UL 2111

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Overheating Protection for Motors

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UL Standard for Safety for Overheating Protection for Motors, UL 2111

First Edition, Dated March 28, 1997

Revisions: This Standard contains revisions through and including January 27, 2006.

Summary of Topics

These editorial revisions to ANSI/UL 2111 replace all references to UL 1020, the Standard for Thermal Cutoffs for Use in Electrical Appliances and Components, with reference to UL 60691, the Standard for Thermal-Links – Requirements and Application Guide. UL 1020 was withdrawn and superseded by UL 60691.

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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 revisions dated January 27, 2006 include a reprinted title page (page1) for this Standard.

The revisions dated January 27, 2006 editorially replace all references to UL 1020 with the reference to UL 60691.

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.

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

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1-2A	January 27, 2006
2B-3	March 28, 2001
4-5	January 27, 2006
6-10	March 28, 2001
11	March 14, 2002
12-12H	March 28, 2001
13	March 28, 1997
14-24F	March 28, 2001
24G-24H	January 27, 2006
24I-28	March 28, 2001
A1	January 27, 2006
A2	March 28, 2001
SR1-SR2	March 28, 2001

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UL 2111

Standard for Overheating Protection for Motors

Prior to the first edition, the requirements for the products covered by this Standard were included in the Standard for Impedance-Protected Motors, UL 519, and the Standard for Thermal Protectors for Motors, UL 547.

First Edition

March 28, 1997

The most recent designation of ANSI/UL 2111 as an American National Standard occurred on January 28, 2002.

This ANSI/UL Standard for Safety, which consists of the First Edition with revisions through January 27, 2006, is under continuous maintenance, whereby each revision is ANSI approved upon publication. Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at http://csds.ul.com.

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

Revisions of this Standard will be made by issuing revised or additional pages bearing their date of issue. A UL Standard is current only if it incorporates the most recently adopted revisions, all of which are itemized on the transmittal notice that accompanies the latest set of revised requirements.

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INTRODUCTION

1 Scope

1.1 The requirements in this standard cover:

a) Impedance-protected motors;

b) Thermal-device-protected motors;

c) Thermal-protective devices; and

d) Motors with solid state thermal protection circuitry.

1.1 revised March 28, 2001

1.2 The requirements in this standard apply only to motors rated 600 V or less.

1.3 The requirements in this standard do not cover:

a) A manual device for opening the circuit;

b) A motor intended for use in a hazardous location;

c) Motors employing a device that serves as a motor protector and a manual motor controller;

d) Motors employing a motor protector with contacts that control a relay coil in a motor starter;

e) Motors protected by devices responsive to current only;

f) Sealed (hermetic) type motor compressors;

g) Impedance-protected motors employing an automatic-starting switch; or

h) Thermal cutoff devices. Thermal cutoffs are covered by the Standard for Thermal-Links – Requirements and Application Guide, UL 60691.

1.3 revised January 27, 2006

1.4 The requirements in this standard are intended to evaluate a specific motor, protector, and motor/protector combination. When either the motor, the protector, or the motor/protector combination is changed, a separate evaluation is required.

1.4 revised March 28, 2001

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

1.5 revised March 28, 2001

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2 Units of Measurement

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

2.1 revised March 28, 2001

3 Glossary

3.1 For the purpose of this standard, the following definitions apply.

3.2 AUTOMATICALLY RESET PROTECTOR – A device that incorporates a bimetal that is calibrated to open the motor circuit upon reaching a certain temperature and automatically closes the circuit once the device has cooled to a lower temperature.

3.2.1 CONTINUOUS DUTY MOTOR – A motor intended to be directly coupled to a load other than a fan or blower and that is intended to operate indefinitely.

3.2.1 added March 28, 2001

3.2.2 FAN DUTY MOTOR – A motor intended to be directly coupled to a fan or blower load only and that is intended to operate indefinitely.

3.2.2 added March 28, 2001

3.3 FIELD-WIRING TERMINAL – A terminal to which connection is capable to be made in the field.

3.4 IMPEDANCE-PROTECTED MOTOR – A motor that relies solely upon the impedance of the windings alone to prevent overheating.

3.4.1 INSULATION SYSTEM – An assembly of insulating materials used to isolate the live parts from ground and from parts of opposite polarity. All materials in contact with the windings are considered part of the system.

3.4.1 added March 28, 2001

3.4.2 INTERMITTENT DUTY MOTOR – A motor intended to be connected to a load other than a fan or blower and that is intended to operate for a specified time period.

3.4.2 added March 28, 2001

3.4.3 LIMITING IMPEDANCE CIRCUIT – A circuit supplied by a series impedance complying with the requirements in 11A.2.

3.4.3 added March 28, 2001

3.4.4 LOCKED-ROTOR CURRENT – The current measured from the line when the armature or rotor is prevented from rotating.

3.4.4 added March 28, 2001

3.4.5 LOW-VOLTAGE CIRCUIT – A circuit involving a peak open-circuit potential of not more than 42.4 volts. It is supplied by a battery, by a Class 2 transformer, or by a combination of a transformer and a fixed impedance that as a unit, complies with all performance requirements for a Class 2 transformer. A circuit derived from a line-voltage circuit by connecting a resistance in series with the supply circuit as a means of limiting the voltage and current is not considered to be a low-voltage circuit.

3.4.5 added March 28, 2001

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3.4.6 LOW-VOLTAGE LIMITED ENERGY CIRCUIT (LVLE) – A low voltage or limiting impedance circuit.

3.4.6 added March 28, 2001

3.5 MANUALLY RESET PROTECTOR – A device that incorporates a bimetal that is calibrated to open the motor circuit upon reaching a certain temperature and requires manual resetting to reclose the motor circuit.

3.5.1 MOTOR STARTER – A device that is intended to start a three-phase motor and contains a method of protection to prevent overheating of a motor. A relay or contactor is not considered to be a motor starter.

3.5.1 added March 28, 2001

3.5.2 MULTI-SPEED MOTOR – A motor that operates at one or more speeds.

3.5.2 added March 28, 2001

3.6 OPEN MOTOR – A motor having ventilating openings that provide for the passage of external cooling air over and around the windings.

3.6.1 PERMANENT-SPLIT CAPACITOR MOTOR – A motor with the same value of capacitance for both starting and running conditions. The motor has no start switch.

3.6.1 added March 28, 2001

3.6.2 POLYPHASE PROTECTOR – A protective device that opens the circuit for each phase of the motor when the protector operates.

3.6.2 added March 28, 2001

3.6.3 PRIMARY PROTECTOR – A protector that is expected to operate during the abnormal testing of a motor sample.

3.6.3 added March 28, 2001

3.7 SECONDARY (BACK-UP) PROTECTION – A protector that does not operate under normal running or locked rotor test conditions, without further stress applied to the motor by increased winding temperature, ambient temperature, or voltage.

3.7.1 SHADED-POLE MOTOR – A single-phase motor with a main winding and one or more short-circuited windings (shaded coils). The motor has no capacitor nor start switch.

3.7.1 added March 28, 2001

3.8 SINGLE-OPERATION DEVICE – A device that incorporates a bimetal that is calibrated to open the motor circuit upon reaching a certain temperature and is resettable only by cooling to minus 35°C (minus 31°F), or lower.

3.8.1 SOLID-STATE PROTECTION – Electronic circuitry integral to or provided with a motor to monitor winding temperature and/or current to prevent overheating. The protection is typically designed to reset automatically after motor temperatures return to normal condition, but circuitry requiring manual reset does exist.

3.8.1 added March 28, 2001

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3.8.2 SPLIT-PHASE MOTOR – A single-phase motor having a main winding and an auxiliary winding, which is designed to operate with no external impedance in either winding. The auxiliary winding is energized only during the starting operation and is open-circuited during the running operation. The motor has no capacitor, but does have a start switch.

3.8.2 added March 28, 2001

3.9 THERMAL CUTOFF – A device that incorporates a melting alloy or other material that is calibrated to permanently open the motor circuit upon reaching a certain temperature.

3.10 THERMAL-DEVICE-PROTECTED MOTOR – A motor that relies upon a device (protector) to prevent overheating.

3.11 THERMAL PROTECTOR – A device installed integrally within a motor that is responsive to motor current and temperature or temperature only and that, when applied as intended, prevents overheating. Types are: thermal cutoff, automatically reset, manually reset and single-operation.

3.12 TOTALLY-ENCLOSED MOTOR – A motor that is enclosed to prevent the free exchange of air between the inside and outside of the winding enclosure and not so enclosed as to be airtight.

3A Components

3A.1 A component of a product covered by this standard shall comply with the requirements for that component and shall be used in accordance with its recognized rating and other limitations of use. See Appendix A for a list of standards covering components used in the products covered by this standard.

3A.1 added March 28, 2001

3A.2 A component is not required to comply with a specific requirement that:

a) Involves a feature or characteristic not required in the application of the component in the product covered by this standard, or

b) Is superseded by a requirement in this standard.

3A.2 added March 28, 2001

3A.3 A component shall be used in accordance with its rating established for the intended conditions of use.

3A.3 added March 28, 2001

3A.4 Specific components are incomplete in construction features or restricted in performance capabilities. Such components are intended for use only under limited conditions, such as certain temperatures not exceeding specified limits, and shall be used only under those specific conditions.

3A.4 added March 28, 2001

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4 Application of Requirements

4.1 This standard is comprised of six parts. Part I applies to all motors. Part II applies to impedance-protected motors. Part III applies to motor/protector combinations. Part IV applies to thermal protectors employed within a motor. Part V consists of manufacturing and production tests. Part VI consists of marking requirements.

4.2 All motors shall comply with the requirements in UL 1004, Standard for Electric Motors.

Added 4.2 effective March 28, 2003

PART I – ALL MOTORS

5 General

5.1 The voltage of the supply circuit shall be as specified in Table 5.1. For motors intended for use over a range of voltages, all applicable nominal voltages shall be tested. For example, a motor rated 200 – 230 volts shall be tested at 208 volts and at 240 volts.

Exception No. 1: A motor having a voltage rating outside the ranges specified in Table 5.1 shall be tested at 100 – 105 percent of the rated voltage, and is not to be less than 100 percent.

Exception No. 2: When the motor is intended for a specific application where the source voltage is outside the range specified in Exception No. 1, the motor is able to be tested at greater than 105 percent of the intended source of supply.

Table 5.1
Test voltages

Motor nameplate rating, volts	Nominal test voltage
110 – 120	120
200 – 208	208
220 – 240	240
254 – 277	277
440 – 480	480
550 – 600	600

5.2 Thermocouples are to consist of wires not larger than No. 30 AWG (0.05 mm^2). The thermocouple wire is to conform with the requirements for special thermocouples as listed in the limits of error of thermocouples given in Temperature-Measurement Thermocouples, ANSI MC96.1-1982(1991).

5.2.1 The thermocouple is to be attached so that the welded point where the wires touch is in direct contact with the component whose temperature is being measured. The contact point is to be held in place by a medium that does not affect the heat transfer such as sodium silicate and glycerin (commonly referred to as water glass).

5.2.1 added March 28, 2001

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5.3 A minimum of 4 thermocouples are to be used to measure the temperature.

5.4 The change-in-resistance method compares the heated coil resistance to the resistance at a known (ambient) temperature and uses the following equation to determine the heated coil temperature:

$$T_2 = R_2 / R_1 (K + T_1) - K$$

in which:

T_2 is the coil temperature at the end of the test in degrees C;

R_2 is the coil resistance at the end of the test;

R_1 is the coil resistance at the beginning of the test;

K is 234.5 for copper, 225.0 for electrical conductor grade (EC) aluminum. The value of K for other conductors is to be determined;

T_1 is the room temperature at the beginning of the test.

5.5 A protector shall be bypassed during any resistance measurements.

5.6 The value of R_2 at shutdown is determined by taking at least 6 resistance measurements at 5 second intervals, beginning quickly at shutdown. A curve of the resistance values and the time is to be plotted and extrapolated to determine the value of R at shutdown, or the values are to be calculated by using linear regression. Other means of measuring the winding resistance are able to be used when agreed upon by all concerned parties.

5.7 Testing is to be conducted at any ambient temperature between 10°C (50°F) and 40°C (104°F) unless a motor is marked with an ambient temperature that does not fall in this range, in which case the motor is to be tested at marked ambient.

5.7 revised March 28, 2001

5.8 For an impedance-protected motor or any motor for which a protector does not cycle during a given test, the measured temperatures are to be normalized to 25°C (77°F). For example: A measured temperature of 160°C at 35°C ambient is to be normalized downwards by 10°C to 150°C. A measured temperature of 110°C at 17°C ambient is to be normalized upwards by 8°C to 118°C.

Exception: Temperatures are not to be normalized for a motor tested at marked ambient.

5.9 A motor shall be tested under each intended operating condition with respect to each rated voltage, frequency, speed, and rotation direction. When rated for two frequencies, the motor shall be tested at both frequencies. When rated for a frequency range, the motor shall be tested at the minimum rating and the maximum rating.

Exception No. 1: Motors, such as split-phase motors, that are reversed by interchanging one winding with respect to another, are not required to be tested in both rotation directions.

Exception No. 2: The locked rotor tests, Sections 9 and 16, are able to be conducted under only certain operating conditions when it is shown that such conditions represent "worst-case" conditions. See 5.9.1.

5.9 revised March 28, 2001

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