

UL 746A

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Polymeric Materials – Short Term Property Evaluations



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

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Revisions: This Standard contains revisions through and including December 26, 2003.

Summary of Topics

Addition of Guidelines for IR, TGA, and DSC Evaluations; General Editorial Revisions

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

The new and/or revised requirements are substantially in accordance with UL's Bulletin(s) on this subject dated August 8, 2003. The bulletin(s) is now obsolete and may be discarded.

The revisions dated December 26, 2003 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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Page	Date
1-3	December 26, 2003
4-5	November 1, 2000
6-8	December 26, 2003
9-13	November 1, 2000
14	December 26, 2003
15	November 1, 2000
16	December 26, 2003
17-18	November 1, 2000
19-20B	December 26, 2003
21-27	November 1, 2000
28	September 6, 2001
29-48	November 1, 2000
SA1-SA4	November 1, 2000
A1-A2	December 26, 2003
B1-B4	December 26, 2003
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1

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This ANSI/UL Standard for Safety, which consists of the Fifth edition with revisions through December 26, 2003, 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. Written comments are to be sent to UL-MEL Standards Department, 1285 Walt Whitman Road, Melville, NY 11747.

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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CONTENTS

FOREWORD	8
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INTRODUCTION

1 Scope	9
2 Units of Measurement	9
3 References	9
4 Supplementary Test Procedures	9
5 Alternate or Equivalent Test Methods	10
6 Characteristics of Polymeric Materials	10
7 Use of Polymeric Materials	11
8 General	11
8.1 Selection of samples and test specimens	11
8.2 Preparation of specimens	11
8.3 Thickness and directional properties	12
8.4 Treatment prior to test	12
8.5 Testing conditions	12
8.6 Testing for temperature effects	12
8.7 Apparatus	12
8.8 Results of tests	13
8.9 Polymer variations	13

TESTING FOR MECHANICAL PROPERTIES

9 Tensile Properties of Thermoplastic Polymeric Materials	14
10 Tensile Properties of Elastomers	15
11 Tensile Properties of Thin Polymeric Sheetting	15
12 Izod Impact Test	15
13 Tensile Impact Test	15
14 Charpy Impact Test	16
15 Flexural Properties of Thermosetting Polymeric Materials	16
16 Shear Properties of Polymeric Materials	16
17 Bond Strength of Plated Polymeric Materials	16
17.1 General	16
17.2 Conditioning	17
17.3 Test procedure	18
17.4 Calculations	18
17.5 Report	18
18 Bond-Strength Properties of Adhesives	19
18.1 General	19
18.2 Method A – shear strength by tension loading	19
18.3 Method B – tensile strength by bar and rod samples	19
18.4 Method C – peel strength by u-bend samples	20
18.5 Method D – peel strength by climbing drum apparatus	20
18.6 Method E – peel resistance by T samples	20A
19 Identification Hardness of Rubber and Plastics by Means of a Durometer	21

TESTING FOR ELECTRICAL PROPERTIES

20 Dielectric Breakdown Voltage and Strength	21
21 D-C Resistance or Conductance of Insulating Materials	22
22 High-Voltage, Low Current, Dry Arc Resistance Performance Level Categories of Solid Electrical Insulation	22
23 Comparative Tracking Index and Comparative Tracking Performance Level Categories of Electrical Insulation Materials	24
24 High-Voltage Arc-Tracking-Rate Performance Level Categories of Solid Insulating Materials	24
24.1 General	24
24.2 Apparatus	25
24.3 Specimens	26
24.4 Test procedure	27
24.5 Report	27
25 Liquid Contaminant, Inclined-Plane Tracking, and Erosion of Insulating Materials	28

MATERIAL DISTORTION UNDER LOAD

26 Deflection Temperature of Polymeric Materials under Load	28
26.1 General	28
27 Vicat Softening Point for Polymeric Materials	29
28 Softening Point by Ring-and-Ball Apparatus	29
29 Ball Pressure Test	30
29.1 General	30
29.2 Test procedure	30

RESISTANCE TO IGNITION OF POLYMERIC MATERIALS

30 General	30
31 Hot Wire Ignition – Performance Level Categories	31
31.1 General	31
32 High-Current Arc Ignition Performance Level Categories	31
32.1 General	31
32.2 Apparatus	32
32.3 Specimen	33
32.4 Test procedure	33
32.5 Report	33
33 High-Voltage Arc Resistance to Ignition Performance Level Categories	34
33.1 General	34
33.2 Apparatus	35
33.3 Specimens	36
33.4 Test procedure	36
33.5 Report	36
34 Glow-Wire Ignitability Test	37
34.1 General	37
34.2 Significance	37
34.3 Apparatus	37
34.4 Specimens	39
34.5 Conditioning	39
34.6 Procedure	39
34.7 Report	40

DIMENSIONAL CHANGE OF POLYMERIC PARTS

35 General	40
36 Method for Measuring Changes in Linear Dimensions of Polymeric Materials	40
37 Method for Measuring Water Absorption of Polymeric Materials	41

RESISTANCE OF POLYMERIC MATERIALS TO CHEMICAL REAGENTS

38 Test for Resistance of Polymeric Materials to Chemical Reagents	41
--	----

TESTS FOR POLYMER IDENTIFICATION

39 General	42
40 Specific Gravity of Polymers	42
41 Density Determination of Foamed Polymeric Materials	42
42 Infrared Spectroscopy	43
42.1 General	43
42.2 Sample preparation	43
42.3 Report	44
43 Determination of Ash Content	44
43.1 General	44
43.2 Materials and equipment	44
43.3 Test procedure	45
43.4 Calculations	45
43.5 Report	45
44 Pyrolytic Gas Chromatography	46
44.1 General	46
44.2 Instrumentation	46
44.3 Report	46
45 Thermogravimetry	47
46 Differential Scanning Calorimetry	47

MARKING

47 General	48
------------------	----

SUPPLEMENT SA - FOLLOW-UP INSPECTION INSTRUCTIONS**INTRODUCTION**

SA1 Scope	SA1
SA2 Glossary	SA1
SA3 Responsibility of the Manufacturer	SA2
SA4 Responsibility of the Field Representative	SA3
SA5 Selection of Samples for Follow-Up Testing	SA3
SA6 Follow-Up Test Program	SA3

APPENDIX A**IR Conformance Criteria for Follow-Up Testing and Revision to Materials (UL 746A)****Infrared (IR) Analysis Conformance Criteria**

A1 Background & Purpose:	A1
A2 Sample Preparation:	A1
A3 Spectral Discrepancies:	A1
A4 Exception Consideration:	A2
A5 Definitions:	A2

APPENDIX B**TGA Conformance Criteria for Follow-Up Testing and Revision to Materials**

B1 Background & Purpose:	B1
B2 Number of Degradations:	B1
B3 Weight Loss Percent:	B1
B4 Onset/Offset Temperature:	B2
B5 Residual Weight:	B2
B6 Curve Shape:	B2
B7 Exception Consideration:	B3
B8 Definitions:	B3

APPENDIX C**Differential Scanning Calorimetry (DSC) Conformance Criteria**

C1 Background & Purpose:	C1
C2 Number and type of thermal events:	C1
C3 Tolerances:	C2
C4 Second Heat:	C2
C5 Exception Consideration:	C2
C6 Definitions:	C2

APPENDIX D

Reference List of Applicable ASTM Test Procedures	D1
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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 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.

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

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 the individual test method, the standard atmospheric conditions surrounding the specimen prior to and during the test shall be between 15°C and 35°C (59°F and 95°F) and between 45 percent and 75 percent relative humidity (ISO 291).

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. In many cases, the flammability classification determined by tests conducted in accordance with the requirements for tests for flammability of plastic materials for parts in devices and appliances (UL 94), may be used as a general indication as to whether the variation has significantly affected critical material properties.

8.9.2 Table 8.1 indicates the items that are to be considered when evaluating polymer variations, and whether a numerical compound designation is required to be assigned different from the basic material designation.

8.9.3 Table 8.1 makes reference to limited performance tests that include flammability (see the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94), comparative tracking index of solid insulating material under moist conditions (see Comparative Tracking Index and Comparative Tracking Performance Level Categories of Electrical Insulation Materials, Section 23), hot-wire ignition (see Hot Wire Ignition— Performance Level Categories, Section 31), and high-current arc ignition (see High-Current Arc Ignition Performance Level Categories, Section 32). If the results of the limited performance tests are significantly different from those of the basic material, additional tests shall be required.

Table 8.1
Test considerations based upon compound variations

Polymer variation	Different material designation required	Remarks
Molecular weight, lubricants, nucleating agents, antistatic agents, colorants, release agents, acid scavengers (used for mold corrosion protection)	No	If results of testing the extremes or maximum loading of the variation indicate that the UL 94 (IEC 707) flammability classification remains unchanged, additional tests are not required. However, a complete series of performance tests shall be conducted if the material is colored with a metallic pigment that affects electrical properties.
Flame-retardant, impact modifier, plasticizer, fillers, reinforcements	Yes ^a	A complete series of flammability, mechanical, electrical, thermal distortion under load, resistance to ignition, and dimensional-change tests shall be conducted.
UV stabilizer, heat stabilizer, antioxidants, metallic stabilizers (used to inhibit part corrosion)	Yes ^a	If the results of flammability tests on the basic, modified and/or extremes of filler and reinforcement levels of material variations indicate the same UL 94 (IEC 707) flammability classification, limited performance tests shall be conducted. Otherwise, a complete series of performance tests shall be conducted. However, a complete series of performance tests shall be conducted if the material is filled with a substance that affects electrical properties, such as ferrite or free carbon.
Inert gas or chemical blowing agent	No	If used to remove sink marks from molded pieces, a 5-percent reduction in the basic material's specific gravity is acceptable without additional tests
	Yes ^a	Foamed materials that result in a specific gravity less than 95 percent of the basic material's value require that a complete series of flammability, mechanical, electrical, thermal distortion under load, resistance to ignition, and dimensional-change tests be conducted.
^a If the results of the complete series of flammability, mechanical, electrical, thermal distortion under load, resistance to ignition, dimensional change, and maximum-use temperature are essentially the same as those of the basic material, then a different material designation is not required.		

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.

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 1184.

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 (ISO 180).

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.

13.2 The energy is delivered by a single swing of a calibrated pendulum of a standardized tension-impact machine. The energy to fracture by shock in tension is determined by the kinetic energy extracted from the pendulum of an impact machine in the process of breaking the specimen. One end of the specimen is to be mounted in the pendulum. The other end of the specimen is gripped by a crosshead that travels with the pendulum until the instant of impact and instant of maximum pendulum kinetic energy, when the crosshead is arrested. The crosshead is supported by the pendulum so that the specimen is not under stress until the moment of impact when the specimen is subjected to a pure tensile force. Type "S" specimens with a 12.7 mm (0.5 inch) tab are preferred.

13.3 From the data, the corrected impact energy to break can be calculated.

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 (number pending) or ISO 179-1 (non-instrumented) or ISO 179-2 (instrumented)

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 (ISO 178).

15.1 revised December 26, 2003

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