UL 796F

STANDARD FOR SAFETY

Flexible Materials Interconnect Constructions

UL Standard for Safety for Flexible Materials Interconnect Constructions, UL 796F

Fourth Edition, Dated February 26, 2021

Summary of Topics

This revision of ANSI/UL 796F dated January 27, 2022 is issued to Update Sample Thickness Measurement Requirements; 12.1.6.9, 12.1.6.10, and 12.1.6.10A

Text that has been changed in any manner or impacted by UL's electronic publishing system is marked with a vertical line in the margin.

The news and revised requirements are substantially in accordance with Proposal(s) on this subject dated November 19, 2021.

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UL 796F

Standard for Flexible Materials Interconnect Constructions

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The most recent designation of ANSI/UL 796F as an American National Standard (ANSI) occurred on January 21, 2022. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at https://csds.ul.com.

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INTRODUCTION

1 Scope

1.1 These requirements apply to flexible material printed wiring board constructions (FMIC's) for use as components in flexible, flex-to-install, rigid, and multilayer rigid-flex composite applications with and without stiffener and adhesive materials in devices or appliances.

1.2 Together with the Standards mentioned in the Supplementary Test Procedures, Section 3, these requirements provide data with respect to the physical, electrical, flammability, thermal, and other properties of the FMIC under consideration and are intended to provide guidance to the fabricator, end product manufacturer, safety engineers and other interested parties.

1.3 Compliance with these requirements does not indicate the product is acceptable for use as a component of an end product without further investigation.

1.4 The singlelayer and multilayer flexible, flex-to-install, and multilayer rigid-flex composite constructions addressed by these requirements consist of conductors affixed to base material, with mid-board interconnections, and cover materials.

1.5 The suitability of additional stiffener and adhesive materials, not evaluated in accordance with Stiffener and adhesive (external bonding) materials, 8.10, the Stiffener bond strength test, 12.12, and Flammability tests, 12.15, are subject to the applicable end-use product construction and performance requirements. See Additional stiffener and adhesive (external bonding) materials, 13.12, for marking requirements for FMIC's provided with additional stiffener and adhesive materials not investigated.

1.6 The requirements for rigid printed wiring boards are in the Standard for Printed Wiring Boards, UL 796.

2 Units of Measurement

2.1 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

3 Supplementary Test Procedures

3.1 These requirements are intended to be used in conjunction with the following requirements or standards:

a) The Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A, the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B, the Standard for Polymeric Materials – Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials Used in Printed Wiring Boards, UL 746E, and the Standard for Polymeric Materials – Flexible Dielectric Film Materials for Use in Printed Wiring Boards and Flexible Materials Interconnect Constructions, UL 746F, contain programs for investigating polymeric materials and industrial laminates.

b) The Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, contains methods for evaluating the flammability of polymeric materials that are intended to be used in electrical equipment.

c) The Standard for Printed Wiring Boards, UL 796, covers the minimum performance requirements for rigid printed wiring boards.

4 References

4.1 Any undated reference to a code or standard appearing in the requirements of this standard shall be interpreted as referring to the latest edition of that code or standard.

4.2 The following publications are referenced in this standard:

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

ASTM D 374 – Standard Test Methods for Thickness of Solid Electrical Insulation.

ASTM D 1000 – Standard Test Methods for Pressure-Sensitive Adhesive-Coated Tapes Used for Electrical and Electronic Applications.

ASTM D 5374 – Standard Test Methods for Forced-Convection Laboratory Ovens for Evaluation of Electrical Insulation.

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

ASTM D 618 – Standard Practice for Conditioning Plastics for Testing

ASTM E 3 – Standard Practice for Preparation of Metallographic Specimens.

IPC TM-650 2.1.1 – Microsectioning, Manual and Semi or Automatic Method.

ISO 291 – Plastics – Standard Atmospheres for Conditioning and Testing.

5 General

5.1 Acceptability of an FMIC in a device or appliance depends on the acceptability of the construction for:

a) Continued use under actual service conditions, including the maximum operating temperature (MOT);

b) Flammability properties; and

c) All other applicable end-product requirements.

5.2 The investigation of an FMIC shall include consideration of the conductor properties, such as weight (thickness), minimum midboard and edge width, and maximum ground plane area, and shall include the conductor forming and materials build-up processes including solder limits.

5.3 Except as indicated in 5.4, the factors considered in testing the FMIC conductor supporting material in its application shall include mechanical strength, moisture absorption, combustibility, resistance to ignition from electrical sources, dielectric strength, insulation resistance, resistance to arc-tracking, and resistance to creeping and distortion at temperatures to which the material is subjected in the end product. The conductor supporting material shall not display a loss of these properties beyond the minimum acceptable level as a result of aging, and relative temperature indices shall be assigned to the conductor supporting material.

5.4 If an FMIC is entitled with flammability classification only, the acceptability of the FMIC shall involve only flammability tests. See Flammability tests, 12.15.

5.5 An FMIC entitled flexible is intended for use where the construction is subject to dynamic flexing applications, yet the flexural endurance of the construction has not been evaluated.

5.6 An FMIC entitled flex-to-install is intended for use where the construction is flexed for installation or service (only) and shall not be subject to dynamic or repeated flexing applications, yet the flexural endurance of the construction has not been evaluated.

5.7 An FMIC entitled rigid is intended for use where the construction is not flexed or subject to dynamic or repeated flexing applications.

5.8 Multilayer rigid flex composite constructions may include single-sided, double-sided, singlelayer and multilayer flexible, flex-to-install, and rigid constructions in various sections of an FMIC.

6 Glossary

6.1 For the purpose of this Standard the following definitions shall apply.

6.2 ACCESS HOLE – Holes on the same axis through successive layers of materials intended to provide access to the surface of the land on an inner conductor layer of a multilayer category construction.

6.3 ADDITIVE PROCESS – A selective or non-selective process used to deposit a pattern of conductor material(s) on clad or unclad base material.

6.4 ADD-ON COMPONENT – Discrete, integrated, packaged, or chip components that are attached to an FMIC to function as part of a complete circuit or assembly.

6.5 ADHESIVE – A substance such as glue or cement used to join, bond, or fasten materials or objects together.

6.6 AS-RECEIVED – Samples or samples in an unconditioned state, prior to being subject to conditioning, or without a history of conditioning.

6.7 ASSEMBLY – Various parts, subassemblies, and combinations thereof, joined together.

6.8 BARE BOARD – An unpopulated FMIC without add-on or embedded components or assemblies.

6.9 BASE DIELECTRIC MATERIAL – An organic or inorganic dielectric barrier material, used to support conductor material.

6.10 BASE MATERIAL – An organic or inorganic insulating material used to support a pattern of conductor material, with or without integral adhesive material, with or without integral conductor material.

6.11 BASE MATERIAL THICKNESS – The thickness of the base dielectric material excluding conductive foil or material deposited on the surfaces. If an adhesive is used for the base material, the adhesive thickness and number of sides is indicated separately.

6.12 BLIND VIA – A via extending to only one surface of the printed wiring board construction.

6.13 BLISTERING – Localized area of delamination. See Delamination, 6.60.

6.14 BONDING FILM– The layer of insulation used to bond discrete layers during lamination of multilayer flexible printed wiring board constructions. A general term used to describe bondply and freefilm. See also Bond Ply 6.16, Supported Bonding Film, 6.162, Freefilm, 6.87, and Unsupported Bonding Film, 6.174.

6.15 BONDING LAYER – An adhesive layer used to bond discrete layers of multilayer category constructions during lamination.

6.16 BOND PLY – See Bonding Film, 6.14.

6.17 BUILD-UP MATERIAL – Multiple layers of HDI materials.

6.18 BUILD-UP THICKNESS – Overall thickness of a combination of materials. Unless otherwise indicated, the build-up thickness will refer to the overall thickness in the area of an FMIC where no internal or external conductor material resides.

6.19 BURIED VIA – A via that does not extend to the surface of an FMIC construction.

6.20 CALCULATED THICKNESS – A thickness value determined by adding suggested material component thicknesses, or a thickness value determined by adding or subtracting one measured value to or from another measured value.

6.21 CAST ON COPPER – Resin is cast onto copper and then polymerized (cured). The process may require a “multilayer” resin to manufacture a double-sided clad material.

6.22 CIRCUIT – Electrical devices and elements interconnected to perform a desired electrical function.

6.23 CIRCUITRY LAYER – Conductor layer or plane in or on an FMIC construction or printed board.

6.24 CLAD MATERIAL – Base material or base dielectric material with conductor material attached.

6.25 CLADDING – A deposited or plated metallic layer or laminated foil used for its protective and/or electrical properties. See Conductive Foil, 6.30.

6.26 COATING – A non-metallic substance applied by some process, such as dipping, curtain coating, film laminating, screening, spraying, or melt-flow.

6.27 COMPONENT – An individual or combination of parts intended to perform a desired function.

6.28 CONDITIONING – The time related exposure of test samples to a specified environment for a period of time, prior to or after testing, and before evaluation.

6.29 CONDUCTIVE (ELECTRICAL) – The ability of a substance or material to conduct electricity.

6.30 CONDUCTIVE FOIL – A thin metal sheet intended for forming a conductor pattern on a base material.

6.31 CONDUCTIVE PASTE – An organic or inorganic paste substance capable of transmitting electricity, used for circuit conductors, including but not limited to carbon, copper, and silver.

6.32 CONDUCTIVITY (ELECTRICAL) – A property exhibited by a material or substance when electricity is transmitted through the material or substance.

6.33 CONDUCTOR – A trace or path for electricity to transmit in a conductor pattern.

6.34 CONDUCTOR ADHESIVE – Adhesive material used to attach conductor material to a base material, or base dielectric material.

6.35 CONDUCTOR AVERAGE TRACE WIDTH – The average width of a length of conductor trace.

6.36 CONDUCTOR BASE WIDTH – The width of a conductor at the interface of the conductor material and base material. See Conductor Width, 6.44.

6.37 CONDUCTOR LAYER – The total conductive pattern formed on one side of a single layer of a base material. This may include all or a portion of ground and voltage planes.

6.38 CONDUCTOR MATERIAL – An organic or inorganic substance capable of transmitting electricity, used for circuit conductors, including but not limited to copper, tin, nickel, gold, copper paste, silver paste, carbon paste, ruthenium oxide paste, etc.

6.39 CONDUCTOR PATTERN – The path, design, or configuration of conductor material on the base material, including but not limited to conductor traces, lands, through-holes, and vias.

6.40 CONDUCTOR SPACING – The minimum distance between adjacent conductors.

6.41 CONDUCTOR THICKNESS – The thickness of the conductor and additional metallic platings or coatings, excluding non-conductive coatings.

6.42 CONDUCTOR TRACE – A linear conductor path of a conductor circuit.

6.43 CONDUCTOR WEIGHT – See Conductor Thickness, 6.41.

6.44 CONDUCTOR WIDTH – The width of the conductor as viewed from a top view or at the plane of the surface of a base material, whichever is less. See Conductor Base Width, 6.36.

6.45 CONFORMAL COATING – An insulating, environmentally protective coating capable of conforming to the objects coated.

6.46 CONNECTOR – A terminal device capable of connect/disconnect service for electrical components.

6.47 CONSTRUCTION – A variation in flexible materials build-up, including but not limited to film, adhesive, base material, bonding film, cover material, dielectric material, laminate, prepreg, or other insulation materials. Variations include singlelayer, multilayer, flexible, flex-to-install, rigid, and multilayer flex-rigid composite constructions.

6.48 CONTACT FINGER – A conductive surface used to provide electrical connection by pressure contact, usually located at an edge of an FMIC.

6.49 CONTINUITY – An uninterrupted path for the flow of electrical current in a circuit.

6.50 CONVERTOR – Manufacturer who prepares materials, such as lamination of copper, adhesive, and base dielectric material for use in the fabrication of FMIC's.

6.51 CORE MATERIAL – The innermost material, FMIC construction, or printed wiring board which may be used to support a subsequent layer or layers of dielectric material and conductor pattern. Core material may be an organic or inorganic material, with or without integral dielectric material. Core material may be referred to as substrate material.

6.52 COVERCOAT – A material deposited as a liquid onto the circuitry that subsequently becomes a permanent dielectric coating. See Cover Material, 6.56.

6.53 COVERFILM – A film made from:

a) A homogenous, single component chemistry;

b) Separate layers of generically similar chemistries; or

c) A composite blend of chemistries.

See Cover Material, 6.56.

6.54 COVERLAY– Film and adhesive made from separate layers of generically different chemistries. See Cover Material, 6.56.

6.55 COVERLAY ADHESIVE – Adhesive used with film to prepare coverlay.

6.56 COVER MATERIAL – A thin dielectric material used to encapsulate circuitry, most commonly for flexible circuit applications. See Covercoat, 6.52, Coverfilm, 6.53, and Coverlay, 6.54.

6.57 CRITICAL OPERATION – Production process or fabrication step considered potentially detrimental to the materials subject to the operation.

6.58 CURRENT – The flow or movement of electrons in a conductor as a result of a voltage difference between the ends of the conductive path.

6.59 DECLAD – A dielectric material from which the foil or conductive material has been removed by etching or other means.

6.60 DELAMINATION – A planar separation of materials (i.e., separation between conductor and base material, bonding film and base material, cover material and conductor, etc.).

6.61 DESICCATOR – A sealable enclosure containing anhydrous calcium chloride, or other drying agent, maintained at a relative humidity not exceeding 20 percent at 23 ±2 °C (73.4 ±3.6 °F).

6.62 DIELECTRIC – A material capable of high resistance to the flow of electrical current and capable of being polarized by electric field.

6.63 DOUBLE-SIDED – A singlelayer construction or printed wiring board with a conductive layer on the two external sides of the base material. Sometimes referred to as di-clad.

6.64 EDGE CONDUCTOR – A conductor parallel with and spaced not more than 1/64 inch (0.4 mm) from the edge of the base material.

6.65 ELECTRODEPOSITION – The depositing of conductor material from a plating solution by the application of electrical current.

6.66 ELECTROLESS DEPOSITION – The depositing of conductor material from an autocatalytic plating solution without the application of electrical current.

6.67 ELECTROPLATING – See Electrodeposition, 6.65.

6.68 EMBEDDED COMPONENT – A discrete component integrated into the FMIC during fabrication.

6.69 END-PRODUCT – An individual part or assembly in its final completed state. See End-Use Product, 6.70.

6.70 END-USE PRODUCT – A device or appliance in which an FMIC is installed as a component.

6.71 ETCHANT – A solution used to remove the unwanted portions of material from a base material or FMIC construction by a chemical reaction.

6.72 ETCHED – A base material in which the conductive layer has been removed by a chemical process.

6.73 ETCHING – The chemical, or chemical and electrolytic, removal of unwanted portions of conductive or resistive material.

6.74 EXTERNAL LAYER – The conductor pattern on the external surface of the construction.

6.75 FABRICATOR – A manufacturer, alternate manufacturer, subcontractor, or multi-site processor who may form the pattern of conductive material, laminate, coat, or process the materials for production of a printed wiring board or FMIC.

6.76 FILLET – Material used to fill the corner or angle created, where two materials are joined.

6.77 FILM – A sheet, thin coating, or membrane material having a thickness not greater than 0.25 mm (0.010 inch).

6.78 FLAMMABILITY CLASSIFICATION ONLY – A printed wiring board intended for use where the construction shall be evaluated for flammability classification only, and the thermal, mechanical, and electrical capacity of the materials is not of concern and only the flammability classification of the resulting FMIC is of concern in the end-use product.

6.79 FLAT (PANEL) – Any number of printed wiring board constructions or FMIC's assembled together in a sheet, usually with a frame around the side, when shipped from the FMIC manufacturer.

6.80 FLEXIBLE INTERCONNECT CONSTRUCTION – A sub-category construction intended for use where some portion of the construction shall be subject to flexing in the end-use product application.

6.81 FLEXIBLE MATERIALS INTERCONNECT CONSTRUCTION (FMIC) – An assembly of printed wiring board constructions, and stiffener and adhesive material, where the assembly is intended for component mounting and interconnection purposes.

6.82 FLEX-TO-INSTALL CONSTRUCTION – A sub-category construction intended for use where some portion of the construction may be subject to flex for installation or service in the end-use product.

6.83 FLUSH-PRESS METAL CONDUCTOR – A metal conductor, such as copper, positioned and secured in a base material by a heat and pressure process.

6.84 FLUX – A surface oxidation removing and protecting compound, used to promote wetting of the base metal surface during soldering operations. Flux shall include, but not be limited to acid flux, inorganic flux, organic flux, and water soluble organic flux.

6.85 FMIC – See Flexible Materials Interconnect Construction (FMIC), 6.81.

6.86 FOIL LAMINATION – A process for bonding a conductive foil to a base dielectric material or other insulating material.

6.87 FREEFILM – An adhesive layer used to bond discrete layers during lamination of multilayer flexible printed wiring board constructions. See Bonding Film, 6.14, and Unsupported Bonding Film, 6.174.

6.88 FULLY-ADDITIVE PROCESS – A fabrication process where the entire thickness of electrically isolated conductors is obtained by electroless deposition.

6.89 GRADE – A designation arbitrarily assigned to a material by the material manufacturer, converter, or vendor.

6.90 GROUND– A common reference point for conductor circuits.

6.91 GROUND PLANE – A conductor plane used as a common reference point for conductor circuits.

6.92 HEATSINK – A device made of high thermal conductivity and low specific heat material capable of dissipating heat generated by a component or assembly.

6.93 HEATSINK PLANE – A continuous sheet of high thermal conductivity and low specific heat material intended to dissipate heat from heat generating components or assemblies.

6.94 HIGH DENSITY INTERCONNECT MATERIALS (HDI) – Thin insulating materials used to support conductor materials requiring mechanical strength from a separate core material and are intended for the production of microvias using sequential build-up and related multilayer interconnect technologies. Some examples of HDI materials: resin coated copper foil (RCF), liquid photoimageable (LPI) dielectric coating materials, photoimageable film dielectric coating materials, and other thin insulating materials when used to support conductor material shall be considered HDI material.

6.95 IDENTICAL PROCESSING – Production or fabrication processes with the same manufacturing steps required to fabricate an FMIC.

6.96 IMMERSION SILVER – Consists of a very thin coating typically less than 0.55 microns (0.0217 mils) of nearly pure silver created by galvanic displacement and may contain a slight amount of organic material deposited with the silver.

6.97 INCLUSIONS – Foreign particles, metallic or nonmetallic, entrapped (cannot be wiped off with a cloth) in the specified material and are not intended as part of the material formulation.

6.98 INFRARED REFLOW (IR) – Melting of tin/lead or remelting of solder using infrared heat as the primary source of energy.

6.99 INNERLAYER CONNECTION – An electrical connection between two or more internal conductor layers of an FMIC construction.

6.100 INTERLAYER CONNECTION – An electrical connection between two or more conductor layers on or in an FMIC construction.

6.101 INTERNAL LAYER – A conductor pattern contained entirely within a multilayer construction.

6.102 LAMINATE (n.) – The product of bonding two or more layers of material.

6.103 LAMINATE THICKNESS – The thickness of the dielectric material (not including adhesive thickness) in a single-sided or double-sided singlelayer metal-clad base material.

6.104 LAMINATING ADHESIVE – A thin film, coating, or membrane material used to laminate multilayer FMIC's and printed wiring boards.

6.105 LAND – Part of the conductor pattern, usually where components are attached, mounted, or connected.

6.106 LAYER-TO-LAYER SPACING – The thickness of dielectric material between adjacent conductor planes (i.e., the physical distance between adjacent conductor planes).

6.107 LEGEND INK – See Marking Ink, 6.108.

6.108 MARKING INK – A non-conductive permanent coating, resistant to solvents and chemicals, used to provide a means of identification in the form of letters, numbers, symbols and patterns to identify component locations and orientation to aid in printed wiring board assembly.

6.109 MAXIMUM AREA DIAMETER (MAD) – The solid, unpierced circle of conductive material depicted in Figure 12.6 represents the maximum area conductor diameter acceptable for any FMIC conductor pattern. The maximum area conductor diameter is determined by inscribing and measuring the largest circle within the maximum unpierced conductor area of the FMIC conductor pattern.

6.110 MAXIMUM OPERATING TEMPERATURE (MOT) – The maximum continuous use temperature the FMIC may be exposed to under normal operating conditions.

6.111 METAL-CLAD BASE MATERIAL – Base material with integral metal conductor material on one or both sides with or without adhesive.

6.112 MIDBOARD CONDUCTOR – A conductor spaced more than 0.4 mm (0.016 inch) from the edge of a printed wiring board.

6.113 MINIMUM CONDUCTOR WIDTH – The minimum width conductor present on the sample or production printed wiring board. See Conductor Base Width, 6.36.

6.114 MIXED COMPONENT-MOUNTING TECHNOLOGY – A component mounting process incorporating both through-hole and surface mounting on the same FMIC.

6.115 MIXED TECHNOLOGY – A component mounting process incorporating both through-hole and surface mounting on one side of the same FMIC.

6.116 MULTILAYER – A printed wiring board construction category that consists of alternate layers of conductor and dielectric materials laminated or bonded together, including at least three conductor layers separated by two dielectric layers, with at least one internal conductor layer.

6.117 MULTILAYER RIGID FLEX COMPOSITE – Hybrid FMIC's consisting of a combination of flexible, flex-to-install, and rigid constructions, and in some cases rigid industrial laminate materials, electrically interconnected by means of conductor plated through holes or vias.

6.118 OVERCOAT – A thin coating or membrane material used to cover a conductive pattern on a base material.

6.119 PATTERN – A configuration of conductive and nonconductive materials on a base dielectric material.

6.120 PERFORMANCE LEVEL CATEGORIES (PLC) – An integer defining a range of test values for a given electrical or mechanical property test.

6.121 PERMANENT MATERIALS – Materials intended to be a part of the FMIC for the life of the product.

6.122 PERMANENT RESIST – A solder resist or mask material intended to be a part of the FMIC, for the life of the product.

6.123 PLATED-THROUGH HOLE – A connection between different planes of conductor patterns on double sided, or on or in multilayer FMIC's, by means of a plating process that deposits a conductor material on the side of a hole.

6.124 PLATING (n.) – A chemical or electrochemical deposition of metal on an entire surface or on a conductive pattern.

6.125 PLATING-UP – The electrochemical deposition of a conductive material on a base dielectric material taking place after the base dielectric material has been made conductive.

6.126 PLUGGED-HOLE MATERIAL – A nonmetallic substance used to plug through holes, buried or blind vias, etc., and applied by some process, such as dipping, curtain coating, film laminating, screening, spraying, or melt-flow.

6.127 POLYMER THICK FILM – Referred to in this Standard as conductive paste. See Conductive Paste, 6.31.

6.128 PREPREG – A sheet of material impregnated with a resin cured to an intermediate stage (B-stage resin).

6.129 PRIMARY STAGE OF MANUFACTURE – The point in time when the product is ready for inspection prior to shipment.

6.130 PRINTED BOARD – See Printed Circuit Board, 6.131, and Printed Wiring Board, 6.135.

6.131 PRINTED CIRCUIT BOARD – A printed board produced from rigid industrial laminate material that provides point-to-point connections and printed components in a predetermined arrangement. See the Standard for Printed Wiring Boards, UL 796. See also Printed Wiring Board, 6.135, and Printed Board, 6.130.

6.132 PRINTED CIRCUIT BOARD ASSEMBLY – An assembly that uses a printed wiring board for component mounting and interconnecting purposes.

6.133 PRINTED CONDUCTOR – A conductor applied to a base material, or to an existing conductor on base material, by means of a printing process.

6.134 PRINTED WIRING – A pattern of conductive material formed on the surface of a base or dielectric material with point-to-point electrical connections or shielding.

6.135 PRINTED WIRING BOARD – A completely processed combination of a printed wiring pattern, including printed components, and the base material. See Printed Circuit Board, 6.131 and Printed Board, 6.130.

6.136 PRINTING – Reproducing a pattern on a surface by any process.

6.137 PRODUCTION BOARD – A complete fabricated FMIC intended for shipment.

6.138 PRODUCTION PROCESS – Fabrication process used to produce FMIC's intended for end-use products.

6.139 REINFORCEMENT MATERIAL – Any material (i.e. fibrous, continuous, sheet, etc.) capable of enhancing the base material mechanical or physical performance.

6.140 RELATIVE THERMAL INDEX (RTI) – Maximum service temperature for a material, where a class of critical property will not be unacceptably compromised through chemical thermal degradation, over the reasonable life of an electrical product, relative to a reference material having a confirmed, acceptable corresponding performance defined RTI.

6.141 RESIN COATED COPPER FOIL (RCF) – Metal foil coated with unreinforced resin using a single- (one pass) or double- (two pass) coated system. Single-coated foils are usually coated with one layer of B-stage resin. Double-coated foils are usually coated with two layers of resin; C-stage resin adjacent to the foil and B-stage resin on the surface of the C-stage resin.

6.142 RESIST COATING – A material supplied in liquid or film form to mask or protect selected areas of a pattern from the effects of an etchant, solder, or plating and which remains on the printed wiring board after processing.

6.143 RIGID – A sub-category construction intended for use where no portion of the construction shall be subject to flexing, bending, or flex-to-install in the end-use product application.

6.144 RIGID INDUSTRIAL LAMINATE – Fibrous reinforcement material impregnated or coated with a thermosetting resin binder, and consolidated under high temperature and pressure into a dense solid product.

6.145 RIGID PRINTED WIRING BOARD – A printed wiring board produced from rigid base dielectric materials.

6.146 ROLL MATERIAL – Flexible materials supplied on a supporting core for the purposes of offwinding for further processing.

6.147 SAMPLE – A test vehicle which may be a production printed wiring board, or a portion there of, or a coupon.

6.148 SEQUENTIALLY LAMINATED MULTILAYER – A multilayer category construction formed by a build-up of plated through-hole double-sided singlelayer category constructions or multilayer constructions, such that some of the conductive layers are interconnected with blind and/or buried vias.

6.149 SHEET MATERIAL – Flexible materials supplied cut to processing dimensions for further processing. May have been prepunched.

6.150 SILVER MIGRATION – The ionic movement of silver due to migration inducing affects.

6.151 SINGLELAYER – Singlelayer constructions are double-sided constructions with one layer of dielectric materials(s) separating the conductor planes, and single-sided constructions with a single conductor plane on one side of a dielectric material(s).

6.152 SINGLE-SIDED – An FMIC construction or printed wiring board with a conductive layer on one external side of the base material(s).

6.153 SOLDER – A metal alloy with a melting temperature below 427 °C (800 °F).

6.154 SOLDER MASK – See Solder Resist, 6.155.

6.155 SOLDER RESIST – A coating material intended to prevent deposition of solder upon selected areas during solder operations.

6.156 SOLDERING – ASSEMBLY SOLDERING PROCESS – The process used for soldering components to a printed wiring board during the assembly process. The soldering process may include but is not limited to reflow, wave, selective soldering or other equivalent soldering techniques.

6.157 SOLDERING – HAND SOLDERING – Hand-held, operator-controlled soldering, usually with a soldering iron.

6.158 SOLDERING – SELECTIVE SOLDERING – An automated process used for soldering components to a printed wiring board during the assembly process. The process targets only selected components on a printed wiring board. The complete printed wiring board may not be subject to the same thermal profile during these soldering processes. Selective Soldering encompasses different techniques but excludes Surface Mount Technology (SMT) reflow soldering and traditional wave soldering. Examples of Selective Soldering are – Laser Soldering, Miniature Wave Select Solder Fountains, and Point-to-Point Robotic Soldering.

6.159 SPUTTERED ON – Metallized pre-polymerized (cured) film. Typically the resin is a thermoset, but may be a thermoplastic.

6.160 STIFFENER – An organic or inorganic material used to provide support or strength to part of an FMIC.

6.161 SUBSTRATE – See Core Material, 6.51.

6.162 SUPPORTED BONDING FILM – A combination of film with integral adhesive on two sides, and a dielectric material used to bond discrete layers during lamination of multilayer category constructions, FMIC's, and printed wiring boards. See Bond ply, 6.16, and Bonding Film, 6.14.

6.163 SURFACE FINISH – See 6.166, Surface Plating.

6.164 SURFACE MOUNT COMPONENT – A leaded or leadless component capable of being attached to an FMIC construction by surface mounting.

6.165 SURFACE MOUNTING – Electrical connection of components on the surface of the conductor pattern.

6.166 SURFACE PLATING – The surface plating/coating shall be on the top surface of patterned conductors and shall not create an interface with the dielectric surface.

6.167 TEMPERATURE PROFILE – The depiction of temperatures a select point traverses as it passes through a process involving multiple temperatures and dwell times.

6.168 TEST PATTERN – The conductor pattern intended for test and inspection purposes.

6.169 TEST SAMPLE – A complete (or portion of a) production FMIC, a complete (or portion of a) panel of FMIC's, or a coupon or panel of coupons (or a portion thereof) formed by the FMIC production processes incorporating specific features.

6.170 TYPE – A unique model or product designation arbitrarily assigned to an FMIC by the fabricator. See Markings, Section 13.

6.171 UNDERCOAT – A thin coating or membrane material between conductor planes intended for use as a dielectric material, used to cover a conductive pattern on a base material, or some portion thereof, and conductor material is applied to the exposed undercoat surface.

6.172 UL/ANSI TYPE MATERIAL – A specific type designation for materials defined in the Standard for Polymeric Materials – Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials Used in Printed Wiring Boards, UL 746E, and the Standard for Polymeric Materials – Flexible Dielectric Film Materials For Use In Printed Wiring Boards and Flexible Materials Interconnect Constructions, UL 746F, as having certain base material, resin, thermal index and profiles of minimum performance.

6.173 UNCLAD – A dielectric material without foil or conductive material (never copper clad).

6.174 UNSUPPORTED BONDING FILM – A coating or membrane adhesive material used to bond discrete layers during lamination of multilayer category constructions, FMIC's, and printed wiring boards. See Bonding Film, 6.14, and Freefilm, 6.87.

6.175 VIA – A conductor plated through-hole, in which there is no intent to insert a component lead or other reinforcement material, for interlayer connection of conductor planes. See also Blind Via, 6.12, and Buried Via, 6.19.

6.176 VOID – The absence of metallic or nonmetallic substance in a localized area, in or on an FMIC.

6.177 X-AXIS – A reference axis, usually horizontal or left-to-right direction in a two dimension coordinate system. The x and y axes are usually perpendicular to one another in a two or three dimension coordinate system.

6.178 Y-AXIS – A reference axis, usually vertical or bottom-to-top direction in a two dimension coordinate system. The x and y axes are usually perpendicular to one another in a two or three dimension coordinate system.

6.179 Z-AXIS – The axis perpendicular to the plane created by the x and y reference axes. This axis usually refers to the thickness of an FMIC.

7 Abbreviations

7.1 The acronym FMIC appears throughout the Standard, and stands for "Flexible Materials Interconnect Construction." See 6.80 for the definition of FMIC.

7.2 The acronym MAD appears throughout the Standard, and stands for "Maximum Area Diameter." See 6.109 for the definition of MAD.

7.3 The acronym MOT appears throughout the Standard, and stands for "Maximum Operating Temperature." See 6.110 for the definition of MOT.

7.4 The acronym RTI appears throughout the Standard, and stands for "Relative Thermal Index." See 6.140 for the definition of RTI.

CONSTRUCTION

8 Materials

8.1 General

8.1.1 Flexible materials shall be defined as materials exhibiting flexible properties.

8.1.2 Each combination of materials, and each applicable material component, film, adhesive, base material, conductor material, bonding film, cover material, dielectric material, laminate, prepreg, stiffener, and other insulation material in a fabricated FMIC shall be determined to be acceptable for use in the intended construction (sub-category) application.

Exception: For the intended application, if the applicable material combinations, in the minimum and maximum build-up construction have previously been evaluated with representative parameter profile indices to the applicable testing requirements in accordance with the Standard for Polymeric Materials – Flexible Dielectric Film Materials, UL 746F, then the (Ambient) bend test, 12.9; Cold-bend test, 12.10; and Repeated flexing test, 12.11; need not be conducted. The Bond strength test, 12.6; Coverlay test, 12.8; and Flammability tests, 12.15; of the minimum build-up construction shall be conducted for the FMIC type.

8.1.3 FMIC test samples shall be provided for each different manufacturer and each different grade of material, for each material component, except as described in 8.1.9.

8.1.4 Each material component shall be identified by the manufacturer, grade designation, and generic material type (i.e. polyimide, polyester, epoxy, acrylic, copper, etc.).

8.1.5 The material components, in an as-received condition, shall be free of defects such as unevenness in the base dielectric material, non-uniformity in any fabric weave or exposure of fibers or threads if applicable, and shall be evenly coated, without pinholes, blisters, voids.

8.1.6 If a difference in a grade designation or catalog number of the same material reflects a minor change such as a change of color or a different manufacturing location for the same supplier, and the difference or minor change does not affect the material performance profile indices, samples need not be provided for both materials and a separate unique Type designation is not required for the FMIC type.

8.1.7 Film, adhesive, base material, bonding film, cover material, dielectric material, coating, laminate, prepreg, stiffener, and other insulation material used as a base material and/or dielectric barrier, in an FMIC shall have acceptable electrical and mechanical relative temperature indices and direct support performance properties at or above the MOT of the FMIC type. The electrical and mechanical relative temperature indices shall be determined in accordance with the Standard for Polymeric Materials – Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials Used in Printed Wiring Boards, UL 746E or the Standard for Polymeric Materials – Flexible Dielectric Film Materials for Use in Printed Wiring Boards and Flexible Materials Interconnect Constructions, UL 746F.

Exception No. 1: If the FMIC type is evaluated for flammability classification only without consideration of an MOT, the materials and applicable material components need not possess electrical and mechanical relative temperature indices or direct support performance properties.

Exception No. 2: If the mechanical and electrical relative temperature indices of the base dielectric material are equal to or exceed the MOT of the FMIC type, the adhesive on one or both sides of the base dielectric material need not possess mechanical and electrical relative temperature indices.

8.1.8 The MOT shall not exceed the electrical or mechanical relative temperature indices of the base material or other insulation material when used as a dielectric barrier and/or substrate for conductors. Suggested values for the MOT include 90, 105, 130, and 150 °C (194, 221, 266, and 302 °F).

8.1.9 Each combination of materials, including each applicable material component in the fabricated FMIC shall be determined to have the same or higher flammability classification as the FMIC type.

8.1.10 The performance profile indexing values of the FMIC type shall be limited to the lowest rated individual indexing values for the dielectric materials in the construction for each combination of materials, including each applicable material component.

8.1.11 If the base material, bonding film, and cover material are manufactured with the same base dielectric material and adhesive (if applicable), and the same conductor material is bonded to the base dielectric material or adhesive, bond strength testing of the conductor to base material shall represent bond strength testing of the conductor to the bonding film and cover material.

8.1.12 When conductor material is laminated or adhered directly to materials such as bonding film, cover material and other insulating material, the resultant combination of insulating material and conductor materials shall be considered base material. See Base Materials, 8.3.

8.1.13 Each material component in combination with each applicable combination of base material, film, adhesive, bonding film, cover material and other insulation material intended in the construction shall comply with the flammability tests in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, according to the desired flammability classification.

Exception No. 1: If the absolute minimum film with the absolute maximum adhesive thicknesses are not intended for production, two sets of samples shall be subject to flammability testing. The first set of samples shall include the absolute minimum film with the corresponding maximum adhesive thickness (which may not be the absolute maximum adhesive thickness to be used in production.) The second set of samples shall include the absolute maximum adhesive thickness with the corresponding minimum film thickness (which may not be the absolute minimum film thickness to be used in production.)

Exception No. 2: If the polyimide film material used to manufacture the base material, bonding film, and/or cover material has been previously evaluated for flammability in the minimum and maximum thickness and the flammability classification is V-0 or VTM-0, flammability testing of the minimum film with the maximum adhesive shall be required assuming the requested flammability rating is the same as the original rating.

Exception No. 3: If the film material used to manufacture the base material, bonding film, and/or cover material has been previously evaluated for flammability in the minimum and maximum thickness and the flammability classification is VTM-1, VTM-2, V-1, V-2, or HB, double-sided and single-sided flammability samples are required.

8.2 Polyimide ANSI-like flammability program

8.2.1 The program applies to flammability testing only.

8.2.2 When the base dielectric material and adhesive combination have been previously investigated for flammability classification in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, and the Standard for Polymeric Materials – Flexible Dielectric Film Materials for Use in Printed Wiring Boards and Flexible Materials Interconnect Constructions, UL 746F, testing is not required to add alternate base materials to an established Flammability Only FMIC when the base dielectric material and adhesive combination meets the following requirements:

a) The alternate film shall be the same generic polyimide type as previously evaluated with the adhesive;

b) The alternate film shall be used with the same adhesive and adhesive thickness or shall be adhesiveless the same as previously evaluated;

c) The alternate film minimum thickness shall be equal to or less than the film minimum thickness previously evaluated with the FMIC;

d) The alternate film maximum thickness shall be equal to or greater than the film maximum thickness previously evaluated with the FMIC;

e) The alternate film shall have a V-0 or VTM-0 flammability rating the same as previously evaluated; and

f) The alternate film and adhesive combination shall have a flammability rating equal to the previous flammability rating of the FMIC.

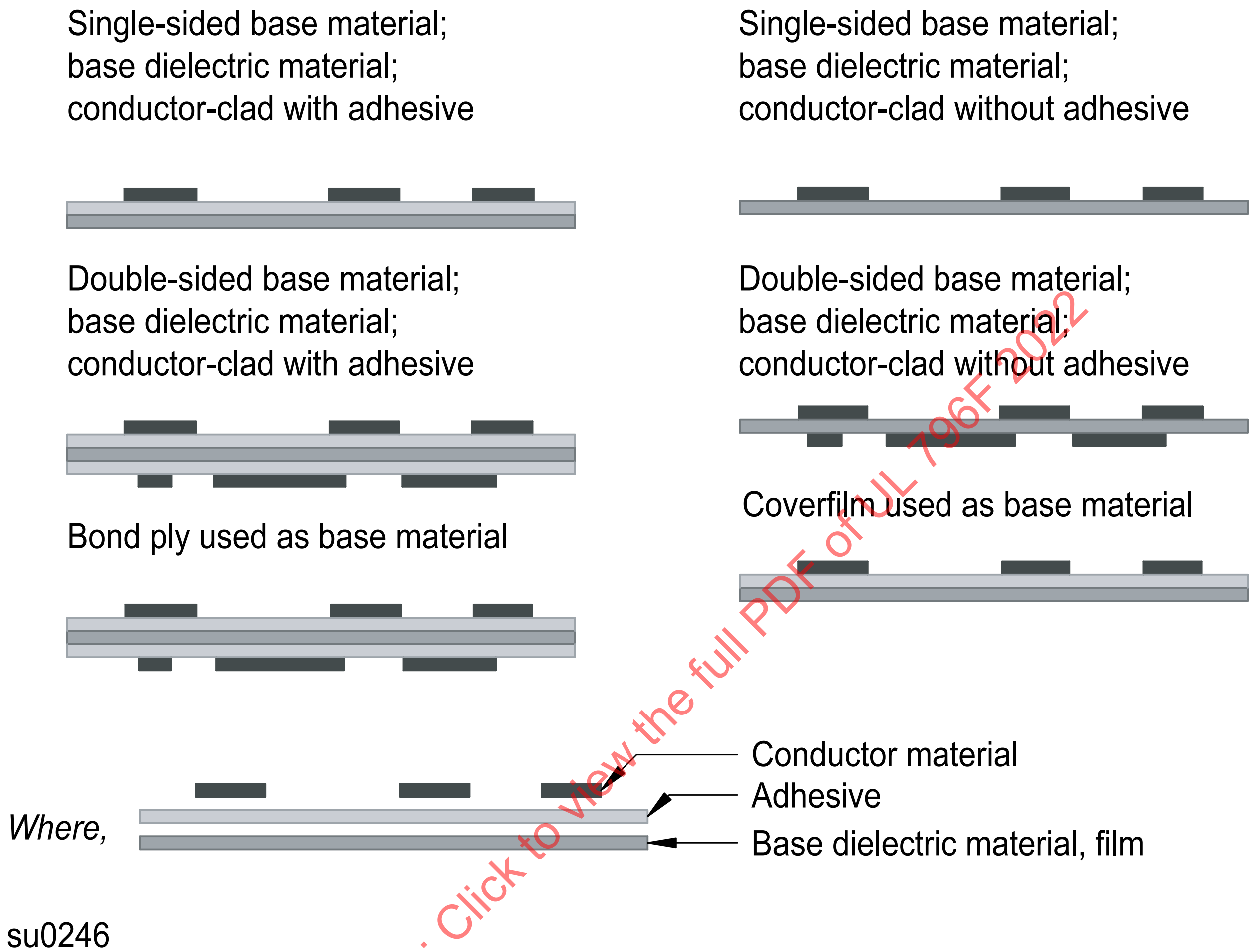
8.3 Base materials

8.3.1 Reference to base materials in this Standard shall apply to materials used to support conductor materials, with or without the use of adhesive materials.

8.3.2 Base materials shall include but not be limited to base dielectric materials, such as film, adhesive (where applicable), and substrate materials supporting conductor material. See Figure 8.1 for examples of base materials used in FMIC constructions.

Figure 8.1

Examples of Base Materials, Used in FMIC Constructions



8.3.3 Base material thickness describes the base material thickness only, without conductor material. Base material with adhesive material shall specify the base dielectric material and adhesive thicknesses separately. Adhesive material shall be specified as being applied on one side or two sides of the base dielectric material.

8.3.4 The minimum and maximum thickness of the base dielectric material shall be identified for each base material grade.

8.3.5 The minimum and maximum thickness of adhesive shall be identified for each base material grade and thickness.

8.3.6 Adhesive materials used to bond conductor material to the base dielectric material shall comply with Conductors and conductor adhesives, 8.4.

8.3.7 The type of conductor material shall be identified for each base material.

8.3.8 The minimum and maximum thickness of each grade of conductor shall be identified for each base material grade and thickness.

8.3.9 Each base material in combination with the integral adhesive in the requested thickness ranges shall comply with the flammability tests as specified in Table 8.1 according to the desired flammability classification, the Standard for Polymeric Materials – Flexible Materials Used in Printed Wiring Boards and Flexible Materials Interconnect Constructions, UL 746F and the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

Table 8.1
Base Material Flammability Test Sample Requirements Based on Film and Adhesive Thickness Ranges

Set	Base dielectric thk	Adhesive thk	Test	Section
1	Minimum	Minimum	Flammability – waive if V-0 or VTM-0 Polyimide	12.15
2	Minimum	Maximum	Flammability	12.15
3	Maximum	Minimum	Flammability – waive if V-0 or VTM-0 Polyimide	12.15
4	Maximum	Maximum	Flammability – waive if V-0 or VTM-0 Polyimide	12.15
NOTE – Flammability sample sets 1, 3, and 4 may be waived if the polyimide film is V-0 or VTM-0 and the requested flammability rating is the same as the original film rating. See the Exception to 8.3.10.				

8.3.10 The flammability classification of the FMIC type shall not exceed the flammability classification determined for the base material, and the base material flammability classification determined for the fabricator shall not exceed the flammability classification established for the base material manufacturer.

Exception: If the flammability classification of base material in combination with cover material exceeds the VTM flammability classification of the base material, the flammability classification of base material in combination with cover material shall be evaluated for the V flammability classification.

8.4 Conductors and conductor adhesives

8.4.1 Reference to conductors in this Standard shall apply to materials used to create the circuit or conductive pattern of the FMIC.

8.4.2 Conductors shall include, but are not limited to, aluminum, copper, copper alloy, copper paste, carbon paste, gold, silver, silver paste, conductive polymer tin, tin/lead, ruthenium oxide, and other conductive material having similar conductive properties.

8.4.3 A conductor surface shall be smooth, even, and free of wrinkles, holes, voids, blisters, corrosion, or other imperfections capable of impairing the functionality.

8.4.4 Representative test samples shall be provided for each conductor thickness (weight) range (minimum and maximum).

8.4.5 Metal conductors shall be investigated for adhesion to the base dielectric material in accordance with Bond strength test, 12.6, or Conductive paste adhesion test, 12.7.

8.4.6 Pastes, inks or non-metal conductors, such as carbon, copper silver or other conductive coating, shall be investigated for adhesion to the base dielectric material in accordance with Conductive paste adhesion test, 12.7. Based on the FMIC production construction, paste type conductor adhesion shall be investigated on each generic base material in combination with each FMIC surface, such as, but not limited to, base dielectric material, adhesive, metal and paste-type conductors, cover materials, in through holes, and the like.

Exception: If the interface of the conductive paste material and base material are identical (e.g., copper paste on base dielectric material without adhesive, and copper paste on the film side cover film, where the same film is used for the base material and the cover film), and, if the sample thickness is the same, testing of the conductor material on one interface shall represent testing of the additional interface.

8.4.7 A separate set of conductor pattern limits can be established for a unique conductor thickness (weight) or range for the FMIC type.

8.4.8 For external copper thickness (weights) up to and including 3 oz/ft^2 (915 g/m^2), the minimum copper thickness (weight) to be used in production may be considered representative of this copper thickness (weight) range for evaluation of the Bond Strength Property only.

8.4.9 If the minimum external copper thickness (weight) to be used in production is less than 33 mic (1 oz/ft^2), the minimum copper thickness (weight) shall be plated with copper as close as possible to a total thickness representative of a weight of 33 mic (1 oz/ft^2) for bond strength test purposes, and is then representative of weights up to and including 102 mic (3 oz/ft^2).

8.4.10 For copper weights greater than 102 mic (3 oz/ft^2), an additional set of test samples including the heaviest copper thickness (weight) to be used in production may be considered representative of copper weights down to 102 mic (3 oz/ft^2) for evaluation of the Bond Strength Property only.

8.4.11 The minimum and maximum external copper thickness (weight) shall be evaluated for each of the following tests requiring copper on the base film:

a) Bond strength test, 12.6 (as described in 8.4.8, 8.4.9, and 8.4.10);

b) Coverlay test, 12.8;

c) (Ambient) bend test, 12.9;

d) Cold-bend test, 12.10; and

e) Repeated flexing test, 12.11.

8.4.12 For metal type conductors, a retest is necessary if the copper thickness (weight) is to be increased or reduced beyond the limits established for the FMIC type or base material grade. Testing shall be conducted in accordance with the Delamination test, 12.4, and Bond strength test, 12.6, (Ambient) bend test, 12.9, Cold-bend test, 12.10, and Repeated flexing test, 12.11. See Conductor weight, 11.6; Conductor width, 11.7; and Maximum area conductor diameter, 11.8; for the applicable tests.

Exception: If the base material has been previously evaluated with minimum and maximum copper weights according to the applicable testing requirements in the Standard for Polymeric Materials – Flexible Dielectric Film Materials for Use in Printed Wiring Boards and Flexible Materials Interconnect Constructions, UL 746F, or the Standard for Polymeric Materials – Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials Used in Printed Wiring Boards, UL 746E, the Ambient Bend, Cold Bend, and Repeated Flexing tests shall not be repeated.

8.4.13 There shall be good registration with the conductor pattern for additive plating and other additive conductor processes.

8.4.14 Representative samples shall be included for each process used to conductor-clad base dielectric material, where additive processes are used to clad the base dielectric material or form the conductor pattern on the base dielectric material.

8.4.15 Conductor test patterns shall include sizes, platings, and contacts in a configuration specified by the fabricator. See Figure 12.8 for a typical conductor test pattern.

8.4.16 A conductor test pattern shall include a mid-board conductor of the minimum width to be used in production, and a mid-board conductor may terminate with its smallest dimension at the edge of an FMIC. The pattern shall also employ a 1.6 mm (0.062 inch) conductor width. Secondary conductor widths can be included in the sample pattern in the event the minimum conductor width receives non-compliant results. See Figure 12.8 for additional information concerning mid-board conductors.

8.4.17 A conductor test pattern shall employ a representative edge conductor of the minimum width to be used in production (see Figure 12.8). The edge conductor shall be within 0.40 mm (0.015 inch) of the board edge, and not sheared at the edge.

8.4.18 If an edge conductor width of less than three times the minimum width of a mid-board conductor is intended in production, an edge conductor of the minimum width shall be provided (see item F of Figure 12.8) on test samples. If an edge conductor is not provided with a width of less than three times the minimum width of a mid-board conductor, the FMIC type shall be assigned an edge conductor minimum width of three times the minimum mid-board conductor width.

8.4.19 A retest is necessary if a reduction in the mid-board and/or edge conductor minimum width is desired. Testing shall be in accordance with the Bond strength test, 12.6. Test coupons need contain only the reduced minimum width conductors. Multilayer constructions shall include internal mirror image conductors.

8.4.20 A conductor test pattern shall include a representative maximum area conductor diameter to be used in production. The solid, unpierced circle of conductive material depicted in Figure 12.6 represents the maximum area conductor diameter acceptable for any FMIC conductor pattern. The maximum area conductor diameter is determined by inscribing and measuring the largest circle within the maximum unpierced conductor area of the FMIC conductor pattern.

8.4.21 If a conductor test pattern representing the maximum area conductor diameter does not conveniently fit within the test coupon overall size dimensions shown in Figure 12.8, an additional set of test samples with a pattern representing the maximum area conductor diameter shall be tested.

8.4.22 A retest is necessary if an increase in the maximum area conductor diameter is desired. Testing shall be in accordance with the Delamination test, 12.4. Samples shall include a pattern representing the maximum area conductor diameter. Multilayer constructions shall include an internal mirror image maximum area conductor diameter.

8.4.23 Plating of a contact surface shall be uniform, smooth, and without nodules. Contact plating shall adhere well to the conductor surface; and, to provide a full contact area, it shall extend to the conductor edges.

8.4.24 If one or more additional platings are intended to be used in the production of FMICs, one plating may be selected as representative of the additional platings and shall be provided on test samples.

Exception: Conductive paste materials, such as silver, carbon, and copper, are not represented by other platings, and shall be provided on test samples.

8.4.25 Conductors consisting of silver, silver plating, or silver paste shall be investigated for silver migration in accordance with Silver migration test, 12.13, when it is determined a hazardous condition could exist in the end-product due to metal migration of silver conductors.

Exception No. 1: Boards intended for use in flammability classification only applications do not require a silver migration investigation. Flammability only boards require a unique type designation.

Exception No. 2: Boards employing conductors coated with Immersion Silver do not require a silver migration investigation.

Exception No. 3: Boards employing silver material encased in copper (such as a plated through hole containing silver material and capped by copper plating) do not require a silver migration investigation.

Exception No. 4: Boards employing silver material on the internal layers of a multilayer construction and are not exposed to the board surface and/or solder resist do not require a silver migration investigation.

Exception No. 5: Boards employing conductors coated with Tin-Silver-Copper (Sn-Ag-Cu (SAC)) alloy, other silver containing tertiary alloys, and Tin-Silver (SnAg) alloy do not require a silver migration investigation.

8.4.26 If plated-through holes are intended to be used on production boards, test coupons shall be provided with plated through-holes.

8.4.27 Solder or other conductive coating applied to conductors on an FMIC shall be smooth, cover the conductor surface, and provide for good electrical connections in the end-product assembly.

8.4.28 Adhesive material used to laminate, bond, or adhere conductor material to base dielectric material shall not be water soluble.

8.4.29 Adhesive material used to laminate, bond, or adhere conductor material to base dielectric material shall be identified by the manufacturer and grade designation of the adhesive material.

Exception: If adhesive used to laminate, bond, or adhere conductor material to base dielectric material is an integral part of a (conductor-clad) base material and has already been evaluated to the applicable testing requirements in the Standard for Polymeric Materials – Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials Used in Printed Wiring Boards, UL 746E or the Standard for Polymeric Materials – Flexible Dielectric Film Materials for Use in Printed Wiring Boards and Flexible

Materials Interconnect Constructions, UL 746F, identification of the manufacturer and grade designation of the adhesive material shall not be repeated.

8.4.30 Adhesive material used to laminate, bond, or adhere conductor material to base dielectric material shall be subject to infrared analyses.

Exception: If the adhesive used to laminate, bond, or adhere conductor material to base dielectric material has already been evaluated to the applicable testing requirements in the Standard for Polymeric Materials – Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials Used in Printed Wiring Boards, UL 746E or the Standard for Polymeric Materials – Flexible Dielectric Film Materials for Use in Printed Wiring Boards and Flexible Materials Interconnect Constructions, UL 746F, and identification analyses have been conducted on the adhesive, infrared analyses shall not be repeated.

8.4.31 Each base material shall comply with the mechanical tests specified in Table 8.2, according to the conductor and base materials in the construction.

Table 8.2
Base Material Tests Based on Type of Conductor Material

Conductor material type	Tests	Section
Clad-conductors (i.e., copper, etc.)	Thermal stress (if applicable)	12.3
	Delamination	12.4
	Plating Adhesion	12.5
	Bond Strength	12.6
	Flammability	12.15
Paste type (i.e., polymer thick film, etc.)	Thermal stress (if applicable)	12.3
	Delamination	12.4
	Conductive Paste Adhesion	12.7
	Flammability	12.15
Platings	Plating Adhesion	12.5

8.4.32 Additionally, each base material in combination with each applicable material component in the FMIC construction shall comply with the mechanical tests specified in Table 8.3 according to the intended construction sub-category. See the Exception to 8.1.2.

Table 8.3
Base Material Tests Based on FMIC Construction Sub-Category

Tests	Section	Construction sub-category		
		Flexible	Flex-to-install	Rigid
Coverlay test	12.8	Yes	Yes	Yes
(Ambient) bend test	12.9	Yes	Yes	Not applicable
Cold-bend test	12.10	Yes	Yes	Not applicable
Repeated flexing test	12.11	Yes	Not applicable	Not applicable

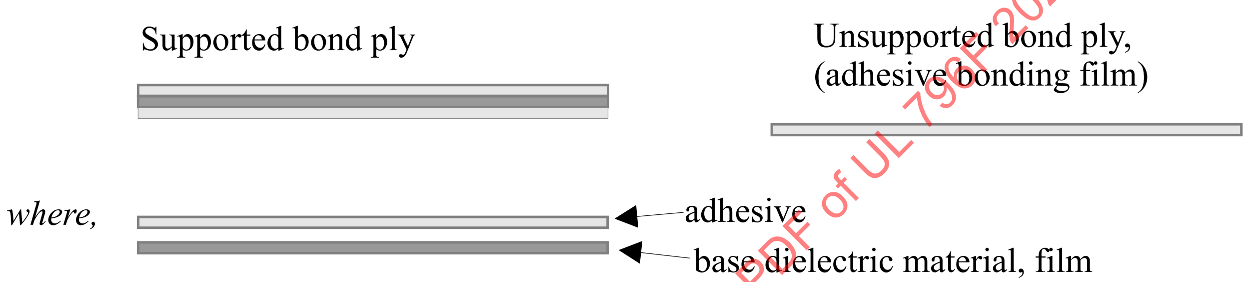
8.5 Bonding film (supported and unsupported) and internal bonding materials

8.5.1 Reference to bonding film in this Standard shall apply to materials used to laminate and adhere materials together.

8.5.2 Bonding film shall include film, adhesive, and other insulation materials used to laminate and adhere materials together. Supported bonding film shall include materials such as base dielectric, woven or non-woven reinforcement materials coated with adhesive on two sides. Unsupported bonding film shall include adhesive only. See Figure 8.2 for examples of bonding film materials.

Figure 8.2

Examples of Bonding Film, Supported and Unsupported



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8.5.3 When conductor material is laminated or adhered directly to bonding film as a base dielectric material, the resultant combination of bonding film and conductor material is considered base material. See Base materials, 8.3.

8.5.4 A prepreg shall be considered a supported bonding film.

8.5.5 Supported bonding film thickness describes the thickness of base dielectric material and adhesive on two sides without conductor material. For supported bonding film made from base dielectric material with adhesive on two sides, the base dielectric material and adhesive thicknesses shall be specified separately. Prepreg thickness describes the thickness of both the reinforcement and resin (adhesive).

8.5.6 Unsupported bonding film thickness describes the thickness of the adhesive without conductor material.

8.5.7 The minimum and maximum thickness of base dielectric material shall be identified for each bonding film grade.

8.5.8 The minimum and maximum thickness of adhesive (if applicable) shall be identified for each bonding film grade and thickness.

8.5.9 The bonding film shall have acceptable mechanical and electrical relative temperature indices and direct support performance properties at or above the MOT of the FMIC type, as described in 8.1.10.

8.5.10 Each bonding film in combination with each applicable combination of film, adhesive, base material, cover material, and other insulation material intended in the construction shall comply with the following mechanical tests specified in Table 8.4, according to the intended construction sub-category.

Table 8.4
Tests for Bonding Film Based on Construction Sub-Category

Tests	Section	Construction sub-category		
		Flexible	Flex-to-install	Rigid
Delamination test	12.4	Yes	Yes	Yes
Flammability tests	12.15	Yes	Yes	Yes
(Ambient) bend test	12.9	Yes	Yes	Not applicable
Cold-bend test	12.10	Yes	Yes	Not applicable
Repeated flexing test	12.11	Yes	Not applicable	Not applicable

8.5.11 Each bonding film shall comply with the flammability tests in accordance with the Standard for Polymeric Materials – Flexible Dielectric Film Materials for Use in Printed Wiring Boards and Flexible Materials Interconnect Constructions, UL 746F, and the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, according to the desired flammability classification.

8.5.12 Each bonding film in combination with each applicable combination of base material, film, adhesive, bonding film, and other insulation material intended in the construction shall comply with the flammability tests in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, according to the desired flammability classification.

8.5.13 The flammability classification of the FMIC type shall not exceed the flammability classification determined for the bonding film, and the bonding film flammability classification determined for the fabricator shall not exceed the flammability classification established for the bonding film material manufacturer.

Exception: If the flammability classification of bonding film in combination with base material and cover material exceeds the flammability classification of the bonding film, the flammability classification of bonding film in combination with base material and cover material for the FMIC type shall exceed the flammability classification of the bonding film; yet, the flammability classification applies to the FMIC type when only the same base material, bonding film, and cover material are used to fabricate the construction.

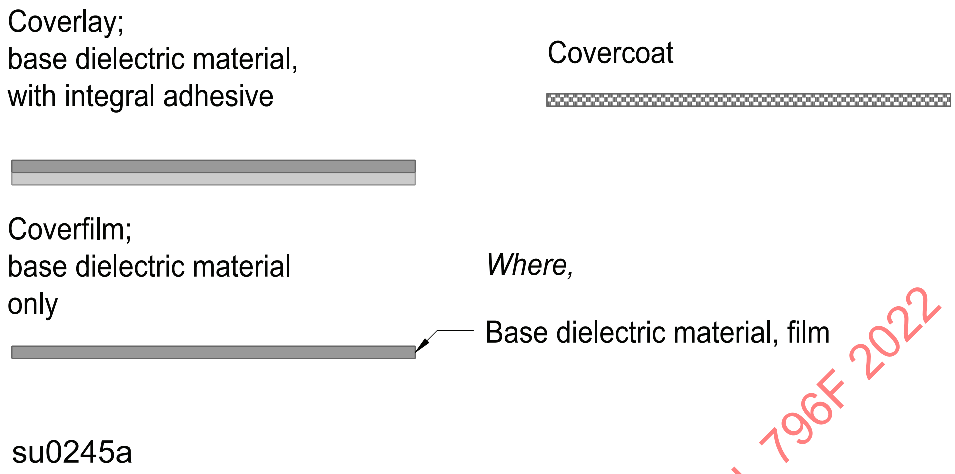
8.6 Cover material (coverlay, coverfilm and covercoat)

8.6.1 Reference to cover material in this Standard shall apply to materials used to partially or entirely cover a conductive pattern on the outer surface(s) of an FMIC or printed wiring board.

8.6.2 Cover material shall be a coverlay, coverfilm, or covercoat material, and shall include film, adhesive, coating, and other insulation materials as defined in the terms. See Figure 8.3 for examples of cover materials.

Figure 8.3

Examples of Cover Materials – Coverlay, Coverfilm and Covercoat



8.6.3 If solder resist is being used in a flexible or flex-to-install construction, the material shall be evaluated as a covercoat. See Solder resist, solder mask, and permanent coatings, 8.7.

8.6.4 Marking ink or flux are not considered a cover material or protective coating.

8.6.5 When conductor material is laminated or adhered directly to cover material, the resultant combination of cover material and conductor materials is considered base material. See Base Materials, 8.3, and Conductors and Conductor Adhesives, 8.4.

8.6.6 Coverlay thickness describes the thickness of base dielectric material and adhesive. The base dielectric material and adhesive thickness shall be specified separately.

8.6.7 Coverfilm thickness shall describe the base dielectric material thickness only as this product is adhesiveless.

8.6.8 Covercoat thickness shall describe the coating thickness.

8.6.9 The minimum and maximum thickness of base dielectric material shall be identified for each cover material grade.

8.6.10 The minimum and maximum thickness of adhesive (if applicable) shall be identified for each coverlay grade and thickness.

8.6.11 Cover material, when used as a dielectric barrier between opposing conductor planes, shall have been previously determined to have acceptable mechanical and electrical relative temperature indices at or above the MOT of the FMIC type and acceptable direct support performance profile values as described in 8.1.10.

8.6.12 Each cover material in combination with each applicable combination of material components intended in the construction shall comply with the mechanical tests specified in Table 8.5, according to the intended construction sub-category.

Table 8.5
Tests for Coverlay Materials, Based on Construction Sub-Category

Tests	Section	Construction sub-category		
		Flexible	Flex-to-install	Rigid
Flammability tests	12.15	Yes	Yes	Yes
Coverlay test	12.8	Yes	Yes	Yes
(Ambient) bend test	12.9	Yes	Yes	Not applicable
Cold-bend test	12.10	Yes	Yes	Not applicable
Repeated flexing test	12.11	Yes	Not applicable	Not applicable

8.6.13 Each cover material shall comply with the flammability tests in accordance with the Standard for Polymeric Materials – Flexible Dielectric Film Materials for Use in Printed Wiring Boards and Flexible Materials Interconnect Constructions, UL 746F, and the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, according to the desired flammability classification.

8.6.14 Each cover material in combination with each applicable material component intended in the construction shall comply with the flammability tests in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, according to the desired flammability classification.

8.6.15 The flammability classification of the FMIC type shall not exceed the flammability classification determined for the cover material.

Exception: If the flammability classification of base material in combination with cover material exceeds the flammability classification of the base material, the flammability classification of base material in combination with cover material shall exceed the flammability classification of base material yet the same cover material must be applied over the entire base material.

8.6.16 Each cover material not previously investigated shall be investigated in accordance with the Standard for Polymeric Materials – Flexible Dielectric Film Materials for Use in Printed Wiring Boards and Flexible Materials Interconnect Constructions, UL 746F.

8.7 Solder resist, solder mask, and permanent coatings

8.7.1 Reference to solder resist, solder mask, and permanent coating materials in this Standard shall apply to permanent materials used as a protective coating of conductor materials. Solder resist and solder mask materials are intended for process operations usually involving the application of molten solder material to conductor materials on an FMIC.

8.7.2 A temporary (non-permanent) coating, such as a strippable or peelable resist, to be removed from the FMIC before installation into the end product, does not require testing.

8.7.3 Solder resist materials shall include, but shall not be limited to, liquid photoimageable coating, dry film, and similar materials.

8.7.4 Solder resist shall be identified separately from cover materials. If the solder resist is dynamically flexed in a flexible construction or bent during installation of the flex-to-install construction, the material shall be evaluated as a covercoat. See Cover material (coverlay, coverfilm and covercoat), 8.6.

8.7.5 Marking ink or flux are not considered to be a solder resist, coverlay, coverfilm, covercoat, or protective coating.

8.7.6 A marking ink applied on the FMIC to provide a means of identification in the form of letters, numbers, or symbols does not require testing. A marking ink applied on the FMIC for any purpose other than letters, numbers or symbols such as a decorative coating, shall be evaluated as a permanent coating.

8.7.7 Permanent coatings thickness shall describe the solder resist, solder mask or other coating thickness.

8.7.8 The minimum and maximum thickness of the permanent coating shall be identified for each material grade.

8.7.9 Solder resist used as a dielectric barrier between opposing conductor planes, shall have been previously determined to have acceptable mechanical and electrical relative temperature indices at or above the MOT of the FMIC type, and acceptable direct support performance profile values as described in 8.1.10.

8.7.10 Each solder resist or permanent coating shall have previously been evaluated in accordance with applicable test (infrared analysis, flammability, and dielectric properties) requirements in the Standard for Polymeric Materials – Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials Used in Printed Wiring Boards, UL 746E, according to the desired flammability classification.

8.7.11 Each solder resist or permanent coating in combination with each material component intended in the construction shall comply with the flammability tests according to the intended construction sub-category.

Exception: See the permanent coatings program in 8.7.14.

8.7.12 Identical permanent coatings applied in multiple layers during the production of an FMIC shall be investigated for Flammability tests, 12.15. Flammability investigation of the maximum number of identical permanent coating layers will represent fewer layers.

8.7.13 Mixed combinations of permanent coatings shall be investigated for Flammability tests, 12.15. Each coating combination shall be investigated.

8.7.14 When a solder resist (permanent coating) has been previously evaluated in accordance with the Standard for Polymeric Materials – Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials Used in Printed Wiring Boards, UL 746E with regard to its flammability after thermal stress, testing for its addition as an alternate coating to one previously tested on the rigid portion of the multilayer rigid flex composite construction (see Figure 9.4) is not required when the coating meets the following requirements:

a) The coating has been evaluated for use on the same ANSI type material as used for the external surface of the rigid portion of the multilayer rigid flex composite construction;

b) The coating shall have a flammability rating equivalent to or better than the multilayer rigid flex composite construction;

c) The solder limits of the coating are equal to or higher than the multilayer rigid flex composite construction; and

d) The minimum thickness of the rigid laminate with which the coating was evaluated is equal to or thinner than the minimum thickness of the rigid laminate applied to the external surface of one side of the multilayer rigid flex composite construction.

8.8 Plugged-hole materials

8.8.1 A plugged-hole material used in the production of a printed wiring board (including but not limited to plated through holes, blind vias, and buried vias) shall be investigated for Flammability tests, 12.15. See Figure 8.4 and Figure 8.5 for an example of the build-up construction test sample. The plugged hole material shall have been previously evaluated as a permanent coating in accordance with the applicable testing requirements in the Standard for Polymeric Materials – Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials Used in Printed Wiring Boards, UL 746E.

Exception: Plugged-hole materials encased in copper in the board construction shall not be investigated for flammability.

Figure 8.4

Plugged-Hole Material

Flammability Sample Construction Example

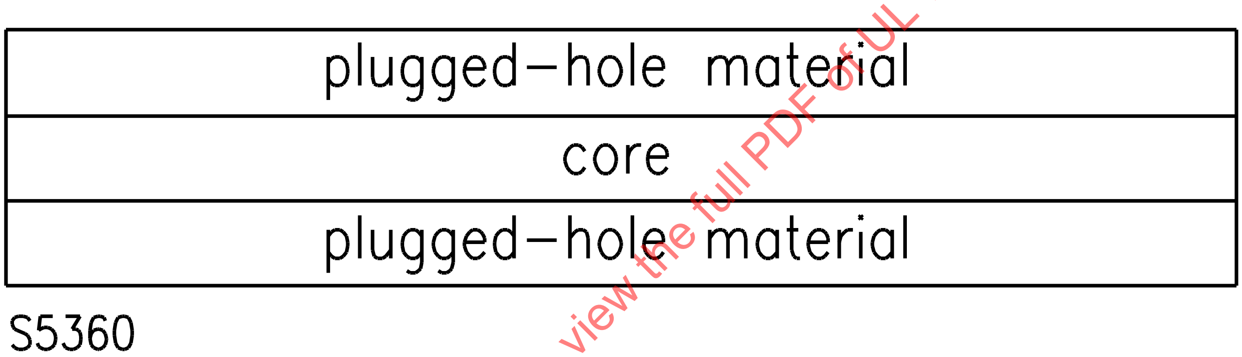
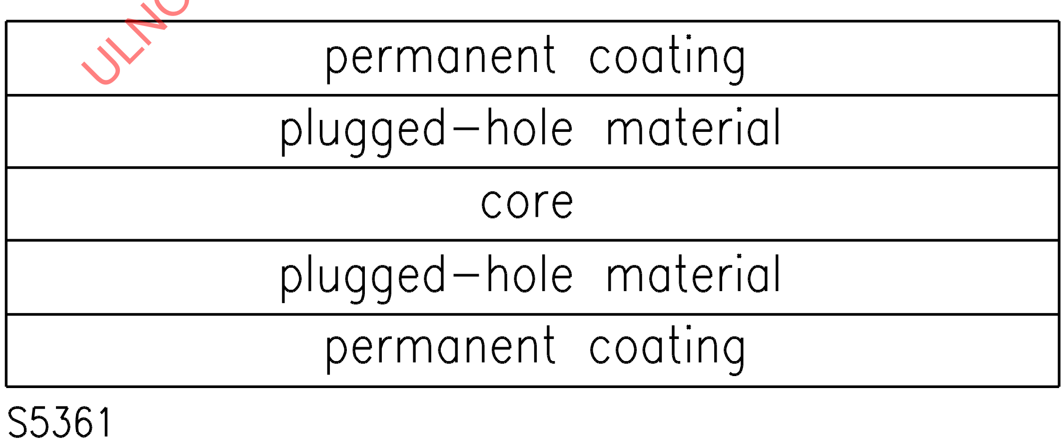


Figure 8.5

Plugged-Hole Material with Permanent Coating

Flammability Sample Construction Example



8.8.2 When a Permanent Coating is used in the production of a printed wiring board utilizing plugged-hole material, the combination of the permanent coating and plugged-hole material shall be investigated for Flammability tests, 12.15. See Figure 8.5 for an example of the build-up construction test sample.

Exception: When an identical material is used as a plugged-hole material and as a permanent coating in the production of a printed wiring board, flammability investigation of two (2) coatings of the material will be considered representative of one (1) coating of the material.

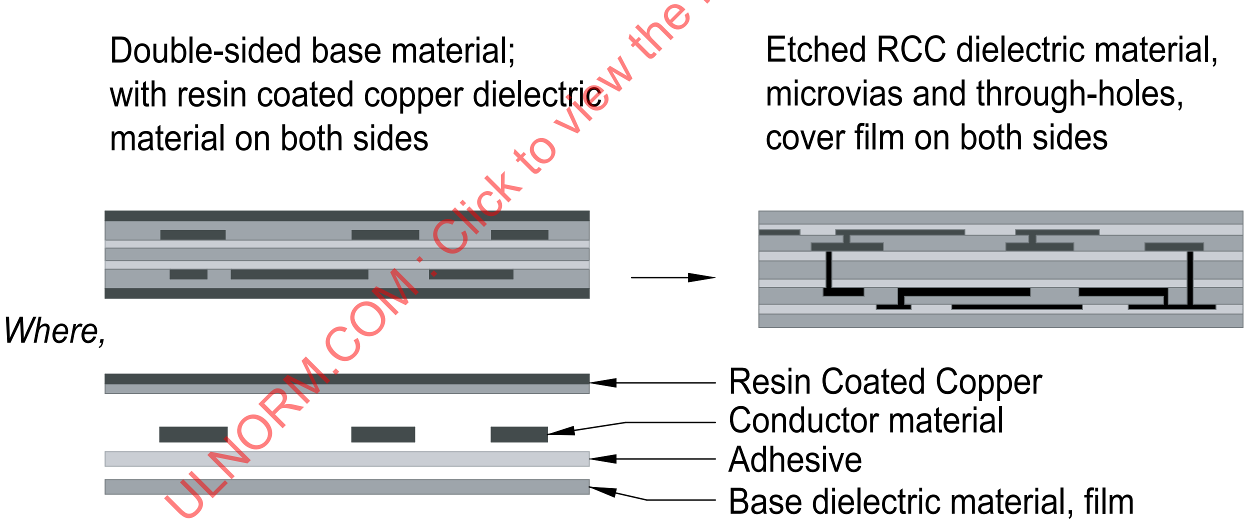
8.9 High density interconnect (HDI) dielectric materials

8.9.1 Reference to high density interconnect materials or multilayer build-up materials in this Standard shall apply to very thin dielectric materials used to support conductor materials, intended for the production of microvias using sequential build-up (SBU) and related multilayer interconnect technologies.

8.9.2 Dielectric materials (i.e., multilayer build-up materials intended for use in high density interconnect constructions) shall include, but not be limited to, very thin thickness dielectric materials supporting conductor material. Materials such as resin coated copper foil (RCF), liquid photoimageable (LPI) dielectric coating materials, photoimageable film dielectric coating materials, and other very thin thickness insulating material when used to support conductor material shall be considered dielectric materials. See Figure 8.6 for an example of a multilayer build-up high density interconnect construction.

Figure 8.6

Example of a Multilayer Build-Up High Density Interconnect Construction



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8.9.3 Dielectric material thickness describes the base dielectric material thickness only, without conductor material. Base dielectric material with adhesive material shall specify the base dielectric material and adhesive thickness separately. Adhesive material shall be specified as being on one side or two sides of the base material.

8.9.4 The minimum and maximum thickness of base dielectric material shall be identified.

8.9.5 The minimum and maximum thickness of adhesive shall be identified for each base dielectric material thickness.

8.9.6 Adhesive materials used to bond or adhere conductor material to the base dielectric material shall comply with Conductors and conductor adhesives, 8.4.

8.9.7 Base dielectric material with conductor material shall specify the base dielectric material and conductor thickness separately.

8.9.8 The type of conductor material shall be identified for each dielectric material.

8.9.9 The minimum and maximum thickness of each type of conductor material shall be identified for each dielectric material type and thickness.

8.9.10 The dielectric material shall have been previously evaluated in accordance with the Standard for Polymeric Materials – Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials Used in Printed Wiring Boards, UL 746E or the Standard for Polymeric Materials – Flexible Dielectric Film Materials For Use In Printed Wiring Boards and Flexible Materials Interconnect Constructions, UL 746F as described in 8.1.10.

8.9.11 Each dielectric material shall comply with the mechanical tests specified in Table 8.6, according to the conductor material, dielectric material, and base material in the interconnect construction.

Table 8.6
Dielectric Material Tests Based on Type of Conductor Material

Conductor material type	Tests	Section
Clad-conductors (i.e., copper, etc.)	Thermal stress (if applicable) Delamination Bond strength	12.3 12.4 12.6
Paste type (i.e., polymer thick film, etc.)	Thermal stress (if applicable) Delamination Conductive paste adhesion	12.3 12.4 12.7
Platings	Plating adhesion	12.5

8.9.12 Dielectric material in combination with each applicable combination of film, adhesive, base material, and other insulation material intended in the interconnect construction shall comply with the mechanical tests specified in Table 8.7, according to the intended interconnect construction sub-category, unless otherwise indicated.

Table 8.7
Dielectric Material Tests Based on Interconnect Construction Sub-Category

Tests	Section	Interconnect construction sub-category		
		Flexible	Flex-to-install	Rigid
Coverlay test	12.8	Yes	Yes	Yes
(Ambient) bend test	12.9	Yes	Yes	Not applicable
Cold-bend test	12.10	Yes	Yes	Not applicable
Repeated flexing test	12.11	Yes	Not applicable	Not applicable

8.9.13 Each dielectric material shall comply with the flammability tests in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, according to the desired flammability classification.

8.9.14 The flammability classification of the FMIC type shall not exceed the flammability classification determined for the dielectric material, and the dielectric material flammability classification determined for the fabricator shall not exceed the flammability classification established for the base material manufacturer.

Exception: If the flammability classification of dielectric material in combination with other applicable insulation material exceeds the flammability classification of the dielectric material, the flammability classification of dielectric material in combination with the said materials shall exceed the flammability classification of dielectric material yet the same said materials shall be used in combination with the same dielectric material.

8.10 Stiffener and adhesive (external bonding) materials

8.10.1 Reference to stiffener materials in this Standard shall apply to materials used to provide additional stiffness, rigidity, or support to constructions, by attaching the stiffener material to the construction. The stiffener material shall not include conductors or integral electrical connection to and from the construction and stiffener material. Stiffener materials shall not be in direct contact with construction or FMIC conductor material. The stiffener material may be applied to any portion of the board not in contact with conductor material.

8.10.2 When conductor material is applied on the stiffener, the resulting combination is considered base material. See Base Material, 8.3, and Conductors and Conductor Adhesives, 8.4.

8.10.3 Stiffener materials shall include, but are not limited to:

a) Industrial laminate materials found to comply with the Standard for Polymeric Materials – Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials Used in Printed Wiring Boards, UL 746E or the Standard for Polymeric Materials – Flexible Dielectric Film Materials For Use In Printed Wiring Boards and Flexible Materials Interconnect Constructions, UL 746F;

b) Cover materials found to comply with the Standard for Polymeric Materials – Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials Used in Printed Wiring Boards, UL 746E or the Standard for Polymeric Materials – Flexible Dielectric Film Materials For Use In Printed Wiring Boards and Flexible Materials Interconnect Constructions, UL 746F;

c) Plastic materials found to comply with the applicable requirements in the Standard for Test for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94; the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A; and the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B; and

d) Other materials of the fabricator's or original equipment manufacturer's choice limited to metal.

Exception: Rigid printed wiring boards, FMICs, and EMI shielding shall not be considered stiffener material as stated in 8.10.1.

8.10.4 Stiffener thickness describes the thickness of the base dielectric material or laminate and adhesive on one side. The base dielectric material or laminate and adhesive thicknesses shall be specified separately. Laminate and/or prepreg thickness describes the thickness of both the reinforcement and resin (adhesive).

8.10.5 The minimum and maximum thickness of base dielectric material or laminate shall be identified for each material grade.

8.10.6 Stiffener materials shall be subject to identification by infrared analyses if organic and not previously evaluated. IR shall be performed in accordance with the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A.

Exception No. 1: Identification by infrared analyses shall not be conducted on stiffener materials indicated in 8.10.3 (a), (b), and (c).

Exception No. 2: FMIC types with stiffener materials applied in accordance with Additional stiffener and adhesive (external bonding) materials, 13.12, shall bear the appropriate system component symbol and size class number markings indicated therein, and the stiffener materials are not required to be subject to identification analyses.

8.10.7 Stiffener materials shall possess a flammability classification considered equal to or greater than the flammability classification of the FMIC type. The stiffener material shall not reduce the flammability classification of the FMIC type.

8.10.8 Each manufacturer and grade of stiffener adhesive (external bonding) in combination with each manufacturer and grade of stiffener shall be evaluated in accordance with the Stiffener bond strength test, 12.12 in accordance with 8.10.10 as applicable.

8.10.9 Each manufacturer and grade of stiffener and stiffener adhesive (external bonding) shall be evaluated in accordance with Flammability tests, 12.15 in accordance with 8.10.10 as applicable.

8.10.10 FMIC test samples in accordance with the Stiffener bond strength test, 12.12, and Flammability tests, 12.15, shall be provided for each different base material and/or cover material to which the stiffener and stiffener adhesive will be attached.

8.10.11 When the stiffener material has been previously investigated for Stiffener Bond Strength and Flammability classification with the established base material and cover material combinations in accordance with 8.10.10, testing is not required to add alternate stiffener materials to an established FMIC when the stiffener material meets the following requirements:

a) The alternate stiffener material is the same UL/ANSI type material as the FMIC stiffener material;

b) The minimum and maximum thickness of the alternate stiffener material is the same or less than the FMIC stiffener material;

c) The same adhesive material and thickness range is used with the alternate stiffener material as with the FMIC stiffener material; and

d) The flammability rating of the alternate stiffener material shall be equivalent or better than the FMIC.

8.10.12 Reference to stiffener adhesive (external bonding) materials or assembly adhesives in this Standard shall apply to materials used to attach stiffener materials to constructions, and shall not be considered a dielectric material.

8.10.13 Stiffener adhesive (external bonding) materials shall include, but not be limited to, epoxy, acrylic, glue, and similar materials used to fasten constructions to stiffeners. Adhesive (external bonding) materials shall include:

a) Industrial laminate (i.e. prepreg) materials found to comply with the Standard for Polymeric Materials – Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials Used in Printed Wiring Boards, UL 746E or with the Standard for Polymeric Materials – Flexible Dielectric Film Materials For Use In Printed Wiring Boards and Flexible Materials Interconnect Constructions, UL 746F;

b) Bonding film materials found to comply with the Standard for Polymeric Materials – Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials Used in Printed Wiring Boards, UL 746E or with the Standard for Polymeric Materials – Flexible Dielectric Film Materials For Use In Printed Wiring Boards and Flexible Materials Interconnect Constructions, UL 746F;

c) Plastic materials found to comply with the applicable requirements in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94; the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A; and the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B; and

d) Other adhesive materials of the fabricator's or original equipment manufacturer's choice.

8.10.14 Stiffener adhesive material shall not be water soluble.

8.10.15 Stiffener adhesive material shall be identified by manufacturer and grade designation.

8.10.16 The minimum and maximum thickness of stiffener adhesive (if applicable) shall be identified for each stiffener grade and thickness.

8.10.17 Stiffener adhesive shall be subject to identification by infrared analyses in accordance with the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A.

9 FMIC Constructions

9.1 General

9.1.1 All FMIC's shall be defined by category and sub-category of the construction, and entitled accordingly.

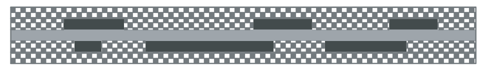
9.1.2 FMIC's shall consist of the construction, with or without stiffener or adhesive materials. See Figure 9.1 for examples of constructions with and without stiffener and adhesive materials.

Figure 9.1

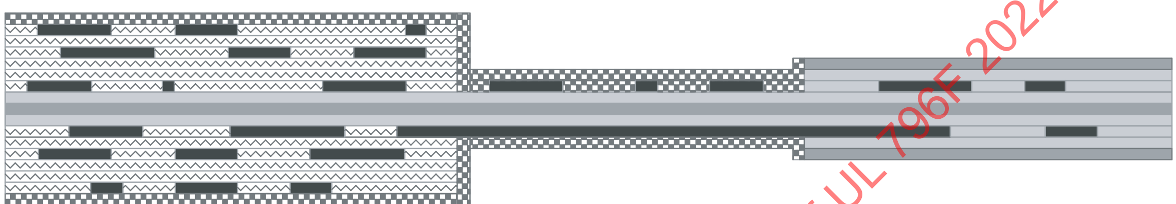
Examples of Constructions With and Without Stiffener and Adhesive Materials

Singlelayer, single-sided (SS), with coverfilm

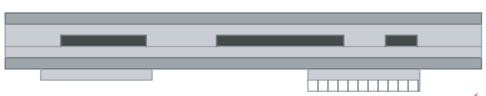
Singlelayer, double-sided (DS), with covercoat



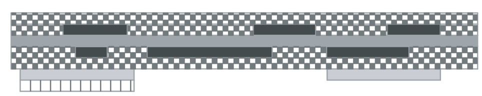
Multilayer rigid flex composite



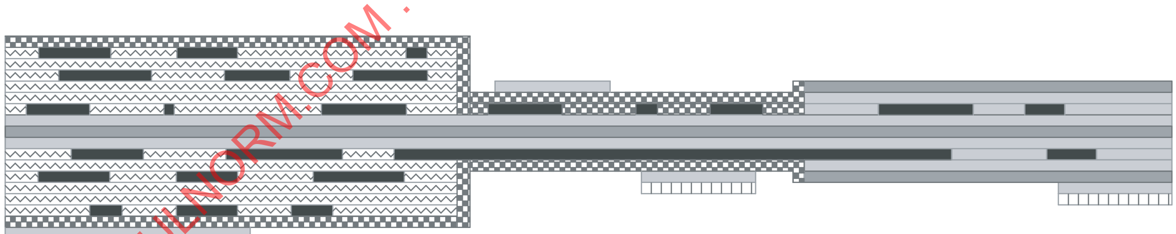
Singlelayer, single-sided (SS), with coverfilm



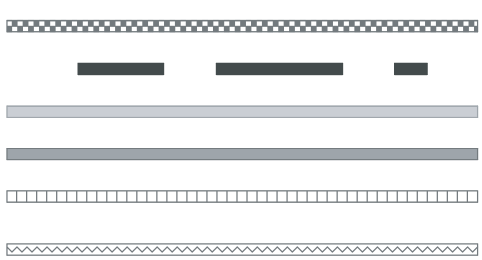
Singlelayer, double-sided (DS), with covercoat



Multilayer rigid flex composite



Where:



= Covercoat

= Conductor

= Adhesive

= Base dielectric material film

= Stiffener

= Rigid industrial laminate (i.e., FR-4, etc.)

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9.1.3 The FMIC construction category shall be identified in accordance with:

a) Singlelayer (dielectrics), 9.2 or

b) Multilayer (dielectrics), 9.3.

9.1.4 Singlelayer and multilayer category constructions, depending upon construction materials build-up and conductor material type, shall comply with one or more of the following tests:

a) Delamination test, 12.4;

b) Plating adhesion test, 12.5;

c) Bond strength test, 12.6;

d) Conductive paste adhesion test, 12.7;

e) Coverlay test, 12.8;

f) Silver migration test, 12.13; and

g) Flammability tests, 12.15.

9.1.5 The FMIC construction sub-category shall be identified in accordance with:

a) Flexible, 9.6;

b) Flex-to-install, 9.7; or

c) Rigid, 9.8.

9.1.6 Multilayer FMIC constructions with integrated multiple sub-category or category constructions shall be identified in accordance with Multilayer rigid flex composite, 9.9.

9.1.7 FMIC's intended for flammability classification only shall be identified in accordance with 9.1.3.

9.1.8 The FMIC shall be entitled in accordance with Glossary of construction and FMIC titles, 9.11.

9.1.9 The construction category and sub-category is independent of the application and shall not differ due to the application of stiffener or adhesive materials.

9.1.10 Each FMIC identified by the markings required in Direct support requirements (DSR), 13.8 for direct support current carrying parts at 120 Vrms or less and 15 A or less, shall have all materials when used as a dielectric barrier and/or substrate for conductors be evaluated to the requirements for direct support of live parts. See Direct support requirements (DSR) tests, 12.16.

Exception: If the FMIC type is evaluated for flammability classification only without consideration of an MOT, the materials and applicable material components need not possess direct support performance properties.

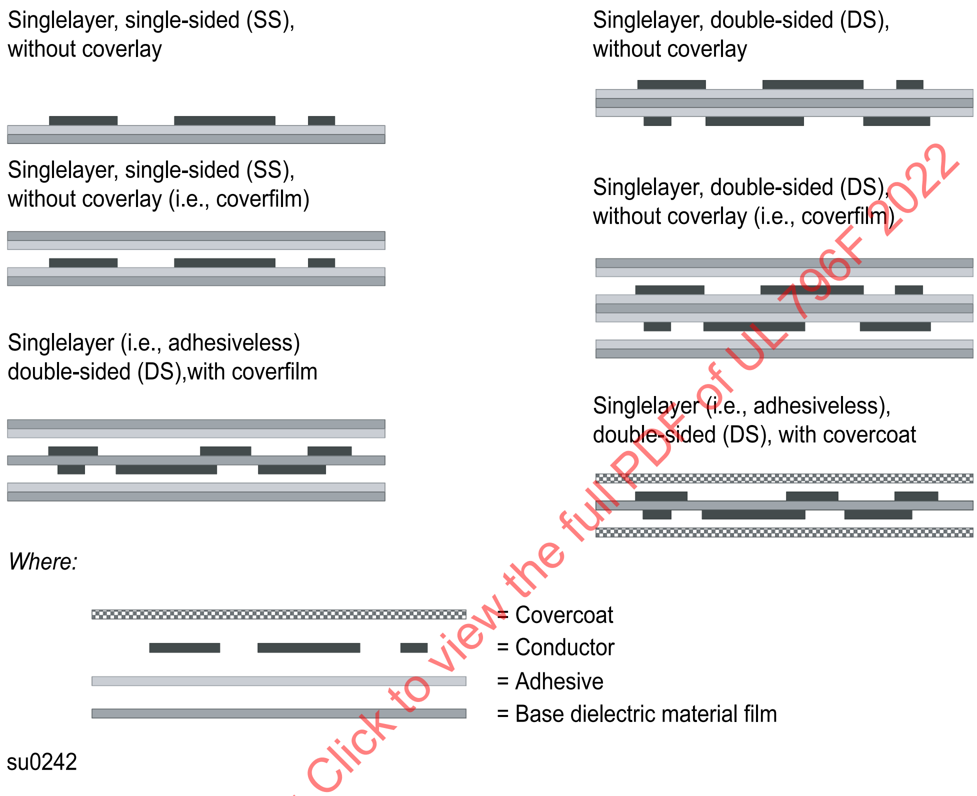
9.2 Singlelayer (dielectrics)

9.2.1 Singlelayer constructions shall consist of base material and/or adhesive with conductor material(s) on one side, or both opposing sides. The base material shall consist of any number of layers of base dielectric material and adhesive (if applicable), and no more than two conductor planes. See Figure 9.2 for examples of singlelayer (dielectric) constructions.

Exception: A copper foil core with cover material on one or both sides of the conductor material shall be considered a singlelayer construction. The cover material in this construction is considered a base material and shall be evaluated as Base materials, 8.3.

Figure 9.2

Examples of Singlelayer (Dielectric) Constructions



9.2.2 In addition to the construction category requirements, a singlelayer construction shall comply with the applicable construction sub-category requirements described in Flexible, 9.6; Flex-to-install, 9.7; or Rigid, 9.8.

9.2.3 Specific combination of material grades or constructions representing the board production build-up shall be provided for investigation, unless otherwise indicated.

9.2.4 A double-sided construction is to be considered representative of a singlesided construction with the same base material, conductor material, parameter profile indices, and cover material and adhesive if used in the fabricated construction.

Exception: For purposes of flammability classification and electrical indexing, a double-sided construction is not considered representative of an identical single-sided construction, and a single-sided construction is not considered representative of a double-sided construction.

9.2.5 The conductor pattern shall be included on both of sides of test samples if double-sided constructions are intended for production.

9.2.6 The conductor pattern shall include contacts, if contacts are intended in production.

9.2.7 A double-sided construction shall be provided with through-holes, if through-holes are intended in production.

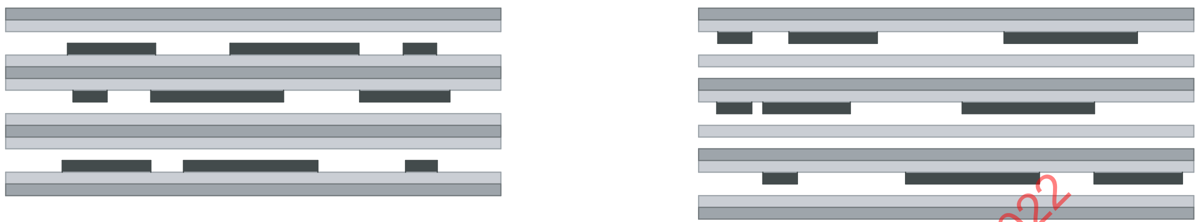
9.3 Multilayer (dielectrics)

9.3.1 Multilayer flexible constructions shall consist of three or more conductor planes, and shall consist of base materials with conductor materials on one or two sides, laminated or bonded together with additional base materials with conductor materials on one or two sides. See Figure 9.3 for examples of multilayer (dielectric) constructions.

Figure 9.3

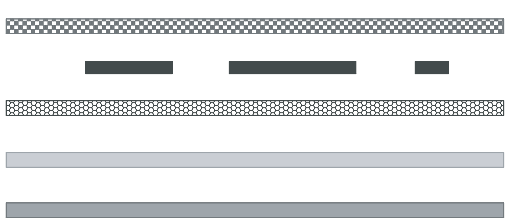
Examples of Multilayer (Dielectric) Constructions

Various multilayer interconnect constructions (pre-lamination) with 3 conductor planes:



Various multilayer interconnect constructions (pre-lamination) with 4 conductor planes:

Where:



= Covercoat

= Conductor

= Conductive paste

= Adhesive

= Base dielectric material, film

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9.3.2 In addition to the construction category requirements, a multilayer construction shall comply with the applicable construction sub-category requirements in Flexible, 9.6; Flex-to-install, 9.7; Rigid, 9.8; and Multilayer rigid-flex composite, 9.9.

9.3.3 The conductor pattern shall be included on internal and both external sides of a sample with good layer registration, if multilayer constructions are intended for production. The internal conductor pattern shall be a mirror image of the external conductor pattern.

9.3.4 Each combination of materials or constructions shall be provided for each type and grade of material, unless otherwise indicated. A representative multilayer construction shall include film, adhesive, base material, conductor, bonding film, cover material, dielectric material, laminate, prepreg, and other applicable insulation and conductor material.

9.3.5 A representative multilayer construction shall include two or the minimum number of internal patterned conductor layers, whichever is greater. See 9.9.12 for representative multilayer rigid-flex construction requirements.

9.3.6 A representative multilayer construction shall include one internal patterned conductor layer of the maximum weight used in production for bond strength and delamination samples. If the maximum internal metal weight cannot be accommodated by the minimum multilayer construction build up, a second set of Bond Strength and Delamination test samples shall be provided. The first set of samples shall contain the maximum internal metal weight that can be accommodated by the minimum multilayer build-up. The second set of Bond Strength and Delamination test samples shall contain the minimum multilayer build up construction that can accommodate the maximum internal metal weight to be used in production.

Exception: Testing of the four conductor layer construction and double-sided singlelayer construction shall be considered representative of the three conductor layer construction.

9.3.7 Intermixing of base material, bonding film, laminate, and prepreg materials is limited to generically identical base dielectric materials (i.e., same generic film types, same generic dielectric materials types, etc.). Additionally, intermixing of base material, bonding film, laminate, prepreg, and cover material, where cover material is used as a dielectric barrier, is limited to generically identical materials.

Exception: Intermixing of base dielectric materials that are not generically identical shall not be employed unless an evaluation is conducted in accordance with Dissimilar Dielectric Materials Evaluation, 9.4, to determine compatibility of the dissimilar materials.

9.4 Dissimilar dielectric materials evaluation

9.4.1 Intermixing of dissimilar dielectric materials, shall comply with the following tests:

a) Dissimilar Dielectric Materials Thermal Cycling test, 12.14 and

b) Flammability test, 12.15.

9.4.2 The direct support, CTI, flammability, and RTI ratings of each individual material shall be considered at the desired minimum build-up thickness of the multilayer FMIC.

9.4.3 Each individual material, in the combination of dissimilar materials, shall have been previously evaluated for performance profile indexing values and RTI's in accordance with the Standard for Polymeric Materials – Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials Used in Printed Wiring Boards, UL 746E, or the Standard for Polymeric Materials – Flexible Dielectric Film Materials For Use In Printed Wiring Boards and Flexible Materials Interconnect Constructions, UL 746F.

9.4.4 The combination of generically dissimilar dielectric materials shall be assigned a flammability rating that does not exceed the flammability rating of the lowest rated dielectric material.

9.4.5 The combination of generically dissimilar dielectric materials shall be assigned an MOT rating that does not exceed the electrical and mechanical RTI of the lowest rated material.

9.4.6 The combination of generically dissimilar dielectric materials shall be assigned performance index values that do not exceed the lowest rated material. If higher performance profile indexing values are requested, the appropriate performance profile tests shall be conducted. The build-up construction(s) shall be limited to the construction tested, and the outer surface base dielectric material shall be defined.

9.5 Mass laminate multilayer (dielectrics)

9.5.1 A multilayer construction shall be considered representative of an identical mass-laminated prefabricated package construction with a representative conductor pattern, if the mass-laminated prefabricated package construction has:

a) The same base material;

b) Conductor;

c) Bonding film, cover material, dielectric material, laminate, prepreg, and other insulation material;

d) Material thickness;

e) Parameter profile indices; and

f) A production process which is considered equal to or less severe than the multilayer construction production process.

9.5.2 A multilayer build-up construction is not considered representative of a singlelayer construction, and a singlelayer construction is not considered representative of a multilayer construction or mass-laminated prefabricated package construction.

9.6 Flexible

9.6.1 Flexible (sub-category) constructions are intended for use in dynamic and repeated flexing application.

Note – The ultimate dynamic capacity or endurance of the flexible construction has not been established via the test program detailed in this Standard.

9.6.2 Flexible (sub-category) constructions shall include the following construction categories and characteristics:

a) Singlelayer (dielectric), single-sided and double-sided;

b) Multilayer (dielectric); and

c) Multilayer mass-laminated prefabricated package.

9.6.3 Flexible (sub-category) constructions shall be entitled in accordance with Glossary of construction and FMIC titles, 9.11.

9.6.4 A singlelayer flexible (sub-category) construction shall comply with Singlelayer (dielectrics), 9.2.

9.6.5 A multilayer flexible (sub-category) construction shall comply with Multilayer (dielectrics), 9.3.

9.6.6 In addition to the singlelayer or multilayer (category) construction requirements described in 9.6.4 and 9.6.5, a flexible (sub-category) interconnect construction shall comply with the following tests:

a) (Ambient) bend test, 12.9;

b) Cold-bend test, 12.10; and

c) Repeated flexing test, 12.11.

9.7 Flex-to-install

9.7.1 Flex-to-install (sub-category) constructions are intended for use in applications where the construction will be bent for installation or servicing.

Note – The ultimate bend capacity or endurance of the flex-to-install sub-category construction has not been established via the test program detailed in this Standard.

9.7.2 Flex-to-install (sub-category) constructions shall include the following categories and characteristics:

a) Singlelayer (dielectric), single-sided and double-sided;

b) Multilayer (dielectric); and

c) Multilayer mass-laminated prefabricated package.

9.7.3 Flex-to-install (sub-category) constructions shall be entitled in accordance with Glossary of construction and FMIC titles, 9.11.

9.7.4 A singlelayer flex-to-install (sub-category) construction shall comply with Singlelayer (dielectrics), 9.2.

9.7.5 A multilayer flex-to-install (sub-category) construction shall comply with Multilayer (dielectrics), 9.3.

9.7.6 In addition to the singlelayer or multilayer (category) construction requirements described in 9.7.4 or 9.7.5, a flex-to-install (sub-category) construction shall comply with the following tests:

a) (Ambient) bend test, 12.9; and

b) Cold-bend test, 12.10.

9.8 Rigid

9.8.1 Rigid (sub-category) constructions are intended for use in applications not subject to flexing or bending due to the thickness or characteristics of the flexible materials in the construction.

9.8.2 Rigid (sub-category) constructions shall include the following construction categories and characteristics:

a) Singlelayer (dielectric), single-sided and double-sided;

b) Multilayer (dielectric); and

c) Multilayer mass-laminated prefabricated package.

9.8.3 A singlelayer rigid (sub-category) construction shall comply with Singlelayer (dielectrics), 9.2.

9.8.4 A multilayer rigid (sub-category) construction shall comply with Multilayer (dielectrics), 9.3.

9.8.5 Flexing and bending tests shall not be conducted for rigid (sub-category) constructions.

9.9 Multilayer rigid flex composite

9.9.1 Multilayer rigid flex composite constructions are intended for use in applications requiring flexible, flex-to-install, and rigid (sub-category) constructions, and/or integral combinations of category and sub-category constructions. See Figure 9.4 and Figure 9.5 for examples of multilayer rigid flex composite constructions.

Figure 9.4

Examples of Multilayer Rigid Flex Composite Constructions (Pre Lamination)

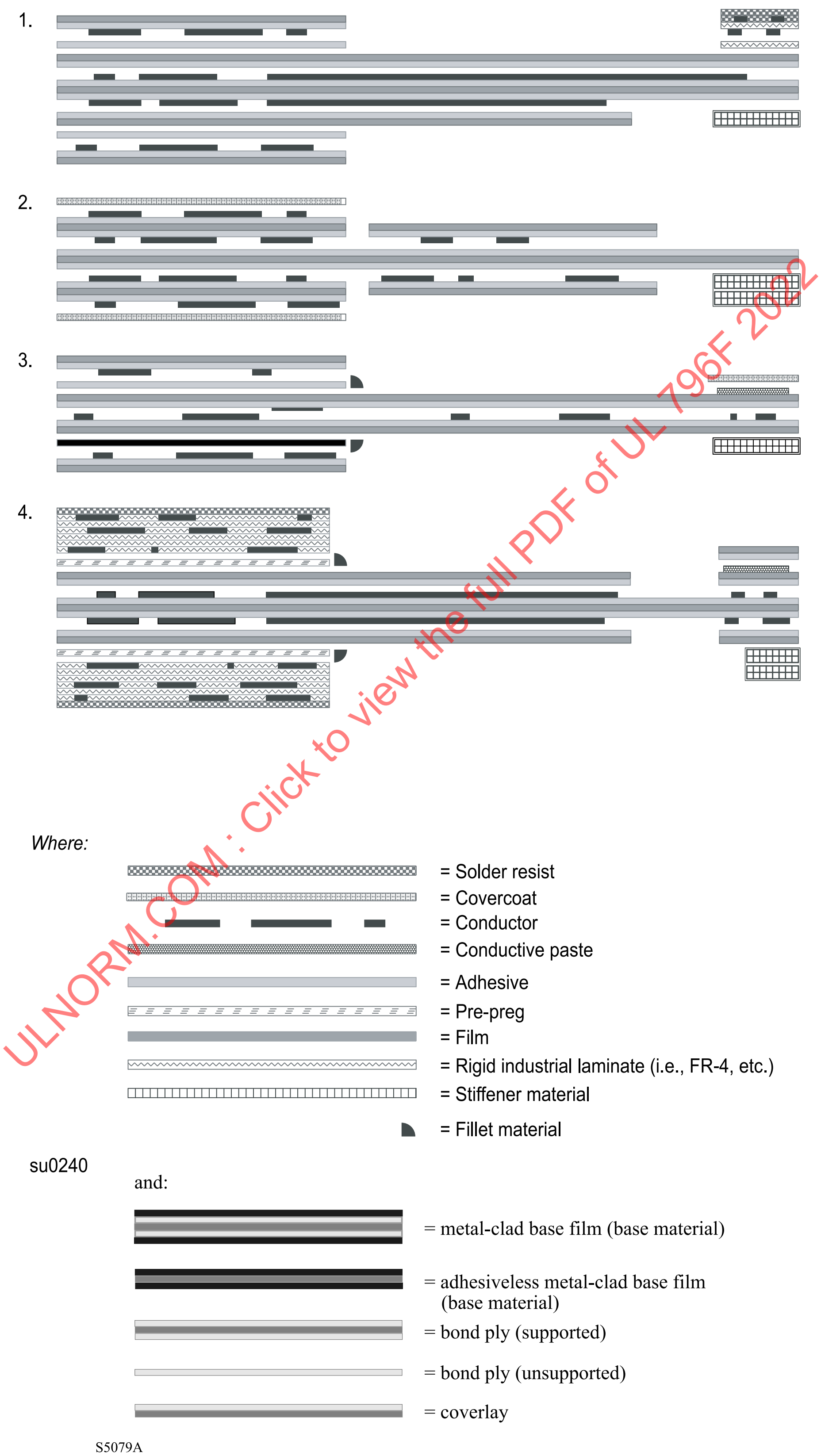
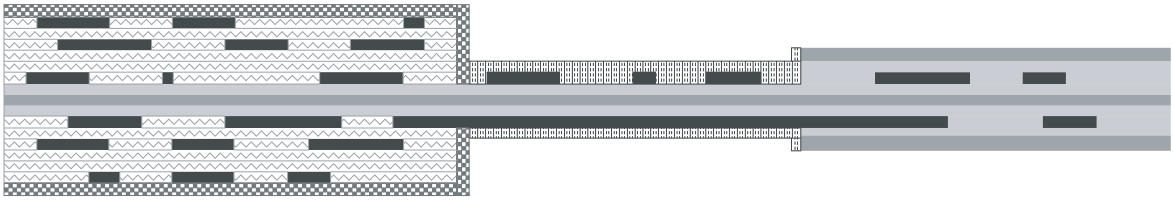
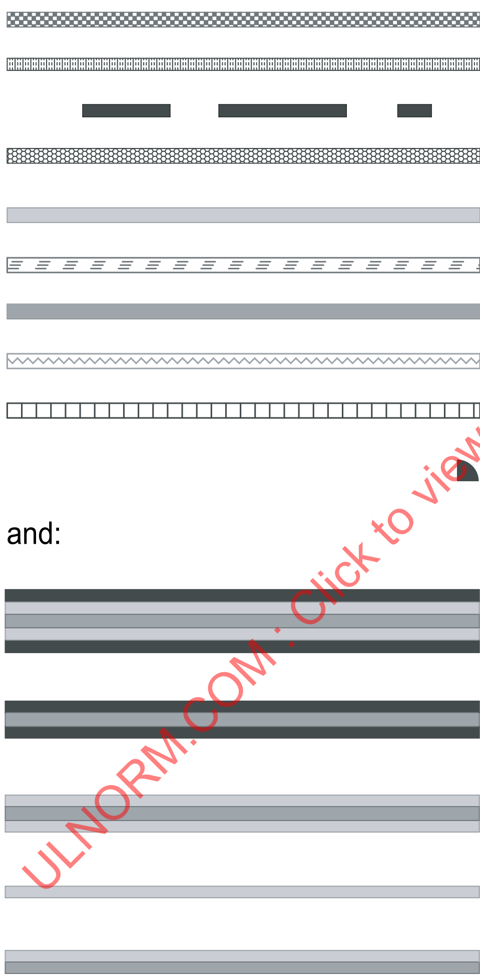


Figure 9.5

Example of a Multilayer Rigid Flex Composite Construction (Post Lamination)



Where:



= Solder resist

= Covercoat

= Conductor

= Conductive paste

= Adhesive

= Pre-preg

= Film

= Rigid industrial laminate (i.e., FR-4, etc.)

= Stiffener material

= Fillet material

and:

= Metal-clad base film (base material)

= Adhesiveless metal-clad base film (base material)

= Bond ply (supported)

= Bond ply (unsupported)

= Coverlay

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9.9.2 Multilayer rigid flex composite constructions shall include an integral electrical connection between flexible, flex-to-install, and rigid (sub-category) construction or rigid printed wiring boards, separated by dielectric material.

9.9.3 Multilayer rigid flex composite constructions shall include the following construction categories and characteristics:

a) Rigid printed wiring boards with integral interconnection to:

1) Singlelayer flex, flex-to-install, and rigid (sub-category) construction; and

2) Multilayer flex, flex-to-install, and rigid (sub-category) construction;

b) Rigid (sub-category) constructions with integral interconnection to:

1) Singlelayer flex, flex-to-install, and rigid (sub-category) construction; and

2) Multilayer flex, flex-to-install, and rigid (sub-category) construction; and

c) With and without reinforcement.

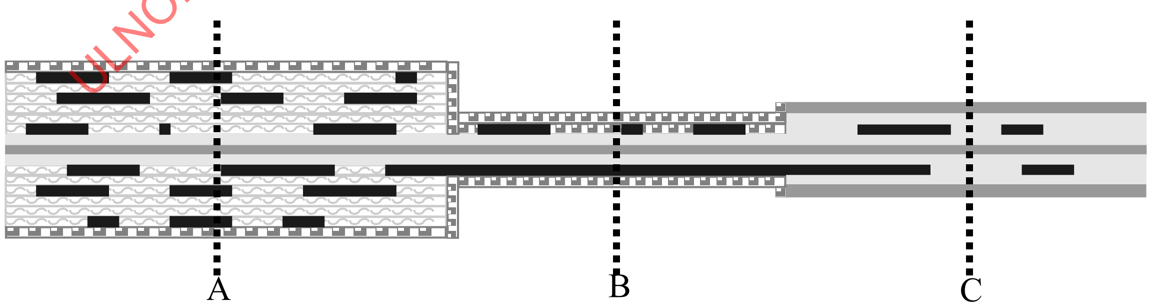
9.9.4 Each sub-section of a multilayer rigid flex composite construction shall be subject to test for the applicable construction category and sub-category.

Exception: If the construction has been subject to the applicable tests for the appropriate category and sub-category, and the tested construction is produced with the same film, adhesive, base material, conductor material, bonding film, cover material, dielectric material, and insulation material, testing of the construction shall not be repeated for use of the construction as a sub-section of a multilayer rigid flex composite FMIC.

9.9.5 The multilayer rigid flex composite construction in Figure 9.6 is divided into three sub-sections (i.e., A, B, and C). The category and subcategory of each sub-section is defined. Sub-section A is considered a rigid (sub-category) construction, sub-sections B and C could be flex, flex-to-install, or rigid (sub-category) constructions depending upon the intended application.

Figure 9.6

Sub-Sections of a Multilayer Rigid Flex Composite Construction



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9.9.6 The materials used to produce a multilayer rigid flex composite construction shall comply with Materials, Section 8.

9.9.7 A singlelayer portion of a multilayer rigid flex composite construction shall comply with Singlelayer (dielectrics), 9.2.

9.9.8 A multilayer portion of a multilayer rigid flex composite construction shall comply with Multilayer (dielectrics), 9.3.

9.9.9 A flexible (sub-category) construction portion of a multilayer rigid flex composite construction shall comply with Flexible, 9.6.

9.9.10 A flex-to-install (sub-category) construction portion of a multilayer rigid flex composite construction shall comply with Flex-to-install, 9.7.

9.9.11 A rigid (sub-category) construction portion of a multilayer rigid flex composite construction shall comply with Rigid, 9.8.

9.9.12 A representative rigid-flex multilayer construction shall include two or the minimum number of internal patterned conductor layers, whichever is greater, in both the rigid portion and the flex portion of the FMIC construction.

9.10 Flammability classification only

9.10.1 FMIC's intended for flammability classification only are subject to limited evaluation; and are intended for use where the mechanical and electrical capacity or endurance of the base materials used to fabricate the FMIC is not of concern and only the flammability classification of the resulting FMIC is of concern in the end-use product.

9.10.2 FMIC's intended for flammability classification only shall include the following category and sub-category constructions, and characteristics:

a) Singlelayer and multilayer construction categories;

b) Flex, flex-to-install, and rigid construction sub-categories;

c) Multilayer rigid flex composite;

9.10.3 A singlelayer FMIC intended for flammability classification only shall be evaluated in accordance with Singlelayer (dielectrics), 9.2.

9.10.4 A multilayer FMIC intended for flammability classification only shall be evaluated in accordance with Multilayer (dielectrics), 9.3.

9.10.5 An FMIC intended for flammability classification only shall comply with Flammability tests, 12.15.

9.10.6 An FMIC intended for flammability classification only shall be identified in accordance with 9.1.3, and entitled in accordance with Glossary of construction and FMIC titles, 9.11.

9.11 Glossary of construction and FMIC titles

9.11.1 For purposes of reflecting the construction build-up and intended application of the FMIC, the following FMIC titles in 9.11.2 – 9.11.4 shall apply to the applicable category and sub-category constructions.

9.11.2 Singlelayer (dielectric) construction titles shall include:

a) Singlelayer flexible FMIC;

b) Singlelayer flex-to-install FMIC; and

c) Singlelayer rigid FMIC.

9.11.3 Multilayer (dielectric) construction titles shall include:

a) Multilayer flexible FMIC;

b) Multilayer flex-to-install FMIC;

c) Multilayer rigid FMIC;

d) Multilayer rigid flex composite FMIC; and

e) Mass-laminated prefabricated package FMIC; see 9.11.4.

9.11.4 Multilayer mass-laminated prefabricated package construction titles shall include:

a) Flexible mass-laminated prefabricated package FMIC;

b) Flex-to-install mass-laminated prefabricated package FMIC;

c) Rigid mass-laminated prefabricated package FMIC; and

d) Multilayer rigid flex composite mass-laminated prefabricated package FMIC.

9.11.5 FMIC's intended for flammability classification only shall be identified by one of the following titles:

a) Singlelayer FMIC with flammability classification only;

b) Multilayer FMIC with flammability classification only.

c) Multilayer rigid flex composite FMIC with flammability classification only; and

d) Multilayer rigid flex composite mass-laminated prefabricated package FMIC with flammability classification only.

9.11.6 FMIC titles are determined by the following procedure:

a) Identify the construction category in accordance with Singlelayer (dielectrics), 9.2, or Multilayer (dielectrics), 9.3; then

b) Identify the construction sub-category in accordance with Flexible, 9.6; Flex-to-install, 9.7; Rigid, 9.8; Multilayer rigid flex composite, 9.9, or Flammability classification only, 9.10; then

c) Combine the construction category and sub-category identified in (a) and (b), in accordance with 9.11.2 or 9.11.3.

9.11.7 FMIC titles for mass-laminated prefabricated package constructions shall be identified and entitled in accordance with 9.11.6, yet the title shall be followed with the identification of mass-laminated prefabricated package in accordance with 9.11.4.

10 Processes

10.1 General

10.1.1 Samples shall be provided for each production process used to fabricate each category and sub-category of FMIC construction.

10.1.2 The process used to fabricate test samples shall reflect the most severe production practices, including the highest temperatures, longest dwell times, highest pressures, and exposure to the maximum number of cycles or repeated steps associated with the production process for the FMIC.

10.1.3 A production process considered more severe than an alternate production process, used to fabricate the same category or sub-category of FMIC construction, shall be considered representative of the less severe production process.

10.1.4 The process of forming conductors shall result in smooth edges, without excessive undercutting when etching, and the conductors shall have dimensions not less than represented by the conductors on the applicable test samples. Undercutting shall not be greater than the conductor thickness.

10.2 Process description

10.2.1 The process description shall be a chronological description reflecting production practices used to fabricate the FMIC.

10.2.2 The process description shall reflect the severity of the production processes including the highest temperatures, longest dwell times, highest pressures, and exposure to the maximum number of cycles or repeated steps associated with the production process used to fabricate the FMIC.

10.2.3 The process description shall reflect the process used to produce the samples submitted for test.

10.2.4 The process description shall identify any etching, plating, laminating, bonding, baking, curing, panelizing, and addition of permanent materials (e.g., adhesive, stiffener, coatings, platings, conductors, etc.) to the FMIC construction during the production process.

10.2.5 The process description shall include the production process steps required for the addition of all adhesive and stiffener materials to FMIC's.

10.3 Variations in processes

10.3.1 A change in the production process shall be considered a variation in the production process.

10.3.2 Any increase in a temperature, time, pressure, or added feature or characteristic of a production process step used to fabricate an FMIC shall be identified in the process description.

10.3.3 If an increase in a temperature, time, pressure, or exposure to the maximum number of cycles of a production process step exceeds the value stated in the established process description, the resulting process description shall be considered more severe than the process description of the production process prior to the variation.

10.3.4 If differences in temperature, time, or pressure are not involved in the variation in the production process step (e.g. change in nomenclature printing method, changing from silk screening to photographic methods, etc.) used to fabricate an FMIC, additional testing for the production process change or variation shall not be required. The production process change or variation shall be identified in the process description, if the process step is included in the process description.

10.3.5 Chromic/sulfuric etchant shall be considered representative of all etchants. Any other acidic or alkaline etchant shall be considered representative of all etchants except chromic/sulfuric.

10.3.6 A retest is necessary for any one or more of the following or similar variations in the production process from the process description:

a) A change in any production process if the temperature on the surface of the FMIC exceeds 100 °C (212 °F) or the MOT of the FMIC type, whichever is greater.

b) Addition of conductor plugged, filled, or plated through-holes not previously identified in the process description.

c) Addition of permanent materials (i.e., film, adhesive, stiffener, coating, conductor material, etc.) not previously identified in the process description.

d) An increase in the laminating pressure and/or number of laminating cycles.

10.3.7 A retest is not necessary for any one or more of the following or similar variations, but should be identified in the process description:

Addition of metallic plating including immersion silver, (see 8.4.25 for additional requirements regarding silver materials), on conductor material, not previously identified in the process description.

11 Parameter Profile Indices

11.1 General

11.1.1 FMIC's, constructions, and the material components therein have been evaluated in accordance with the established test procedures to define their properties, in order to facilitate evaluation of their use in end-product applications. The resulting values for the properties investigated shall be referred to as the parameter profile indices.

11.1.2 The parameter profile indices for an FMIC type shall consist of the applicable physical, mechanical, electrical, and thermal ratings, classifications, indices, and measured values established for the construction or combination of materials used to fabricate the FMIC. The parameter profile indices for an FMIC type shall include, but not be limited to:

a) Minimum and maximum material component thickness;

b) Minimum build-up thickness;

c) Minimum mid-board conductor width;

d) Minimum edge conductor width;

e) Minimum and maximum conductor thickness (or weight);

f) Maximum area conductor diameter;

g) Number of conductor planes (i.e., single-sided, double-sided, multilayer);

h) Solder limits;

i) MOT;

j) UL 94 flammability classification; and

k) Comparative tracking index (CTI).

11.1.3 Deviations in a parameter profile index shall not extend beyond the limit established, or the deviation shall be subject to investigation.

11.1.4 Performance level category (PLC) ratings are used to avoid an excessive level of implied precision and bias. The resultant value for several electrical tests are recorded as PLC, based on the mean test results (rather than recording the exact numerical results). PLC values are indicated in the specific test methods.

11.1.5 The performance profile index values of the FMIC type shall be limited to the lowest rated individual component indexing values for the dielectric materials in the construction for each combination of materials, including each applicable material component.

11.2 Maximum operating temperature (MOT)

11.2.1 The maximum operating temperature (MOT) is the maximum continuous use temperature that the FMIC may be exposed to under normal operating conditions.

11.2.2 The MOT is a temperature value determined by analyses of physical property data obtained from evaluation of a metal-clad polymeric material, construction, or FMIC following short-term thermal conditioning.

The FMIC construction is conditioned at a temperature(s) reflecting the anticipated service environment. The physical property is measured or visually inspected following short-term thermal conditioning, usually two months or less. The measurement and visual inspection results are compared to established criteria, depending upon but not limited to the test, test sample(s), property evaluated, conditioning temperature, and in some cases anticipated service conditions. If the criteria are met, the MOT is granted to the FMIC construction.

11.2.3 Each FMIC type shall have an MOT, specified by the FMIC fabricator reflecting the end product service environment, if applicable. The MOT will be used for conditioning samples as indicated in the required tests. The conditioning temperature reflecting the MOT is incorporated into the applicable test methods. See Table 11.1.

Exception: If an FMIC is intended for flammability classification only, the acceptability of the FMIC shall involve only flammability tests and an MOT shall not be granted.

Table 11.1
Tests Incorporating the MOT

Test	Section
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

11.2.4 The MOT of the FMIC type shall not exceed either the mechanical or electrical relative temperature index RTI of the film, base material, bonding film, coverfilm, dielectric material, or other insulation material when used as a dielectric barrier between conductor planes.

11.3 Flammability classification

11.3.1 Each FMIC type shall have a flammability classification.

11.3.2 The flammability classifications of FMIC types shall be determined in accordance with the Standard for Test for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

11.3.3 The hierarchy of flammability classifications shall be considered from highest to lowest as follows: V-0, V-1, V-2, HB.

11.3.4 The hierarchy of alternate flammability classifications shall be considered from highest to lowest as follows: VTM-0, VTM-1, VTM-2.

11.4 Assembly soldering process – solder limits

11.4.1 Assembly soldering process (solder limits) are profile(s), temperature(s) and time(s) representing the anticipated printed wiring board production assembly process(es). The acceptability of the assembly soldering process is determined by analyses of the FMIC physical property data following the thermal stress test.

Exception: Hand soldering processes do not require thermal stress conditioning before investigation of the FMIC properties.

11.4.2 The FMIC maximum surface temperature during the assembly soldering process determines the thermal stress test peak temperature.

11.4.3 FMICs for use with reflow assembly processes shall be thermally stressed using the default 260 °C profile with thermal stress conditions of 260 °C peak temperature and six (6) cycles to represent multiple soldering processes and potential rework. If a low temperature profile is being used in assembly, the FMIC fabricator can specify the 245 °C or 230 °C profile for testing. If a lower number of cycles are being used in assembly, the FMIC fabricator can specify three (3) cycles instead of six (6) cycles.

11.4.4 If special/unique thermal stress reflow conditions are defined by FMIC fabricator or OEM/ODM purchase order, the following parameters are needed: ramp rate (R1), cooling rate (C1), peak temperature (T2), dwell time (t2) and the number of cycles (X).

11.4.5 FMICs for use with wave soldering and/or selective soldering assembly processes shall be thermally stressed using conditions specified by the FMIC fabricator: the maximum temperature, maximum time, and maximum cycles. Unless specified otherwise by the FMIC fabricator, the default standardized conditions described in 11.4.3 for reflow assembly shall represent wave soldering and/or selective soldering processes.

11.4.6 When required, a removable solder resist or solder mask can be applied so that solder does not adhere. The removable solder resist or solder mask shall be removed from the samples before testing.

11.4.7 A retest shall be required when the FMIC Assembly Soldering Process parameters are increased above the existing assembly profile temperature, time and/or cycles.

11.4.8 Assembly Soldering Process parameters are used for thermal stress conditioning samples in the tests listed in Table 11.2.

Table 11.2
Assembly Soldering Process Test Methods

Test	Section
Thermal stress test	12.3
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
Flammability tests	12.15

11.5 Thickness

11.5.1 Thickness shall be physically measured and calculated for a build-up of material.

11.5.2 The thickness of each material component in an FMIC shall be identified, and measured when possible. A thickness tolerance for each material component in an FMIC shall be identified when known.

11.5.3 The measured build-up thickness of an FMIC shall include film, adhesive, base material, bonding film, cover material, dielectric material, laminate, prepreg, and other insulation material, where no conductor material resides on the inner or outer surfaces of the FMIC.

11.5.4 The calculated build-up thickness of an FMIC shall be a summation thickness of the material components (i.e., film, adhesive, base material, bonding film, cover material, dielectric material, laminate, prepreg, and other insulation material), where no conductor material resides on the inner or outer surfaces of the FMIC.

11.5.5 Minimum thickness and minimum build-up thickness shall be of the thinnest thickness intended for production.

11.5.6 Maximum thickness and maximum build-up thickness shall be of the thickest thickness intended for production.

11.6 Conductor weight

11.6.1 The minimum and maximum conductor weight (or thickness) intended in production shall be identified for conductor material on an FMIC.

11.7 Conductor width

11.7.1 The minimum (external-surface) conductor width intended in production shall be identified and provided on samples for conductor material on an FMIC.A mid-board and edge conductor minimum width shall be established for each FMIC type.

Exception: If an FMIC is intended for flammability classification only, the acceptability of the FMIC shall involve only flammability tests and minimum mid-board and edge conductor widths shall not be required.

11.8 Maximum area conductor diameter

11.8.1 The maximum area conductor diameter of any conductor pattern on an FMIC is determined by the largest circle that can be inscribed within the unpierced conductor pattern.

11.8.2 The introduction of very small conductor or plating voids in a large conductor area, for the sole purpose of reducing the maximum conductor area diameter, does not constitute a pierced conductor area and the maximum area conductor diameter shall be determined accordingly.

11.9 Direct support requirements (DSR)

11.9.1 An FMIC identified by markings required in Markings, Section 13, for the direct support of current-carrying parts at 120 V rms and 15 A or less shall have the film, base material, bonding film, cover film, dielectric material, or build-up construction when used as a dielectric barrier between conductor planes complying with the parameter profile indices in Table 11.3.

11.9.2 An FMIC intended for direct support of current carrying parts shall have an acceptable maximum operating temperature (MOT) rating for the end use product application.

Exception: The FMIC direct support testing can be waived if each individual material in the build-up construction, used as a dielectric barrier and/or substrate for conductors, has previously been evaluated for each performance test in Table 11.3 and complies with the requirements.

Table 11.3
Direct Support Requirements (DSR) of Dielectric Materials

Test[a]	Units or PLC	V-0, V-1, V-2, HB, VTM-0, VTM-1, VTM-2	Thickness (inches)[b]
High current arc ignition	Max PLC	3	Actual[c]
Hot wire ignition	Max PLC	4	Actual[c]
Volume resistivity-dry	Min ohm-cm	50	1/16[d]
Volume resistivity-wet	$x10^6$	10	1/16[d]
Dielectric strength-dry	kv	6.89	1/16[d]
Dielectric strength-wet	per mm	6.89	1/16[d]
Comparative tracking index	Max PLC	4	1/8[d]
Heat deflection	Degrees C	e	1/8[d]

[a] Testing is to be as described in the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A.

[b] Test sample thickness on which the index value is based.

[c] Actual thickness or minimum thickness or material being considered.

[d] Test sample representative of all thickness.

[e] Not required for thermosets and films; for thermoplastics, at least 10 °C (18 °F) above maximum temperature, with 90 °C (194 °F) min.

PERFORMANCE

12 Tests

12.1 General

12.1.1 Tests

12.1.1.1 The tests described in 12.3 – 12.13 are intended to determine the acceptability of film, adhesive, base material, conductor, bonding film, cover material, dielectric material, laminate, prepreg, stiffener, and other insulation materials, in combination as a representative construction, and characterize the FMIC for the intended end-use application.

12.1.1.2 The test methods for the determination of the flammability classification of FMIC's are described in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94. UL 94 flammability test samples for FMIC's shall be established in accordance with Flammability tests, 12.15.

12.1.1.3 The test methods for the determination of the electrical indexing values of FMIC's are described in the Standard for Tests for Polymeric Materials – Short Term Property Evaluations, UL 746A. Electrical indexing tests sample configurations for materials to be used in the production of FMIC's shall be established in accordance with the Standard for Polymeric Materials – Flexible Dielectric Film Materials For Use In Printed Wiring Boards and Flexible Materials Interconnect Constructions, UL 746F, or the Standard for Polymeric Materials – Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials Used in Printed Wiring Boards, UL 746E. The electrical indexing tests needed to establish acceptability of FMIC's for direct support requirements are listed in Direct support requirements (DSR) tests, 12.16.

12.1.1.4 FMIC test samples shall be provided for each different manufacturer and each different grade of material in the FMIC, unless otherwise indicated.

12.1.1.5 Each combination of materials intended for use in the FMIC shall be subject to the applicable test program, unless otherwise indicated.

12.1.1.6 If the applicable film, adhesive, base material, conductor material, bonding film, cover material, dielectric material, laminate, prepreg, and other insulation material in the minimum build-up interconnect construction and maximum build-up construction have already been evaluated to the applicable test requirements in accordance with the Standard for Polymeric Materials – Flexible Dielectric Film Materials For Use In Printed Wiring Boards and Flexible Materials Interconnect Constructions, UL 746F, or the Standard for Polymeric Materials – Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials Used in Printed Wiring Boards, UL 746E, for the applicable FMIC in accordance with this Standard, and if the same materials combination is used within the parameter profile indices established by testing in accordance with UL 746E, then the (Ambient) bend test, 12.9; Cold-bend test, 12.10; and Repeated flexing test, 12.11; need not be conducted and only the Bond strength test, 12.6; Coverlay test, 12.8; and Flammability tests, 12.15 in the minimum build-up construction shall be conducted for the FMIC type.

12.1.2 Applicable documents

12.1.2.1 ASTM D 5374 – Standard Test Methods for Forced-Convection Laboratory Ovens for Evaluation of Electrical Insulation.

Exception: Compliance with the thermal lag time criteria outlined in ASTM D 5374 is not required; therefore, it is not necessary to conduct the procedures to determine thermal lag time.

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.

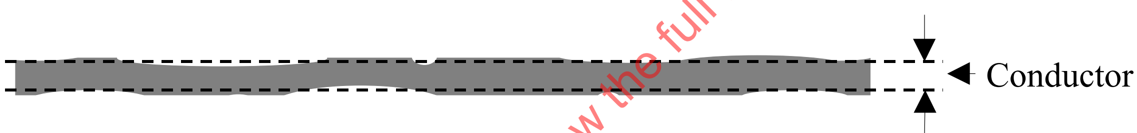
Figure 12.1

Measuring Conductor Trace Average Width (Side-View)

S5082

Figure 12.2

Measuring Conductor Trace Average Width (Top-View)

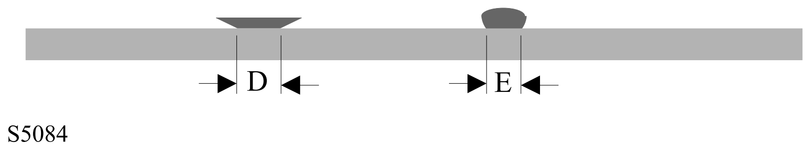


S5083

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

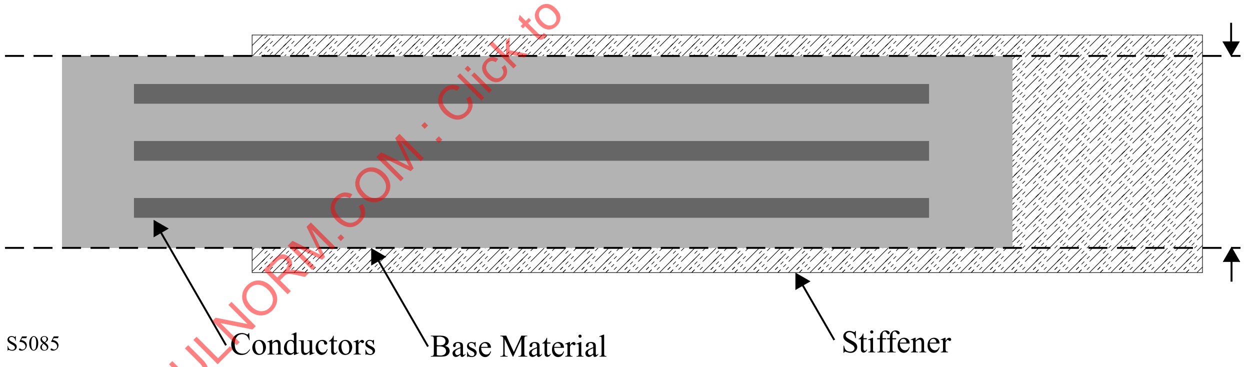
Measuring Conductor Trace Average Width (Side-View)



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

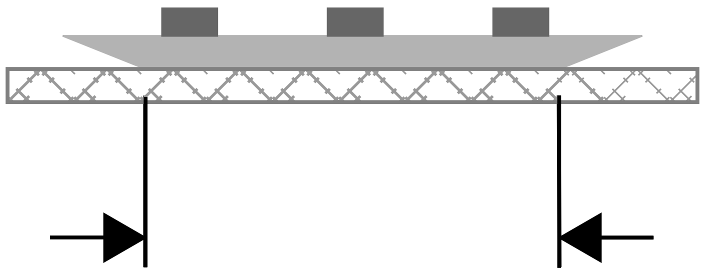
Measuring Construction Average Width (Top-View)



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)

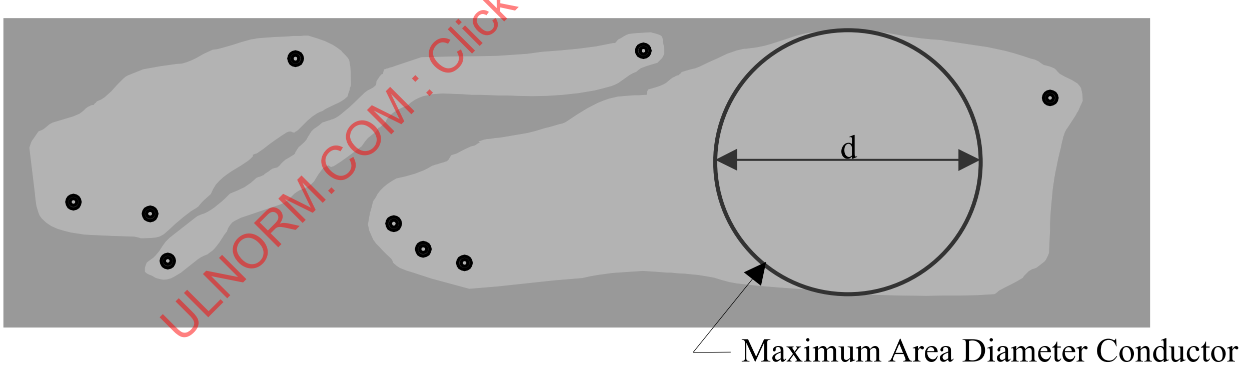


S5086

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

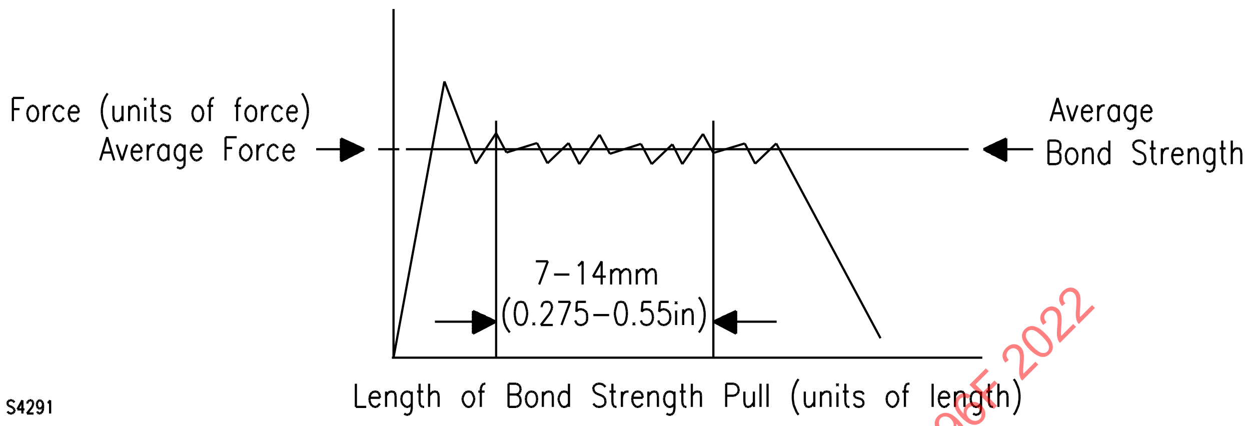


S5087

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



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.

12.3.4.5 Thermal stress shall be conducted using one of the apparatus specified below for other soldering processes:

a) Convection Oven – Attention shall be directed to maintaining the test temperature, when introducing and removing the samples into and from the oven chamber.

b) Sand Bath – Attention shall be directed to the uniformity of temperature throughout the fluidized bed, and avoid mechanical damage imposed by an inadequately fluidized sand bath. Samples shall be prepared to prevent adhesion of sand. Samples shall not be tested for flammability if sand adheres to the sample.

c) Solder Pot – Attention shall be directed to the samples when removing them from the solder pot so the solder does not join with the conductor traces. Samples shall be prepared so as not to have solder resist or excess solder on conductor traces.

12.3.5 Procedure

12.3.5.1 The samples shall be preconditioned to remove moisture by baking at 121 ±2 °C (250 ±3.6 °F) minimum for 1.5 hours minimum prior to being subjected to the thermal stress unless specified otherwise.

12.3.5.2 Subject the samples to a thermal stress within 30 minutes after removal from the 121 °C oven. If not conducted within 30 minutes, the samples shall be stored in a desiccator to prevent moisture absorption.

12.3.5.3 All samples shall be subjected to reflow soldering conditions or equivalent process specified by the FMIC fabricator. The standardized thermal stress conditions described in Table 12.4 shall be used for this investigation.

Table 12.4
Sample Thermal Stress Standardized Conditions

Assembly process	Maximum peak temp	Dwell time	Cycles
Reflow 260 °C, 245 °C or 230 °C	T1 (default 260 °C)	IPC TM-650 2.6.27	X (default 6)
Reflow Special	T2	t2 plus profile conditions	X
Wave / Selective soldering	T3	t3	X

Notes:

1 – Default reflow conditions are 260 °C peak temperature and 6 cycles. FMIC fabricator shall specify alternate conditions if necessary for the thermal stress test.

2 – Reflow - The peak temperature (T1) and number of cycles (X) shall be specified.

3 – Reflow Special - Unique conditions defined by FMIC fabricator for ramp rate (R1), cooling rate (C1), peak temperature (T2), dwell time (t2) and cycles (X).

4 – Wave / Selective - The peak temperature (T3) and dwell time (t3) shall be specified.

5 – The peak temperature shall be measured on the board surface.

6 – See reflow profile figures in IPC TM-650 2.6.27.

12.3.5.4 FMICs for use with reflow assembly processes shall be thermally stressed using one of the standardized profile conditions Reflow 260 °C, Reflow 245 °C, Reflow 230 °C, or Reflow Special in accordance with IPC TM-650 2.6.27. The thermal stress maximum temperature and maximum cycles shall be specified by the fabricator. The Reflow 260 °C profile using six (6) cycles shall be the default thermal stress unless specified otherwise.

12.3.5.5 FMICs for use with wave solder and/or selective soldering assembly processes shall be thermally stressed using the maximum temperature, maximum time, and maximum cycles specified by the fabricator. One (1) cycle shall be the default unless specified otherwise.

12.3.5.6 Cool the test samples to room temperature.

12.3.5.7 Examine the samples using normal or corrected 20/20 vision, and record any presence of loosening, wrinkles, cracks, blisters, or delamination in the conductors or insulation material.

12.3.6 Data collection

12.3.6.1 Record and report the following test conditions and equipment:

a) The preconditioning temperature(s) and time(s) used to remove moisture from the samples.

b) The thermal stress temperature(s), time(s) and cycle(s) subjected to the samples.

c) The apparatus used for the thermal stress operation.

12.3.6.2 Record and report the following test results prior to preconditioning to remove moisture and following the thermal stress operation and cooling to room temperature:

a) The presence of any wrinkles, cracks, blisters, or loose conductors or

b) Any delamination, wrinkles, cracks, blisters, or loose film, adhesive, base material, bonding film, cover material, dielectric material, laminate, prepreg, or other insulation material.

12.4 Delamination test

12.4.1 Purpose

12.4.1.1 The purpose of this test method is to provide a consistent procedure for assessing the physical endurance of FMIC's, following exposure to solder limits, and solder limits and thermal conditioning based on the maximum operating temperature. The test is designed to assess physical fatigue of test samples exposed to the anticipated production soldering temperatures and anticipated service temperatures via elevated temperature conditioning.

12.4.2 Compliance criteria

12.4.2.1 There shall be no presence of any wrinkling, cracking, blistering, or loosening of any conductor, or any delamination, wrinkling, cracking, blistering, or loosening of any film, adhesive, base material, bonding film, cover material, dielectric material, or other insulation material as a result of the pre-conditioning, thermal stress, oven conditioning, or cooling.

12.4.3 Test samples

12.4.3.1 Four (4) samples, representing a minimum build-up interconnect construction, shall include all material components in accordance with Materials, Section 8; and, for the desired construction(s) in accordance with FMIC Constructions, Section 9.

12.4.3.2 A representative conductor pattern is shown in Figure 12.6 or Figure 12.8. If it is intended for samples to be tested with a maximum area conductor diameter larger than can be provided on samples indicated in Figure 12.8, an additional set of samples with a pattern containing the largest maximum area conductor as depicted in Figure 12.6 or a pattern containing only an unpierced circle of the largest maximum area conductor diameter shall be tested. Samples can include multiple conductors with various maximum area conductor diameters.

12.4.3.3 External conductors of the initial minimum weight shall be provided on samples for test.

12.4.3.4 Cover material and solder resist materials shall not be present on the external surfaces of the samples.

12.4.3.5 Singlelayer Constructions. See Singlelayer, 12.1.3.2.

12.4.3.6 Multilayer Constructions. See Multilayer, 12.1.3.3.

12.4.4 Procedure

12.4.4.1 Subject the samples to the Thermal stress test, 12.3.

12.4.4.2 Place two (2) of the minimum build-up construction samples and two (2) of the maximum build-up construction samples in a full-draft circulating-air oven for 240 consecutive hours, maintained at a temperature determined by the following formula:

$$t_2 = 1.076(t_1 + 288) - 273$$

in which:

t_2 is the oven conditioning temperature in °C for 240-hours oven conditioning, and

t_1 is the MOT in °C of the FMIC type.

See Table 12.2 for the 240-hours oven conditioning temperatures corresponding to the desired or established MOT.

12.4.4.3 When the fabricator so requests, a longer oven conditioning time at a lower temperature than described in 12.4.4.2 shall be used. Two of the minimum build-up construction samples and two of the maximum build-up construction samples shall be placed for 1344 consecutive hours in a full-draft circulating-air oven, maintained at a temperature determined by the following formula:

$$t_3 = 1.02(t_1 + 288) - 273$$

in which:

t_3 is the oven conditioning temperature in °C for 1344-hours oven conditioning, and

t_1 is the MOT in °C of the FMIC type.

See Table 12.2 for the 1344-hours oven conditioning temperatures corresponding to the desired or established MOT.

12.4.4.4 Cool the samples to room temperature.

12.4.4.5 Examine the samples using normal or corrected 20/20 vision, and record any presence of loosening, wrinkles, cracks, blisters, or delamination in the conductors or insulation material.

12.4.5 Data collection

12.4.5.1 Record and report the following FMIC information:

a) Solder limits of the FMIC type; and

b) MOT (temperature t_1, °C) of the FMIC type.

12.4.5.2 Record and report the following test results:

a) The presence of any loosening, wrinkles, cracks, blisters, or delamination in the conductors or insulation material prior to thermal stress in accordance with 12.4.4.1 and

b) Thermal stress test data collected (if applicable) in accordance with 12.4.4.1.

12.4.5.3 Record and report the following test results for the 240-hours oven conditioning at temperature t_2:

a) The oven conditioning temperature (t_2) used in accordance with 12.4.4.2 and

b) The presence of any loosening, wrinkles, cracks, blisters, or delamination in the conductors or insulation material after the 240-hours oven conditioning or cooling to room temperature, in accordance with 12.4.4.4.

12.4.5.4 Record and report the following test results for the 1344-hours oven conditioning at temperature t_3:

a) Oven conditioning temperature (t_3) used in accordance with 12.4.4.3 and

b) The presence of any loosening, wrinkles, cracks, blisters, or delamination in the conductors or insulation material after the 1344-hours oven conditioning or cooling to room temperature, in accordance with 12.4.4.4.

12.5 Plating adhesion test

12.5.1 Purpose

12.5.1.1 The purpose of this test method is to provide a consistent procedure for assessing the adhesion of plated metallic conductors of FMIC's without exposure to solder limits or thermal conditioning. The test is designed to assure adhesion of plated conductor material(s) on test samples, not subject to solder limits or thermal conditioning.

12.5.2 Compliance criteria

12.5.2.1 There shall be no evidence of the plating, protective plating, or the conductor pattern being removed as shown by pattern particles adhering to the pressure-sensitive cellophane tape.

Note – When small particles of metal adhere to the pressure-sensitive cellophane tape, it may be evidence of overhang and not non-compliant plating adhesion.

12.5.3 Applicable documents

12.5.3.1 ASTM D1000-82(1988) – Standard for Methods of Testing Pressure Sensitive Adhesive Coated Tapes Used for Electrical Insulation.

12.5.4 Test samples

12.5.4.1 One (1) sample, representing a minimum build-up construction, shall include all material components in accordance with Materials, Section 8; and, for the desired construction(s) in accordance with FMIC Constructions, Section 9.

12.5.4.2 A representative conductor pattern is shown in Figure 12.8.

12.5.4.3 The conductor pattern on the plating adhesion test samples shall reflect the conductor pattern submitted for the Bond strength test, 12.6, as shown in Figure 12.8.

12.5.4.4 External conductors of the initial minimum weight with a maximum amount of plating intended for production shall be provided for test.

12.5.4.5 Conductors on the sample for plating adhesion test shall be continuous, and may be tapered at one end.

12.5.4.6 The samples shall be provided with contacts if contacts are intended in production.

12.5.4.7 The samples shall be provided with plated through-holes if plated through-holes are intended in production. See Conductors and conductor adhesives, 8.4.

12.5.4.8 The samples shall be provided with through-holes filled with conductive material(s) if through-holes filled with conductive material(s) are intended in production.

Exception: If a sample with conductor material applied over through-holes filled with conductive material(s) is subject to the plating adhesion test, the plating adhesion test need not be repeated on a sample without conductor material applied over through-holes filled with the same conductive material(s).

12.5.4.9 The samples shall be provided with conductor material applied over through-holes filled with conductive material(s) if constructions will be produced with conductor material applied over through-holes filled with conductive material(s).

12.5.4.10 Cover material and solder resist material shall not be present on the external surfaces of the samples.

12.5.4.11 Testing of minimum build-up construction samples shall be considered representative of the maximum build-up construction samples, for investigation of the same conductor plating material(s) and process.

12.5.5 Apparatus or material

12.5.5.1 Double-faced adhesive tape or an adhesive system with an adhesive strength capable of attaching a rigid supplemental reinforcement material to the test sample for plating adhesion testing shall be used for this test. The double-faced adhesive tape or adhesive system shall be compatible with the materials used in the construction, and shall not be detrimental to or adversely affect the materials in the construction.

12.5.5.2 A rigid supplemental stiffener material to be bonded to the test samples shall be used for this test. The rigid supplemental stiffener material is intended to eliminate tenting or flexing of the sample during the plating adhesion test.

Note – The stiffener material should be compatible with the materials used in the construction, and should not be detrimental to or adversely affect the materials in the construction.

12.5.5.3 A steel roller 80 mm ±2.5 mm (3.25 inch) in diameter, 45 mm ±1 mm (1.75 in) wide, and weighing 2000 g ±50 g (4.5 pounds) covered with rubber approximately 6 mm (0.25 in) in thickness shall be used for this test.

12.5.5.4 Pressure-sensitive cellophane tape, 13 mm (0.5 inch) wide, with an adhesion of 0.38 ±0.05 N/mm (35 ±5 ounces per inch), as determined by the Standard for Methods of Testing Pressure-Sensitive Adhesive Coated Tapes Used for Electrical Insulation, ASTM D1000 shall be used for this test.

Note – The adhesive tape should be compatible with the material components used in the construction, and should not be detrimental to or adversely affect the materials in the construction.

12.5.6 Procedure

12.5.6.1 Attach a rigid reinforcement material to the back-side of the sample, the side not being subjected to the plating adhesion test, using double-faced adhesive tape or an adhesive system in accordance with 12.5.5.1.

Note – The reinforcement material is intended to eliminate flexing and tenting of the sample during the plating adhesion test.

12.5.6.2 Apply a minimum 50.8 mm (2 inches) effective test length of pressure-sensitive cellophane tape in accordance with 12.5.5.4, on the sample reinforced in accordance with 12.5.6.1. The pressure-sensitive cellophane tape shall be applied in an area on the sample so two additional applications, for a total of three applications of the pressure-sensitive cellophane tape, can be made on untested areas of the sample.

12.5.6.3 Use a steel roller in accordance with 12.5.5.3 to remove all air bubbles in the 50.8 mm (2 inches) minimum effective test length of pressure-sensitive cellophane tape on the conductor pattern.

12.5.6.4 Mechanically remove the pressure-sensitive cellophane tape applied in 12.5.6.3 by gripping one end of the tape, and removing it at a rate of approximately 25.4 mm in 5 seconds (1 inch in 5 seconds) at an angle of approximately 90 degrees to the base material.

12.5.6.5 Examine the pressure-sensitive cellophane tape removed in accordance with 12.5.6.4 using normal or corrected 20/20 vision, and record any presence of any plating or conductor pattern material adhering to the pressure-sensitive cellophane tape.

12.5.6.6 Repeat application of the pressure-sensitive cellophane tape in accordance with 12.5.6.2 and removal of air bubbles in the effective test length in accordance with 12.5.6.3. Using new pressure-sensitive cellophane tape for each application, repeat steps 12.5.6.2 – 12.5.6.5 in order, two more times. The pressure-sensitive cellophane tape shall be applied on a different untested area of the sample each time, for a total of three applications.

12.5.7 Data collection

12.5.7.1 Indicate the type of supplemental reinforcement attached to the samples in accordance with 12.5.6.1, after thermal stress (if applicable) and before being subjected to the plating adhesion test.

12.5.7.2 Record and report the following test data, in accordance with:

a) The presence of any loosening, wrinkles, cracks, blisters, or delamination, in the conductors or insulation materials in accordance with 12.6.5.1, prior to the plating adhesion test in accordance with 12.5.6.2 – 12.5.6.5; and

b) The presence of any plating or conductor pattern material adhering to the pressure-sensitive cellophane tape in accordance with 12.5.6.5, for each of the three applications in accordance with 12.5.6.6.

12.6 Bond strength test

12.6.1 Purpose

12.6.1.1 The purpose of this test method is to provide a consistent procedure for assessing the physical endurance and bond strength of metallic conductors on base materials of FMICs, following exposure to solder limits, and solder limits and thermal conditioning based on the maximum operating temperature. The test is designed to assess physical fatigue of test samples exposed to the anticipated production soldering temperatures and anticipated service temperatures, via elevated temperature conditioning.

12.6.2 Compliance criteria

12.6.2.1 The average bond strength between the conductor and base material shall not be less than:

a) 2 lbf/inch (0.350 N/mm) for each individual conductor trace, for the average bond strength determined in accordance with 12.6.6.6(a), after being subject to thermal stress; and

b) 2 lbf/inch (0.350 N/mm) for each individual conductor trace, for the average bond strength determined in accordance with 12.6.6.6(b), after being subject to thermal stress and 240-hours oven conditioning; or

c) 1 lbf/inch (0.175 N/mm) for each individual conductor trace, for the average bond strength determined in accordance with 12.6.6.6(c) after being subject to thermal stress and 1344-hours oven conditioning.

12.6.2.2 There shall be no presence of any wrinkling, cracking, blistering, or loosening of any conductor, or any delamination, wrinkling, cracking, blistering, or loosening of any film, adhesive, base material, bonding film, cover material, dielectric material, or other insulation material as a result of the pre-conditioning, thermal stress, oven conditioning, or cooling.

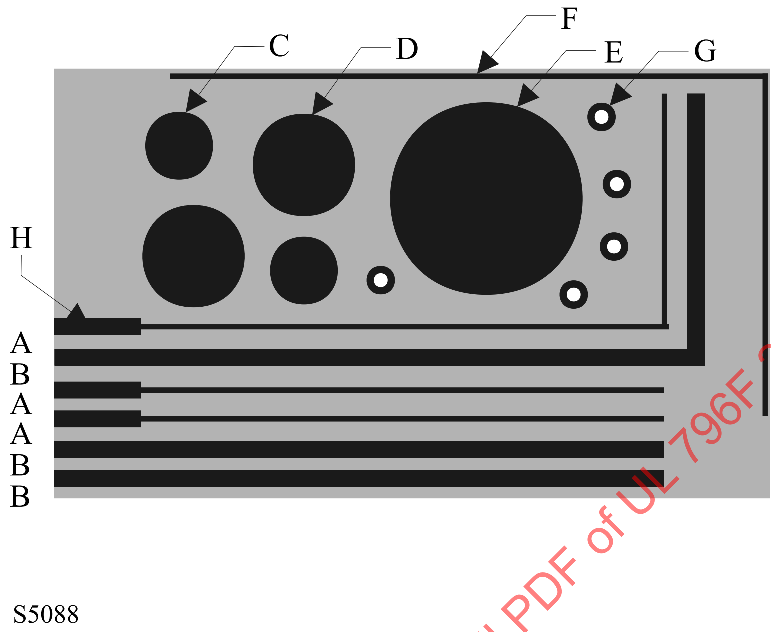
12.6.3 Test samples

12.6.3.1 Ten (10) samples, representing a minimum build-up construction, shall include all material components, in accordance with Materials, Section 8; and, for the desired construction(s), in accordance with FMIC Constructions, Section 9.

12.6.3.2 A representative conductor pattern is shown in Figure 12.8.

Figure 12.8

Typical Bond Strength Test Sample Pattern



A – Minimum average width conductor, specified by the fabricator.

B – 1.6 ± 0.13 mm (0.062 inch) average width conductor.

C – 10 mm (0.375 inch) diameter unpierced circular conductor.

D – 13 mm (0.5 inch) diameter unpierced circular conductor.

E – Maximum area conductor diameter, specified by the fabricator.

F – Edge conductor, shall be within 0.40 mm (0.015 inch) of the sample edge, not sheared [a].

G – Plated through-holes [a]. At least four (4) plated through holes shall be present on the samples.

H – Plated contacts, at least three, of maximum width [a].

[a] Optional, but must be on sample if intended for production constructions.

12.6.3.3 External conductors of the initial minimum weight shall be provided for the bond strength test. For initial conductor weights less than 1 oz/ft^2 (33 mic), the conductors shall be plated to a thickness reflecting 1 oz/ft^2.

Exception: The initial conductor weight and narrow width of minimum average width conductors may prohibit plating to a thickness corresponding to 1 oz/ft^2, so narrow width conductors shall be plated to the maximum conductor weight intended for production of the corresponding conductor width.

12.6.3.4 Conductors on the samples for bond strength test shall be continuous, and may be tapered at one end to aid initiating the bond strength pull.

12.6.3.5 The samples shall be provided with contacts if contacts are intended in production.

12.6.3.6 The samples shall be provided with plated through-holes if plated through-holes are intended in production.

12.6.3.7 The samples shall be provided with through-holes filled with conductive material if through-holes filled with conductive material are intended in production. If constructions will be produced with conductor material applied over through-holes filled with conductive material, samples shall be provided with conductor material applied over through-holes filled with conductive material.

Exception: If samples with conductor material applied over through-holes filled with conductive material are subject to the bond strength test, the bond strength test need not be repeated on samples without conductor material applied over through-holes filled with the same conductive material.

12.6.3.8 Cover material and solder resist materials shall not be present on the external surfaces of the construction. The bond strength test shall be conducted by peeling the conductor from the base material without obstruction of cover material or solder resist materials.

12.6.4 Apparatus or material

12.6.4.1 Double-faced adhesive tape or an adhesive system with an adhesive strength capable of attaching a rigid supplemental reinforcement material to the test sample for bond strength testing shall be used for this test.

Note – The double-faced adhesive tape or adhesive system should be compatible with the materials used in the construction, and should not be detrimental to or adversely affect the materials in the construction.

12.6.4.2 A rigid supplemental reinforcement material to be bonded to the test samples shall be used for this test. The rigid supplemental reinforcement material is intended to eliminate tenting and flexing of the sample during the bond strength test.

Note – The reinforcement material should be compatible with the materials used in the construction, and should not be detrimental to or adversely affect the materials in the construction.

12.6.4.3 A pry tool, such as a knife or scalpel, capable of separating the conductor from the substrate adhesive or film material to initiate the conductor bond strength pull shall be used for this test.

12.6.4.4 A conditioning (convection) oven capable of maintaining the specified conditioning temperatures in 12.6.5.5 and 12.6.5.6 shall be used for this test.

12.6.4.5 A bond strength tester capable of providing and measuring the force required to separate the conductor material from the substrate material with an accuracy within 10 percent of the measured force value shall be used for this test.

12.6.5 Procedure

12.6.5.1 Subject the samples to the Thermal stress test, 12.3. The samples shall be subjected to the Thermal stress test without any reinforcement attached; a supplemental reinforcement material shall be applied to these samples only after the Thermal stress test.

12.6.5.2 Attach a rigid reinforcement material to the back-side, the side of the sample not being subjected to the bond strength test, of four (4) of the minimum build-up construction samples and four (4) of the maximum build-up construction samples using double-faced adhesive tape or adhesive system in accordance with 12.6.4.1, following the thermal stress test in accordance with 12.6.5.1.

12.6.5.3 Separate the conductor from the base material in accordance with 12.6.5.4 and measure the force required to separate the conductor from the base material in accordance with 12.6.5.5, on three (3) of the minimum build-up construction samples subjected to the thermal stress test in 12.6.5.1 and reinforced in 12.6.5.2.

12.6.5.4 Separate or pry the end of the conductor from the base material, so that the conductor can be grasped for the bond strength pull.

Exception: After attempting to pry up an end of a conductor, if the conductor material and base material interface remain intact, the base material rips or tears when the bond strength pull is conducted, and the forces imparted to the conductor material exceeds 2 lbf/inch (0.350 N/mm), the bond strength of that conductor shall be considered greater than 2 lbf/inch.

12.6.5.5 Peel a uniform width of the conductor from the sample surface for a distance of at least 6.4 mm (0.25 inch) at a uniform rate of approximately 300 mm/min (12 inches/min) [or, approximately 6.4 mm (0.25 inch) in 1.25 seconds]. The angle between the conductor and the base material shall be maintained at not less than 85 degrees during the test. Three force determinations are to be made on each conductor width described below:

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

b) A 1.6 mm (0.063 inch) wide conductor;

c) An edge conductor having the minimum average width within 0.4 mm (0.015 inch) of the board edge and not sheared at the board edge, except as described in Conductor and conductor adhesives, 8.4. 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

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

Exception No 1: As an alternative to using three force determinations, one force determination can be made on each conductor described below on each sample tested by peeling a uniform width conductor from the sample surface for a distance of at least 19 mm (0.75 inch).

Exception No 2: When the characteristics of the conductor material of unconditioned (i.e., no thermal stress and no oven conditioning) or conditioned (i.e., thermal stress or oven conditioning) samples inhibit measurement of the bond strength with test equipment, the bond strength shall be evaluated manually. A reference material previously evaluated with test equipment and found to have bond strength greater than 2 lbf/inch (0.350 N/mm) for each individual conductor trace of similar average width shall be used to compare with the bond strength of each individual conductor trace of similar average width on unconditioned and oven conditioned samples. A tool can be used to pry the conductor from the base material surface and the bond strength shall be evaluated manually, in accordance with 12.6.5.4.The *same conductor traces on unconditioned and oven conditioned samples shall be evaluated in the same manner as described above, and the bond strength of the unconditioned, oven conditioned, and reference samples shall compare favorably with one another.*

12.6.5.6 Place two (2) of the minimum build-up construction samples subjected to the thermal stress test in accordance with 12.6.5.1 in a full-draft circulating-air oven in accordance with 12.6.4.4, for 240 consecutive hours, maintained at a temperature determined by the following formula:

$$t_2 = 1.076(t_1 + 288) - 273$$

in which:

t_2 is the oven conditioning temperature in °C for 240-hours oven conditioning, and

t_1 is the MOT in °C of the FMIC type.

See Table 12.2 for the 240-hours oven conditioning temperatures corresponding to the desired or established MOT.

12.6.5.7 When the fabricator so requests, a longer oven conditioning time at a lower temperature than described in 12.6.5.6 shall be used. Place two (2) of the minimum build-up construction samples and two (2) of the maximum build-up construction samples subjected to the thermal stress test in 12.6.5.1 in a full-draft circulating-air oven in accordance with 12.6.4.4, for 1344 consecutive hours, maintained at a temperature determined by the following formula:

$$t_3 = 1.02(t_1 + 288) - 273$$

in which:

t_3 is the oven conditioning temperature in °C for 1344-hours oven conditioning, and

t_1 is the MOT in °C of the FMIC type.

See Table 12.2 for the 1344-hours oven conditioning temperatures corresponding to the desired or established MOT.

12.6.5.8 Cool the test samples to room temperature.

12.6.5.9 Examine the samples using normal or corrected 20/20 vision, and record any presence of loosening, wrinkles, cracks, blisters, or delamination in the conductors or insulation material.

12.6.5.10 Attach a rigid reinforcement material to the back-side of the samples using double-faced adhesive tape or an adhesive system in accordance with 12.6.4.1, so the samples do not flex or tent during the bond strength test.

Note – The test samples shall be oven conditioned in accordance with 12.6.5.6 or 12.6.5.7 without any supplemental reinforcement attached. A supplemental reinforcement material shall be applied to the test samples only after the stabilization period following oven conditioning and cooling.

12.6.5.11 The force required to separate the conductor from the base material shall be initiated in accordance with 12.6.5.4 and measured in accordance with 12.6.5.6 on the two (2) minimum build-up construction samples conditioned in accordance with 12.6.5.6 (240-hours oven conditioning at temperature t_2).

12.6.5.12 If the fabricator requests an oven conditioning temperature lower than described in 12.6.5.6 (240-hours oven conditioning, at temperature t_2), the force required to separate the conductor from the base material shall be initiated in accordance with 12.6.5.4 and measured in accordance with 12.6.5.5 on the two (2) minimum build-up construction samples conditioned in accordance with 12.6.5.7 (1344-hours oven conditioning at temperature t_3).

12.6.6 Data collection

12.6.6.1 Record and report the following FMIC information:

a) Solder limits of the FMIC type; and

b) MOT of the FMIC type.

12.6.6.2 Record and report the following test data:

a) The presence of any loosening, wrinkles, cracks, blisters, or delamination in conductors or insulation materials prior to thermal stress or oven conditioning;

b) Test data collected from the thermal stress test (if applicable), in accordance with 12.6.5.1;

c) The type of supplemental reinforcement attached to the samples in accordance with 12.6.5.2, after thermal stress (if applicable) in accordance with 12.6.5.1 and before being subjected to the bond strength test in accordance with 12.6.5.3; and

d) The forces required to separate the conductors from the base material in accordance with 12.6.5.5 after thermal stress (if applicable) in accordance with 12.6.5.1 and before oven conditioning in accordance with 12.6.5.6.

12.6.6.3 Record and report the following test data for samples subjected to 240-hours oven conditioning at temperature t_2:

a) Oven conditioning temperature (t_2) used in accordance with 12.6.5.6;

b) The presence of any loosening, wrinkles, cracks, blisters, or delamination in the conductors or insulation material after 240-hours oven conditioning or cooling to room temperature;

c) Materials used for supplemental reinforcement, attached to the samples after thermal stress and 240-hours oven conditioning, before being subjected to the bond strength test in accordance with 12.6.5.5; and

d) The forces required to separate the conductors from the base material in accordance with 12.6.5.10 after 240-hours oven conditioning at temperature t_2.

12.6.6.4 Record and report the following test data for samples subjected to 1344-hours oven conditioning at temperature t_3:

a) Oven conditioning temperature (t_3) used in accordance with 12.6.5.7;
b) The presence of any loosening, wrinkles, cracks, blisters, or delamination in the conductors or insulation materials after 1344-hours oven conditioning or cooling to room temperature;

c) Materials used for supplemental reinforcement, attached to the construction or FMIC samples after thermal stress and 1344-hours oven conditioning, before being subjected to the bond strength test in 12.6.5.5; and

d) The forces required to separate the conductors from the base material in accordance with 12.6.5.11, after 1344-hours oven conditioning at temperature t_3.

12.6.6.5 Indicate if the bond strength was conducted manually in accordance with the Exception to 12.6.5.5. If the bond strength test was conducted manually in accordance with the Exception to 12.6.5.5, the forces required to separate the conductors from the base material in 12.6.5.5, 12.6.5.11, and 12.6.5.12 shall be noted as being obtained manually.

12.6.6.6 Calculate the average bond strength in force per unit width (lbf/inch; N/mm) for the forces recorded in:

a) 12.6.6.2(d), after thermal stress and before 240-hours or 1344-hours oven conditioning, for each corresponding conductor average width;

b) 12.6.6.3(d), after thermal stress and 240-hours oven conditioning, for each corresponding conductor average width; and

c) 12.6.6.4(d), after thermal stress and 1344-hours oven conditioning, for each corresponding conductor average width.

12.7 Conductive paste adhesion test

12.7.1 Purpose

12.7.1.1 The purpose of this test method is to provide a consistent procedure for assessing the physical endurance and adhesion of conductive paste and polymer thick film type conductors applied on film, adhesive, base material, conductor, bonding film, cover material, laminate, prepreg, and other insulation or conductor material in the FMIC following exposure to thermal cycling, including thermal conditioning, water immersion, cold, and high humidity environments. The test is designed to assess physical fatigue and adhesion of conductive paste type conductors of test samples exposed to environmental stresses.

12.7.2 Compliance criteria

12.7.2.1 There shall be no evidence of the plating, protective plating, or the conductor pattern being removed as shown by conductor pattern particles adhering to the pressure-sensitive cellophane tape.

Note – When small particles of conductor material adhere to the pressure-sensitive cellophane tape, it may be evidence of overhang and not non-compliant conductive paste adhesion.

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

12.7.3 Test samples

12.7.3.1 Three (3) samples, representing a minimum build-up construction, shall include all material components in accordance with Materials, Section 8; and, for the desired constructions, as described in FMIC Constructions, Section 9. If test samples are provided with overcoat or covercoat, three additional samples with the same conductor pattern, without overcoat or covercoat shall be provided. See 12.7.3.7.

12.7.3.2 A representative conductor pattern is shown in Figure 12.8.

12.7.3.3 The conductor pattern on the conductive paste adhesion test samples shall reflect the conductors pattern submitted for the Bond strength test, 12.6.

12.7.3.4 External conductors of the initial minimum weight with the maximum amount of plating or printing intended for production shall be provided for test.

12.7.3.5 Conductors on the samples for the conductive paste adhesion test shall be continuous, and may be tapered at one end.

12.7.3.6 Conductor material shall be applied on each of the surfaces to which it will be applied in production. Each of the material surfaces including conductor material on film, adhesive, base material, conductor, cover material, coating, dielectric material, industrial laminate, prepreg, or other insulation or conductor material are subject to the conductive paste adhesion test.

12.7.3.7 Each covercoat or overcoat material shall be applied over each type of conductor material. If a conductive paste material is to be covered or encapsulated with a covercoat or overcoat material, each covercoat or overcoat material shall be applied over each type of conductor material and shall be subject to the conductive paste adhesion test.

Exception: If test samples representative of an construction and process are subject to the conductive paste adhesion test without covercoat or overcoat material applied over the conductor material subject to test, the conductive paste adhesion test need not be repeated for representative samples of the same process and construction with cover coat or overcoat materials.

12.7.3.8 Each combination of covercoat and overcoat material shall be applied, over each type of conductor material. If a conductive paste material is to be covered or encapsulated with a combination of covercoat or overcoat material, or covercoat and overcoat material, each combination shall be applied over each type of conductor material and shall be subject to the conductive paste adhesion test.

Exception: If test samples representative of an construction and process are subject to the conductive paste adhesion test without covercoat or overcoat material applied over the conductor material subject to test, the conductive paste adhesion test need not be repeated for representative samples of the same process and construction with combinations of covercoat and overcoat materials.

12.7.3.9 Cover material shall not be present on the external surfaces of the construction, so that the conductive paste adhesion test can be conducted without obstruction of base dielectric film.

12.7.3.10 Samples shall be provided with contacts, if contacts are intended in production.

12.7.3.11 Samples shall be provided with plated through-holes, if plated through-holes are intended in production.

12.7.3.12 Samples shall be provided with through-holes filled with conductive material(s), if through-holes filled with conductive material(s) are intended in production. If constructions will be produced with conductor material applied over through-holes filled with conductive material(s), a sample shall be provided with conductor material applied over through-holes filled with conductive material(s). See Figure 12.8.

Exception: If a sample with conductor material applied over through-holes filled with conductive material(s) is subject to the plating adhesion test, the plating adhesion test need not be repeated on a sample without conductor material applied over through-holes filled with the same conductive material(s).

12.7.3.13 Conductive paste adhesion testing of the minimum build-up construction shall be considered representative of the maximum build-up construction, for investigation of the same base material and conductor material; and, if applicable, the same overcoat or covercoat material.

12.7.4 Apparatus or material

12.7.4.1 Double-faced adhesive tape or an adhesive system with an adhesive strength capable of attaching a rigid supplemental reinforcement material to the test sample for conductive paste adhesion testing shall be used for this test.

Note – The double-faced adhesive tape or adhesive system should be compatible with the materials used in the construction, and should not be detrimental to or adversely affect the materials in the construction.

12.7.4.2 A rigid supplemental reinforcement material to be bonded to the test samples shall be used for this test. The rigid supplemental reinforcement material is intended to eliminate tenting or flexing of the sample during the conductive paste adhesion test.

Note – The reinforcement material should be compatible with the materials used in the construction, and should not be detrimental to or adversely affect the materials in the construction.

12.7.4.3 A steel roller 80 mm ±2.5 mm (3.25 inch) in diameter, 45 mm ±1 mm (1.75 in) wide, and weighing 2000 g ±50 g (4.5 pounds) covered with rubber approximately 6 mm (0.25 in) in thickness shall be used for this test.

12.7.4.4 Pressure-sensitive cellophane tape, 13 mm (0.5 inch) wide, with an adhesion of 0.38 ±0.055 N/mm (35 ±5 oz/inch), as determined by the Standard Test Method for Pressure-Sensitive Adhesive-Coated Tapes Used for Electrical and Electronic Applications, ASTM D 1000, is to be used for this test.

Note: The adhesive tape should be compatible with the material components used in the construction and should not be detrimental to or adversely affect the materials in the construction.

12.7.4.5 A conditioning (convection) oven capable of maintaining the specified conditioning temperature in accordance with 12.7.2.2 shall be used for this test.

12.7.4.6 A cold conditioning chamber capable of maintaining the specified conditioning temperature shall be used for this test.

12.7.4.7 A humidity conditioning chamber capable of maintaining the specified conditioning temperature and relative humidity shall be used for this test.

12.7.5 Procedure

12.7.5.1 Subject the three samples to the Thermal stress test, 12.3.

12.7.5.2 Place the three samples subjected to the thermal stress test in a full-draft circulating-air oven in accordance with 12.7.4.5, for 48 consecutive hours, maintained at a temperature determined by the following formula:

$$t_2 = (t_1 + 10) \pm 2$$

in which:

t_2 is the oven conditioning temperature in °C for 48-hours oven conditioning, and

t_1 is the MOT in °C of the FMIC type.

12.7.5.3 Place the samples in a humidity conditioning oven in accordance with 12.7.4.7 maintained at a temperature of 35.0 ±2.0 °C (95.0 ±3.6 °F) at 90 ±5 percent RH for 64 consecutive hours, immediately following exposure to the thermal conditioning in accordance with 12.7.5.2.

12.7.5.4 Place the samples in a cold chamber in accordance with 12.7.4.6 at 0 -2.0 °C (32.0 -3.6 °F) for eight consecutive hours, immediately following exposure to the humidity conditioning in accordance with 12.7.5.3.

12.7.5.5 Place the samples in a humidity conditioning oven in accordance with 12.7.4.7 maintained at a temperature of 35.0 ±2.0 °C (95.0 ±3.6 °F) at 90 ±5 percent RH for 64 consecutive hours, immediately following exposure to the cold conditioning in accordance with 12.7.5.4.

12.7.5.6 Examine the test samples using normal or corrected 20/20 vision, and record any presence of loosening wrinkles, cracks, blisters, or loose conductors, or delamination in the conductors or insulation material.

12.7.5.7 Repeat the environmental cycling and examination in the steps outlined in 12.7.5.2 – 12.7.5.6 two more times so the samples are exposed to and examined for three complete cycles.

12.7.5.8 Attach a rigid reinforcement material in accordance with 12.7.4.2 to the back-side, the side of the sample not being subjected to the conductive paste adhesion test, of the sample conditioned in accordance with 12.7.5.7 using double-faced adhesive tape or an adhesive system in accordance with 12.7.4.1. The samples shall be subjected to the thermal cycling and examination in accordance with 12.7.5.2 – 12.7.5.6 without any supplemental reinforcement attached; a supplemental reinforcement material shall be applied to the samples only after the thermal cycling.

12.7.5.9 Apply a minimum 50 mm (2 inches) effective test length of pressure-sensitive cellophane tape in accordance with 12.7.4.4, on the sample reinforced in accordance with 12.7.5.8.

Note – The pressure-sensitive cellophane tape shall be applied in an area on the sample so that two additional applications, for a total of three applications, of the pressure-sensitive cellophane tape can be made on new areas of the sample.

12.7.5.10 Use a steel roller in accordance with 12.7.4.2 to remove all air bubbles in the minimum of 50.8 mm (2 inches) minimum effective test length of pressure-sensitive cellophane tape on the conductor pattern, following application of the pressure-sensitive cellophane tape in accordance with 12.7.5.9.

12.7.5.11 Mechanically remove the pressure-sensitive cellophane tape pressed-on in accordance with 12.7.5.10 by gripping one end of the tape, and removing it at a rate of approximately 25.4 mm in 5 seconds (1 inch in 5 seconds) at an angle of approximately 90 degrees to the base material.

12.7.5.12 Examine the pressure-sensitive cellophane tape removed in accordance with 12.7.5.11 using normal or corrected 20/20 vision, and record any presence of any plated or printed conductor pattern material and any presence of plated or printed conductor pattern material attached to covercoat or undercoat material adhering to the pressure-sensitive cellophane tape.

12.7.5.13 Repeat application of the pressure-sensitive cellophane tape in accordance with 12.7.5.9 and removal of air bubbles in the effective test length in accordance with 12.7.5.10. Using new pressure-sensitive cellophane tape for each application, repeat the steps outlined in 12.7.5.9 – 12.7.5.12 in order, two more times. The pressure-sensitive cellophane tape shall be applied on a different untested area of the sample each time, for a total of three applications.

12.7.6 Data collection

12.7.6.1 Record and report the following FMIC information:

a) Solder limits of the FMIC type; and

b) MOT of the FMIC type.

12.7.6.2 The type of conductive paste material being subjected to the conductive paste adhesion test:

a) Copper;

b) Carbon;

c) Silver; or

d) Other, specify _____*_____.

* – Please specify the type of material.

12.7.6.3 The material to which the conductive paste type material is applied:

a) Base material;

b) Conductor material, ____*____;

* – Please specify the type of conductor material.

c) Covercoat or overcoat;

d) Coverfilm;

e) Dielectric material;

f) Adhesive; and

g) Other, specify _____*_____.

* – Please specify the type of material.

12.7.6.4 Record and report the following test data:

a) The presence of any loosening, wrinkles, cracks, blisters, or delamination in the conductors or insulation materials prior to thermal stress or oven conditioning;

b) The test data collected from the thermal stress test (if applicable) in accordance with 12.7.5.1;

c) The conditioning temperature used in accordance with 12.7.5.2;

d) The presence of any loosening, wrinkles, cracks, blisters, or delamination in the conductors or insulation materials in accordance with 12.7.5.6, following:

1) The first cycle of environmental conditioning;

2) The second cycle of environmental conditioning; and

3) The third cycle of environmental conditioning;

e) The type of supplemental reinforcement attached to the samples in accordance with 12.7.5.8, after environmental conditioning in accordance with 12.7.5.7 and prior to application of the pressure-sensitive adhesive tape for the conductive paste adhesion test in accordance with 12.7.5.9;

f) The presence of any plated or printed conductor pattern material adhering to the pressure-sensitive cellophane tape in accordance with 12.7.5.12, for each application of pressure-sensitive adhesive tape in accordance with 12.7.5.13, on each of the three samples, after the:

1) First application of pressure-sensitive adhesive tape;

2) Second application of pressure-sensitive adhesive tape; and

3) Third application of pressure-sensitive adhesive tape.

12.8 Coverlay test

12.8.1 General

12.8.1.1 The purpose of this test method is to provide a consistent procedure for assessing the physical endurance of cover materials and conductors on base materials of FMIC's following exposure to thermal cycling, including thermal conditioning, water immersion, cold, and high humidity environments. The test is designed to assess physical fatigue of test samples exposed to environmental stresses.

12.8.2 Compliance criteria

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

12.8.3 Test Samples

12.8.3.1 Ten (10) samples shall include all material components in accordance with Materials, Section 8, with cover material present on the external surfaces of the samples; and, for the desired construction(s) in accordance with FMIC Constructions, Section 9:

a) Five (5) samples shall include all material components representing a minimum build-up construction with cover material on the external surfaces and

b) Five (5) samples shall include all material components representing a maximum build-up construction with cover material on the external surfaces.

Exception: If the base material, conductor, and cover material for the minimum and maximum build-up construction have been evaluated 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 base material, conductor, and cover material are used in the candidate construction, within the parameter profile indices established from testing in accordance with UL 746E, then testing of the base material and conductor material for the representative maximum build-up construction shall not be repeated.

12.8.3.2 A representative conductor pattern is shown in Figure 12.8, as the typical bond strength test pattern.

12.8.3.3 Conductors on the cover material test samples shall reflect the conductors submitted for the Bond strength test, 12.6.

Exception: Due to the materials thickness and copper weights used to produce the maximum build-up construction samples, the conductor trace average widths on the maximum build-up construction samples submitted for test can be wider than on the minimum build-up construction samples submitted for test.

12.8.3.4 Samples shall be provided with contacts, if contacts are intended in production.

12.8.3.5 Samples shall be provided with plated through-holes if plated through-holes are intended in production.

12.8.3.6 Samples shall be provided with through-holes filled with conductive material(s) if through-holes filled with conductive material(s) are intended in production.

Exception: If samples with conductor material applied over through-holes filled with conductive material(s) are subject to the cover layer test, the coverlay test need not be repeated on samples without conductor material applied over through-holes filled with the same conductive material(s).

12.8.3.7 Samples shall be provided with conductor material applied over through-holes filled with conductive material(s) if constructions will be produced with conductor material applied over through-holes filled with conductive material(s).

12.8.4 Apparatus or material

12.8.4.1 A conditioning (convection) oven capable of maintaining the specified conditioning temperature, in accordance with 12.8.5.1 shall be used for this test.

12.8.4.2 A cold conditioning chamber capable of maintaining conditioning temperature shall be used for this test.

12.8.4.3 A humidity conditioning chamber capable of maintaining the specified conditioning temperature and relative humidity shall be used for this test.

12.8.4.4 A vessel capable of holding liquid water with the test samples completely immersed can be used for this test.

12.8.5 Procedure

12.8.5.1 Place the examined minimum and maximum build-up samples in a full-draft circulating-air oven in accordance with 12.8.4.1 maintained at 71.0 ±2 °C (159.8 ±3.6 °F) for 48 consecutive hours.

12.8.5.2 Immerse the samples in water at 25.0 ±2.0 °C (77.0 ±3.6 °F) for 48 consecutive hours, immediately following exposure to the thermal conditioning in accordance with 12.8.5.1.

12.8.5.3 Place the samples in a cold chamber at minus 35.0 -2.0 °C (minus 31.0 -3.6 °F) for eight consecutive hours, immediately following exposure to the moisture conditioning in accordance with 12.8.5.2.

12.8.5.4 Subject the samples to 40.0 ±2.0 °C (104.0 ±3.6 °F) at 95 – 100 percent RH for 64 consecutive hours, immediately following exposure to the cold conditioning in accordance with 12.8.5.3.

12.8.5.5 Cool the test samples to room temperature at standard ambient laboratory conditions, following humidity conditioning in accordance with 12.8.5.4. 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.

12.8.5.6 Examine the test samples using normal or corrected 20/20 vision, and record any presence of loosening wrinkles, cracks, blisters, or delamination in the conductors or insulation material.

12.8.6 Data collection

12.8.6.1 Record and report the following test data:

a) The presence of any loosening, wrinkles, cracks, blisters, or delamination in the conductors or insulation materials prior to thermal cycling; and

b) The presence of any loosening, wrinkles, cracks, blisters, or delamination in the conductors or insulation material in accordance with 12.8.5.6, following thermal cycling, cooling, and stabilization.

12.9 (Ambient) bend test

12.9.1 Purpose

12.9.1.1 The purpose of this test method is to provide a consistent procedure for bending and assessing the integrity and physical endurance of FMIC's intended for flexible and flex-to-install applications at ambient conditions following exposure to solder limits, and solder limits and thermal conditioning based on the maximum operating temperature. The test is designed to provide a limited assessment of the bend-ability and physical fatigue at ambient conditions of test samples exposed to the anticipated production soldering temperatures and anticipated service temperatures, via elevated temperature conditioning.

12.9.2 Compliance criteria

12.9.2.1 Flexible and flex-to-install constructions shall show no evidence of cracking, splitting, or delamination of the base material, film, adhesive, conductor, bonding film, cover material, dielectric material, laminate, prepreg, and other insulation material when subjected to the bend test at ambient temperature.

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

12.9.3 Test samples

12.9.3.1 Twenty (20) 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:

a) Ten (10) samples shall include all material components representing a minimum build-up construction and

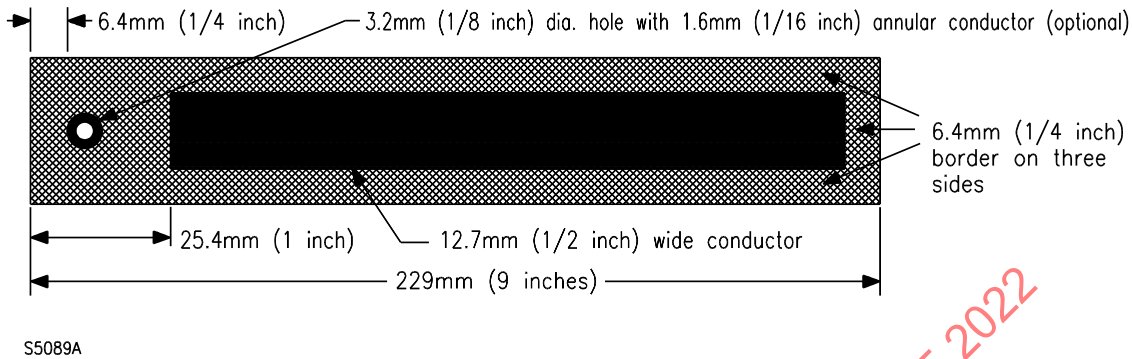
b) Ten (10) samples shall include all material components representing a maximum build-up construction.

12.9.3.2 The test samples shall include the same material components and component thickness used to prepare the minimum and maximum build-up construction samples for the Bond strength test, 12.6.

12.9.3.3 The test sample conductor pattern is shown in Figure 12.9.

Figure 12.9

(Ambient) Bend Test – Sample Configuration



Note – Figure 12.9 drawing is not to scale.

12.9.3.4 Samples shall be tested without imbedded or attached components, such as capacitors and resistors.

12.9.4 Apparatus or material

12.9.4.1 A conditioning (convection) oven capable of maintaining the specified conditioning temperatures in 12.9.5.3 and 12.9.5.4 shall be used for this test.

12.9.4.2 A 6.35 mm (0.25 inch) diameter rigid mandrel, maintained at standard ambient laboratory conditions shall be used for this test.

12.9.5 Procedure

12.9.5.1 Verify the 12.7 mm (1/2 inch) conductor trace average width on the samples.

12.9.5.2 Subject the twenty (20) samples to the Thermal stress test, 12.3.

12.9.5.3 Place five (5) of the minimum build-up construction samples and five (5) of the maximum build-up construction samples subjected to the thermal stress test in accordance with 12.9.5.2 in a full-draft circulating-air oven in accordance with 12.9.4.1, for 240 consecutive hours, maintained at a temperature determined by the following formula:

$$t_2 = 1.076(t_1 + 288) - 273$$

in which:

t_2 is the oven conditioning temperature in °C for 240-hours oven conditioning, and

t_1 is the MOT in °C of the FMIC type.

See Table 12.2 for the 240-hours oven conditioning temperatures corresponding to the desired or established MOT.

12.9.5.4 Place the remaining five (5) minimum build-up construction samples and five (5) maximum build-up construction samples subjected to the thermal stress test in accordance with 12.9.5.2 in a full-draft circulating-air oven in accordance with 12.9.4.1, for 1344 consecutive hours, maintained at a temperature determined by the following formula:

$$t_3 = 1.02(t_1 + 288) - 273$$

in which:

t_3 is the oven conditioning temperature in °C for 1344-hours oven conditioning, and

t_1 is the MOT in °C of the FMIC type.

See Table 12.2 for the 1344-hours oven conditioning temperatures corresponding to the desired or established MOT.

12.9.5.5 Cool the test samples to room temperature.

12.9.5.6 Examine the samples using normal or corrected 20/20 vision, and record any presence of loosening, wrinkles, cracks, blisters, or delamination in the conductors or insulation material.

12.9.5.7 Bend a sample around a 6.35 mm (0.25 inch) diameter rigid mandrel for five completely closed turns, noting where the first turn is completed, following examination in accordance with 12.9.5.6. The first bend shall be initiated at least 25.4 mm (1 inch) away from the end of the sample. Bending of the sample around the mandrel shall be initiated at an angle to the mandrel, such that overlap of the sample is maximized, the sample is intimately wrapped onto the mandrel and previous wrap of sample, and the number of completely closed turns can be easily counted. If a sample has asymmetrical construction, one set of samples will be tested with a surface wrapped to the inside, and another set of samples will be tested with a surface wrapped to the outside.

Note – Due to sample thickness or material rigidity, six turns may be required to establish five completely closed turns; in this case, note where the first turn is initiated and completed.

12.9.5.8 Release the completely closed turns of the sample wrapped around the mandrel in accordance with 12.9.5.7 without altering the resulting configuration or condition of the sample due to the bending around the rigid mandrel.

12.9.5.9 Examine the sample using normal or corrected 20/20 vision, and record any presence of loosening, wrinkles, cracks, blisters, or delamination in the conductors or insulation material.

Note – In the case when six turns are required to establish five completely closed turns, where the first turn was initiated and where the first turn was completed shall be noted. Disregard examination of the sample in the area between where the first turn was initiated and where the first turn was completed, and examine the area of the five completely closed turns following the completion of the first turn.

12.9.5.10 Slowly and carefully flatten the sample by hand, being careful not to crease or fold the sample, and allow the sample to relax, after examining the sample in accordance 12.9.5.9.

12.9.5.11 Examine the sample using normal or corrected 20/20 vision, and record any presence of loosening, wrinkles, cracks, blisters, or delamination in the conductors or insulation material.

Note – In the case when six turns are required to establish five completely closed turns, where the first turn was initiated and where the first turn was completed shall be noted. Disregard examination of the sample in the area between where the first turn was initiated and where the first turn was completed, and examine the area of the five completely closed turns following the completion of the first turn.

12.9.5.12 Repeat the procedure steps outlined in 12.9.5.7 – 12.9.5.11 for the remaining samples examined in accordance with 12.9.5.6.

12.9.6 Data collection

12.9.6.1 Record and report the following FMIC information:

a) Solder limits of the FMIC type; and

b) MOT of the FMIC type.

12.9.6.2 Record and report the following measurement test data in accordance with 12.9.5.1: Verification of the 12.7 mm (0.5 inch) conductor trace average width.

12.9.6.3 Record and report the following test data:

a) The presence of any loosening, wrinkles, cracks, blisters, or delamination in the conductors or insulation materials prior to thermal stress or oven conditioning and

b) Test data collected from the thermal stress test (if applicable) in accordance with 12.9.5.2.

12.9.6.4 Record and report the following test data for samples subjected to 240-hours oven conditioning at temperature t_2:

a) Oven conditioning temperature (t_2) used in accordance with 12.9.5.3;

b) The presence of any loosening, wrinkles, cracks, blisters, or delamination in the conductors or insulation materials:

1) After 240-hours oven conditioning and cooling to room temperature in accordance with 12.6.5.6;

2) After bending the sample around the 6.35 mm mandrel, after releasing the sample from the mandrel, and prior to flattening and allowing the sample to relax in accordance with 12.9.5.9; and

3) After bending the sample around the 6.35 mm mandrel, after releasing the sample from the mandrel, and after flattening the sample then allowing the sample to relax in accordance with 12.9.5.10.

Note – Disregard evaluation of the sample in the area of the first completely closed turn if six turns are required to establish five completely closed turns.

12.9.6.5 Record and report the following test data for samples subjected to 1344-hours oven conditioning at temperature t_3:

a) Oven conditioning temperature (t_3) used in accordance with 12.9.5.4;

b) The presence of any loosening, wrinkles, cracks, blisters, or delamination in the conductors or insulation materials:

1) After 1344-hours oven conditioning or cooling to room temperature in accordance with 12.6.5.6;

2) After bending the sample around the 6.35 mm mandrel, after releasing the sample from the mandrel, and prior to flattening and allowing the sample to relax in accordance with 12.9.5.9; and

3) After bending the sample around the 6.35 mm mandrel, after releasing the sample from the mandrel, and after flattening the sample then allowing the sample to relax in accordance with 12.9.5.10.

Note – Disregard evaluation of the sample in the area of the first completely closed turn, if six turns are required to establish five completely closed turns.

12.10 Cold-bend test

12.10.1 Purpose

12.10.1.1 The purpose of this test method is to provide a consistent procedure for bending and assessing the integrity and physical endurance of FMIC's intended for flexible and flex-to-install applications while at low temperature, following exposure to low temperature conditioning. The test is designed to provide a limited assessment of the bend-ability and physical fatigue at low temperature conditions of test samples exposed to below ambient service temperature conditions.

12.10.2 Compliance criteria

12.10.2.1 Flexible and flex-to-install constructions shall show no evidence of cracking, splitting, or delamination of the film, adhesive, base material, conductor, bonding film, cover material, dielectric material, laminate, prepreg, or other insulation materials when subjected to the bend test at cold temperature.

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

12.10.3 Test samples

12.10.3.1 Ten (10) 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:

a) Five (5) samples shall include all material components representing a minimum build-up construction and

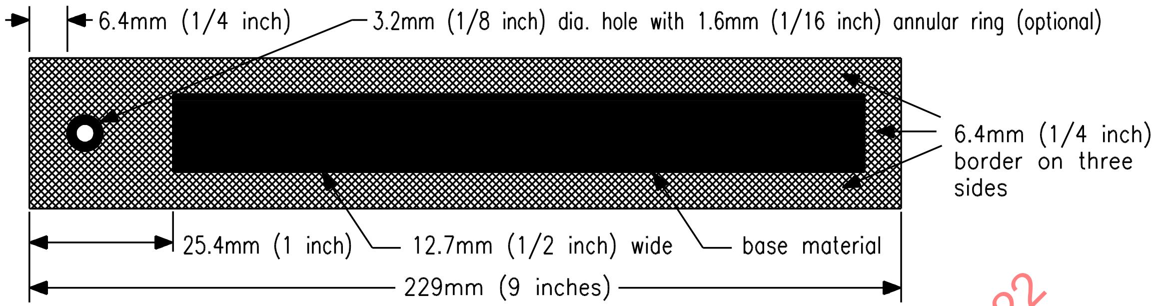
b) Five (5) samples shall include all material components representing a maximum build-up construction.

12.10.3.2 The test samples shall include the same material components and component thicknesses used to prepare the minimum build-up construction and maximum build-up construction samples for the Bond strength test, 12.6.

12.10.3.3 The test sample conductor pattern is shown in Figure 12.10.

Figure 12.10

Cold-Bend Test – Sample Configuration



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Note – Figure 12.10 drawing is not to scale.

12.10.4 Apparatus or material

12.10.4.1 A cold conditioning chamber capable of maintaining the specified conditioning temperature of minus 20 ±2.0 °C (minus 4.0 ±3.6 °F) for a minimum of one hour shall be used for this test.

12.10.4.2 A 6.35 mm (0.25 inch) diameter rigid mandrel maintained at minus 20 ±2.0 °C (minus 4.0 ±3.6 °F) shall be used for this test.

12.10.5 Procedure

12.10.5.1 Verify the 12.7 mm (1/2 inch) conductor trace average width on the samples measured.

12.10.5.2 Subject the samples to minus 20 ±2.0 °C (minus 4.0 ±3.6 °F) for a minimum of 1 hour following examination.

12.10.5.3 Bend a sample around a 6.35 mm (0.25 inch) diameter rigid mandrel for five completely closed turns, noting where the first turn is completed, immediately following exposure to cold conditioning in accordance with 12.10.5.2. The first bend shall be initiated at least 25.4 mm (1 inch) away from the end of the sample. Bending of the sample around the mandrel shall be initiated at an angle to the mandrel, such that overlap of the sample is maximized, the sample is intimately wrapped onto the mandrel and previous wrap of sample, and the number of completely closed turns can be easily counted. If a sample has asymmetrical construction, one set of samples will be tested with a surface wrapped to the inside, and another set of samples will be tested with a surface wrapped to the outside.

Note – Due to sample thickness or material rigidity, six turns may be required to establish five completely closed turns; in this case, note where the first turn is initiated and completed.

12.10.5.4 Release the completely closed turns of the sample wrapped around the mandrel in accordance with 12.10.5.3 without altering the resulting configuration or condition of the sample due to the bending around the rigid mandrel.

12.10.5.5 Examine the sample using normal or corrected 20/20 vision, and record any presence of loosening, wrinkles, cracks, blisters, or loose conductors, or any delamination, wrinkles, cracks, blisters, or delamination in the conductors or insulation material.

Note – In the case when six turns are required to establish five completely closed turns, where the first turn was initiated and where the first turn was completed shall be noted. Disregard examination of the sample in the area between where the first turn was initiated and where the first turn was completed, and examine the area of the five completely closed turns following the completion of the first turn.

12.10.5.6 Slowly and carefully flatten the sample by hand, being careful not to crease or fold the sample, and allow the sample to relax, after examining the sample in accordance with 12.10.5.5.

12.10.5.7 Examine the sample using normal or corrected 20/20 vision, and record any presence of loosening, wrinkles, cracks, blisters, or loose conductors, or any delamination, wrinkles, cracks, blisters, or delamination in the conductors or insulation material.

Note – In the case when six turns are required to establish five completely closed turns, where the first turn was initiated and where the first turn was completed shall be noted. Disregard examination of the sample in the area between where the first turn was initiated and where the first turn was completed, and examine the area of the five completely closed turns following the completion of the first turn.

12.10.5.8 Repeat the procedure steps outlined in 12.10.5.3 – 12.10.5.7 for the remaining samples.

12.10.6 Data collection

12.10.6.1 Record and report the following FMIC information:

a) Solder limits of the FMIC type; and

b) MOT of the FMIC type.

12.10.6.2 Record and report the following measurement test data in accordance with 12.10.5.1: Verification of the 12.7 mm (0.5 inch) conductor trace average width.

12.10.6.3 Record and report the following test data:

a) The presence of any loosening, wrinkles, cracks, blisters, or delamination in the conductors or insulation materials prior to the cold conditioning;

b) The presence of any loosening, wrinkles, cracks, blisters, or delamination in the conductors or insulation materials:

1) After bending the sample around the 6.35 mm mandrel, after releasing the sample from the mandrel, and prior to flattening and allowing the sample to relax in accordance with 12.10.5.5; and

2) After bending the sample around the 6.35 mm mandrel, after releasing the sample from the mandrel, and after flattening the sample then allowing the sample to relax in accordance with 12.10.5.7.

Note – Disregard evaluation of the sample in the area of the first completely closed turn if six turns are required to establish five completely closed turns.

12.11 Repeated flexing test

12.11.1 Purpose

12.11.1.1 The purpose of this test method is to provide a consistent procedure for limited flexing and assessing the integrity, physical endurance, and conductor continuity of FMIC's intended for flexible applications. The test is designed to provide a limited assessment of the flexibility and physical fatigue of test samples exposed to flexing in anticipated ambient service conditions, by flexing a test sample incorporating a continuity circuit pattern.

12.11.2 Compliance criteria

12.11.2.1 Flexible constructions shall show no evidence of cracking, splitting, or delamination of the film, adhesive, base material, conductor, bonding film, cover material, dielectric material, laminate, prepreg, or other insulation material and the continuity circuit shall remain in a closed condition when subjected to 50 cycles of flexing to 180 degrees about a rigid 6.4 mm (1/4 inch) mandrel at standard laboratory ambient conditions.

12.11.3 Test samples

12.11.3.1 Four (4) samples shall include all material components, in accordance with Materials, 8; and, for the desired construction(s) in accordance with FMIC Constructions, Section 9:

a) Two (2) samples shall include all material components representing a minimum build-up construction and

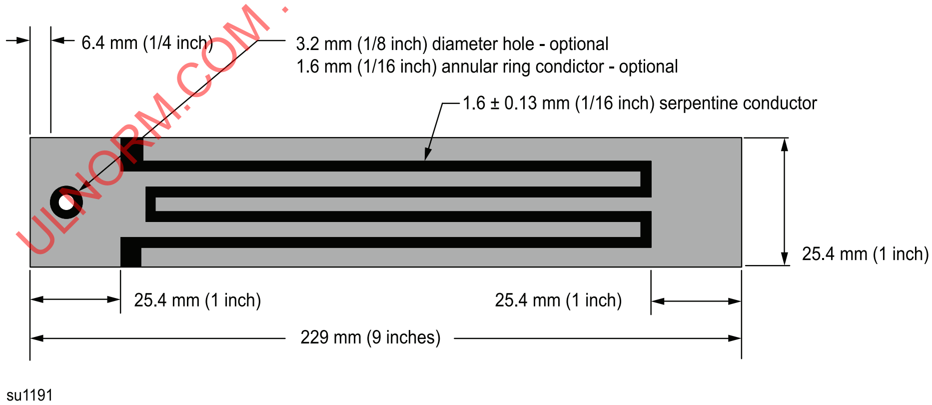
b) Two (2) samples shall include all material components representing a maximum build-up construction.

12.11.3.2 The test samples shall include the same material components and component thicknessses used to prepare the minimum and maximum build-up construction samples for the Bond strength test, 12.6.

12.11.3.3 The test sample conductor pattern without cover material is shown in Figure 12.11, and the test sample with cover material is shown in Figure 12.12.

Figure 12.11

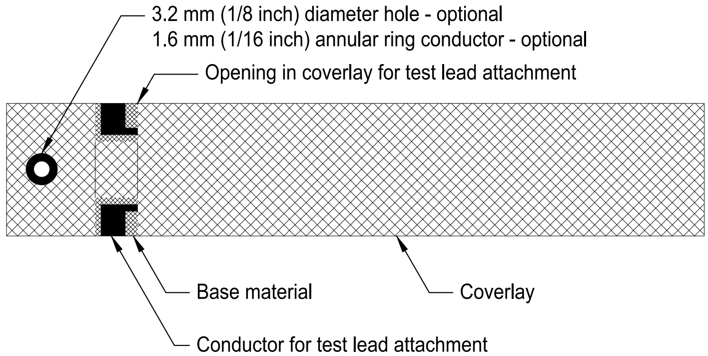
Repeated Flexing Test – Sample Configuration (Without Cover Material)



Note – Figure 12.11 drawing is not to scale.

Figure 12.12

Repeated Flexing Test – Sample Configuration (With Cover Material)



Note – Figure 12.12 drawing is not to scale.

12.11.3.4 Singlelayer Constructions. See Singlelayer, 12.1.3.2.

12.11.3.5 Multilayer Constructions. See Multilayer, 12.1.3.3.

12.11.3.6 Stiffener material may be adhered to test samples, in order to provide additional reinforcement to the end of the sample where the test weight shall be hung from. When additional stiffener material is added, care shall be taken to retain clearance for the test lead attachment, and excessive weight shall not be imposed by the additional stiffener material.

12.11.4 Apparatus or material

12.11.4.1 A device capable of imposing a detector current and identifying an open condition of a continuity circuit shall be used for this test.

12.11.4.2 Two 12.7 mm (0.50 inch) diameter rigid mandrels, maintained parallel, at a fixed distance apart, maintained at standard ambient laboratory conditions shall be used for this test.

12.11.4.3 A minimum weight of 213 g (0.47 lbf) is to be hung from the bottom of the test sample for this test. The weight hung from the test sample is not to exceed the maximum weight of 241 g (0.53 lbf), including any clamp or wire used to hang the weight from the test sample. For referee purposes, a weight of 227 ±14 g (0.5 lbf ±0.5 oz) shall be hung from the bottom of the test sample for this test.

12.11.5 Procedure

12.11.5.1 Verify the equally spaced 1.6 mm (1/16 inch) serpentine conductor trace average widths on the samples.

12.11.5.2 Place one of the samples between two parallel 12.7 mm (0.50 inch) diameter rigid mandrels, with 0.8 mm (1/32 inch) clearance on each side of the sample, so the longitudinal axis of the sample is perpendicular to the parallel mandrels and the surfaces of the sample are parallel to the mandrels. Attach a weight of 227 ±14 g (0.5 lbf ±0.5 oz) to the bottom of the test sample, and allow the weight to hang freely so the bottom of the test sample is at least 25.4 mm (1 inch) below the two mandrels. See Figure 12.13.