

UL 746A

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Polymeric Materials – Short Term Property Evaluations

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UL Standard for Safety for Polymeric Materials – Short Term Property Evaluations, UL 746A

Fifth Edition, Dated November 1, 2000

Revisions: This Standard contains revisions through and including May 30, 2006.

Summary of Topics

These Revisions to ANSI/UL 746A include the following topics that are being adopted:

- 1. Polymer Variations - Revision of Table 8.1***
- 2. Revising Section 23 to Denote Differences between ASTM 3638 and IEC 60112***
- 3. Added Exceptions for Ambient Temperature Limits for Some UL 746A Tests***
- 4. Corrections for References to Some Outside Standards***
- 5. Elimination of Dated References to Codes and Standards***
- 6. Correction of Ball Pressure Test Description to Match IEC Standard***

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The new and/or revised requirements are substantially in accordance with UL's Proposal(s) on this subject dated October 14, 2005 and April 7, 2006

The revisions dated May 30, 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.

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

The UL Foreword is no longer located within the UL Standard. For information concerning the use and application of the requirements contained in this Standard, the current version of the UL Foreword is located on ULStandardsInfoNet at: <http://ulstandardsinfo.net/ulforeword.html>

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This Standard consists of pages dated as shown in the following checklist:

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1-4	May 30, 2006
5	November 1, 2000
6-7	December 26, 2003
8	May 30, 2006
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ANSI/UL 746A-2006

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UL 746A

Standard for Polymeric Materials – Short Term Property Evaluations

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November 1, 2000

The most recent designation of ANSI/UL 746A as an American National Standard (ANSI) occurred on May 24, 2006.

This ANSI/UL Standard for Safety, which consists of the Fifth edition with revisions through May 30, 2006, except for Supplement SA 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.

The Department of Defense (DoD) has adopted UL 746A 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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INTRODUCTION

1 Scope

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

1.2 Together with the requirements mentioned in Supplementary Test Procedures, Section 4, 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.

2 Units of Measurement

2.1 If a value for measurement as given in these requirements is followed by an equivalent value in other units, in parentheses, the second value may be only approximate. The first stated value is the other requirement.

3 References

3.1 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.

3.2 Appendix A contains a list of ASTM test procedures referenced in this standard.

4 Supplementary Test Procedures

4.1 The requirements in 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 – 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. 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. The test procedures include reference to the data obtained from the standard property tests in UL 746A, as well as other practical means of evaluation. The Standard for Polymeric Materials – Fabricated Parts, UL 746D, contains requirements for traceability and performance of parts molded and fabricated from polymeric materials.

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4.2 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. Other requirements for the bond strength of plated plastics are described in Bond Strength of Plated Polymeric Materials, Section 17 of this standard.

4.3 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 this standard.

4.4 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.

5 Alternate or Equivalent Test Methods

5.1 If a designation for a test method is followed by an alternate or equivalent designation, in parenthesis, the latter method can be considered technically equivalent, though not necessarily identical, and might yield somewhat different numerical test results. Where significant differences exist, the use of such alternate or equivalent methods should be restricted to studies of comparative behavior using the same method exclusively, such as monitoring degradation behavior before, during and/or after thermal aging (746B) or other special conditioning.

6 Characteristics of Polymeric Materials

6.1 Polymeric materials include thermoplastic, thermosetting, and elastomeric materials. A thermoplastic material can be easily softened and re-softened by repeated heating. A thermosetting material cures by chemical reaction when heated and, when cured, cannot be re-softened by reheating. 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.

6.2 Characteristics of polymeric materials that are to be given additional consideration include:

- a) Molded stresses
- b) Insulating quality
- c) Resistance to ignition
- d) Extinguishing characteristics
- e) Production of smoke and gases
- f) Physical and electrical properties
- g) Compatibility with solvents
- h) Melting or distortion
- i) Cold flow, if under stress
- j) Fuel contribution

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k) Dimensional stability

7 Use of Polymeric Materials

7.1 The safety of electrical equipment depends upon the correct selection of materials, design, and processing of parts as well as the assembly, mounting, and relative positions of these parts.

7.2 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 of lower impact strength that is reinforced may also be satisfactory.

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

7.4 The information gained from the data obtained from these tests can be used as an aid to 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.

8 General

8.1 Selection of samples and test specimens

8.1.1 Samples shall be obtained if possible from the products to be tested, taken at random, and in such case shall be taken in accordance with the requirements for the particular material.

Exception: When it is not practical to obtain test specimens from the finished article, the manufacturer shall furnish molded test specimens, or sample sheets as required in the individual test method. The number of specimens to be tested in each type of test shall be as specified in the individual test method; if not so specified, at least five specimens shall be tested.

8.2 Preparation of specimens

8.2.1 When it is necessary to machine specimens, the work is to be done in accordance with the manufacturer's recommended technique for the material involved. Tools are to be kept sharp and used so that the possibility of overheating is minimized. Machined surfaces of specimens are to be finished (No. 3/0 abrasive paper is acceptable) to eliminate all irregularities, such as tool marks, where such finishing results in a more perfect surface than can be obtained by machining alone. Where a more perfect finish is desired, a polishing compound is to be used. For mechanical test specimens, the direction of cutting and finishing is to be at right angles to the expected line of fracture whenever possible.

8.3 Thickness and directional properties

8.3.1 The properties of plastics may vary with thickness and with orientation of the material. Therefore, when preparing specimens, consideration is to be given to the testing of specimens that are representative of both the thickest and the thinnest sections of the product, and where mechanical tests are involved, the testing of specimens that have been cut lengthwise, crosswise, and also normal to the surface of the material.

8.4 Treatment prior to test

8.4.1 Samples and specimens for tests shall not be heated, immersed in water, or subjected to any mechanical or chemical treatment prior to test except as specifically described in the individual test method.

8.4.2 Unless otherwise specified in the individual test method, thermoplastic materials are to be injection molded while thermoset materials are to be compression or transfer molded.

8.5 Testing conditions

8.5.1 Unless otherwise specified in an ASTM or ISO material specification or in an individual test method, the standard atmospheric conditions surrounding the specimen for a minimum of 88 hours prior to and during the test shall be $23 \pm 2^\circ \text{C}$ ($73.4 \pm 3.6^\circ \text{F}$) and 50 ± 10 percent relative humidity (Class 2 in accordance with ISO 291).

Exception: The Infrared Spectroscopy in section 42, Pyrolytic Gas Chromatography in 44, Thermogravimetry in 45, and Differential Scanning Calorimetry in 46 do not require the default ambient indicated above.

8.5.1 revised May 30, 2006

8.6 Testing for temperature effects

8.6.1 When the relation of properties to temperature is to be determined, tests shall be performed at one or more of the following standard atmospheric temperatures: minus 55°C (minus 67°F), minus 40°C (minus 40°F), minus 35°C (minus 28°F), 0°C (32°F), 50°C (122°F), 70°C (158°F), and 77.0°C (170.6°F). In all cases, specimens shall be conditioned at the testing temperature and humidity for at least 24 hours immediately prior to test, unless otherwise specified in the individual test method.

8.6.2 The temperature, the relative humidity, and the period of time for conditioning shall all be recorded.

8.7 Apparatus

8.7.1 Unless otherwise specified in the individual test method, properties shall be determined in any standard type of testing machine that is calibrated and accurate to 1 percent in the range used.

8.8 Results of tests

8.8.1 Unless otherwise specified in the individual test method, the average of the results for the specimens tested shall be used to determine conformance of materials tested under this standard.

8.8.2 Unless otherwise specified in the individual test method, results for specimens that break at some obvious flaw or that do not break between the predetermined bench marks shall be discarded.

8.8.3 Unless otherwise specified in the individual test method, results that deviate from the mean value of all tests shall be rejected if the deviation of the doubtful value is more than three times the standard deviation from the mean obtained by including the doubtful value.

8.8.4 Additional specimens shall be tested in place of any for which the results are discarded in accordance with 8.8.2 and 8.8.3.

8.9 Polymer variations

8.9.1 Polymeric materials are available in different molecular weights and colors, and with different types and quantities of fillers, reinforcements, and additives.

8.9.1 revised May 30, 2006

8.9.2 Table 8.1 indicates the properties that are to be considered leading indicators when evaluating polymer variations. If the results of side-by-side testing based on the test program shown in Table 8.2 demonstrates comparable results (for polymer variations evaluated for use with either the same or a new designation) or better results (for polymer variations only for use under a new designation), then all ratings from the original formulation may be extended to the variation. However, if all tests do not indicate comparable results, then no ratings shall be extended to the variation unless determined through direct testing.

8.9.2 revised May 30, 2006

8.9.3 Deleted May 30, 2006

8.9.4 In order to extend any specific rating from the original formulation to the variation, the rating shall be based on actual testing of the original formulation and not a rating based solely on the previous application of the polymer variation analysis.

8.9.4 added May 30, 2006

Table 8.1
Test considerations based upon compound variations

Table 8.1 revised May 30, 2006

Additive	Addition (absolute %)	Deletion / Replacement (absolute %)	Change in Level (normalized %)
Acid Acceptor (Scavenger)	≤2%, See A 2 – 5%, See B ≥5%, See BD	≤2%, See A 2 – 5%, See B ≥5%, See BD	<30%, See A ≥30%, See B
Antimicrobial, Copolymer ⁽¹⁾ , Crosslinking Agent, Curing Agent, Flame Retardant, Polymer Blend ⁽¹⁾ , Conductive Material, Impact Modifier	See C	See C	<30%, See B ≥30%, See C
Antioxidant	<0.5%, See A ≥0.5%, See B	<0.5%, See AD ≥0.5%, See BD	+ ≥30%, See BD + <30%, See A - <30%, See AD - ≥30%, See BD
Antistatic Agent, Compatibilizer, Halogen Scavenger, Low Wear Additive, Lubricant/Release Agent, Processing Aid	<5%, See A ≥5%, See BD	<5%, See A ≥5%, See BD	<30%, See A ≥30%, See BD
Blowing Agent ⁽²⁾	<1%, See O ≥1%, See C	O	See O, if not + ≥30%, See C
Catalyst	O	O	O
Colorant /Pigment (Inorganic)	<5%, See A ≥5%, See AD	A	<5% ⁽³⁾ , See A ≥5% ⁽³⁾ , See AD
Colorant/Pigment (Organic)	<0.5%, See A ≥0.5%, See AD	A	<5% ⁽³⁾ , See A ≥5% ⁽³⁾ , See AD
Corrosion Inhibitor	≤1%, See A 1 – 2%, See B ≥2%, See BD	≤1%, See A 1 – 2%, See B ≥2%, See BD	<30%, See A ≥30%, See BD
Coupling Agent	<1%, See AD ≥1%, See BD	<1%, See AD ≥1%, See BD	<30%, See A ≥30%, See BD
Drip Inhibitor, Nucleating Agent	<1%, See A ≥1%, See BD	<1%, See A ≥1%, See BD	<30%, See A ≥30%, See BD
Filler/Reinforcement	<5%, See B ≥5%, See C	<5%, See B ≥5%, See C	<30%, See B ≥30%, See C
Heat Stabilizer	<0.5%, See A ≥0.5%, See B	<0.5%, See AD ≥0.5%, See BD	+ ≥30%, See B + <30%, See A - <30%, See AD - ≥30%, See BD
Hydrolytic Stabilizer	<0.5%, See A ≥0.5%, See BD	<0.5%, See A ≥0.5%, See BD	<30%, See A ≥30%, See BD
Plasticizer	≤1%, See A 1 – 5%, See B ≥5%, See BD	≤1%, See A 1 – 5%, See B ≥5%, See BD	<30%, See A ≥30%, See BD
UV stabilizer	≤0.3%, See A 0.3 – 0.5%, See AD ≥0.5%, See BD	<0.5%, See A ≥0.5%, See BE	+ ≥30%, See BD + <30%, See A - <30%, See AE - ≥30%, See BD

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Table 8.1 Continued on Next Page

Table 8.1 Continued

Additive	Addition (absolute %)	Deletion / Replacement (absolute %)	Change in Level (normalized %)
Molecular Weight	Variations that result in a change in level of branching and/or cross-linking, See AD Variations that do not result in a change in the level of branching and/or cross-linking, See A		
Footnotes			
(1): Normalized percentage of the minor component level			
(2): All use of Blowing Agents that reduce the original density by more than 5% require Full Testing			
(3): Changes in Level of colorants/pigments are to be evaluated as Absolute percentage			

Table 8.2
Test Programs based upon compound variations

Table 8.2 added May 30, 2006

Program Code from Table 8.1	Test Program
O	No testing necessary
A	Flame, minimum thickness at all flame ratings assigned to the original material formulation
B	All the testing required in Program Code A, plus: HWI - Hot Wire Ignition CTI - Comparative Tracking Index HDT- Heat Deflection Temp. or VT - Vicat Temp. or BP- Ball Pressure Temp (thermoplastics only)
C	Full side by side testing of all critical properties testing required
D	UL 746B Long Term Thermal Aging
E	UL 746C Suitability for Outdoor Use

TESTING FOR MECHANICAL PROPERTIES**9 Tensile Properties of Thermoplastic Polymeric Materials**

9.1 The test method for determination of tensile properties of polymeric materials is to be as described in the Standard Test Method for Tensile Properties of Plastics, ANSI/ASTM D 638 (ISO 527-2)^a. See ASTM D638 for general features of the specimen. While ASTM D 638 Type I or ISO 527-2 Type 1A specimens are preferred, other type specimens may be used, as appropriate.

9.1 revised December 26, 2003

9.2 Values of the maximum tensile strength at either yield or break, and percentage elongation at yield or break can be calculated from the data obtained.

^aASTM standards are available from: American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428. ISO standards are available from: American National Standards Institute, 11 West 42nd Street, New York, NY 10018.

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10 Tensile Properties of Elastomers

10.1 The test method for the determination of the effects of the application of tension to elastomeric materials is to be as described in the Standard Test Methods for Rubber Properties in Tension, ASTM D 412 (ISO 1798). This test is not applicable to the testing of materials ordinarily classified as hard rubber, or to emulsion films including styrene butadiene rubber, polystyrene, polyvinylchloride, polyvinylidene chloride, polyacrylate resins, or reclaimed rubber.

10.2 Specific dimensions of dies needed to form the specimens are described in ASTM D 412. Generally, die "C" is to be used.

10.3 From the test data the tensile stress at a specified elongation or at rupture, tensile strength at break, percentage of elongation, and the ultimate elongation can be determined.

11 Tensile Properties of Thin Polymeric Sheeting

11.1 The test method for the determination of the tensile properties of thin polymeric sheeting less than 1.0 mm (0.04 inch) in thickness is described in the Standard Test Methods for Tensile Properties of Thin Plastic Sheeting, ASTM D 882 (Method A) or ISO 527-3.

11.1 revised May 30, 2006

11.2 From the data obtained, breaking factor, tensile strength, tensile strength at break, percentage of elongation at break, and percentage of elongation at yield can be determined.

12 Izod Impact Test

12.1 The test method for the determination of the relative susceptibility to fracture by shock of polymeric and electrical insulating materials is described in the Standard Test Methods for Impact Resistance of Plastics and Electrical Insulating Materials, ASTM D 256 or ISO 180.

12.1 revised May 30, 2006

13 Tensile Impact Test

13.1 The test method for the determination of the energy required to rupture standard tension-impact specimens is described in the Standard Test Method for Tensile-Impact Energy to Break Plastics and Electrical Insulating Materials, ASTM D 1822 or ISO 8256.

13.1 revised May 30, 2006

13.2 Type "S" specimens with a 12.7 mm (0.5 inch) tab are preferred. From the data, the corrected impact energy to break can be calculated.

13.2 revised May 30, 2006

13.3 Deleted May 30, 2006

14 Charpy Impact Test

14.1 The test method for the determination of the impact energy absorbed in breaking a notched specimen is described in the Standard Test Method for Determination of Charpy Impact Strength of Rigid Materials, ASTM D 6110 or ISO 179-1 (non-instrumented) or ISO 179-2 (instrumented).

14.1 revised May 30, 2006

14.2 The test method supports a test specimen as a horizontal beam. The specimen is broken by a single swing of a calibrated pendulum, with the line of impact midway between the supports and directly opposite the notch. The specimen shall be Type 1 with a Type A notch.

15 Flexural Properties of Thermosetting Polymeric Materials

15.1 The test method for the determination of the flexural properties of polymeric materials and electrical insulating materials is described in the Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials, ASTM D 790 or ISO 178.

15.1 revised May 30, 2006

15.2 If the specimen ruptures, the flexural strength (modulus of rupture) can be calculated. If the rupture does not occur before 5 percent strain, the value at 5 percent fiber strain is to be reported.

15.3 For certain materials, load-deflection curves are used to calculate flexural yield strength. This calculation makes use of the point at which the load does not increase with an increase in the deflection.

16 Shear Properties of Polymeric Materials

16.1 The test method for determining the shear strength of test specimens of polymeric materials is described in the Standard Test Method for Shear Strength of Plastics by Punch Tool, ASTM D 732.

16.2 From the data obtained, the shear strength of the material can be calculated.

17 Bond Strength of Plated Polymeric Materials

17.1 General

17.1.1 This method is intended to evaluate the integrity of the bond between a plastic substrate and a metal coating. The results of the program can then be used to judge the acceptability of plated plastic parts in end products where loss of the bond strength might result in a reduction of the spacings required by the product Standard.

17.1.2 A calibrated testing machine is needed that can be operated at constant rates of crosshead motion over the range indicated. The load-indicating mechanism shall be capable of measuring the applied force within ± 2 percent at the crosshead rate used.

17.1.3 Plastic plaques approximately 76 by 127 mm (3 by 5 inches) (Figure 17.1), using the same process as that under investigation, are to be plated with a nominal 0.05 mm (0.002 inch) thickness of deposited ductile copper and then prepared as follows:

- a) The plaque is to be trimmed off at A along line a.
- b) The metal layer is to be cut through, just into the plastic substrate, along lines b, c, d, and e to form strips 25.4 mm (1 inch) wide as shown in Figure 17.1