UL 796F

STANDARD FOR SAFETY

Flexible Materials Interconnect Constructions

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

Fourth Edition, Dated February 26, 2021

Summary of Topics

This new edition ANSI/UL 796F includes the following changes in requirements:

- ***Clarify the Term Cladding***
- ***Clarify the Term Type***
- ***Clarify References in Sections 8.6 and 8.10 Regarding Base Materials***
- ***Clarify Stiffener Adhesive Requirements***
- ***Clarify Rigid-flex Multilayer Sample Construction Requirements***
- ***Revision to the Stabilization Period Requirements***
- ***Addition of References to Tests Using the Oven Conditioning in 12.1.5.4***
- ***Addition of Alternate Bond Strength Force Determination Method***
- ***Revision to the Dissimilar Dielectric Materials Thermal Cycling Test Procedure***
- ***Revision to Cover Materials Example in Figure 8.3***
- ***Clarification of Requirements for Solder Limit Evaluation for Base Films and FMICs***
- ***Clarify the Polyimide ANSI-like Flammability Program in Section 8.2***
- ***Align Terms Printed Board, Printed Circuit Board, and Printed Wiring Board with Industry Use***
- ***Clarify Reference to Conductor Test Pattern in Section 8.4***
- ***Clarify Dissimilar Material Evaluation for Rigid Flex Constructions***
- ***Editorial Updates***
- ***Align Relative Humidity Percentages with UL 796***
- ***Clarification and Renumbering of Multilayer Mass Laminate Constructions***
- ***Clarification of Production Board Testing***
- ***Revision to Microsection Analysis Based on IPC Test Method***
- ***Clarify the Direct Support Requirements in Section 11.9***
- ***Clarification of Flammability in Section 12.15***
- ***Correct the Reference for Permanent Coating Program***

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated October 16, 2020.

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UL 796F

Standard for Flexible Materials Interconnect Constructions

First Edition – September, 2000
Second Edition – October, 2010
Third Edition – August, 2015

Fourth Edition

February 26, 2021

This ANSI/UL Standard for Safety consists of the Fourth Edition.

The most recent designation of ANSI/UL 796F as an American National Standard (ANSI) occurred on February 23, 2021. 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.

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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.

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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

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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.

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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.

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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.

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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.

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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.

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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.

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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.

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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).

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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.

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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.

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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.

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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:

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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.

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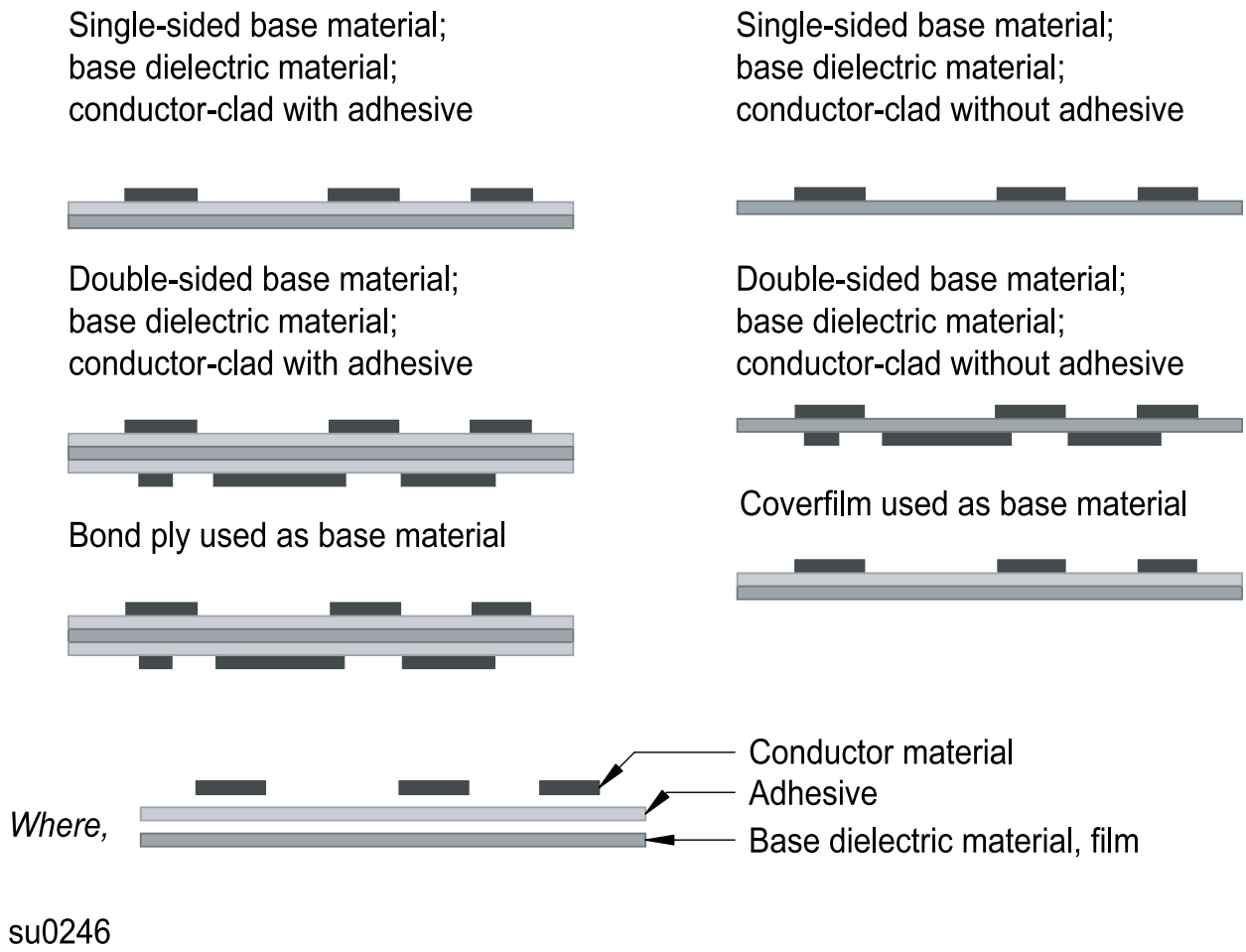
Figure 8.1

Examples of Base Materials, Used in FMIC Constructions



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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.

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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.

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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.

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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

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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

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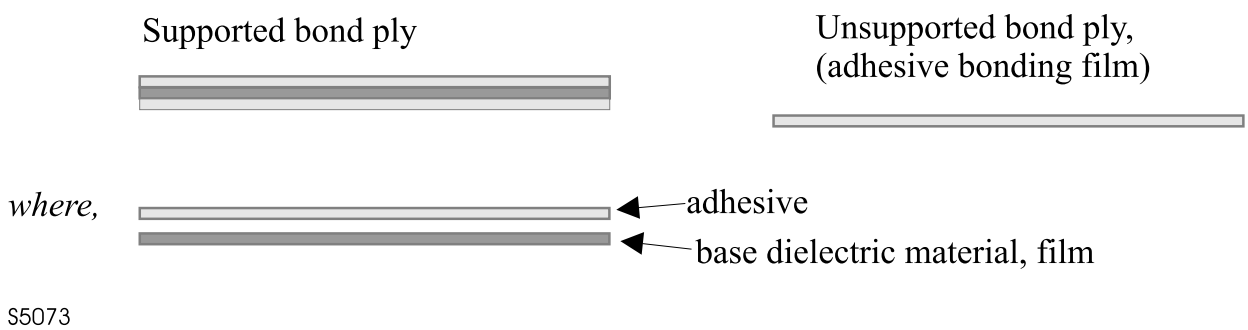
8.5 Bonding film (supported and unsupported) and internal bonding materials

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



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.

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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.

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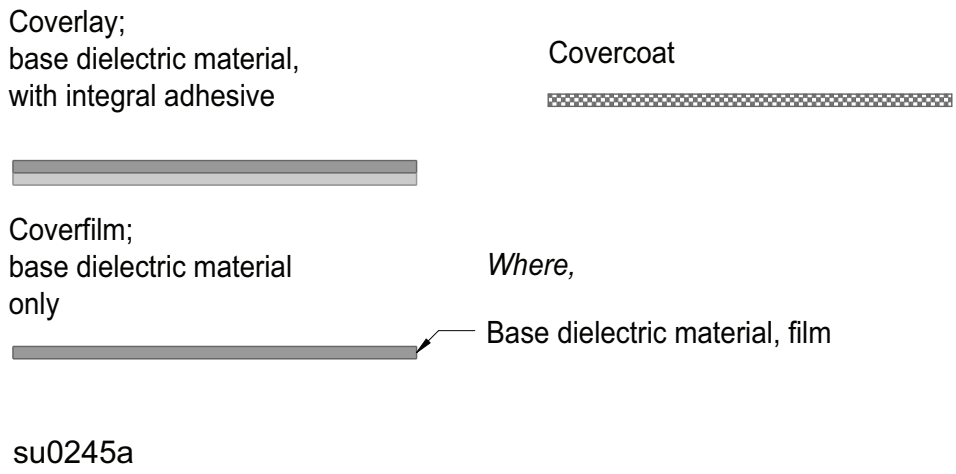
Figure 8.3

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.

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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.

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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.

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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

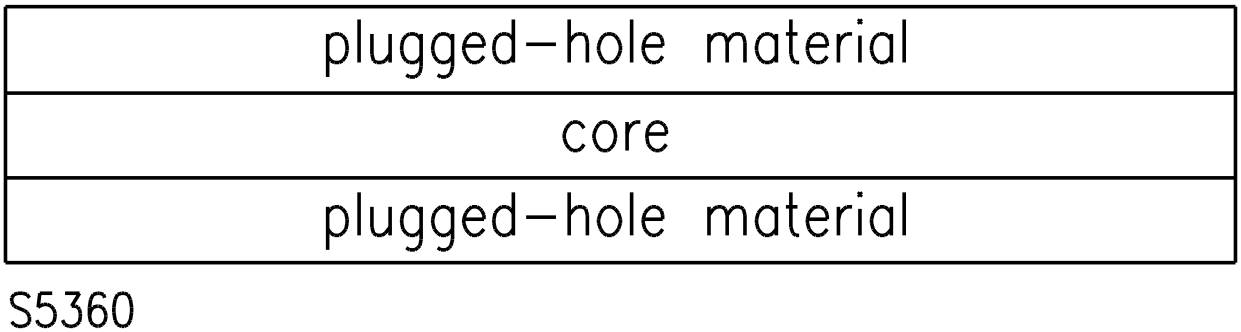
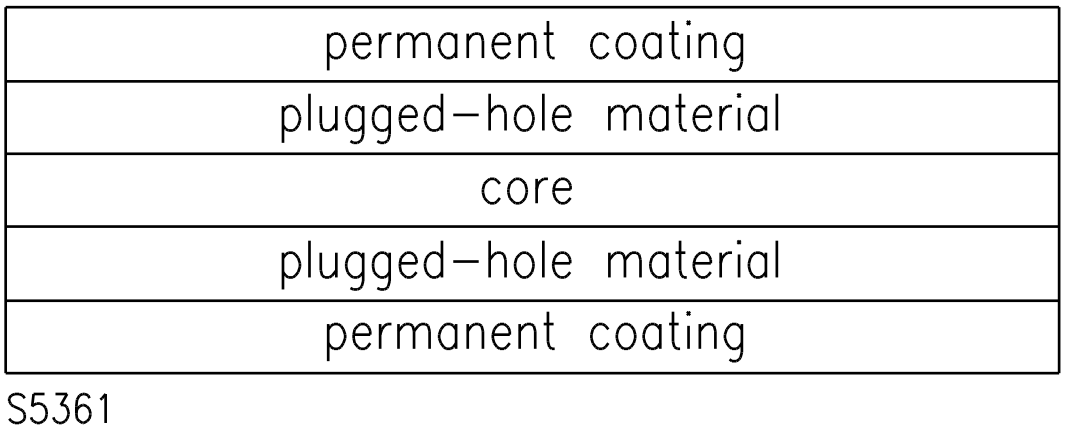


Figure 8.5

Plugged-Hole Material with Permanent Coating

Flammability Sample Construction Example



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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.

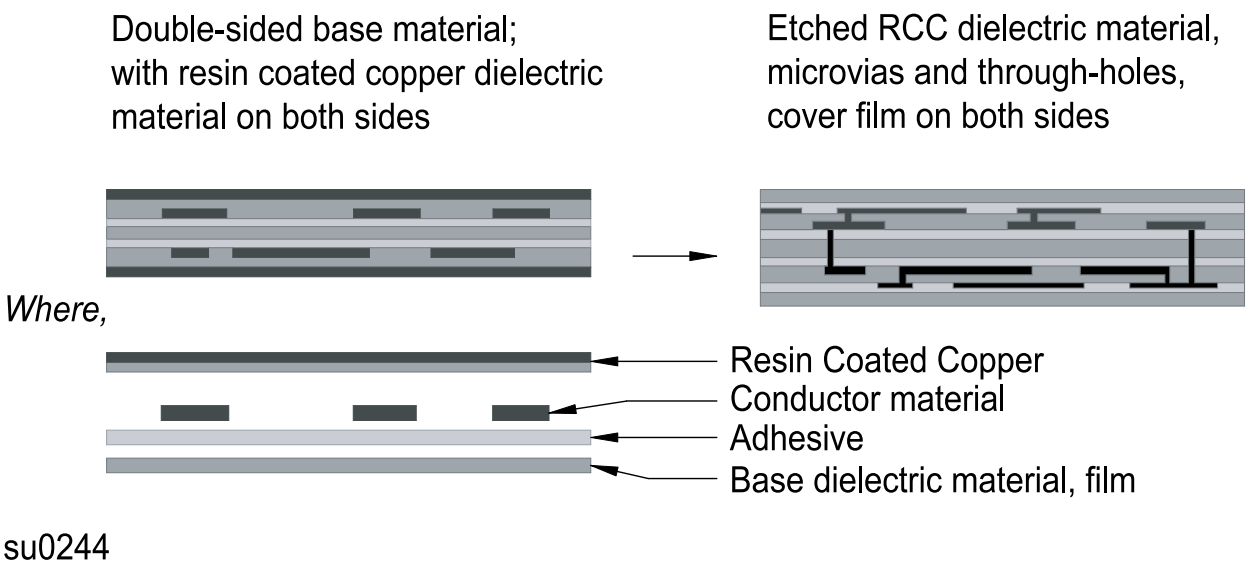
8.9 High density interconnect (HDI) dielectric materials

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



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.

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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)	12.3
	Delamination	12.4
	Bond strength	12.6
Paste type (i.e., polymer thick film, etc.)	Thermal stress (if applicable)	12.3
	Delamination	12.4
	Conductive paste adhesion	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.

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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

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