UL 746F

STANDARD FOR SAFETY

Polymeric Materials – Flexible Dielectric Film Materials for Use in Printed Wiring Boards and Flexible Materials Interconnect Constructions

UL Standard for Safety for Polymeric Materials – Flexible Dielectric Film Materials for Use in Printed Wiring Boards and Flexible Materials Interconnect Constructions, UL 746F

Third Edition, Dated March 4, 2021

Summary of Topics

This revision of ANSI/UL 746F dated June 27, 2025 includes the following changes in requirements:

> ***– Clarification of the UL 94 VTM test method; Table 8.1 – Table 8.4, 8.1.4A – 8.1.4C, 8.1.13A, 8.3, 8.5.1.12, 8.6.12, 8.6.13, 8.7.17***

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

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated April 18, 2025.

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Standard for Polymeric Materials – Flexible Dielectric Film Materials for Use in Printed Wiring Boards and Flexible Materials Interconnect Constructions

First Edition – May, 2006
Second Edition – January, 2012

Third Edition

March 4, 2021

This ANSI/UL Standard for Safety consists of the Third Edition including revisions through June 27, 2025.

The most recent designation of ANSI/UL 746F as an American National Standard (ANSI) occurred on June 27, 2025. 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 ULSE at any time. Proposals should be submitted via a Proposal Request in the Collaborative Standards Development System (CSDS) at https://csds.ul.com.

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INTRODUCTION

1 Scope

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

1.2 These requirements cover short term and long term test procedures to be used for the evaluation of flexible material, film, base material, conductor adhesive material, bonding film, cover lay, and other thin film materials used for parts intended for specific applications in end products.

1.3 Together with the Standards mentioned in the Supplementary Test Procedures, Section 6, these requirements provide data with respect to the physical, electrical, flammability, thermal, and other properties of the materials under consideration and are intended to provide guidance to the material manufacturer, the fabricator, the end product manufacturer, safety engineers and other interested parties.

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

1.5 These requirements do not apply to the evaluation of rigid industrial laminates having a thickness greater than 0.25 mm (0.010 inch). For materials with thicknesses greater than 0.25 mm refer to the Standard for Polymeric Materials – Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials Used in Printed Wiring Boards, UL 746E.

1.6 For constructions and materials not specifically addressed in this Standard:

- The printed wiring board should provide safeguards not less than that generally afforded by this document and the principles of safety contained herein. This includes printed wiring boards with technologies, materials, or methods of construction, including the manufacturing process, not specifically addressed in this document.

- Propose for discussion with the Technical Committee the need for additional detailed requirements to address a new situation in a timely manner.

2 Abbreviations

2.1 The acronym "FMIC" appears throughout this Standard, and stands for "Flexible Materials Interconnect Construction." See 7.57 for the definition of FMIC.

2.2 The acronym "MOT" appears throughout this Standard, and stands for "Maximum Operating Temperature." See 7.70 for the definition of MOT.

2.3 The acronym "RTI" appears throughout this Standard, and stands for "Relative Thermal Index." See 7.81 for the definition of RTI.

3 Units of Measurement

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

4 Measurement Accuracy and Testing Conditions

4.1 A measuring device used to perform the tests required by this Standard shall be capable of measuring the specified parameter with an accuracy within 10 percent of the measured parameter.

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

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

4.4 Once samples are removed from the thermal or humidity pre-conditioning environment, samples shall be cooled in the desiccator for at least 4 hours at room temperature and tested within 30 minutes after removal from the desiccator.

5 References

5.1 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.

5.2 The following publications are referenced in this Standard:

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

ASTM D 618 – Standard Practice for Conditioning Plastics for Testing

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

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

ASTM E 3 – Standard Guide for Preparation of Metallographic Specimens

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

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

6 Supplementary Test Procedures

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

a) 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 used for parts in electrical equipment.

b) The Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A, contains short term test procedures to be used for the evaluation of materials used for parts intended for specific applications in electrical end products.

c) The Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B, contains long term test procedures to be used for the evaluation of materials used for parts intended for specific applications in end products.

d) The Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, contain programs for evaluating polymeric materials. UL 746C is intended for the evaluations of polymeric materials in specific applications in end products.

e) The Standard for Polymeric Materials – Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials Used in Printed Wiring Boards, UL 746E, contain programs for evaluating polymeric materials. UL 746E is intended for the evaluation of polymeric materials in specific applications in printed wiring boards.

f) The Standard for Printed Wiring Boards, UL 796, contains the minimum performance requirements for printed wiring boards.

g) The Standard for Flexible Materials Interconnect Constructions, UL 796F, contains the minimum performance requirements for flexible printed wiring boards and interconnect constructions.

7 Glossary

7.1 For the purposes of this Standard, the following definitions apply.

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

7.3 ADHESIVELESS – Sputtered on or Cast on film. Adhesiveless does not include Laminated materials.

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

7.5 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.

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

7.7 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.

7.8 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.

7.9 BONDING FILM – The layer of insulation used to bond discrete layers during lamination of multilayer flexible printed wiring board constructions. A general term used to describe bondply and freefilm. See also Bondply and Freefilm.

7.10 BONDING LAYER – An adhesive layer used to bond discrete layers during lamination.

7.11 BONDPLY – See Bonding Film.

7.12 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 a flexible material where no internal or external conductor material resides.

7.13 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.

7.14 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.

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

7.16 CIRCUITRY LAYER – Conductor layer or plane in or on an interconnect construction or printed board.

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

7.18 CLADDING – A deposited or plated metallic layer or laminated foil used for its protective and/or electrical properties. See Conductive Foil, 7.22.

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

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

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

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

7.23 CONDUCTOR – A single conductive in a conductive pattern.

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

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

7.26 CONDUCTOR BASE WIDTH – The width of a conductor at the interface of the conductor material and base material. See also Conductor Width.

7.27 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.)

7.28 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.

7.29 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.

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

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

7.32 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.

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

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

7.35 CONVERTOR – Manufacturer who prepares materials, such as lamination of copper, adhesive, and base dielectric material for use in the fabrication of flexible materials.

7.36 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.

7.37 COVERCOAT – A material deposited as a liquid onto the circuitry that subsequently becomes a permanent dielectric coating. See Cover Material, 7.41.

7.38 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, 7.41.

7.39 COVERLAY – Film and adhesive made from separate layers of generically different chemistries. See Cover Material, 7.41.

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

7.41 COVER MATERIAL – A thin dielectric material used to encapsulate circuitry, most commonly for flexible circuit applications. See Covercoat, 7.37, Coverfilm, 7.38, and Coverlay, 7.39.

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

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

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

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

7.46 DOUBLE-SIDED – A flexible material with a conductive layer on the two external sides of the base dielectric material.

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

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

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

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

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

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

7.53 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.

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

7.55 FLAMMABILITY RATED ONLY – A flexible material intended for use where the construction shall be evaluated for a 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.

7.56 FLEXIBLE MATERIALS 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. See the Standard for Flexible Materials Interconnect Construction, UL 796F.

7.57 FMIC – See Flexible Materials Interconnect Construction.

7.58 FOIL LAMINATION – A process for bonding a conductive foil to a dielectric base material or interconnect construction.

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

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

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

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

7.63 INTERCONNECT CONSTRUCTION – An integral combination of film, adhesive, base material, conductor, bonding film, cover lay, 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.

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