

UL 796F

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Flexible Materials Interconnect Constructions

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Underwriters Laboratories Inc. (UL)
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UL Standard for Safety for Flexible Materials Interconnect Constructions, UL 796F

First Edition, Dated September 18, 2000

Revisions: This Standard contains revisions through and including September 1, 2006.

Summary of Topics

These revisions to UL 796F are being issued to:

- 1. Clarify the Definition of Immersion Silver;**
- 2. Clarify the Requirement in Paragraph 5.1.2.6.3 for Representative Singlelayer Interconnect Construction Samples; and**
- 3. Clarify the Procedure for the Silver Migration Test Method.**

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Text that has been changed in any manner is marked with a vertical line in the margin. Changes in requirements are marked with a vertical line in the margin and are followed by an effective date note indicating the date of publication or the date on which the changed requirement becomes effective.

The new and revised requirements are substantially in accordance with UL's Proposal(s) on this subject dated June 16, 2006.

The revisions dated September 1, 2006 include a reprinted title page (page1) for this Standard.

As indicated on the title page (page 1), this UL Standard for Safety is an American National Standard. Attention is directed to the note on the title page of this Standard outlining the procedures to be followed to retain the approved text of this ANSI/UL Standard.

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ANSI/UL 796F-2006

1

UL 796F

Standard for Flexible Materials Interconnect Constructions

First Edition

September 18, 2000

The most recent designation of ANSI/UL 796F as an American National Standard (ANSI) occurred on September 1, 2006.

This ANSI/UL Standard for Safety, which consists of the First Edition with revisions through September 1, 2006 is under continuous maintenance, whereby each revision is ANSI approved upon publication. 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 <http://csds.ul.com>.

An effective date included as a note immediately following certain requirements is one established by Underwriters Laboratories Inc.

Revisions of this Standard will be made by issuing revised or additional pages bearing their date of issue. A UL Standard is current only if it incorporates the most recently adopted revisions, all of which are itemized on the transmittal notice that accompanies the latest set of revised requirements.

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1 Introduction

1.1 Scope

1.1.1 These requirements apply to flexible, flex-to-install, rigid, and multilayer rigid flex composite interconnect constructions with and without stiffener and adhesive materials as flexible materials interconnect constructions (FMIC's) for use as components in devices or appliances. Compliance with these requirements does not indicate the product is acceptable for use as a component of an end product without further investigation.

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

1.1.3 Deleted February 12, 2004

1.1.4 The suitability of additional stiffener and adhesive materials, not evaluated in accordance with the Stiffener bond strength test, Section 5.11, and Flammability tests, Section 5.13, are subject to the applicable end-use product construction and performance requirements. See Additional stiffener and adhesive (external bonding) materials, Section 7.12, for marking requirements for FMIC's provided with additional stiffener and adhesive materials.

1.1.4 revised February 12, 2004

1.1.5 Deleted February 4, 2002

1.2 Units of measurement

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

1.3 General

1.3.1 Acceptability of a component FMIC in a device or appliance depends on the acceptability of the construction for:

- a) Continued use under actual service conditions and
- b) All other applicable end-product requirements.

1.3.2 The investigation of an FMIC shall include consideration of the conductor properties, such as shape, minimum width, maximum ground plane area, solder limits, and shall include the conductor forming and materials build-up processes.

1.3.3 Except as indicated in 1.3.4, 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.

1.3.4 If an FMIC is entitled with flammability classification only, the acceptability of the FMIC shall involve only flammability tests. See Flammability tests, Section 5.13.

Revised 1.3.4 effective February 4, 2003

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

1.3.6 An FMIC entitled flex-to-install is intended for use where the interconnect 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 interconnect construction has not been determined or evaluated.

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

1.3.8 Multilayer rigid flex composite constructions may include singlesided, doublesided, singlelayer and multilayer flexible, flex-to-install, rigid interconnect constructions, and printed wiring boards in various sections of an FMIC.

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1.4 Glossary

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

1.4.2 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.

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

1.4.4 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.

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

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

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

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

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

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

1.4.11 BASE MATERIAL THICKNESS – The thickness of the base dielectric material. If an adhesive is used for the base material, the adhesive thickness and number of sides is indicated separately.

1.4.12 BLIND VIA – A via extending to only one surface of the interconnect construction.

1.4.13 BONDING LAYER – An adhesive layer used to bond discrete layers of multilayer interconnect category constructions.

1.4.14 BOND PLY – A thin film, adhesive, thin film and adhesive, or membrane material used to laminate multilayer category interconnect constructions, FMIC's, and printed wiring boards. See also Supported Bond Ply, 1.4.130, and Unsupported Bond Ply, 1.4.137.

1.4.15 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 interconnect construction or FMIC where no internal or external conductor material resides.

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

1.4.17 CALCULATED THICKNESS – The calculated thickness is 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.

- 1.4.18 CIRCUIT – Electrical devices and elements interconnected to perform a desired electrical function.
- 1.4.19 CIRCUITRY LAYER – Conductor layer or plane in or on an interconnect construction.
- 1.4.20 COATING – A non-metallic substance applied by some process, such as dipping, curtain coating, film laminating, screening, spraying, or melt-flow.
- 1.4.21 COMPONENT – An individual or combination of parts intended to perform a desired function.
- 1.4.22 CONDITIONING – Exposure of test samples to an environment for a period of time, prior to or after testing, and prior to evaluation.
- 1.4.23 CONDUCTIVE FOIL – A thin metal sheet intended for forming a conductor pattern on a base material.
- 1.4.24 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.
- 1.4.25 CONDUCTIVITY (ELECTRICAL) – A property exhibited by a material or substance when electricity is transmitted through the material or substance.
- 1.4.26 CONDUCTOR – A trace or path for electricity to transmit in a conductor pattern.
- 1.4.27 CONDUCTOR ADHESIVE – Adhesive material used to attach conductor material to a base material, or base dielectric material.
- 1.4.28 CONDUCTOR AVERAGE TRACE WIDTH – The average width of a length of conductor trace.
- 1.4.29 CONDUCTOR BASE WIDTH – The width of a conductor at the interface of the conductor material and base material.
- 1.4.30 CONDUCTOR LAYER – A single plane of a conductor material or pattern on base material.
- 1.4.31 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.
- 1.4.32 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.
- 1.4.33 CONDUCTOR SPACING – The minimum distance between adjacent conductors.
- 1.4.34 CONDUCTOR THICKNESS – The thickness of the conductor and additional metallic platings or coatings, excluding non-conductive coatings.
- 1.4.35 CONDUCTOR TRACE – A linear conductor path of a conductor circuit.
- 1.4.36 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.
- 1.4.37 CONFORMAL COATING – An insulating, environmentally protective coating capable of conforming to the objects coated.

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

1.4.39 CONSTRUCTION – A variation in flexible materials build-up, including but not limited to film, adhesive, base material, bond ply, cover layer, dielectric material, laminate, pre-preg, or other insulation materials. Variations include singlelayer, multilayer, flexible, flex-to-install, rigid, and multilayer flex/rigid composite constructions.

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

1.4.41 CONTINUITY – An uninterrupted path of electrical current.

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

1.4.43 CORE MATERIAL – The innermost material, interconnect 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.

1.4.44 COVER COAT – A thin coating or membrane material used to cover a conductor pattern, on a base material or dielectric material. Cover coat is not considered a dielectric material.

1.4.45 COVER FILM – A film or a combination of film and adhesive used to cover a conductor pattern, on a base material or dielectric material. The film may be a base dielectric material.

1.4.46 COVER FILM ADHESIVE – Adhesive used with film to prepare cover film.

1.4.47 COVER LAYER – General term used to describe cover film and cover coat materials.

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

1.4.49 CURRENT – The movement or flow of electrons in a conductor due to a voltage potential difference at opposing ends of the conductor.

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

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

1.4.52 DOUBLESIDED – A singlelayer interconnect construction or printed wiring board with conductor pattern on the two external sides of the base material. Sometimes referred to as di-clad.

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

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

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

1.4.56 ELECTROPLATING – See Electrodeposition, 1.4.54.

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

1.4.58 END-PRODUCT – See End-Use Product, 1.4.59.

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

1.4.60 ETCHANT – A chemically reactive solution used to remove portions or all material from a base material or interconnect construction.

1.4.61 ETCHING – The action of chemical, or chemical and electrolytic, removal of conductive or resistive material.

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

1.4.63 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 an interconnect construction or FMIC.

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

1.4.65 FILM – A thin coating or membrane material, usually 0.010 inch (0.25 mm) or less in thickness.

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

Added 1.4.65.1 effective February 4, 2003

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

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

1.4.68 FLEXIBLE MATERIALS INTERCONNECT CONSTRUCTION (FMIC) – An assembly of an interconnect construction, and stiffener and adhesive material, where the assembly is intended for component mounting and interconnection purposes.

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

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

1.4.71 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.

1.4.72 FMIC – See Flexible Materials Interconnect Construction (FMIC), 1.4.68.

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1.4.73 FOIL LAMINATION – A fabrication process for multilayer category interconnect constructions, where the interconnect construction and conductor foil are bonded to the external surface during one operation.

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

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

1.4.76 GROUND – A common reference point for conductor circuits.

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

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

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

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

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

1.4.81.1 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.

1.4.81.1 revised September 1, 2006

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

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

1.4.84 INTERCONNECT CONSTRUCTION – An integral combination of film, adhesive, base material, conductor, bond ply, cover layer, dielectric material, and other insulation material, fabricated to form point-to-point connections in a predetermined arrangement. The interconnect construction does not include stiffener or adhesive (external bonding) materials.

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

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

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

1.4.88 LAMINATE THICKNESS – The thickness of the dielectric material in a singlesided or doublesided singlelayer metal-clad base material.

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

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

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

1.4.92 *Deleted effective February 4, 2003*

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

1.4.94 METAL-CLAD BASE MATERIAL – Base material with integral metal conductor material on one or both sides.

1.4.95 MIDBOARD CONDUCTOR – A conductor spaced more than 0.4 mm (0.016 inch) from the edge of an interconnect construction.

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

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

1.4.98 MULTILAYER – Interconnect 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.

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

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

1.4.101 PATTERN – An arrangement of conductor material on interconnect constructions.

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

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

1.4.104 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.

1.4.105 PLATING (n.) – A chemically or electrochemically deposited metallic coating.

1.4.106 PLATING-UP – The addition of plating material onto existing conductor or plating material.

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1.4.107 POLYMER THICK FILM – Referred to in this Standard as conductive paste.

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1.4.108 PRE-PREG – Fibrous reinforcement material impregnated or coated with a thermosetting resin binder, and consolidated and cured to an intermediate stage semi-solid product (B-stage resin).

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

1.4.110 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.

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

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

1.4.113 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.

1.4.114 PRINTED WIRING BOARD – A completely processed combination of a printed-wiring pattern, including printed components, and the base material.

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

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

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

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

1.4.119 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.

1.4.120 RIGID PRINTED WIRING BOARD – A printed wiring board produced from rigid industrial laminate material.

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

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

1.4.123 SINGLELAYER – Singlelayer interconnect constructions are doublesided constructions with one layer of dielectric material(s) separating the conductor planes, and singlesided constructions with a single conductor plane on one side of a dielectric material(s).

1.4.124 SINGLESIDED – An interconnect construction, FMIC, or printed wiring board with conductor pattern on one side of dielectric material(s).

1.4.124 revised February 12, 2004

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

1.4.126 SOLDER MASK – See Solder Resist, 1.4.127.

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

1.4.128 STIFFENER – An organic or inorganic material used to provide support or strength to interconnect constructions as part of an FMIC.

1.4.129 SUBSTRATE – See Core Material, 1.4.43.

1.4.130 SUPPORTED BOND PLY – A combination of film with integral adhesive on two sides, and a dielectric material used to laminate multilayer category interconnect constructions, FMIC's, and printed wiring boards. See also Bond Ply, 1.4.14, and Unsupported Bond Ply, 1.4.137.

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

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

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

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

1.4.135 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.

1.4.136 TYPE – A designation arbitrarily assigned to an FMIC by the fabricator.

1.4.136.1 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.

1.4.136.1 added February 4, 2002

1.4.137 UNSUPPORTED BOND PLY – A coating or membrane material used to laminate multilayer category interconnect constructions, FMIC's, and printed wiring boards. See also Bond Ply, 1.4.14, and Supported Bond Ply, 1.4.130.

1.4.138 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, 1.4.12, and Buried Via, 1.4.16.

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

1.4.140 X-AXIS – A reference axis, usually horizontal or left-to-right direction in a two dimension coordinate system.

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1.4.141 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.

1.4.142 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 interconnect construction or FMIC.

1.5 Abbreviations

1.5.1 The acronym FMIC appears throughout the Standard, and stands for "Flexible Materials Interconnect Construction." See 1.4.68 for the definition of FMIC.

1.5.2 *Deleted effective February 4, 2003*

1.5.3 The acronym MOT appears throughout the Standard, and stands for "Maximum Operating Temperature." See 1.4.93 for the definition of MOT.

2 Materials

2.1 General

2.1.1 Flexible materials shall be defined as films or materials exhibiting flexible properties.

2.1.2 FMIC test specimens shall be provided for each different manufacturer and each different grade of material, for each material component, except as described in 2.1.4.

2.1.3 Each combination of materials, and each applicable material component, film, adhesive, base material, conductor material, bond ply, cover layer, dielectric material, laminate, pre-preg, and other insulation material in a fabricated FMIC shall be determined to be acceptable for use in the intended interconnect construction (sub-category) application.

Exception: For the intended application, if the applicable materials, film, adhesive, base material, conductor material, bond ply, cover layer, dielectric material, laminate, pre-preg, and other insulation material in the minimum build-up interconnect construction and maximum build-up interconnect construction have already been evaluated to the applicable testing 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 combination is used within the parameter profile indices established when tested in accordance with UL 746E, then the (Ambient) bend test, Section 5.8; Cold-bend test, Section 5.9; and Repeated flexing test, Section 5.10; need not be conducted and only the Bond strength test, Section 5.5; Cover layer test, Section 5.7; and Flammability tests, Section 5.13; of the minimum build-up interconnect construction shall be conducted for the FMIC type.

2.1.4 Film, adhesive, base material, bond ply, cover layer, dielectric material, coating, laminate, pre-preg, and other insulation material used as a base material, dielectric barrier, and stiffener for an FMIC shall have acceptable electrical and mechanical properties at the MOT of the FMIC type. The electrical and mechanical relative temperature indices shall be determined in accordance with the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B.

Exception: Film, adhesive, base material, bond ply, cover layer, dielectric material, coating, laminate, pre-preg, and other insulation material used as a base material, dielectric barrier, and stiffener materials in an FMIC type, evaluated for flammability classification only without consideration of an MOT, need not possess electrical and mechanical relative temperature indices.

Revised 2.1.4 effective February 4, 2003

2.1.5 Suggested values for the MOT include 90, 105, 130, and 150°C (194, 221, 266, and 302°F), and shall not exceed the electrical or mechanical relative temperature indices of the base material and when applicable, film, adhesive, bond ply, cover layer, dielectric material, coating, laminate, pre-preg, or other insulation material when used as a dielectric barrier, substrate for conductors, or stiffener.

2.1.6 Each combination of materials, including each applicable material component, film, adhesive, base material, conductor material, bond ply, cover layer, dielectric material, coating, laminate, pre-preg, and other insulation material in the fabricated FMIC shall be determined to have the same or higher flammability classification as the FMIC type.

2.1.7 The least favorable of all electrical indexing values of the individual base materials in the interconnect construction shall be the electrical indexing values for the FMIC type, for each combination of materials, including each applicable material component, film, adhesive, base material, conductor material, bond ply, cover layer, coating, laminate, pre-preg, and other insulation material.

2.1.8 If the base material, bond ply, and cover film are manufactured with the same base dielectric material and adhesive (if applicable), and the same conductor material is laminated, adhered, or 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 bond ply and cover film.

2.1.9 Each manufacturer and each grade of stiffener adhesive (external bonding) material and each manufacturer and each grade of stiffener shall be evaluated in accordance with Stiffener and adhesive (external bonding) materials, Section 2.8.

2.2 Base materials

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

2.2.2 Base materials shall include but not be limited to base dielectric materials, films, and substrate materials supporting conductor material. Materials such as bond ply, cover layer, dielectric material, laminate, pre-preg, and other insulating material when used to support conductor material shall be considered base material. See Figure 2.2.1 for examples of base materials used in interconnect constructions.

Figure 2.2.1

Examples of base materials, used in interconnect constructions

Singlesided base material;
base dielectric material;
conductor-clad with adhesive



Singlesided base material;
base dielectric material;
conductor-clad without adhesive



Doublesided base material;
base dielectric material;
conductor-clad with adhesive



Doublesided base material;
base dielectric material;
conductor-clad without adhesive



Bond ply used as base material

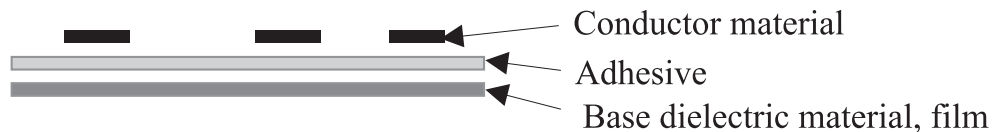


Cover film used as base material



Where,

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2.2.3 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 on one side or two sides of the base material.

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

2.2.5 Adhesive materials used to bond or adhere conductor material to the base dielectric material shall comply with Conductors and conductor adhesives, Section 2.3.

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

2.2.7 The minimum and maximum thickness of each type of conductor shall be identified for each base material type and thickness.

2.2.8 Test samples shall be provided for each different manufacturer and each different grade of base material in the FMIC.

Exception: If the base material in combination with the applicable film, adhesive, conductor material, bond ply, cover layer, laminate, pre-preg, and other insulating material in the minimum build-up interconnect construction and maximum build-up interconnect construction have already been evaluated to the applicable testing 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, for the applicable FMIC, and if the same materials combination is used within the parameter profile indices established in accordance with the UL 746E testing conducted, with regard to the bond strength between the base material and conductor material after thermal shock and thermal conditioning, including the Bond strength test, Section 5.5; (Ambient) bend test, Section 5.8; Cold-bend test, Section 5.9; Repeated flexing test, Section 5.10; Cover layer test, Section 5.7; and Flammability tests, Section 5.13; and:

- a) The FMIC fabricator shall have been previously investigated for an interconnect construction using a generically similar base material, or material build-up with external surfaces of the same base material, via test coupons produced from the representative production process, and tested for parameter profile indices including MOT, solder limits, minimum build-up thickness, conductor thickness, and conductor pattern limits equal to or exceeding the parameter profile indices of the candidate base material;*
- b) The MOT established for the FMIC type shall remain unchanged, and shall not exceed the MOT established for the base material in the same thickness*
- c) The solder limits for the FMIC type shall remain unchanged, and shall not exceed the solder limits established for the base material grade;*
- d) The pattern limits of the FMIC type shall remain unchanged; and*
- e) The conductor material, number of sides with conductor material, and minimum and maximum thickness of conductor material for the FMIC type shall be within the same range established for the base material grade,*

then the (Ambient) bend test, Section 5.8; Cold bend test, Section 5.9; and Repeated flexing test, Section 5.10; need not be conducted and only the Bond strength test, Section 5.5; Cover layer test, Section 5.7; and Flammability tests, Section 5.13; of the minimum build-up interconnect construction shall be conducted for the FMIC type.

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2.2.9 If a difference in a grade designation or catalog number of the same base 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 base material performance profile indices, samples need not be provided for both base materials and a separate unique Type designation is not required for the FMIC type.

2.2.10 The base material or base dielectric material shall have been previously determined to have acceptable mechanical and electrical relative temperature indices at or above the MOT of the FMIC type, or long term thermal aging shall be conducted in accordance with the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B, to establish appropriate relative temperature indices.

Exception: Base material or base dielectric material in a fabricated FMIC type, evaluated for flammability classification only, without consideration of an MOT, need not possess electrical and mechanical relative temperature indices.

Revised 2.2.10 effective February 4, 2003

2.2.11 The base material or base dielectric film shall have acceptable mechanical and electrical properties, at the MOT of the FMIC type. Suggested values for the MOT include 90, 105, 130, and 150°C (194, 221, 266, and 302°F), but shall not exceed the MOT or relative temperature indices established for the base material.

2.2.12 Each base material shall comply with the mechanical tests specified in Table 2.2.1, according to the conductor and base materials in the construction.

Table 2.2.1
Base material tests based on type of conductor material

Conductor material type	Tests	Section
Clad-conductors (i.e., copper, etc.)	Thermal shock (if applicable)	5.2
	Delamination	5.3
	Bond strength	5.5
Paste type (i.e., polymer thick film, etc.)	Thermal shock (if applicable)	5.2
	Delamination	5.3
	Conductive paste adhesion	5.6
Platings	Plating adhesion	5.4

2.2.13 Additionally, each base material in combination with each applicable combination of materials, films, adhesives, bond ply, cover layer, dielectric material, and other insulation material intended in the interconnect construction shall comply with the mechanical tests specified in Table 2.2.2 according to the intended interconnect construction sub-category. See the Exceptions to 2.2.8 and 2.2.10.

Table 2.2.2
Base material tests based on interconnect construction sub-category

Table 2.2.2 revised February 12, 2004

Tests	Section	Interconnect construction sub-category		
		Flexible	Flex-to-install	Rigid
Cover layer test	5.7	Yes	Yes	Yes
(Ambient) bend test	5.8	Yes	Yes	Not applicable
Cold-bend test	5.9	Yes	Yes	Not applicable
Repeated flexing test	5.10	Yes	Not applicable	Not applicable

2.2.14 Each base material shall comply with the optional 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.

2.2.15 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 film exceeds the flammability classification of the base material, the flammability classification of base material in combination with cover film shall exceed the flammability classification of base material yet the same cover film must be applied to the same base material.

2.2.16 Each base material shall be subject to identification by infrared analyses. If a base dielectric material is coated with adhesive on one or both sides, the base dielectric material and adhesive shall be subject to identification by infrared analyses, independently. Each adhesive shall be subject to identification by infrared analyses.

Exception: If the base 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, and identification analyses have been conducted, infrared analyses shall not be repeated.

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

2.2.18 When the metal clad base material has been previously investigated for flammability classification of the base material (after etching off the cladding metal and after thermal shock) 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 – Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials Used in Printed Wiring Boards, UL 746E, testing is not required to add alternate base materials to an established Flammability Only FMIC when the metal-clad base material 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 or shall be adhesiveless;

- 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 solder limits are equal to or higher than previously evaluated with the FMIC;
- f) The alternate film shall have a V-0 or VTM-0 flammability rating; and
- g) The alternate film and adhesive combination shall have a flammability rating equal to the previous flammability rating of the FMIC.

2.2.18 added September 15, 2005

2.3 Conductors and conductor adhesives

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

2.3.2 Conductors shall include, but are not limited to, etched, die-stamped, pre-cut, flush-press, additive-type, adhesive backed, aluminum, copper, copper alloy, copper paste, carbon, carbon paste, gold, silver, silver paste, tin, tin/lead, ruthenium oxide, and other conductive material having similar conductive or corrosion resisting properties.

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

2.3.4 Representative test samples shall be provided for each conductor weight range or conductor weight for the FMIC type.

2.3.5 A retest is necessary if the weight of the conductive material 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 Bond strength test, Section 5.5, or Conductive paste adhesion test, Section 5.6, depending upon the type of conductor material.

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

2.3.7 For external copper weights up to and including 3 oz/ft² (915 g/m²), the minimum copper weight to be used in production may be considered representative of this copper weight range for evaluation of the Bond Strength Property only. The minimum and maximum external copper weight shall be evaluated for each of the following tests requiring copper on the base film:

- a) Cover layer test, Section 5.7;
- b) (Ambient) bend test, Section 5.8;
- c) Cold-bend test, Section 5.9; and

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d) Repeated flexing test, Section 5.10.

If the minimum copper weight to be used in production for an external-surface conductor is less than 1 oz/ft² (305 g/m²), the minimum copper weight shall be plated with copper as close as possible to a total thickness representative of a weight of 1 oz/ft² for bond strength test purposes, and is then representative of weights up to and including 3 oz/ft².

2.3.7 revised September 15, 2005

2.3.8 For copper weights greater than 3 oz/ft² (915 g/m²), an additional set of test samples including the heaviest copper weight to be used in production may be considered representative of copper weights down to 3 oz/ft².

2.3.9 A retest is necessary if the copper 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, Section 5.3, and Bond strength test, Section 5.5, (Ambient) bend test, Section 5.8, Cold-bend test, Section 5.9, and Repeated flexing test, Section 5.10. See Conductor weight, Section 6.7; Conductor width, Section 6.8; and Maximum area conductor diameter, Section 6.9; 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 – 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.

2.3.9 revised September 15, 2005

2.3.10 A separate set of conductor pattern limits can be established for a unique copper weight or range for the FMIC type.

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

2.3.12 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.

2.3.13 Conductor test patterns shall include sizes, platings, and contacts in a configuration specified by the fabricator. See Figure 5.5.1 for a typical conductor test pattern.

2.3.14 The conductor width dimension shall be measured as described in Data collection, Section 5.1.4.

2.3.15 A conductor pattern shall include a mid-board conductor of the minimum width to be produced, and a mid-board conductor may terminate with its smallest dimension at the edge of an FMIC. See Figure 5.5.1 for additional information concerning mid-board conductors.

2.3.16 Deleted September 15, 2005.

2.3.17 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 5.5.1) 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.

2.3.18 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, Section 5.5. Test coupons need contain only the reduced minimum width conductors. Multilayer interconnect constructions shall include internal mirror image conductors, yet the internal mirror image conductors need not be the same width.

2.3.18 revised September 15, 2005

2.3.19 The solid, unpierced circle of conductive material depicted in Figure 5.1.6 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.

2.3.20 If a pattern representing the maximum area conductor diameter does not conveniently fit within the bond strength test coupon overall size dimensions, an additional set of test samples with a pattern representing the maximum area conductor diameter shall be tested.

2.3.21 A retest is necessary if an increase in the maximum area conductor diameter is desired. Testing shall be in accordance with the Delamination test, Section 5.3. Samples shall include a pattern representing the maximum area conductor diameter. Multilayer interconnect constructions shall include an internal mirror image maximum area conductor diameter.

2.3.22 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.

2.3.23 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.

2.3.24 Silver, carbon, and copper conductive paste materials are not represented by other platings, and each conductive paste shall be provided on each base material for test. Conductors consisting of conductive paste materials shall be investigated for Conductive paste adhesion test, Section 5.6.

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.

2.3.24 revised September 15, 2005

2.3.25 Conductors consisting of silver, silver plating, or silver paste shall be investigated for silver migration in accordance with Silver migration test, Section 5.12, when it is determined a hazardous condition could exist in the end-product due to metal migration of silver conductors.

Exception: Boards intended for flammability classification only or boards employing conductors coated with Immersion Silver need not be subjected to the Silver migration test, Section 5.12.

2.3.25 revised September 15, 2005

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

2.3.27 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.

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

2.3.29 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, identification of the manufacturer and grade designation of the adhesive material shall not be repeated.

2.3.30 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, and identification analyses have been conducted on the adhesive, infrared analyses shall not be repeated.

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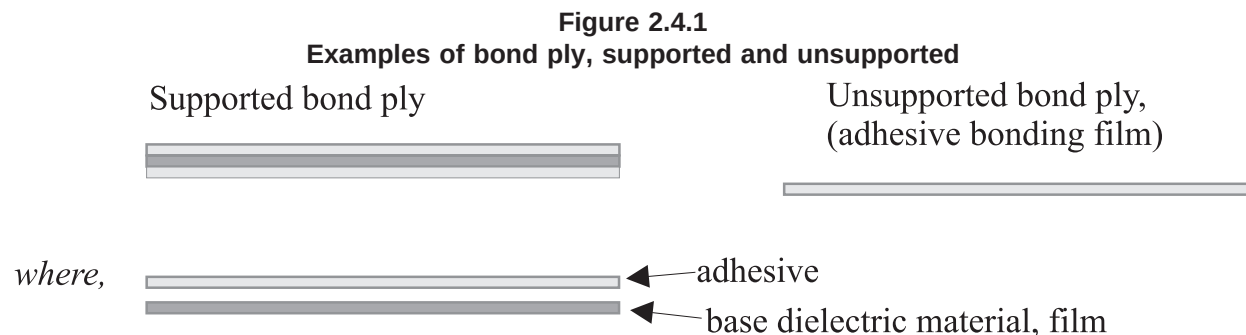
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2.4 Bond ply (supported and unsupported) and internal bonding materials

2.4.1 Reference to bond ply in this Standard shall apply to materials used to laminate and adhere materials together.

2.4.2 Bond ply materials shall include film, adhesive, and other insulation materials used to laminate and adhere materials together. Supported bond ply shall include materials such as base dielectric materials coated with adhesive on two sides, and unsupported bond ply materials shall include materials such as adhesive bonding film. See Figure 2.4.1 for examples of bond ply materials.



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2.4.3 When conductor material is laminated or adhered directly to bond ply as a base dielectric material, the resultant combination of bond ply and conductor material is considered base material. See Base materials, Section 2.2.

2.4.4 Undercoat and pre-preg shall not be considered bond ply material.

2.4.5 Bond ply thickness describes the thickness of base dielectric material with adhesive on two sides, or the thickness of adhesive bonding film, without conductor material. For bond ply made from base dielectric material with adhesive on two sides, the base dielectric material and adhesive thicknesses shall be specified separately.

2.4.6 An adhesive used to bond, laminate, or adhere materials together shall be identified, including the manufacturer's name and grade designation of the adhesive material.

2.4.7 Bond ply, 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, or long term thermal aging shall be conducted in accordance with the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B, to establish appropriate relative temperature indices.

2.4.8 Test specimens shall be provided for each different manufacturer and each different grade of bond ply in the FMIC.

Exception: If the bond ply material in combination with the applicable film, adhesive, conductor material, cover layer, laminate, pre-preg, and other insulating material in the minimum build-up interconnect construction and maximum build-up interconnect construction have 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, for the applicable FMIC, and if the same materials combination is used within the parameter profile indices established in accordance with the UL 746E testing conducted, with regard to the bond strength between the base material and conductor material after thermal shock and thermal conditioning, including Bond strength test, Section 5.5; (Ambient) bend test, Section 5.8; Cold-bend test, Section 5.9; Repeated flexing test, Section 5.10; Cover layer test, Section 5.7; Flammability tests, Section 5.13; and:

- a) The FMIC fabricator shall have been previously investigated for an FMIC using a generically similar bond ply material, or if applicable a material or interconnect construction build-up with external surfaces of the same bond ply, via test coupons produced from the representative production process, and tested for parameter profile indices including MOT, solder limits, minimum build-up thickness, conductor thickness, and conductor pattern limits equal to or exceeding the parameter profile indices of the candidate bond ply;*
- b) The MOT established for the FMIC type shall remain unchanged, and shall not exceed the MOT established for the bond ply material in the same thickness;*
- c) The solder limits for the FMIC type shall remain unchanged, and shall not exceed the solder limits established for the bond ply material grade;*
- d) The pattern limits of the FMIC type shall remain unchanged; and*
- e) If applicable, the minimum and maximum thickness of conductor material for the FMIC type shall be within the same range established for the bond ply material grade,*

then the (Ambient) bend test, Section 5.8; Cold-bend test, Section 5.9; and Repeated flexing test, Section 5.10; need not be conducted and only the Bond strength test, Section 5.5; Cover layer test, Section 5.7; and Flammability tests, Section 5.13; in the minimum build-up interconnect construction shall be conducted for the FMIC type.

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2.4.9 If a difference in a grade designation or catalog number of the bond ply 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 parameter profile indices of the bond ply or bond ply in combination with base material, and cover layer, if applicable, samples need not be provided for both grades of bond ply and a separate unique Type designation is not required for the FMIC type.

2.4.10 The bond ply shall have been previously determined to have acceptable mechanical and electrical relative temperature indices at or above the MOT of the FMIC type, or long term thermal aging shall be conducted in accordance with the Standard for Polymeric Materials – Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials Used in Printed Wiring Boards, UL 746E, to establish appropriate relative temperature indices.

Exception No. 1: Bond ply in a fabricated FMIC type, evaluated for flammability classification only, without consideration of an MOT, need not possess electrical and mechanical relative temperature indices.

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 the two sides of the base dielectric material need not possess mechanical and electrical relative temperature indices.

Revised 2.4.10 effective February 4, 2003

2.4.11 Bond ply shall have acceptable mechanical and electrical properties at the MOT of the FMIC type. Suggested values for the MOT of the FMIC type include 90, 105, 130, and 150°C (194, 221, 266, and 302°F), but shall not exceed the MOT or relative temperature indices established for the bond ply or base material.

Exception: Bond ply shall possess an MOT, or testing shall be conducted to establish the MOT of bond ply in combination with base material, film, adhesive, dielectric material, cover layer, and other insulation material intended in the FMIC type. The MOT shall apply only to the specific material combination and build-up thickness tested, and shall not exceed the MOT of the base material.

2.4.12 Each bond ply used as a base material shall comply with the mechanical tests specified in Table 2.4.1, according to the type of conductor material in the construction.

Table 2.4.1
Tests for bond ply used as base material, based on type of conductor material

Conductor material type	Tests	Section
Clad-conductors (i.e., copper, etc.)	Thermal shock (if applicable)	5.2
	Delamination	5.3
	Bond strength	5.5
Paste type (i.e., polymer thick film, etc.)	Thermal shock (if applicable)	5.2
	Delamination	5.3
	Conductive paste adhesion	5.6
Platings	Plating adhesion	5.4

2.4.13 Each bond ply in combination with each applicable combination of film, adhesive, base material, cover layer, dielectric material, and other insulation material intended in the interconnect construction shall comply with the following mechanical tests specified in Table 2.4.2, according to the intended interconnect construction sub-category. See the Exceptions to 2.4.8 and 2.4.10.

Table 2.4.2
Tests for bond ply used as base material, based on interconnect construction sub-category

Table 2.4.2 revised February 12, 2004

Tests	Section	Construction sub-category		
		Flexible	Flex-to-install	Rigid
Cover layer test	5.7	Yes	Yes	Yes
(Ambient) bend test	5.8	Yes	Yes	Not applicable
Cold-bend test	5.9	Yes	Yes	Not applicable
Repeated flexing test	5.10	Yes	Not applicable	Not applicable

2.4.14 Each bond ply shall comply with the optional 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.

2.4.15 Each bond ply in combination with each applicable combination of base material, film, adhesive, bond ply, dielectric material, and other insulation material intended in the interconnect construction shall comply with the optional 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.

2.4.15 revised July 9, 2004

2.4.16 The flammability classification of the FMIC type shall not exceed the flammability classification determined for the bond ply, and the bond ply flammability classification determined for the fabricator shall not exceed the flammability classification established for the bond ply material manufacturer.

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

2.4.17 Each bond ply shall be subject to identification by infrared analyses. If a base dielectric material is coated with adhesive on both sides, the base dielectric material and adhesive shall be subject to identification by infrared analyses, independently. Each adhesive bonding film shall be subject to identification by infrared analyses.

Exception: If the bond ply has already been evaluated to the applicable testing 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 identification analyses have been conducted, infrared analyses shall not be repeated.

2.4.18 The bond ply material, 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, and voids.

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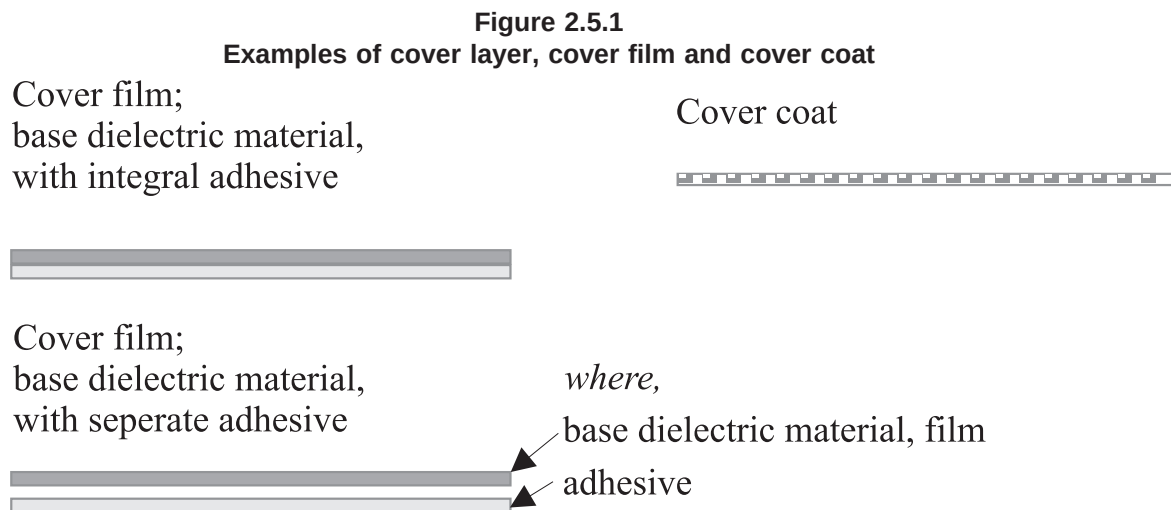
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2.5 Cover layer (cover film and cover coat)

2.5.1 Reference to cover layer in this Standard shall apply to insulating materials used to partially or entirely cover a conductive pattern on the outer surface(s) of an interconnect construction or FMIC.

2.5.2 Cover layer shall be a cover film or cover coat material, and shall include film, adhesive, coating, and other insulation materials used to partially or entirely cover a conductive pattern on the outer surface(s) of an interconnect construction or FMIC. See Figure 2.5.1 for examples of cover layer materials.



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2.5.3 Solder mask, solder resist, and overcoat are not considered a cover layer. If the solder resist is being used in a flexible or flex-to-install construction, the material shall be evaluated as a cover coat. See Solder resist and solder mask, Section 2.6.

2.5.3 revised July 9, 2004

2.5.4 Marking ink or flux are not considered a cover layer or protective coating.

2.5.5 When conductor material is laminated or adhered directly to cover layer as base dielectric material, the resultant combination of cover layer and conductor materials is considered base material. See Base materials, Section 2.2.

2.5.6 Cover layer thickness describes the thickness of base dielectric material with adhesive on one side, or the thickness of cover coat, without conductor material. For cover layer of separate base dielectric material and adhesive, the base dielectric material and adhesive thickness shall be specified separately.

2.5.7 Cover layer, 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, or long term thermal aging shall be conducted in accordance with the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B, to establish appropriate relative temperature indices.

2.5.8 Test specimens shall be provided for each different manufacturer and each different grade of cover layer intended for use with the FMIC.

Exception: If the cover layer material in combination with the applicable film, adhesive, base material, conductor material, bond ply, laminate, pre-preg, and other insulating material in the minimum build-up construction and maximum build-up construction have already been evaluated to the applicable testing 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, for the applicable FMIC, and if the same materials combination is used within the parameter profile indices established in accordance with the UL 746E testing conducted, with regard to the bond strength between the base material and conductor material after thermal shock and thermal conditioning, including Bond strength test, Section 5.5; (Ambient) bend test, Section 5.8; Cold-bend test, Section 5.9; Repeated flexing test, Section 5.10; Cover layer test, Section 5.7; and Flammability tests, Section 5.13; and:

- a) The FMIC fabricator shall have been previously investigated for an FMIC using a generically similar cover layer material, or if applicable a material or interconnect construction build-up with external surfaces of the same cover layer, by test samples produced from the representative production process, and tested for parameter profile indices including maximum operating temperature, solder limits, minimum build-up thickness, and if applicable the conductor thickness and pattern limits, equal to or exceeding the parameter profile indices of the candidate cover layer;*
- b) The MOT established for the FMIC type shall remain unchanged, and shall not exceed the MOT established for the cover layer material in the same thickness;*
- c) The solder limits for the FMIC type shall remain unchanged, and shall not exceed the solder limits established for the cover layer material grade;*
- d) The pattern limits of the FMIC type shall remain unchanged; and*
- e) If applicable, the minimum and maximum thickness of conductor material for the FMIC type shall be within the same range established for the cover layer material grade;*

then the (Ambient) bend test, Section 5.8; Cold-bend test, Section 5.9; and Repeated flexing test, Section 5.10; need not be conducted and only the Bond strength test, Section 5.5; Cover layer test, Section 5.7; and Flammability tests, Section 5.13; in the minimum build-up interconnect construction shall be conducted for the FMIC type.

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2.5.9 If a difference in a grade designation or catalog number of the cover layer 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 parameter profile indices of the cover layer or cover layer in combination with base material, samples need not be provided for both grades of cover layer and a separate unique Type designation is not required for the FMIC type.

2.5.10 Deleted September 15, 2005.

2.5.11 Deleted September 15, 2005.

2.5.12 Each cover layer used as a base material shall comply with the mechanical tests specified in Table 2.5.1, according to the type of conductor material in the construction.

Table 2.5.1
Tests for cover layer used as base material, based on type of conductor material

Conductor material type	Tests	Section
Clad-conductors (i.e., copper, etc.)	Thermal shock (if applicable)	5.2
	Delamination	5.3
	Bond Strength	5.5
Paste type (i.e., polymer thick film, etc.)	Thermal shock (if applicable)	5.2
	Delamination	5.3
	Conductive paste adhesion	5.6
Platings	Plating adhesion	5.4

2.5.13 Each cover layer in combination with each applicable combination of base material, film, adhesive, bond ply, dielectric material, and other insulation material intended in the interconnect construction shall comply with the mechanical tests specified in Table 2.5.2, according to the intended interconnect construction sub-category. See the Exceptions to 2.5.8 and 2.5.10.

Table 2.5.2
Tests for cover layer materials, based on interconnect construction sub-category

Table 2.5.2 revised February 12, 2004

Tests	Section	Interconnect construction sub-category		
		Flexible	Flex-to-install	Rigid
Cover layer test	5.7	Yes	Yes	Yes
(Ambient) bend test	5.8	Yes	Yes	Not applicable
Cold-bend test	5.9	Yes	Yes	Not applicable
Repeated flexing test	5.10	Yes	Not applicable	Not applicable

2.5.14 Each cover layer shall comply with the optional 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.

2.5.15 Each cover layer in combination with each applicable combination of base material, film, adhesive, bond ply, dielectric material, and other insulation material intended in the interconnect construction shall comply with the optional 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.

2.5.16 The flammability classification of the FMIC type shall not exceed the flammability classification determined for the cover layer, and the cover layer flammability classification determined for the fabricator shall not exceed the flammability classification established for the cover layer material manufacturer.

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

2.5.17 Each cover layer shall be subject to identification by infrared analyses. If a base dielectric material is coated with adhesive on one side, the base dielectric material and adhesive shall be subject to identification by infrared analyses, independently. Each cover coat shall be subject to identification by infrared analyses.

Exception: If the cover layer has already been evaluated to the applicable testing 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 identification analyses have been conducted, infrared analyses shall not be repeated.

2.5.18 The cover layer material, 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, and voids.

2.6 Solder resist and solder mask

2.6.1 Reference to solder resist and solder mask materials in this Standard shall apply to permanent and non-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 interconnect construction or FMIC.

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

2.6.3 Cover film and cover coat material are not considered solder resist or solder mask materials, and solder resist and solder mask materials shall be identified separately from cover film and cover coat 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 cover coat. See Cover layer (cover film and cover coat), Section 2.5.

2.6.3 revised September 15, 2005

2.6.4 Marking ink or flux are not considered to be a solder resist, solder mask, cover film, cover coat, or protective coating.

2.6.5 FMIC test samples shall be provided for each different manufacturer and each different grade of solder resist and/or solder mask material.

Exception: If the solder resist or solder mask material in combination with the applicable materials, film, adhesive, base material, conductor material, bond ply, cover layer, laminate, pre-preg, and other insulation material in the minimum build-up interconnect construction have already been evaluated to the applicable testing 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, for the applicable interconnect construction, and if the same materials combination is used within the parameter profile indices established in accordance with the UL 746E testing, then the (Ambient) bend test, Section 5.8; Cold-bend test, Section 5.9; and Repeated flexing test, Section 5.10; need not be conducted and only the Bond strength test, Section 5.5; Cover layer test, Section 5.7; and Flammability tests, Section 5.13; in the minimum build-up interconnect construction shall be conducted for the FMIC type.

2.6.6 If a difference in a grade designation or catalog number of the same solder resist or solder mask 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 flammability characteristics of the solder resist or solder mask material, samples need not be provided for both materials and a separate unique Type designation is not required for the FMIC type.

2.6.7 Solder resist and solder mask material used as a support of conductor material shall have been previously determined to have acceptable mechanical and electrical relative temperature indices at or above the MOT of the FMIC type, or long term thermal aging shall be conducted in accordance with the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B, to establish appropriate relative temperature indices.

Exception: Solder resist material or solder mask material in a fabricated FMIC type, evaluated for flammability classification only, without consideration of an MOT, need not possess electrical and mechanical relative temperature indices.

Revised 2.6.7 effective February 14, 2003