UL 1446

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Systems of Insulating Materials – General

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UL Standard for Safety for Systems of Insulating Materials – General, UL 1446

Fifth Edition, Dated May 16, 1997

Revisions: This Standard contains revisions through and including January 13, 2005.

Summary of Topics

This revision to UL 1446 is issued to correct the effective date of paragraph 10.2.1.

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The following table lists the future effective dates with the corresponding reference:

Future Effective Dates	References
July 29, 2007	Paragraphs 5.2.4, 9.1.1, 9.2.1, 10.2.1, and the Reference Publication ANSI/NEMA MW1000 in Clause 2

The revisions dated January 13, 2005 include a reprinted title page (page1) for this Standard.

The revisions dated January 13, 2005 are issued to correct the incorrect effective date of July 29, 2004 of paragraph 10.2.1 to the correct future effective date of July 29, 2007.

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

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The requirements in this Standard are now in effect, except for those paragraphs, sections, tables, figures, and/or other elements of the Standard having future effective dates as indicated in the note following the affected item. The prior text for requirements that have been revised and that have a future effective date are located after the Standard, and are preceded by a ″SUPERSEDED REQUIREMENTS″ notice.

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

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

Page	Date
1	January 13, 2005
2	July 29, 2004
2A	October 25, 2004
2B-3	April 26, 2000
4	July 29, 2004
5-6	August 19, 2004
7-9	July 29, 2004
10-10B	October 25, 2004
11-12	July 29, 2004
13-14	October 25, 2004
15-20B	July 29, 2004
20C	January 13, 2005
20D	July 29, 2004
21-22	April 26, 2000
23	July 29, 2004
24	April 26, 2000
25-28B	July 29, 2004
29-34	April 26, 2000
A1	July 29, 2004
A2	October 25, 2004
SR1-SR2	October 25, 2004

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MAY 16, 1997
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UL 1446

Standard for Systems of Insulating Materials – General

First Edition – June, 1978
Second Edition – June, 1980
Third Edition – January, 1991
Fourth Edition – December, 1994

Fifth Edition

MAY 16, 1997

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

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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Appendix A – Information for Magnet Wire Substitution

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INTRODUCTION

1 Scope

1.1 These requirements cover test procedures to be used in the evaluation of Class 120(E) or higher electrical insulation systems intended for connection to branch circuits rated 600 volts or less. These requirements also cover the investigation of the substitution of minor components of insulation in a previously evaluated insulation system and also the test procedures to be used in the evaluation of magnet wire coatings, magnet wires, and varnishes.

1.2 These requirements do not cover a single insulating material or a simple combination of materials, such as a laminate or a varnished cloth, printed circuit boards, or planar transformers.

1.2 revised July 29, 2004

1.3 These requirements do not cover insulation systems exposed to radiation or operating in oils, refrigerants, soaps, or other media that potentially degrade insulating materials.

1.4 These requirements shall be modified or supplemented as determined by the applicable requirements in the end-product standard covering the device, appliance, or equipment in which the insulation system is used.

1.5 Deleted July 29, 2004

1.6 Deleted July 29, 2004

1.7 Deleted July 29, 2004

2 Reference Publications

2.1 This Standard refers to the following publications and where such reference is made it shall be to the edition listed below. 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.

2.1 revised July 29, 2004

ANSI Standards

ANSI/NEMA MW1000-2003,
Standard for Magnet Wire

Reference Publication ANSI/NEMA MW1000-2003 effective July 29, 2007

ASTM Standards

ASTM D1676,
Test Methods for Film-Insulated Magnet Wire

ASTM D1932,
Test Method for Thermal Endurance of Flexible Electrical Insulating Varnishes

ASTM D2307-86,
Test Method for Relative Thermal Endurance of Film-Insulated Round Magnet Wire

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ASTM D2519,
Standard Method of Test for Bond Strength of Electrical Insulating Varnishes by Helical Coil Test

ASTM D3145,
Test Method for Thermal Degradation/Endurance by Helical Coil Method

ASTM D3251,
Test Method for Thermal-Aging Characteristics of Electrical Insulating Varnishes Applied Over Film-Insulated Magnet Wire

ASTM D5642,
Test Method for Sealed Tube Chemical Compatibility Test

ASTM E178,
Standard Practice for Dealing with Outlying Observations

Reference Publication ASTM D2307-86 revised August 19, 2004

IEC Standards

IEC 61857 (All Parts),
Electrical Insulation Systems – Procedures for Thermal Evaluation

IEEE Standards

IEEE No. 1,
General Principles for Temperature Limits in the Rating of Electrical Equipment

IEEE No. 99,
Guide for the Preparation of Test Procedures for the Thermal Evaluation of Insulation Systems for Electric Equipment

IEEE No. 101,
Guide for the Statistical Analysis of Thermal Life Test Data

IEEE No. 117,
Standard Test Procedure for Evaluation of Systems of Insulating Materials for Random-Wound AC Electrical Machinery

IEEE No. 259,
Standard Test Procedure for Evaluation of Systems of Insulation for Dry-Type Specialty and General-Purpose Transformers

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3 Units of Measurement

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

3.1 revised April 26, 2000

4 Glossary

4.1 For the purpose of this standard, the following definitions apply:

4.2 APPARENT THERMAL INDEX – The unadjusted thermal index of an insulation system derived from a regression analysis of that system's thermal aging data, usually higher in value than the system's rated temperature class. For Class 105(A) systems used as controls, the temperature 105.0°C is to be used in place of an apparent thermal index.

4.2.1 CATALYST – A substance that alters (usually increases) the rate at which a reaction occurs without being consumed into the reaction.

4.2.1 added July 29, 2004

4.2.2 CURING AGENT – A substance or mixture of substances that promote or control the reaction process and is consumed in the reaction.

4.2.2 added July 29, 2004

4.3 CYCLE – A period of heat aging, typically one-tenth of the estimated total time required, to induce deterioration at the specific aging temperature, followed by a sequence of exposures to vibration, cold shock (when applicable), humidity, and voltage stress.

4.3.1 DEAD METAL – Metallic part that is at no electrical potential. With respect to the requirements in this Standard dead metal parts are to be considered the same as if they were at ground potential.

4.3.1 added July 29, 2004

4.4 GEOMETRIC MEAN – The antilogarithm of the data set logarithmic average.

4.5 INSULATION SYSTEM – A unique intimate combination of two or more insulating materials used in electrical equipment. One example of this is the combination of magnet wire, ground insulation, varnish, lead wire insulations, and outer wrapping of a coil. These intimate combinations are evaluated as unique groups. When multiple groups exist, either within a given insulation system or a different insulation system, components of one unique group shall not be added to another unique group. However, more than one group is able to be used within a single device when at least a 3.05 mm (0.125 inch) air space is used to separate them. Any material or component existing outside the outer wrap of the device or not in contact with the windings is not determined to be part of the insulation system.

4.6 INSULATION SYSTEM CLASS – A temperature class of an insulation system that is numerically equal to a maximum hot-spot operating temperature. Hot-spot temperatures for various insulation systems are specified in Table 4.1. The methods of measuring temperatures and determining hot-spot temperature allowances are specified in end-use standards.

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Table 4.1
Maximum hot-spot temperatures of insulation systems

System class	Maximum hot-spot temperature,	
	°C	(°F)
120(E)	120	(248)
130(B)	130	(266)
155(F)	155	(311)
180(H)	180	(356)
200(N)	200	(392)
220(R)	220	(428)
240(S)	240	(464)
Over 240(C)	Over 240	(Over 464)

4.7 MOTORETTE – A unit constructed in accordance with the specifications in IEEE No. 117, Standard Test Procedure for Evaluation of Systems of Insulating Materials for Random-Wound AC Electrical Machinery, except that:

a) The slot assembly, comprised of both inner and outer slot plates, shall be constructed of stainless steel; and

Exception: When stainless steel is not able to be used due to difficulty in material adhesion, such as an epoxy coating, or similar problem, cold rolled steel is able to be used.

b) The magnet wire shall be No. 18 AWG (0.82 mm^2) unless unavailable, in which case any wire size No. 18 AWG – No. 24 AWG (0.20 mm^2) is able to be used.

4.8 SAMPLE – Actual electrotechnical products, components thereof, or non-functional models representing the product, e.g. motorette, used in the evaluation of an insulation system.

4.9 SYSTEM – An insulation system. See 4.5.

4.10 SYSTEM COMPONENTS – Grouped as follows:

a) MAJOR COMPONENTS – The components of an insulation system that are relied upon to prevent a risk of electric shock or fire. Examples of this type of insulation include ground, interwinding, turn, encapsulant, and varnish. See Table 4.2.

b) MINOR COMPONENTS – The components of an insulation system that are used typically in mechanical or thermal conduction capacities, and are not relied upon to prevent risk of fire or electric shock. See Table 4.2.

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Table 4.2
Major and minor components

Table 4.2 revised July 29, 2004

Component	Major	Minor	Definition/[Comments]
Balancing Compound (Motor Term)	–	X	A material applied to a rotor to reduce vibration.
Bobbin or Core Tube (Transformer Term)	X	X	The form around which the conductor is wound. [It is **major** when it is the sole insulation between windings and grounded or dead metal. It is **minor** when it is always provided with a supplemental (major) insulation between isolated windings and grounded or dead metal.]
Crossover Insulation	–	X	Component providing isolation between the magnet wire at the point where it enters the coil and all subsequent layers in the same winding. This insulation is made of either a separate dielectric material, or is integral to the bobbin construction.
Enameled Magnet Wire	X	–	Winding wire that relies on its enamel coating for turn insulation. With respect to dead or grounded metal enameled magnet wire is considered to be a bare conductor and can not be relied upon for ground insulation.
Encapsulant	X	–	A molding material which is typically cast or injection molded around the electrical insulation system and is intended to insulate and protect the winding wires. Encapsulated devices do not employ supplementary surrounding shells hence the encapsulant may function as an electrical enclosure.
End Spider (Motor Term)	X	X	The material provided between rotor laminations and the winding as it passes from slot to slot. [It is **major** when no supplemental (major) insulation is provided between conductors and ground. It is **minor** when provided with required ground insulation or a 1/32-inch (0.8-mm) minimum air space between conductors and the end spider.]
Filament Winding	X	–	Windings constructed of the type of wire typically used as lead wires.
Ground Insulation	X	–	The electrical insulation between the conductor and grounded or dead metal.
Integral Ground	X	–	A coating, such as epoxy, that is fused directly to the grounded or dead metal core and serves as ground insulation.
Interwinding Insulation (Transformer Term)	X	–	The electrical insulation between individual windings. [Does not apply to material used between series-parallel windings in multi-voltage devices.]
Layer Insulation (Transformer Term)	–	X	The material interleaved between successive layers of an insulated conductor in the same winding. [Used in a mechanical application only, and does not serve as electrical insulation.]
Lead Wire	–	X	The insulated wire attached to the end of a winding to connect the device to a circuit. [It is identified as part of the system when its insulation enters the confines of the winding or outer wrap. When used to form a magnetic winding, it is identified as a filament winding.]
Litz wire (Transformer Term)	X	X	A bundle of magnet wire bound together by a strand of magnet wire or another material (dacron, fiberglass, aramid fiber, or similar materials). The magnet wire portion of a Litz wire is considered a Major component. The non-wire portion wrapped or extruded around the bundle and/or core material is considered a Minor component. Typically used in high frequency transformers.]
Magnet Wire	X	–	A conductor insulated with turn insulation.

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