

UL 746B

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Polymeric Materials – Long Term Property Evaluations

Underwriters Laboratories Inc. (UL)
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UL Standard for Safety for Polymeric Materials – Long Term Property Evaluations, UL 746B

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Announcement Bulletin(s): This Standard contains the announcement bulletin(s) dated March 20, 2001. The announcement bulletin is located at the end of the Standard (after the adoption bulletin(s)).

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 Bulletin(s) on this subject dated December 29, 2000.

The revisions dated November 28, 2001 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.

As indicated on the title page (page1), this UL Standard for Safety has been adopted by the Department of Defense.

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New product submittals made prior to a specified future effective date will be judged under all of the requirements in this Standard including those requirements with a specified future effective date, unless the applicant specifically requests that the product be judged under the current requirements. However, if the applicant elects this option, it should be noted that compliance with all the requirements in this Standard will be required as a condition of continued Classified, Recognition, and Follow-Up Services after the effective date, and understanding of this should be signified in writing.

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UL 746B

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

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The Department of Defense (DoD) has adopted UL 746B on November 3, 1988. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

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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FOREWORD

A. This Standard contains basic requirements for products covered by Underwriters Laboratories Inc. (UL) under its Follow-Up Service for this category within the limitations given below and in the Scope section of this Standard. These requirements are based upon sound engineering principles, research, records of tests and field experience, and an appreciation of the problems of manufacture, installation, and use derived from consultation with and information obtained from manufacturers, users, inspection authorities, and others having specialized experience. They are subject to revision as further experience and investigation may show is necessary or desirable.

B. The observance of the requirements of this Standard by a manufacturer is one of the conditions of the continued coverage of the manufacturer's product.

C. A product which complies with the text of this Standard will not necessarily be judged to comply with the Standard if, when examined and tested, it is found to have other features which impair the level of safety contemplated by these requirements.

D. A product that contains features, characteristics, components, materials, or systems new or different from those covered by the requirements in this standard, and that involves a risk of fire or of electric shock or injury to persons shall be evaluated using appropriate additional component and end-product requirements to maintain the level of safety as originally anticipated by the intent of this standard. A product whose features, characteristics, components, materials, or systems conflict with specific requirements or provisions of this standard does not comply with this standard. Revision of requirements shall be proposed and adopted in conformance with the methods employed for development, revision, and implementation of this standard.

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F. Many tests required by the Standards of UL are inherently hazardous and adequate safeguards for personnel and property shall be employed in conducting such tests.

INTRODUCTION

1 Scope

1.1 These requirements cover long-term test procedures to be used for the evaluation of materials used for parts intended for specific applications in end products.

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

1.3 A product that contains features, characteristics, components, materials, or systems new or different from those covered by the requirements in this standard, and that involves a risk of fire or of electric shock or injury to persons shall be evaluated using appropriate additional component and end-product requirements to maintain the level of safety as originally anticipated by the intent of this standard. A product whose features, characteristics, components, materials, or systems conflict with specific requirements or provisions of this standard does not comply with this standard. Revision of requirements shall be proposed and adopted in conformance with the methods employed for development, revision, and implementation of this standard.

1.3 revised November 29, 2000

2 References

2.1 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.

3 Supplementary Test Procedures

3.1 The Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, covers flammability of polymeric materials used for parts in devices and appliances. 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. The Standard for Polymeric Materials – Fabricated Parts, UL 746D, contains requirements for traceability and performance of parts molded and fabricated from polymeric materials.

3.1 revised February 22, 2000

3.2 Programs for the investigation of material part modifications, such as the plating of plastics or the use of flame-retardant paints, are contained in the Standard for Polymeric Materials– Use in Electrical Equipment Evaluations, UL 746C.

3.3 Data concerning the effect of various environments and contaminants upon the properties of materials can also be obtained through standard test procedures. The more commonly used procedures are briefly described in the Standard for Polymeric Materials– Short Term Evaluations, UL 746A.

3.4 Test procedures are provided in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluation, UL 746C, for the evaluation of polymeric materials in specific applications in end products. These test procedures include references to the data obtained from the standard property tests as well as other practical means of evaluation.

3.5 Requirements for materials that have been modified to match the requirements of a specific application, including the use of recycled and regrind materials, the use of additives and colorants, and the blending of two or more materials, are described in the Standard for Polymeric Materials – Fabricated Parts, UL 746D.

4 Characteristics of Polymeric Materials

4.1 Polymeric materials include thermoplastic, thermosetting, and elastomeric materials. A thermoplastic material can be easily softened and resoftened by repeated heating. A thermosetting material cures by chemical reaction and, when cured, cannot be resoftened. An elastomeric material is capable of being stretched at room temperature to at least twice its length under low stress and recovers to its original length when released from the stress.

4.2 Characteristics of polymeric materials that necessitate additional consideration include:

- a) Mold stresses
- b) Insulating quality
- c) Resistance to ignition
- d) Extinguishing characteristics
- e) Production of smoke and gases
- f) Mechanical Strength
- g) Compatibility with solvents
- h) Melting or distortion
- i) Cold flow, if under stress
- j) Fuel contribution
- k) Dimensional stability

5 Use of Polymeric Materials

5.1 The reduction to an acceptable level of the risks of electric shock, fire, and personal injury from electrical equipment depends upon the selection of materials, design, and processing of parts as well as the assembly, mounting, and relative positions of these parts.

5.2 The properties needed by individual parts are defined by the function or functions of the part. An enclosure, for example, must ordinarily be designed to withstand mechanical abuse. Accordingly, a material known to have substantial impact strength would normally be used although a material that has a lower impact strength, but is reinforced, might also be acceptable.

5.3 Electrical equipment of necessity employs many materials that usually have divergent properties. The ability to match the demands of the application with the characteristics of a material as well as the ability to compare the properties of one material with those of another can lead to an acceptable selection of materials.

5.4 The information gained from the data obtained from these tests can be used as an aid in the evaluation of electrical equipment using parts made of polymeric materials. Knowledge of materials can be obtained from an analysis of data from standard tests conducted on small specimens.

DETERMINATION OF THE RELATIVE THERMAL INDICES OF POLYMERIC MATERIALS

6 General

6.1 A relative thermal index of a material is an indication of the material's ability to retain a particular property (physical, electrical, etc.) when exposed to elevated temperatures for an extended period of time. It is a measure of the material's thermal endurance. For each material, a number of relative thermal indices can be established, each index related to a specific property and a specific thickness of the material.

6.2 In determining the relative thermal index of a material, the basic concepts to be followed are stated in the Institute of Electrical and Electronics Engineers Specifications No. 1, General Principles for Temperature Limits in the Rating of Electrical Equipment; No. 98, Guide for the Preparation of Test procedures for the Thermal Evaluation of Electrical Insulating Materials; No. 101, Guide for the Statistical Analysis of Thermal Life Test Data.

6.3 The relative thermal index of a material is to be based upon an evaluation of long-term thermal-aging data obtained under the program described in Relative Thermal Index – Based Upon Long-Term Thermal-Aging Programs, Section 8. Thermal indices on a generic basis have been established through knowledge of extensive field-service records, as outlined in Relative Thermal Index – Based Upon Historical Record, Section 7. Relative thermal indices may also be established based upon a study and evaluation of the interrelationship of all of the data mentioned in Supplementary Test Procedures, Section 3, which can also be coupled with knowledge concerning the material's performance in insulating systems gained through experience or long-term aging tests.

6.4 A comparison of the thermal-aging characteristics of one material of proven field service at a particular temperature level with the thermal-aging characteristics of another material with no field service history provides a means for estimating the relative thermal index level at which the second material might also provide acceptable field service.

6.5 Another explanation of a relative thermal index is the maximum temperature below which a material maintains its characteristics over a reasonable period. This relative thermal index serves the very great need to evaluate materials that are exposed to heat sources in electrical products in which they are not used as part of an insulating system and in which they are not subjected to other major degradation influences. It is to be assumed that neither excessively long nor excessively short duty cycles are involved.

6.6 To be valid for use in a specific application, a relative thermal index of a material must be established by a study of the degradation rates of all properties that are relied upon in that application. As a corollary to this principle, more than one relative thermal index can be assigned to a material depending on the relative degradation rates of the properties of the material and depending on which of these properties are considered in establishing the indices.

7 Relative Thermal Index – Based Upon Historical Record

7.1 Table 7.1 presents a list of materials, each of which is assigned a relative thermal index based on acceptable service experience, the chemical structure of the material, and a knowledge of the performance of the material in tests of insulating systems and electrical equipment. The assigned relative thermal index is applicable to each member of the generic material class.

7.2 Unless otherwise indicated in Table 7.1, the generic thermal index of a material is to be considered 50°C (122°F).

7.3 Unless otherwise indicated in Table 7.1, the generic thermal index of a material is independent of thickness and pigmentation.

Table 7.1
Relative thermal indices based upon past field-test performance and chemical structure^a

Table 7.1 revised November 28, 2001

Material	ISO designation	Generic thermal index,°C
Polyamide (Type 6, 11, 12, 66, 610, or 612 nylon) ^b	(PA)	65
Polycarbonate ^b	(PC)	80
Polyethylene terephthalate – molding resin ^b	(PET)	75
film (0.010 inch, 0.25 mm)	(PET)	105
Polybutylene (polytetramethylene) terephthalate ^b	(PBT)	75
Polyphenylene Oxide ^j	(PPE – PS)	65
Polypropylene ^{b,h}	(PP)	65
Polyetherimide ^g	–	105
Polyphenylene Sulfide ^b	(PPS)	130
Polyimide film (0.25 mm, 0.010 inch max)	(PI)	130
Molded phenolic ^c	(PF)	150
Molded melamine ^{c,d} and Molded melamine/ phenolic ^{c,d} – specific gravity < 1.55		130
specific gravity ≥ 1.55		150
Polytetrafluoroethylene	(PTFE)	180
Polychlorotrifluoroethylene	(PCTFE)	150
Fluorinated ethylene propylene	(FEP)	150
Urea Formaldehyde ^c	(UF)	100

Table 7.1 Continued on Next Page

Table 7.1 Continued

Material	ISO designation	Generic thermal index, °C
Acrylonitrile – butadiene – styrene ^b	(ABS)	60
Silicone – molding resin ^{c,d}		150
Silicone rubber –		
molding resin	(SIR)	150
room-temperature vulcanizing or heat-cured paste	(RTV)	105
Epoxy –		
molding resin ^{c,d}		130
powder coating materials		105
casting or potting resin ^{b,i}	(EP)	90
Molded diallyl phthalate ^{c,d}		130
Molded unsaturated polyester ^{c,d}	(UP)	
alkyd (AMC), bulk (BMC), dough (DMC), sheet (SMC),		
thick (TMC), and pultrusion molding compounds	(electrical)	105 ^e
	(mechanical)	130
Liquid crystalline thermotropic aromatic polyester ^f	(LCP)	130
Ligno-cellulose laminate		60
Vulcanized fiber		90
Cold-molded phenolic, melamine or melamine-phenolic compounds ^d –		
specific gravity < 1.55		130
specific gravity ≥ 1.55		150
Cold-molded inorganic (hydraulic-cement, etc.) compounds		200
Integrated mica, resin-bonded –		
epoxy, alkyd or polyester binder		130
phenolic binder		150
silicone binder		200

^aGeneric thermal index is for homopolymer resins only unless a specific copolymer or blend is indicated. In the case of alloys, the lowest generic index of any component shall be assigned to the composite.

^bIncludes glass-fiber reinforcement and/or talc, asbestos, mineral, calcium carbonate, and other inorganic fillers.

^cIncludes only compounds molded by high-temperature and high-pressure processes such as injection, compression, pultrusion, and transfer molding and match-metal die molding; excludes compounds molded by open-mold or low-pressure molding processes such as hand lay-up spray-up, contact bag, filament winding, rotational molding, and powder coating (fluidized bed, electrostatic spray, hot dip, flow coating).

Table 7.1 Continued

Material	ISO designation	Generic thermal index, °C
^d Includes materials having filler systems of fibrous (other than synthetic organic) types but excludes fiber reinforcement systems using resins that are applied in liquid form. Synthetic organic fillers are to be considered acceptable at temperatures not greater than 105°C. ^e Except 130°C generic thermal index if the material retains at least 50% of its unaged dielectric strength after a 504-hour exposure at 180°C in an air circulating oven. Specimens are to be tested in a dry, as molded, condition. Specimens that are removed from the oven are to be cooled over desiccant for at least 2 hours prior to testing. ^f Includes only wholly aromatic liquid crystalline thermotropic polyesters; wholly aromatic polyester/amides and wholly aromatic polyester/ethers; excluding amorphous, lyotropic and liquid crystalline aliphatic-aromatic polyesters which are aliphatic in the backbone chain or main chain, and substituted aromatic polyesters (except for methyl or aromatic). ^g Includes only polyetherimide molding resin. ^h Includes polypropylene copolymers containing not more than 25% ethylene comonomer, by weight. ⁱ Multi-part liquid epoxy materials incorporating acid anhydride or aromatic amine curing agents receive a 130°C generic thermal index. ^j Includes only those polyphenylene oxide materials in which the PPO component is not less than 30% of the total composition by weight and that have a Heat Deflection Temperature of at least 70°C at a load (fiber stress) of 1.80 M Pa (264 psi).		

8 Relative Thermal Index – Based Upon Long-Term Thermal-Aging Programs

8.1 The properties of a polymeric material degrade with time when exposed to various environments. A prime cause of degradation is exposure to heat.

8.2 The behavior of a material that is subjected to thermal aging in air cannot be assumed to be the same as its behavior under service conditions; however, a knowledge of the thermal-aging behavior of a material can be used as a basis for comparison of polymeric materials.

8.3 The thermal-aging characteristics of a material can be determined by measuring the changes in its properties to a predetermined level by aging at each of several elevated temperatures; plotting log of time-to end-of-life at each temperature against the reciprocal of absolute temperature; and plotting the best-fit straight line by regression analysis. The plotted line is often referred to as the life-line of a material.

8.4 The manufacturer of the material is responsible for:

- a) The estimation of the different applications in which the material can be used, and
- b) The selection of the temperatures, properties, and thicknesses that are to be measured during the thermal-aging investigation.

If products of decomposition of one material are suspected of having an adverse effect on the other, for example, if two materials are not of the same generic type or if a flame retardant or other additive in one material adversely affects the other material, then they should not be aged simultaneously in the same oven. It is desirable that the oven exhaust be positively vented outside the test facility.

9 Apparatus

9.1 Ovens

9.1.1 The thermal-aging ovens that are used in the aging program shall comply with the Standard Test Methods for Forced-Convection Laboratory Ovens for Evaluation of Electrical Insulation, ASTM D 5374-93^a, and with the Standard Specification for Forced-Convection Laboratory Ovens for Evaluation of Electrical Insulation, ASTM D 5423-93^a for Type I ovens, primarily with respect to Rate of Ventilation, Set Temperature, Temperature Variation and Thermal Lag Time.

Exception: Non air-circulating static ovens and/or forced-draft circulating-air convection ovens not capable of providing replacement of fresh air at the rate of not less than 5 changes per hour may be employed provided that:

- a) The oven is capable of maintaining the Set Temperature, Temperature Variation and Thermal Lag Time described in ASTM D 5423-93^a. The Thermal Lag Time is not applicable if the oven is not subjected to frequent openings, and if the ratio of oven aging time to open-oven time is large.*
- b) The products of the material decomposition are not expected to further degrade the polymer – in other words, shall not be autocatalytic, and*
- c) A control material of known performance is aged in the same ovens and for the same time duration as the candidate materials.*

^a ASTM standards are available from the American Society for Testing and Materials, 100 Bar Harbor Drive, West Conshohocken, PA 19428.

9.1.1 revised November 29, 2000

9.1.2 The oven temperature control is to be capable of long-term operation. It is desirable that the oven be provided with a timer and also with an oven-temperature cut-off to prevent loss of specimens, loss of data, or loss of test continuity. Ordinarily, at least four ovens of applicable capacity are needed to contain the aging specimens; however, two ovens can be effectively used by completing the work at the two higher thermal-aging temperatures first and then switching the oven settings to the two lower thermal-aging temperatures.

9.1.3 Temperatures for heat aging are to be accurately controlled and monitored. At the start of the program, oven temperatures are to be checked frequently. The use of several thermocouple locations to check variations throughout the ovens is required. As the test progresses, monitoring can be done less frequently.

10 Scope of Test Programs

10.1 Selection of test properties

10.1.1 The specific properties to be evaluated in the thermal-aging program shall be determined.

10.1.2 The contemplated applications of the material (as intended by the manufacturer of the material), the flammability characteristics, and the physical and electrical properties that the material needs to have for these applications are to be considered.

10.1.3 Table 10.1 provides a list of properties that can serve as an aid in the determination of the properties to fall within the scope of the investigation. The properties are to be as nearly as possible representative of the properties required for the end application.

Table 10.1
List of properties and test methods

Table 10.1 revised November 29, 2000

Property ^a	Test Method
Mechanical Properties	
Maximum Tensile Stress or Flexural Strength	UL 746A
Tensile Impact, Izod Impact, or Charpy Impact	UL 746A
Electrical Properties	
Dielectric Strength	UL 746A
Flammability Properties	
Vertical Burning	UL 94
^a The list of properties given in this table is not complete. Other properties that are critical in a particular end-use application are to be included in the program.	

10.1.4 The results of Tensile, Charpy or Izod Impact testing of standard specimens in the nominal 4 mm thickness, can be considered representative of the testing of reduced thicknesses not less than 0.75 mm, provided such reduced thicknesses have been evaluated for non-impact mechanical properties. The assigned thermal indices for impact properties in the reduced thicknesses shall be lowered by an offset equal to the corresponding lower offset, if any, of the thermal indices of the non-impact properties at the reduced thicknesses. Table 10.2 illustrates a hypothetical example of this offset.

10.1.4 revised November 28, 2001