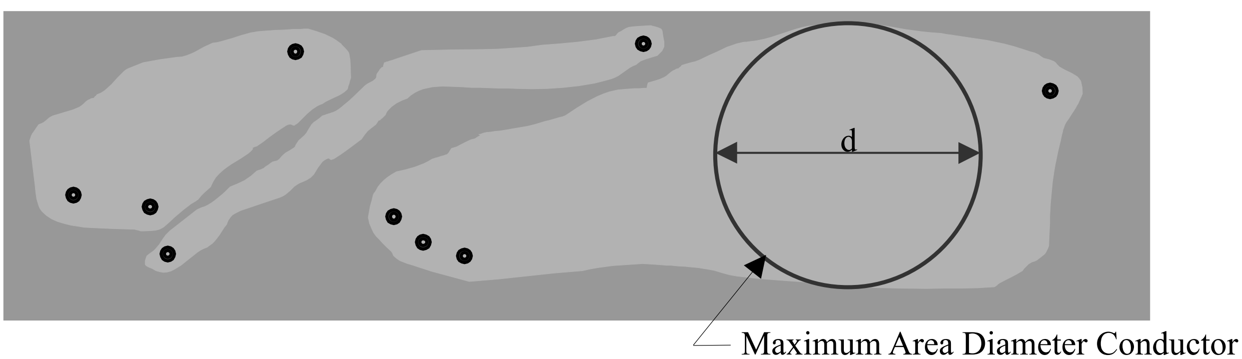


S5086

12.1.6.5 The maximum area conductor diameter (d) as shown in Figure 12.6 shall be determined and reported by inscribing and measuring the largest circle within the maximum unpierced area of the conductor pattern The maximum area conductor diameter (d) shall be determined on the test sample from a top-view as seen from above the sample. Alternate conductor area diameters shall also be determined if necessary for the test method.

Figure 12.6

Measuring Maximum Area Conductor Diameter

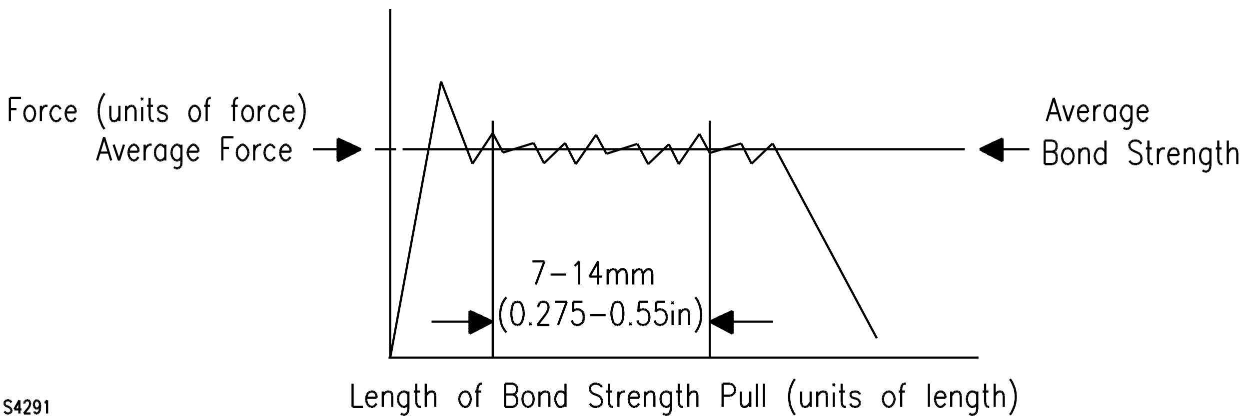


S5087

12.1.6.6 The average bond strength (average force/average width) shall be determined and reported by establishing the average force required to separate the materials, and dividing the average force by the contact or interface average width (i.e., conductor trace average width, or construction average width) in the tested length of materials. See Figure 12.7.

Figure 12.7

Determining Average Bond Strength from the Average Force



S4291

12.1.6.7 The external conductor thickness (weight) including foil thickness and plating shall be determined on the sample test pattern. In addition, the external conductor foil and conductor surface plating thickness shall be determined and reported on the sample test pattern to verify the total conductor thickness is appropriate for the bond strength pull.

12.1.6.8 For multilayer samples with internal conductor test patterns, the internal conductor thickness (weight) shall be determined and reported for each internal conductor layer.

12.1.6.9 The average build up thickness of the uncoated flammability sample shall be determined and reported by measuring the sample thickness on the sample.

12.1.6.10 The average build up thickness of all samples containing conductor patterns, such as but not limited to the bond strength, delamination, conductive paste adhesion, cover material test, flexibility tests, stiffener bond strength, and silver migration test samples shall be determined and reported by measuring the sample thickness, where no conductor material resides on the internal or external surfaces of the sample construction.

12.1.6.10A Visual examination of the test sample shall be used to determine uniformity of the conductor pattern parameters, overall sample build up thickness and cover material thickness. If sample uniformity is suspect, three thickness measurements of the parameter in question shall be made in separate areas on the sample in accordance with the instructions above.

12.1.6.11 Record and report the following information and measured parameter for each set of samples and each material component (i.e., film, adhesive, base material, bonding film, cover material, dielectric material, laminate, prepreg, and other insulation material; as applicable) in the construction used to fabricate the FMIC:

a) Type designation for the FMIC;

b) Title of the FMIC type;

c) Material component;

d) Manufacturer;

e) Grade designation;

f) Material component thickness;

g) Film thickness (if applicable);

h) Adhesive thickness (if applicable);

i) External conductor thickness before etching or plating;

j) External conductor thickness after plating;

k) Minimum internal conductor thickness (if applicable); and

l) Maximum internal conductor thickness (if applicable).

12.2 Microsection analysis

12.2.1 General

12.2.1.1 The purpose of the microsection examination is to evaluate and determine compliance of the materials, construction, and test pattern of the printed wiring board with the applicable standard and test method sample coupon construction requirements. The same basic procedures may be used to evaluate other areas of the sample.

12.2.1.2 Guidelines for preparing microsectioning samples are described in the Standard Practice for Preparation of Metallographic Specimens, ASTM E 3, and Microsectioning, Manual and Semi or Automatic Method, IPC TM-650 2.2.1.

12.2.2 Test samples

12.2.2.1 The microsection samples shall be cut from the printed wiring board or test coupon to include representative areas of the parameters to be measured. This may require multiple microsections. All samples must maintain required traceability. Three common types of cutting tools are diamond saws, routers, and punching dies. Samples shall be cut perpendicular to the evaluation surface with enough clearance to prevent damage to the examination area. The recommended minimum clearance is 2.5 mm (0.1 inch). Depending on the printed wiring board or test coupon design care shall be exercised in choosing a microsection location such that a complete examination can be made.

12.2.2.2 Samples sizes are generally not more than 12 to 25 mm (0.5 to 1.0 in.) square. The sample height shall be determined for convenience in handling during polishing.

12.2.2.3 Samples shall be cleaned thoroughly with isopropyl or ethyl alcohol to remove all greases, oils, and residue from the cutting tools. Dry the sample thoroughly. Cleanliness during sample preparation is important for good adhesion of the mounting resin. Poor adhesion of the mounting resin can cause gaps between the sample and the mounting material which make proper examination difficult.

12.2.2.4 Samples shall be mounted prior to grinding and polishing in a castable resin/potting material. A release agent shall be applied to the plate and mount mold. The sample shall stand in the mount perpendicular to the base with the surface to be evaluated facing the mounting surface. Clips or tape may be used to support the sample until the potting material is cured.

12.2.2.5 The mount mold shall be filled with potting material carefully to reduce bubbles in the potting material. Allow samples to cure and remove mount mold.

12.2.2.6 The samples shall be rough planar ground using an abrasive medium. ANSI 180 – 240 abrasive paper (or equivalent) may be used as a starting grit size using metallographic equipment to remove the sectioning/cutting damage. The sample shall be held firmly in contact with the rotating wheel in a circular path against the rotation of the wheel. Rinse the sample with running water and dry. Wheel speeds of 200 to 300 rpm are generally used during grinding. Rotate the sample 90 degrees planar between successive grit size and grind to remove the scratches from the previous step. The successive grinding time may be three times longer than the previous step. Scratches are grooves in the surface of the sample produced by the abrasive particles in the grinding paper. The surface of the sample shall be flat with one set of unidirectional grinding scratches. Water flow must be maintained for removal of grinding debris and to prevent overheating and damage to the sample.

12.2.2.7 Continue grinding the samples with fine grit size. ANSI 400 – 1200 grit (or equivalent) may be used in successive order to remove the rough and finer grinding damage/scratches. Less time shall be spent on the larger grit and more time on the smaller grit for better sample quality. The scratch removal can be verified by microscopic inspection between steps. Rinse and dry samples between each step to avoid contamination by grinding particles.

12.2.2.8 Polish the samples to remove the scratches from intermediate steps. Diamond polish is preferred. Smearing of the printed wiring board material or potting material may occur if lubrication levels are too low or if excessive load is used during grinding. Increase or change the lubricant and reduce the applied load to reduce smearing.

12.2.3 Micro-etching the sample surface

12.2.3.1 When the required microsection quality has been achieved, the sample shall be etched to allow examination of the copper foil and plating interface.

12.2.3.2 The etching solution shall be prepared daily and is a mixture of 7 drops Ammonium Hydroxide solution and 9 drops Hydrogen Peroxide solution. The Ammonium Hydroxide solution is a 1:1 ratio solution of reagent grade Ammonium Hydroxide and deionized water. The Hydrogen Peroxide solution is a 1:1 ratio solution of stabilized Hydrogen Peroxide (3 percent by volume) and deionized water.

12.2.3.3 The etching solution shall be applied for 2 to 3 seconds. If necessary, repeat the application of the etchant 2 to 3 times to show the plating surface. Rinse in running tap or deionized water to remove etchant.

Note: Over etching may obscure the demarcation line between the copper foil and electroplate copper, preventing accurate evaluation. Thin copper foil and special plating processes can require the etching time to be modified.

12.2.4 Material and test pattern parameter examination.

12.2.4.1 The microsection sample shall be evaluated at a minimum 100X magnification with bright field illumination.

12.2.4.2 All parameters required by the standard shall be measured and observed including, but not limited to, overall construction build up thickness, laminate layer thickness, bonding layer thickness, number and thickness of reinforcement layers, conductor thickness (weight), conductor base width, etc.

12.3 Thermal stress test

12.3.1 Purpose

12.3.1.1 The purpose of this test method is to evaluate the physical fatigue of representative samples or production boards exposed to assembly soldering. See Table 12.3 for the test methods to be conditioned using the thermal stress test.

Table 12.3
Test Methods Requiring Thermal Stress Conditions

Test	Section
Flammability test	12.15
Delamination test	12.4
Bond strength test	12.6
Conductive paste adhesion test	12.7
(Ambient) bend test	12.9
Stiffener bond strength test	12.12

12.3.2 Compliance criteria

12.3.2.1 There shall be no presence of any wrinkling, cracking, blistering, loosening, or delamination of any conductor, adhesive, base material, bonding film, cover material, dielectric material, laminate, prepreg, or other insulation material as a result of the thermal stress test.

12.3.3 Test samples

12.3.3.1 Samples shall include all material components in accordance with Materials, Section 8; and for the desired construction(s) in accordance with FMIC Constructions, Section 9.

12.3.4 Apparatus or material

12.3.4.1 A fixture for racking samples can be used for this test. The fixture shall not interfere with the test area of or heat transfer to the samples. The entire sample shall be exposed to the preconditioning and thermal stress temperatures. A tab or area of the sample used to secure the sample in a rack shall not interfere with the heat transfer to the test area of the sample during preconditioning or thermal stress.

12.3.4.2 A preconditioning (convection) oven capable of maintaining the intended temperature for the desired time, and calibrated to the Standard Test Method for Forced-Convection Laboratory Ovens for Evaluation of Electrical Insulation, ASTM D 5374, and the Standard Specification for Forced-Convection Laboratory Ovens for Evaluation of Electrical Insulation, ASTM D 5423, shall be used for this test.

12.3.4.3 A dry storage device or desiccator capable of maintaining the preconditioned samples at 20 percent RH or less at room temperature shall be used for this test.

12.3.4.4 Thermal stress reflow conditions shall be conducted using the following apparatus:

Reflow Oven – The reflow system shall have adequate environmental controls to maintain the tolerance range and limits in the designated temperature profile. IR reflow requires attention to the uniformity of temperature across the sample due to the susceptibility of the materials to infrared absorption.