

UL 746C

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Polymeric Materials – Use in Electrical Equipment Evaluations

Underwriters Laboratories Inc. (UL)
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UL Standard for Safety for Polymeric Material – Use in Electrical Equipment Evaluations, UL 746C

Fourth Edition, Dated December 27, 1995

Revisions: This Standard contains revisions through and including February 12, 2001.

These pages are being issued to correct omissions that occurred with the October 16, 2000 pages.

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The following table lists the future effective dates with the corresponding item.

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The revisions dated February 12, 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 Recognition, and Follow-Up Services after the effective date, and understanding of this should be signified in writing.

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The Department of Defense (DoD) has adopted UL 746C 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 employing materials or having forms of construction which conflict with specific requirements of the Standard cannot be judged to comply with the Standard. A product employing materials or having forms of construction not addressed by this Standard may be examined and tested according to the intent of the requirements and, if found to meet the intent of this Standard, may be judged to comply with the Standard.

E. UL, in performing its functions in accordance with its objectives, does not assume or undertake to discharge any responsibility of the manufacturer or any other party. The opinions and findings of UL represent its professional judgment given with due consideration to the necessary limitations of practical operation and state of the art at the time the Standard is processed. UL shall not be responsible to anyone for the use of or reliance upon this Standard by anyone. UL shall not incur any obligation or liability for damages, including consequential damages, arising out of or in connection with the use, interpretation of, or reliance upon this Standard.

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 parts made of polymeric materials that are used in electrical equipment and describe the various test procedures and their use in the testing of such parts and equipment.

1.2 These requirements do not cover the specific insulating systems that are covered by the requirements contained in the Standard for Systems of Insulating Materials, General, UL 1446.

1.3 Test procedures are provided herein for the evaluation of polymeric materials in specific applications. These test procedures include references to data obtained from small-scale property tests conducted under standard conditions as well as other practical means of evaluation.

1.4 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 General

2.1 If a value for measurement is followed by a value in other units, the use of either value can be expected to provide equivalent results in the application of such requirements. Each of the requirements is stated in SI units as well as in U.S. customary units. Equivalent, although not necessarily exactly identical results, are to be expected from applying a requirement in SI units or U.S. customary units. Equipment calibrated in metric units is to be used when a requirement is applied in metric terms.

2.2 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.

2.3 For reference purposes, Figure 2.1 describes the procedure to be followed in the evaluation of parts made of polymeric materials and covered by the requirements in this standard.

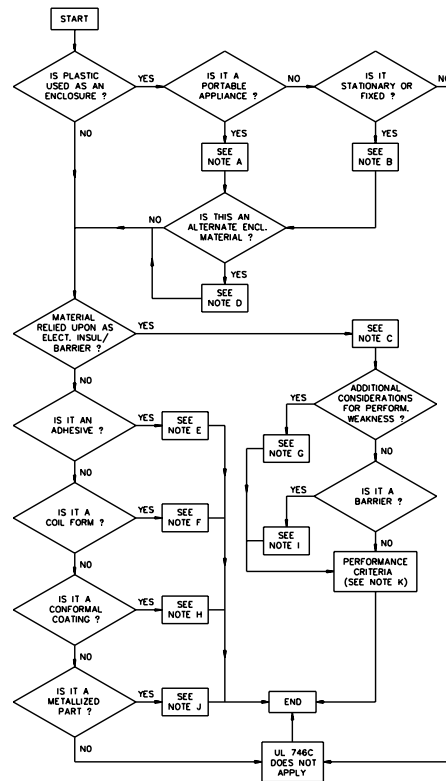
2.4 The requirements for tests for flammability of plastic materials for parts in devices and appliances, UL 94, covers flammability of polymeric materials used for parts in devices and appliances. The Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A, contains short-term test 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 – 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. The Standard for Polymeric Materials – Fabricated Parts, UL 746D, contains requirements for traceability and performance of parts molded and fabricated from polymeric materials.

2.4 added April 12, 1995

2.5 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.

2.5 added April 12, 1995

Figure 2.1
Flowchart of UL 746C procedures to evaluate polymeric parts



S3553

- A. Section 5
- B. Section 6
- C. Sections 8, 9, Table 8.1
- D. Section 7
- E. Sections 40 – 42, 69
- F. Section 43
- G. Table 8.2
- H. Sections 44, 70
- I. Table 9.1
- J. Sections 45 – 47, 71
- K. Sections 10 – 39

3 Glossary

3.1 For the purposes of this standard the following definitions apply:

3.2 ACCESSIBLE PART – A part so located that it can be contacted by a person, either directly or by means of a probe or a tool, or that is not recessed the required distance behind an opening.

3.3 ATTENDED INTERMITTENT-DUTY HOUSEHOLD APPLIANCE – *Deleted effective June 1, 2004*

3.3.1 ATTENDED EQUIPMENT– Equipment requiring a level of attendance where operator presence is normally required during use. Examples may include hand-held drills, electric knives, can openers, hand-held hair dryers, blenders, and vacuum cleaners.

Added 3.3.1 effective June 1, 2004

3.4 BRANCH CIRCUIT – A branch circuit is that portion of the building wiring system beyond the final overcurrent device on the power- distribution panel protecting the circuit to the field-wiring terminals of permanently connected equipment or to the receptacle outlet for cord-connected appliances.

3.5 COMPARATIVE TRACKING INDEX – Comparative tracking index (CTI) is determined by the method described in the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A, Recommended Method for Determining the Comparative Tracking Index of Solid Insulating Materials Under Moist Conditions.

CTI range – tracking index (Volts)	Assigned PLC
$600 \leq TI$	0
$400 \leq TI < 600$	1
$250 \leq TI < 400$	2
$175 \leq TI < 250$	3
$100 \leq TI < 175$	4
$0 \leq TI < 100$	5

3.6 CONFORMAL COATING – A protective covering applied on a printed wiring board to increase the dielectric voltage-withstand capability between conductors and to protect against environmental conditions.

3.7 CORD-CONNECTED UNIT – An appliance or product intended for connection to the branch-circuit power line by means of a power supply cord.

3.8 COUNTER-SUPPORTED APPLIANCE – An appliance that is physically supported by a counter, table or bench during the performance of its intended function.

3.9 DECORATIVE PART – A part used for ornamental purposes only and not as an enclosure or insulation of electrically live parts.

3.10 ENCLOSURE – That part of the product that:

- a) Renders inaccessible all or any parts of the equipment that may otherwise present a risk of electric shock and/or
- b) Retards propagation of flame initiated by electrical disturbances occurring within.

3.11 FIELD-WIRING TERMINAL – Any terminal where a power supply or other wire can be connected by an installer in the field.

3.12 FIXED EQUIPMENT – Any equipment or appliance that is intended to be permanently connected electrically to the wiring system.

3.13 FLAMMABILITY CLASSIFICATION – The flammability classification of a material is determined by tests described in the requirements for tests for flammability of plastic materials for parts in devices and appliances, UL 94.

3.13 revised February 3, 1997

3.14 GLOW WIRE RESISTANCE TO IGNITION – Glow wire resistance to ignition performance is expressed as the number of seconds required to ignite a specimen by an electrically heated bar operating at a specified temperature. This test is described in the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A.

3.15 GROUND – Earth ground, unless otherwise specified.

3.16 HAND-SUPPORTED APPLIANCE – An appliance that is physically supported by any part of the body of the user during the performance of its intended functions.

3.17 HIGH-CURRENT ARC RESISTANCE TO IGNITION – High-Current arc resistance to ignition (HAI) performance is expressed as the number of arc-rupture exposures (standardized as to electrode type and shape and electrical circuit) that are necessary to ignite a material when they are applied at a standard rate on the surface of the material. This test is described in the Standard for Polymeric Materials – Short Term Property Evaluation, UL 746A.

HAI range – mean number of arcs to cause ignition (NA)	Assigned PLC
$120 \leq NA$	0
$60 \leq NA < 120$	1
$30 \leq NA < 60$	2
$15 \leq NA < 30$	3
$0 \leq NA < 15$	4

3.18 HOT-WIRE RESISTANCE TO IGNITION – Hot-wire resistance to ignition (HWI) performance is expressed as the mean number of seconds needed to ignite standard specimens that are wrapped with resistance wire that dissipates a specified level of electrical energy. The test is described in the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A.

HWI range – mean ignition time (sec.)	Assigned PLC
$120 \leq IT <$	0
$60 \leq IT < 120$	1
$30 \leq IT < 60$	2
$15 \leq IT < 30$	3
$7 \leq IT < 15$	4
$0 \leq IT < 7$	5

3.19 HOUSEHOLD APPLIANCE – An appliance intended for use in the home.

3.20 INSULATED LIVE PART – An electrically live part that is provided with complete protection against electric shock and does not rely upon other parts for insulation.

3.21 INSULATION, FUNCTIONAL – The insulation necessary for the proper functioning of the product and for basic protection against electric shock.

3.21.1 INTERMITTENT OPERATION EQUIPMENT – Operation in a series of specified cycles each composed of a period of operation under NORMAL LOAD, followed by a rest period with the equipment switched off or running idle.

Added 3.21.1 effective June 1, 2004

3.21.2 LEVEL OF ATTENDANCE – The level of operator attendance is determined by whether or not operator presence is normally required or essential in order for the equipment to perform its intended task or purpose. Consideration should be given to whether the equipment has to be kept switched on by hand or foot, or equipment, which is continuously loaded by hand under normal use. The end-product standard should be referenced when determining the applicable level.

Added 3.21.2 effective June 1, 2004

3.22 LIVE PARTS – Denotes metal or other conductive parts that, during intended use, has an electrical potential difference with respect to earth ground or any other conductive part.

3.23 NON-HAZARDOUS ENERGY CIRCUIT – A circuit that is not considered to have a risk of electric shock or fire.

3.24 PERFORMANCE LEVEL CATEGORY – An integer that defines a range of test values for a given electrical/mechanical property test.

3.25 PORTABLE APPLIANCE – An appliance that is easily carried or conveyed by hand, and is provided with a power-supply cord for connection to the supply circuit.

3.26 POWER-SUPPLY CORD – The flexible electrically insulated cord provided to connect the product to the supply circuit.

3.27 PRIMARY CIRCUITS – The wiring and components that are conductively connected to the supply circuit.

3.28 PRINTED-WIRING BOARD – The finished combination of a pattern of conductive paths either on or within multilayer sheets of insulating material.

3.29 RISK OF ELECTRIC SHOCK – A risk of electric shock is considered to exist at any part if,

- a) The potential between the part and earth ground or any other accessible part is more than 42.4 V peak, and
- b) The continuous current flow through a 1500 ohm resistor connected across the potential exceeds 0.5 mA.

3.30 RISK OF FIRE – A risk of fire is considered to exist at any two points in a circuit where;

- a) The open circuit voltage is more than 42.4 V peak and the energy available to the circuit under any condition of load including short circuit, results in a current of 8 A or more after 1 minute of operation, or
- b) A power of more than 15 watts can be delivered into an external resistor connected between the two points.

3.30 revised February 3, 1997

3.31 SAME BASIC COMPOSITION – Materials that are of the identical generic material type having equivalent percentage and type of fillers, additives, resins and reinforcements.

3.32 SECONDARY CIRCUIT – A secondary circuit is a circuit supplied from a secondary winding of an isolating transformer.

3.33 STATIONARY EQUIPMENT – Any equipment or appliance that is intended to be fastened in place or located in a dedicated space, and is provided with a power-supply cord for connection to the supply circuit.

3.34 SUPPLY CIRCUIT – The branch circuit supplying electrical energy to the product.

3.34.1 UNATTENDED EQUIPMENT – Equipment where operator presence is likely, but absence is possible. Examples may include flatirons, and toasters. Equipment where operator presence is not required. Examples may include electric fry pans and coffee makers.

Added 3.34.1 effective June 1, 2004

3.35 UNINSULATED LIVE PART – A part involving the risks of fire or electric shock that is bare or has insulation that is not acceptable for the operating conditions (electrical potential, temperature, and the like) involved.

3.36 USER SERVICING – The replacing, cleaning, or adjusting done by the user.

3.37 VULCANIZED FIBER – A term used in this standard to denote a material normally used as electrical insulation. Vulcanized fiber is made by combining layers of chemically gelled paper. The zinc chloride used in gelling the paper is subsequently removed by a water leaching treatment, and the resultant product, after being dried and finished by calendering, is a dense material of partially regenerated cellulose where the fibrous structure is retained in varying degrees, depending upon the grade of fiber. Cellulose fiberboard, pressboard, fullerboard, or cardboard are not acceptable as the equivalent of fiber. Fishpaper is a designation commonly used in the trade to refer to thin sheets of electrical grade vulcanized fiber.

ENCLOSURES

4 General

4.1 Equipment having an enclosure, or parts of the enclosure, comprised of polymeric material shall comply with the applicable requirements in Table 4.1.

Revised 4.1 effective June 1, 2004

4.2 The requirements in this Section, do not cover the additional considerations that must be given to enclosure materials exposed to oils, acids, solvents, cleaning agents, and the like in use. The performance of the material shall not be adversely affected by such environments (if encountered in the end-use application) as determined by applicable tests as detailed in the Standard for Polymeric Materials – Short Term Property Evaluation, UL 746A.

Added 4.2 effective June 1, 2004

4.3 Polymeric material used to enclose a metal housing that encloses insulated or uninsulated live parts or as a decorative part, shall be classed either 5VA, 5VB, V-0, V-1, V-2, or HB by the burning tests described in the requirements for tests for flammability of plastic materials, UL 94, and comply with the Flame Spread requirements in Section 21 for large mass applications.

Exception No. 1: Decorative parts are not required to be made of a material classed 5VA, 5VB, V-0, V-1, V-2, or HB, providing the part: does not occupy a volume greater than 2 cubic centimeters (0.122 cubic inch), does not have any dimension greater than 3 cm (1.18 inch), and is located so it cannot propagate flame from one area to another or bridge between a possible source of ignition and other ignitable parts.

Exception No. 2: A material is to be considered equivalent if it complies with the requirements in 17.1, 51.1 – 51.5, 19.1, 53.1 – 53.5, when flame tested as used in the equipment. The use of a flame-retardant coating applied to the inside of a polymeric enclosure is not acceptable unless the coating/material interface is found to be acceptable by separate investigation (see Flame-Retardant Coatings, Section 22).

Added 4.3 effective June 1, 2004

Table 4.1
Enclosure Requirements

Added Table 4.1 effective June 1, 2004

Type of Equipment	Portable Attended Household Equipment	All other Portable Equipment	Stationary And Fixed
Type of Use			
Applicable requirements shown below			
Minimum Flammability Rating	HB ^{a,d}	V ^{b,d}	5VA ^{c,d}
Material Properties per Table 8.1	Yes	Yes	Yes
Impact Test per Section 24	Yes	Yes	Yes
Crush Resistance per 23.1	No	No	Yes
Abnormal Operations Test per 28.1	Yes	Yes	Yes
Severe Conditions Test per 29.1	Yes ^j	No ^j	Yes
Mold-Stress Relief Distortion per Section 30.1	Yes ^e	Yes ^e	Yes ^e
Input after Mold-Stress Relief per 31.1	Yes	No	Yes
Strain Relief Test per 31.1	Yes ^f	Yes ^f	Yes ^f
UV Resistance per 26.1	Yes ^g	Yes ^g	Yes ^g

Table 4.1 Continued on Next Page

Table 4.1 Continued

Type of Equipment	Portable Attended Household Equipment	All other Portable Equipment	Stationary And Fixed
Type of Use			
Applicable requirements shown below			
Minimum Flammability Rating	HB ^{a,d}	V ^{b,d}	5VA ^{c,d}
Water Exposure and Immersion per Sec. 27	Yes ^h	Yes ^h	Yes ^h
Dimensional Stability per 27.2	Yes	Yes	Yes
Conduit Connections	No	No	Yes ⁱ

^a HB or the enclosure complies with the 12 mm or 20 mm end-product flame tests as described in section 17 and 18 respectively.

^b V=V-0, V-1 or V-2 classed materials, or the enclosure complies with the 12 mm or 20 mm end-product flame tests as described in section 17 and 18 respectively. Exception: Use of a HB enclosure material may be acceptable if determined by the applicable requirements in the end-product standard.

^c 5VA or the enclosure complies with the 127 mm end-product flame tests as described in section 19.

^d May require flame spread per section 21.

^e Mold-Stress Relief for HB enclosures use section 62.2. For V, 5VA or enclosures that comply with the 12 mm or 20 mm end-product flame tests as described in section 17 and 18 respectively use section 62.1.

^f This test is only required if the means relief is secured to the enclosure or is an integral part of the polymeric enclosure.

^g This test is only required if the equipment is constructed such that exposure to outdoor weather conditions or UV radiation could increase the risk of fire, electrical shock, or injury to persons.

^h This test is only required if the equipment is constructed such that exposure to water could increase the risk of fire, electrical shock, or injury to persons.

ⁱ This test is required only if the equipment is permanently connected electrically to the wiring system. The continuity of the conduit system shall be a metal-to-metal contact. If the integrity of the polymeric enclosure is relied upon to provide for bonding between the parts of the conduit system at any location where conduit may be connected, the bonding shall be evaluated by the requirements contained in the Standard for Enclosures for Electrical Equipment, UL 50. If the polymeric enclosure is intended for connection to a rigid conduit system, it shall acceptably perform when tested using the pullout, torque and bending tests as described in the Standard for Industrial Control Equipment, UL 508.

^j This test is only required for materials that are rated HB.

5 Portable Appliances

Section 5 deleted effective June 1, 2004. Applicable requirements for Portable Appliances moved to Section 4

5.1 *Deleted effective June 1, 2004*

5.2 *Deleted effective June 1, 2004*

5.3 *Deleted effective June 1, 2004*

5.4 *Deleted effective June 1, 2004*

5.5 *Deleted effective June 1, 2004*

5.6 *Deleted effective June 1, 2004*

Figure 5.1
Enclosure requirements for portable appliances

Figure 5.1 deleted effective June 1, 2004

5.7 Deleted effective June 1, 2004

5.8 Deleted effective June 1, 2004

5.9 Deleted effective June 1, 2004

5.10 Deleted effective June 1, 2004

5.11 Deleted effective June 1, 2004

6 Fixed or Stationary Equipment

Section 6 deleted effective June 1, 2004. Applicable requirements for Fixed or Stationary Equipment moved to Section 4

6.1 Deleted effective June 1, 2004

6.2 Deleted effective June 1, 2004

6.3 Deleted effective June 1, 2004

6.4 Deleted effective June 1, 2004

6.5 Deleted effective June 1, 2004

6.6 Deleted effective June 1, 2004

6.7 Deleted effective June 1, 2004

6.8 Deleted effective June 1, 2004

6.9 Deleted effective June 1, 2004

Figure 6.1 Enclosure requirements for fixed or stationary equipment

Figure 6.1 deleted effective June 1, 2004

6.10 Deleted effective June 1, 2004

6.11 Deleted effective June 1, 2004

7 Alternate Enclosure Material Considerations

Section 7 deleted October 16, 2000. Applicable requirements being relocated to Appendix A

7.1 Deleted October 16, 2000

7.2 Deleted October 16, 2000

7.3 Deleted October 16, 2000

7.4 Deleted October 16, 2000

7.5 Deleted October 16, 2000

7.6 Deleted October 16, 2000

7.7 Deleted October 16, 2000

Table 7.1
Alternative enclosure material consideration

Table 7.1 deleted October 16, 2000

ELECTRICAL INSULATION

8 Material Property Considerations

Revised 8 effective June 1, 2004

8.1 General

8.1.1 Mechanical and electrical properties of materials are to be judged with respect to the particular “end use” application. The requirements in this Section establish general minimum requirements for applications where the polymeric material is relied upon to reduce the risks of fire and electric shock.

Revised 8.1.1 effective June 1, 2004

8.1.2 These requirements do not cover the additional considerations that must be given to applications employing large masses of polymeric materials. Whether or not such materials protect against electric shock or injury to persons, consideration is to be given to the likelihood of ignition of the material by sources inside the product or by sources outside the product. See 21 for Flame Spread requirements to be applied to large mass applications.

Revised 8.1.2 effective June 1, 2004

8.1.3 These requirements supplement the requirements for enclosures in Section 4.

Revised 8.1.3 effective June 1, 2004

8.1.4 Figure 8.1 is to be used as a guide to determine the applicable material-property requirements. First, the construction features found in the end product are to be matched to the Figurative examples given in Figure 8.1. By referring back to Table 8.1, it can be determined which minimum property values are required for each of the typical constructions (Figurative examples).

Exception: End product tests may be used instead of pre-selection tests to determine if the material is acceptable in the application, as indicated in Table 8.2.

Note – As an example of using Table 8.1 and Figure 8.1, a polymeric material used in an application that most closely matches figurative example No. 7 of Figure 8.1, would be evaluated with respect to the mold-stress relief, resistance to creep, and maximum-use temperature properties indicated in Table 8.1.

Revised 8.1.4 effective June 1, 2004

8.1.5 *Deleted effective June 1, 2004*

8.1.6 To determine a polymeric material's performance profile, certain tests are to be performed according to the methods contained in the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A and the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B. These tests, general engineering considerations, and minimum performance levels are tabulated in Table 8.1. Specific applications may require different limits than are shown in the general case. Refer to 8.2 for considerations to be used in determining the acceptability of an insulating material that does not meet with the requirements tabulated in Table 8.1.

Revised 8.1.6 effective June 1, 2004

8.1.7 In establishing acceptable performance levels, consideration has been given to the service experience and to property values of presently available materials. Minimum performance characteristics have been grouped into four distinct levels based upon a material's flammability classification. The basis for the grouping is a relationship developed between resistance to ignition and persistence or rate of burning.

8.1.8 Nonrigid foamed materials – having a tensile or flexural modulus less than 0.69 gigapascals (100,000 lbf/in²), and a density less than 0.5 gram per cubic centimeter (31.3 lb/ft³) – are generally not considered acceptable for the direct or indirect support of live parts.

8.2 Evaluation of Materials Not Meeting Preselection Test Performance Levels in Table 8.1

Revised 8.2 effective June 1, 2004

8.2.1 Some materials may have performance characteristics less than the minimum required for the construction type (Figurative example) in Table 8.1. In such cases, the application can be considered in the context of the complete end product construction and special tests conducted to determine if the lower value can be accepted without increasing the likelihood of risk for the particular end-product.

Revised 8.2.1 effective June 1, 2004

8.2.2 Table 8.2 indicates which end-product tests, or other considerations such as increased thicknesses or spacings, may be used as alternatives to the requirements in Table 8.1.

Revised 8.2.2 effective June 1, 2004

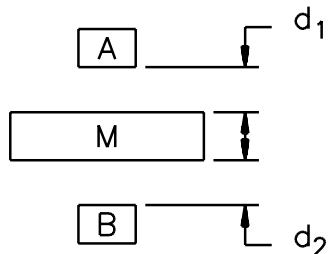
Pages 21–24 deleted.

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Figure 8.1
Figurative examples for Table 8.1

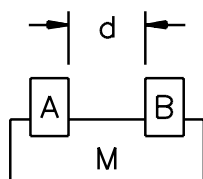
Figure 8.1 revised July 15, 1998

1.



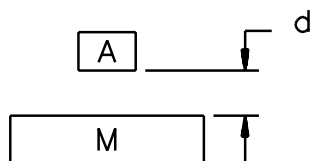
$d_1 + d_2 < S_a$
 WHERE d_1, d_2 = THROUGH AIR SPACING
 S_a = APPLICABLE THROUGH AIR
 SPACING REQUIREMENT

2.



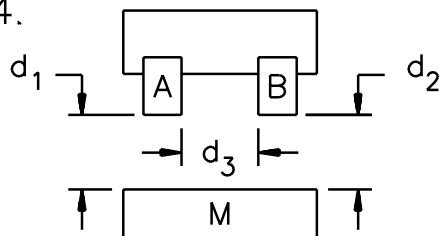
$d < 12.7\text{mm}$
 WHERE d = OVER SURFACE SPACING

3.



$0 \leq d < 0.8\text{mm}$
 WHERE d = THROUGH AIR SPACING

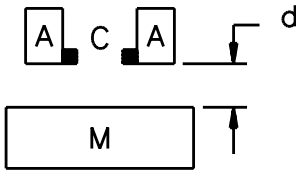
4.

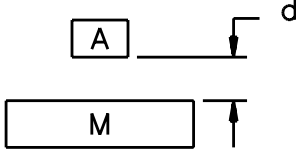


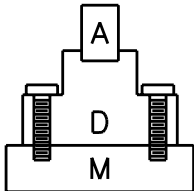
$d_1, d_2 < 0.8\text{mm}$
 $d_3 < 12.7\text{mm}$
 WHERE d_1, d_2 = THROUGH AIR SPACINGS
 d_3 = OVER SURFACE SPACING

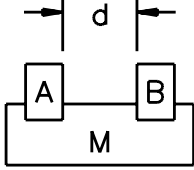
S3463B-1

Figure 8.1 (Cont.)
Figurative examples for Table 8.1

5.  $d < 12.7\text{mm}$
WHERE d = THROUGH AIR SPACING
C = ELECTRICAL CONTACTS, e.g.
SWITCH CONTACTS,
RELAY CONTACTS,
BRUSH/COMMUTATOR CONTACTS

6.  $0.8\text{mm} \leq d < 12.7\text{mm}$
WHERE d = THROUGH AIR SPACING

7.  D = ACCEPTABLE INSULATING MATERIAL
IN CONTACT WITH "A" AND MOUNTED
ON "M" BY SCREWS

8.  $d \geq 12.7\text{mm}$

A = UNINSULATED LIVE PART

B = (1) UNINSULATED LIVE PART HAVING DIFFERENCE IN POTENTIAL FROM A, OR
(2) DEAD METAL PART THAT MAY BE GROUNDED IN SERVICE OR IS EXPOSED TO CONTACT.

M = POLYMERIC MATERIAL UNDER CONSIDERATION

Note: (1) ALL SPACINGS ASSUMED TO BE RELIABLY MAINTAINED.
(2) UNLESS SHOWN IN CONTACT WITH "M", ALL LIVE PARTS ARE SUPPORTED BY STRUCTURES NOT DEPENDENT ON "M".

S3463B-2

Table 8.1
Material property considerations

Revised Table 8.1 effective June 1, 2004

Property	Test	Method	Units of PLC	Recommended levels related to flammability classification ^a				Applications ^b	Figurative examples from Fig. 8.1
				V-0 VTM-0	V-1 VTM-1	V-2 VTM-2	HB		
ELECTRIC STRENGTH	Volume – resistivity (Sec. 16)	UL 746A	Min Ohm-cm (dry)	50 x 10 ⁶	50 x 10 ⁶	50 x 10 ⁶	50 x 10 ⁶	Material serves as insulation between uninsulated live parts of opposite polarity or between uninsulated live parts and (1) dead metal parts that may be grounded in service or (2) any surface exposed to contact	(1), (2), (3), (8)
			Min Ohm-cm (after 90% humidity)	10 x 10 ⁶	10 x 10 ⁶	10 x 10 ⁶	10 x 10 ⁶		
	Dielectric strength (Sec. 12)	UL 746A	Min V (rms) (both dry & after 90% humidity)	5000	5000	5000	5000	Same as above	(1), (2), (3), (8)
TRACKING RESISTANCE	Comparative tracking index (CTI) (Sec.11)	UL 746A	Max ^c PLC					Material surface is in contact with or in close proximity (less than 1/32 inch (0.8mm)) to (a) uninsulated live parts of opposite polarity, or (b) uninsulated live parts and either (1) dead metal parts that may be grounded in service, or (2) any surface exposed to contact Higher CTI values are required where a greater degree of contamination is involved, as follows: Indoor equipment exposed to relatively clean environment Outdoor and indoor equipment exposed to moderate contaminate environments	(2), (3), (4)
				4	4	4	4		
				3	3	3	3		
				2	2	2	2		
	CTI	UL 746A	Max ^c PLC	2	2	2	2	Outdoor and indoor equipment exposed to severe contaminate environments	
	Inclined-plane tracking (Sec. 15)	UL 746A	Min time (min) to track 25.4 mm at 2.5 kV excitation	60	60	60	60	Same as above for CTI except that the application voltage range is 601 V-5 kV	(2), (3), (4), (8)
				300	300	300	300	Same as above for CTI except that application voltage range 5,001 V-35 kV	(2), (3), (4), (8)

Table 8.1 Continued on Next Page

Table 8.1 Continued

Property	Test	Method	Units of PLC	Recommended levels related to flammability classification ^a				Applications ^b	Figurative examples from Fig. 8.1
				V-0 VTM-0	V-1 VTM-1	V-2 VTM-2	HB		
PERMANENCE	Dimensional change after water exposure (Sec. 27.2.1)	UL 746A	Max percent change	2	2	2	2	Same as Volume Resistivity above but also includes applications where the material maintains the relative positioning of live parts and the parts could be subjected to high humidity or moisture	(1), (2), (3), (4), (7), (8)
DISTORTION UNDER LOAD	Heat deflection temperature under load or	UL 746A	Min °C at 66 psi	10°C (18°F) greater than the use temperature but not less than 90°C				All applications except decorative parts	(1), (2), (3), (4), (5), (6), (7), (8)
	25°C greater than the use temperature but not less than 105°C (221°F)								
	Greater than the use temperature by the difference between 40°C and the ambient, but not less than 95°C								
DIMENSIONAL CHANGE DUE TO EXTERNAL STRESSES	Resistance to Creep (Sec. 24A)	UL 746C		Resistance to creep should be evaluated in the specific application				All applications with mechanical stresses due to external sources	(1), (2), (3), (4), (5), (6), (7), (8)
RESISTANCE TO ELECTRICAL IGNITION SOURCES	High current arc resistance to ignition (HAI) (Sec. 13)	UL 746A	Max PLC ^d	3	2	2	1	Material is in contact with or in close proximity to uninsulated live parts 0.8 mm (1/32 inch) for nonarcing parts or 12.7 mm (1/2 inch) for arcing parts	(1), (2), (3), (4), (5), (8)
	Hot wire ignition HWI (Sec. 14)	UL 746A	Max PLC ^e	4	3	2	2	Material is in contact with or close proximity to uninsulated live parts [less than 0.8 mm (1/32 inch)]	(2), (3), (4), (8)
MECHANICAL	Tensile or flexural strength; tensile, Izod, or Charpy impact (Sec. 24)	UL 746A	MPa KJ/m ² or J/m notch	Mechanical strength is judged in the application				Material maintains the relative positioning of live parts or encloses live parts	(2), (4), (7), (8)
MAXIMUM USE TEMPERATURE	Relative thermal index (RTI) (Sec. 37 – 39)	UL 746A	Minimum °C	The maximum operating temperature of the part shall not exceed materials' temperature limit determined by the method, indicated in Table 33.1 (See Sections 33 – 39)				All applications except decorative parts	(1), (2), (3), (4), (5), (6), (7), (8)
^a Materials classed as 5VA and 5VB only by the Vertical Burning Test described in the requirements for tests for flammability of plastic materials for parts in devices and appliances, UL 94, or a material when flame tested as used in the equipment, complies with the requirements in Flammability - 12 mm flame, Section 17, Flammability - 3/4-inch flame, Section 18, or Flammability - 127 mm (5 inch) flame, Section 19, shall be considered with respect to the recommended performance levels of a material classed as V-1									

Table 8.1 Continued on Next Page

Table 8.1 Continued

Property	Test	Method	Units of PLC	Recommended levels related to flammability classification ^a				Applications ^b	Figurative examples from Fig. 8.1
				V-0 VTM-0	V-1 VTM-1	V-2 VTM-2	HB		
^b Materials located in nonhazardous-energy circuitry, as defined in the appropriate end-product standard, shall only be considered with respect to their flammability, distortion under load and mold stress relief, mechanical and maximum use temperature properties except the resistance to electrical ignition sources property may also be considered if the material is located less than 12.7 (1/2 inch) from arcing parts or sources of ignition.									
^c				CT1 Range – Tracking Index (Volts)		Assigned PLC			
				600 ≤ TI		0			
				400 ≤ TI < 600		1			
				250 ≤ TI < 400		2			
				175 ≤ TI < 250		3			
				100 ≤ TI < 175		4			
				0 ≤ TI < 100		5			
^d During the HAI test, the electrodes are to be positioned as indicated in 13.2									
				HAI Range – mean number of arcs to cause ignition		Assigned PLC			
				120 ≤ NA		0			
				60 ≤ NA < 120		1			
				30 ≤ NA < 60		2			
				15 ≤ NA < 30		3			
				0 ≤ NA < 15		4			
^e				HWI Range – mean ignition time		Assigned PLC			
				120 ≤ IT		0			
				60 ≤ IT < 120		1			
				30 ≤ IT < 60		2			
				15 ≤ IT < 30		3			
				7 ≤ IT < 15		4			
				0 ≤ IT < 7		5			

Table 8.2
Additional considerations for materials not meeting pre-selection test performance levels

Revised Table 8.2 effective June 1, 2004

Test		Additional end product considerations
1.	Volume resistivity	Conduct end product leakage current test – see 16.1
2.	Dielectric strength	Use thicker material section – see 12.1
3.	Comparative tracking index (CTI)	Increase spacings
4.	Inclined Plane tracking	Increase spacings
5.	Permanence	Conduct end product conditioning test – see 27.2
6.	Distortion under load	Conduct end product mold stress-relief distortion test where stress is internal (i.e., results from molding or fabrication process) – see 30.1
7.	High current arc ignition (HAI)	Conduct end product arc resistance test – see 13.3 and 13.4

Table 8.2 Continued on Next Page

Table 8.2 Continued

Test		Additional end product considerations
8.	Hot wire ignition (HWI)	Conduct end product abnormal overload test, or end-product Glow-Wire Test – see Hot-Wire Ignition (HWI)) – Abnormal Overload Test, Section 14
9.	Maximum Use Temperature	Conduct end product thermal aging test – see Relative Thermal Index, Section 36, Relative Thermal Capability, Section 37, and Temperature Excursions Beyond the Maximum Use Temperature, Section 39

9 Internal Barriers

9.1 A barrier or liner employed where spacings are unacceptable between uninsulated live parts of opposite polarity or between uninsulated live parts and accessible metal parts, shall comply with all of the following:

- a) The barrier or liner shall be of insulating material that complies with Table 8.1.
- b) The minimum thickness of the barrier or liner shall be at least 0.71 mm, except that 0.33 mm is acceptable where used in conjunction with an air space of at least one-half of the required clearance.

Exception No. 1: The thickness of the barrier may be less than that specified in 9.1(b) providing that the results of a separate investigation indicate acceptable performance. Resin bonded mica 0.15 mm thick is considered to meet this thickness requirement when its use is limited to applications where it is protected from mechanical abuse or movement. Polyethylene terephthalate (PETE) film 0.18 mm thick, or greater, is considered to meet the thickness requirement.

- c) The barrier or liner shall be equivalent to vulcanized fiber in mechanical strength (tensile strength, tear resistance, puncture strength, Cold Flow, and the like) if likely to be subject to mechanical damage. See Polymeric Materials – Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials used in Printed Wiring Boards, UL 746E, Vulcanized Fibre, Section 9, for specific performance indexing data on vulcanized fiber.

Revised 9.1 effective June 1, 2004

9.2 A material, that is used as a physical barrier against contact with parts that can cause injury to persons during intended operation and user servicing, or to restrict access to circuitry where there is an increased risk of electric shock, shall comply with the requirements in Table 8.1.

Revised 9.2 effective June 1, 2004

Table 9.1
Material requirements for internal barriers

Table 9.1 deleted effective June 1, 2004

9.3 Deleted effective June 1, 2004

PERFORMANCE CRITERIA

10 General

10.1 Sections 10– 39 indicate the test methods and minimum performance levels specified in Table 4.1 and Table 8.1. Some materials may not comply with all of the general properties required for the application. In such cases, the application must be further considered to determine if the material's characteristics are not acceptable, or if a reduced value can be accepted without increasing the likelihood of risk for the particular end-product.

Revised 10.1 effective January 1, 2004

10.2 Many of the sections make reference to one or more performance tests on the end-product that can be used to determine the acceptability of a material where performance does not meet the minimum requirements.

ELECTRICAL

11 Comparative Tracking Index (CTI)

11.1 A risk of fire or electric shock may develop within electrical equipment as a result of electrical tracking of insulating material that is exposed to various contaminating environments and surface conditions. The comparative tracking index provides a comparison of the performance of insulating materials under wet and contaminated conditions.

11.2 Comparative tracking index (CTI) is determined by the method described in the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A, Recommended Method for Determining the Comparative Tracking Index of Solid Insulating Materials Under Moist Conditions. The comparative tracking voltage is an index and is not directly related to the suitable operating voltage in actual service.

11.3 The comparative tracking index provides an indication of the relative track resistance of the material at voltages up to 600V. The incline plane tracking test described in Inclined Plane Tracking, Section 15 should be used to evaluate the track resistance of materials at voltages that are greater than 600V.

11.4 As indicated in Table 8.1, an insulating material that is in contact with or close proximity to less than 0.8 mm (1/32 inch) uninsulated live parts or such parts and dead metal parts that may be grounded in service or any surface exposed to contact, shall have a maximum CTI PLC of 4 for indoor equipment in a relatively clean environment; a maximum CTI PLC of 3 is required for most outdoor and indoor equipment that may be exposed to moderate contaminate environments; a maximum CTI PLC of 2 is required for equipment that is likely to be subjected to severe contaminate environments.

Exception: In lieu of demonstrating compliance through the use of a pre-selection test, The Proof Tracking Test, described in IEC 112, can be conducted on a portion of the product enclosure to determine compliance with the specified Proof Tracking Index (PTI) specified in the end-product standard.

11.4 revised July 7, 1999

11.5 The values specified in Table 8.1 are for reference, higher or lower values may be required in specific end-product equipment.

12 Dielectric Strength

12.1 If an enclosure of polymeric material is depended upon to serve as electrical insulation, it shall have a dielectric strength in the use thickness at 50 – 60 Hz of at least 5000 V, rms, both after conditioning for 40 hours at $23.0 \pm 2.0^{\circ}\text{C}$ ($73.4 \pm 3.6^{\circ}\text{F}$) and 50 ± 5 percent relative humidity and after conditioning for 96 hours to moist air having a relative humidity of 90 ± 5 percent at a temperature of $35.0 \pm 2.0^{\circ}\text{C}$ ($95.0 \pm 3.6^{\circ}\text{F}$).

13 High Current Arc Resistance to Ignition (HAI)

13.1 A polymeric material shall resist ignition to the levels shown in Table 8.1 when tested in accordance with the High Current Arc Resistance to Ignition Test described in the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A.

Exception: The high current arc resistance-to-ignition test need not be conducted for non-hazardous energy circuits.

13.2 During the test the electrodes are to be positioned as follows:

- a) If the live parts are located less than 0.8 mm (1/32 inch) from the polymeric material, then the electrodes are to be positioned on the surface of the material, or
- b) If the source of an arc for an arcing live part is located at least 0.8 mm (1/32 inch) but less than 12.7 mm (1/2 inch) from the material, the electrodes are to be positioned above the surface of the material at a distance equal to the minimum distance between the arc source and the material used in the application.

13.3 A material that does not comply with 13.1 may be evaluated by using the power (current, voltage, and power factor) of the circuit in the end product by conducting a short-circuit test using the procedures described in 49.1. (Arcing Test)

13.4 There shall be no ignition;

- a) Within 15 arcs for materials classed V-0,
- b) Within 30 arcs for materials classed V-1 and V-2, or
- c) Within 60 arcs for materials classed HB.

In addition, there shall not be a permanent carbon conductor path judged by application of a dielectric voltage-withstand potential between the live part and the adjacent part of different potential indicated in 49.1, as required in the end-product Standard but not less than 1000 volts, 60 hertz for 1 minute.

13.4 revised July 17, 1997

13.5 The end-product tests described in 49.1 may show that the shape, over-surface distance, thickness, heat sinks, and the like, provide more ignition resistance than occurred as a result of testing plastic specimens using the method described in the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A.

14 Hot-Wire Ignition (HWI) – Abnormal Overload Test or Glow-Wire End-Product Test

14.1 General

14.1.1 Materials that do not comply with the minimum hot-wire ignition levels shown in Figure 5.1, Tables 7.1, 8.1 or 9.1 may be evaluated by an abnormal overload test or the glow-wire end-product test. The abnormal overload test passes abnormal currents through current-carrying members as described in 14.2. Over-current values and times are shown in Table 50.1 as a function of the circuit over-current device rating. The glow-wire end-product test subjects the end-product to an electrically heated wire. Glow-wire test temperatures are shown in Table 73.1 and are determined by end-product use.

Exception No. 1: The abnormal overload test or the glow-wire end-product test need not be conducted if the electrically live parts are spaced 0.8 mm (1/32 inch) or more from the material.

Exception No. 2: The abnormal overload test or the glow-wire end-product test need not be conducted for non-hazardous energy circuits.

14.1.1 revised July 15, 1998

14.2 Abnormal overload test

14.2.1 A polymeric material shall be capable of withstanding the temperatures that are generated during or as a result of the abnormal overload test described in 50.1 and 50.2 without ignition.

14.2.2 If there is no overcurrent protective device as part of the equipment or it cannot be relied upon, evaluation shall be based upon the available energy to the end-product using percentages of the intended branch-circuit overcurrent device, but not less than a 30 A normal-acting protective device.

14.2.3 If the overcurrent protective device is part of the equipment, it shall be relied upon only if the protector is not user-serviceable unless substitution of a higher-rated protector value is prevented by keying, other constructional features, or if there is a permanent marking limitation.

14.3 Glow-wire end-product test (GWEPT)

Revised 14.3 effective June 1, 2004

14.3.1 A polymeric material shall be capable of withstanding the effects of an electrically heated wire as described in 73.1.1 – 73.6.2. The specimen is considered to have satisfactorily withstood the glow-wire end-product test if either:

- a) There is no ignition, or
- b) All flaming and glowing of the specimen, the parts surrounding the specimen, and (if a material was used other than the tissue paper/pinewood board) the flaming particle indicator, ceases within 30 ± 1 s after removal of the glow-wire. The results are not acceptable if the specimen, the parts surrounding the specimen, or the flaming particle indicator are completely consumed.

14.3.1 added April 12, 1995

15 Inclined Plane Tracking

15.1 The inclined plane tracking test described in the Standard for Polymeric Materials – Short Term Property Evaluations, (UL 746A), provides an indication of the relative track resistance of the material at voltages that are greater than 600 V, but less than 35 kV.

15.2 As indicated in Table 8.1, an insulating material that is in contact with or close proximity to uninsulated live parts or such parts and dead metal parts that may be grounded in service or any surface exposed to contact, shall not track beyond one inch in less than 300 minutes using the time-to-track method. For materials subjected to voltage stresses between 5,001 V and 35 kV.

Exception: A minimum 60 minute time-to-track time is required for materials subjected to voltage stresses between 601 V and 5 kV.

16 Volume Resistivity

16.1 The volume resistivity of the polymeric material shall not be less than:

- a) 50 megohm-centimeters after conditioning for 40 hours at $23.0 \pm 2.0^{\circ}\text{C}$ ($73.4 \pm 3.6^{\circ}\text{F}$) and 50 ± 5 percent relative humidity.
- b) 10 megohm-centimeters immediately after exposure for 96 hours to moist air having a relative humidity of 90 ± 5 percent at a temperature of $35.0 \pm 2.0^{\circ}\text{C}$ ($95.0 \pm 3.6^{\circ}\text{F}$).

Exception: A material that exhibits a low value of volume resistivity may be considered acceptable, provided that the equipment complies with the leakage-current requirements in 16.3.

16.2 The volume resistivity is to be determined in accordance with the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A.

16.3 The leakage current of a cord-connected appliance rated for a nominal 120 V supply when tested in accordance with 72.1 – 72.5 shall not be more than:

- a) 0.5 mA for an ungrounded (two-wire) portable, stationary, or fixed appliance,
- b) 0.5 mA for a grounded (three-wire) portable appliance, and
- c) 0.75 mA for a grounded (three-wire) stationary or fixed appliance employing a standard attachment plug rated 20 A or less.

16.4 Leakage current refers to all currents, including capacitively coupled currents, which may be conveyed between exposed conductive surfaces of an appliance and ground or other exposed conductive surfaces of an appliance.

FLAMMABILITY

17 Flammability – 12 mm Flame

17.1 When equipment is tested as described in 51.1 – 51.6, the material shall not flame for more than 1 minute after two 30-second applications of a test flame, with an interval of 1 minute between applications of the flame. The results are not acceptable if the sample is completely consumed.

Exception: Parts that are molded from materials that are classed as 5VA, 5VB, V-0, V-1, or V-2 by the vertical burning test described in UL 94, need not be subjected to the flammability test described in 51.1 – 51.6.

17.1 revised July 17, 1997

18 Flammability – 3/4-Inch Flame

18.1 When equipment is tested as described in 52.1 – 52.5, the material shall not flame for more than 1 minute after two 30-second applications of a test flame, with an interval of 1 minute between applications of the flame. The results are not acceptable if the sample is completely consumed.

Exception: Parts that are molded from materials that are classed as 5VA, 5VB, V-0, V-1, or V-2 by the vertical burning test described in UL 94, need not be subjected to the flammability test described in 52.1 – 52.5.

18.1 revised July 17, 1997

19 Flammability – 127 mm (5 Inch) Flame

19.1 Except as indicated in the Exception to 53.1, when equipment is tested as described in 53.1 – 53.5, all of the following results shall be obtained:

- a) The material shall not continue to burn for more than 1 minute after the fifth 5-second application of the test flame, with an interval of 5 seconds between applications of the flame,
- b) Flaming drops or flaming or glowing particles that ignite surgical cotton 305 mm (12 inch) below the test specimen shall not be emitted by the test sample at any time during the test, and
- c) The material shall not be destroyed in the area of the test flame to such an extent that the integrity of the part is affected with regard to containment of fire.

Exception: Parts that are molded from materials that are classed as 5VA by the five inch burning test described in UL 94, need not be subjected to the flammability tests described in 53.1 – 53.5.

19.1 revised July 17, 1997

Pages 37–38 deleted.

20 Enclosure Flammability – 746-5VS

20.1 Test criteria

20.1.1 When tested as described in 54.1.1 – 54.2.7, coated materials shall:

- a) Not have any plaques which burn with flaming or glowing combustion, or both, for more than 5 seconds after removal of the flame.
- b) Not have any plaques which drip flaming particles that ignite the dry absorbent surgical cotton located 305 mm (12 inch) below the test plaque.
- c) Not have any plaques that exhibit burn through.

20.1.2 If only one plaque from a set of five fails to comply with the requirements, another set of five plaques is to be tested. All plaques from this second set shall comply with the requirements in order for the material in that thickness to be considered acceptable.

21 Enclosure Flammability – Large Mass Considerations

21.1 A polymeric material enclosure having in any single unbroken section, a projected surface area greater than 0.93 m² (10 ft²) or a single linear dimension greater than 1.83 m (6 ft) shall have a maximum flame-spread rating of 200 as determined by the requirements for tests for surface burning characteristics of building materials, UL 723, or the radiant-panel test in the requirements for tests for flammability of plastic materials for parts in devices and appliances, UL 94, may be used optionally to determine the flame spread characteristics of the material, in noncritical applications.

Exception: If the projected surface area is broken with a minimum 305 mm (12 inch) fire separation, or the polymeric material is used for the enclosure of equipment not permanently affixed to a power supply source, then the radiant panel test described in the requirements for tests for flammability of plastic materials for parts in devices and appliances, UL 94, shall be used to determine the flame spread characteristics of the material. The material shall have a maximum flame spread index of 200 as determined by the radiant panel test.

22 Flame-Retardant Coatings

22.1 General

22.1.1 The requirements in Section 22 and Flame-Retardant Coatings Test, Section 55 cover flame-retardant coatings that are employed on enclosures of polymeric materials in order to comply with the applicable flame test requirements (refer to Portable Appliances, Section 5 and Fixed or Stationary Equipment, Section 6 of this Standard).

22.1.2 The coating/enclosure material combination may be considered equivalent to a material possessing the applicable minimum flammability classification providing:

- a) The basic polymeric enclosure material is classified at least HB by the test method described in the requirements for tests for flammability of plastic materials for parts in devices and appliances, UL 94,
- b) Samples of the base material with the flame-retardant coating properly applied are found to comply, both before and after conditioning, with the minimum required flammability classification and adhesion tests,
- c) Additional coatings applied to the enclosure for coloring, finish, and the like do not adversely affect the complete enclosure with respect to its flammability classification,
- d) The addition of the flame-retardant coating does not adversely affect the insulating characteristics of the enclosure. This characteristic may not be a factor in all equipment designs, and
- e) An acceptable process-control program is to be established by the manufacturer at the location where the flame-retardant coating is applied to the enclosure material.

22.1.2 revised July 15, 1998

22.1.3 In all cases, the flame-retardant coating shall comply with the requirements of Section 22 and Flame-Retardant Coatings Test, Section 55 and the base enclosure material shall be acceptable for the temperatures that are encountered in the end product.

22.1.4 The tests in 22.2.1, 55.1.1.1 – 55.1.6.1 apply to the coating/material interface when it is exposed to a maximum use temperature of 60°C (140°F).

22.2 Test criteria

22.2.1 Both before and after completing the conditioning described in 55.1.1.1, 55.1.2.1 and 55.1.3.2, the specimens shall be tested to determine that:

- a) The flammability classification is essentially the same or better than that of the unconditioned samples,
- b) The specimens do not exhibit any evidence of flaking, cracking, or blistering of the coating after the test described in 55.1.4.3, and

c) The impact and/or flexural strength properties have not been reduced by more than 50 percent from the as-received (or unconditioned) value.

d) The surface resistivity of the specimens.

22.2.2 When the maximum use temperature exceeds 60°C (140°F), the acceptability of the coating/material interface is to be determined by a long-term thermal-aging study of the critical properties, including flammability, adhesion, and flexural or impact strength. Refer to the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B, for thermal-aging test procedures.

MECHANICAL

23 Crushing Resistance

23.1 Equipment that is not easily moved from one place to another during intended use, shall withstand a 1 minute application of the crushing force described in 56.1 without resulting in any of the following:

- a) Reduction of spacings below the minimum acceptable values.
- b) Making bare live parts or internal wiring accessible to contact.
- c) Such breakage, cracking, rupture, and the like as to produce an adverse effect on the insulation.
- d) Producing any other condition that would increase the likelihood of electric shock or fire, or both, during use of the equipment.

24 Resistance to Impact

24.1 The equipment shall withstand the impact described in 57.1 or 57.3 (whichever is applicable) without occurrence of any of the following:

- a) Making uninsulated live parts accessible to contact (use the accessibility probe of the product standard for this evaluation);
- b) Producing a condition that might affect the mechanical performance of the equipment; or
- c) Producing a condition that would increase the likelihood of an electric shock.

24.2 With reference to 24.1(b), cracking or denting of the enclosure is not to affect the function of any safety controls or constructional features such as thermostats, overload protective devices, waterseals, or strain relief. Cracking or denting of the enclosure is not to result in exposure of moving parts capable of causing injury to persons.

24.3 With reference to 24.1(c), the equipment is to comply with the dielectric voltage-withstand requirements applicable to the equipment after being subjected to the impact.

DIMENSIONAL CHANGE OF POLYMERIC PARTS

24A Creep

Section 24A added July 15, 1998

24A.1 Creep is defined as the dimensional change with time of a material under load. If a constant load is applied to a polymeric material, the initial dimensional change is predictable from the stress-strain modulus but, with time, the dimensional change continues to increase slowly until a point is reached at which the elongation suddenly again increases or rupture occurs. From experience, these effects are considered not to apply to rigid thermoset materials.

24A.2 Creep can occur when a polymeric part is under any type of long-time loading (for example, bending, compressive, or tensile loading, leaf or coil springs, or gravity).

24A.3 Where the end-product application is such that the creep is self-relieving, 300 hours at normal operating temperature, and with maximum loading, determines the effect of plastic flow. Creep is to be considered self-relieving if the stress is eliminated due to the change in dimension of the polymeric part.

24A.4 Where the end-product application is such that the creep is not self-relieving, such as when the external force is provided by gravity, 1,000 hours at normal operating temperature, and with maximum loading, determines the effect of plastic flow.

24A.5 As a result of the above, there is to be no warpage of distortion that:

- a) interferes with normal operation or servicing,
- b) results in accessibility of live parts,
- c) reduces electrical spacings below the level necessary to comply with the applicable requirements pertaining to dielectric strength and leakage current,
- d) for outdoor-use products, exposes internal components to the effects of weathering or water, and
- e) results in an unacceptable reduction of the pressure involved in metal-to-metal joints relied upon for safety including joints providing a bonding path and joints serving as current carrying parts.

24A.6 Manufacturer's data concerning the creep characteristics of material can be used for creep analysis. In applying such data, consideration is to be given to the similarity of the test method to the end application. The more nearly alike the environmental conditions, the geometry of the parts, and the stresses of both the test and the end application, the more valid a prediction can be made based on the test data.

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