UL 2111

ISBN 0-7629-0166-7

Overheating Protection for Motors

Underwriters Laboratories Inc. (UL)
333 Pfingsten Road
Northbrook, IL 60062-2096

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 March 14, 2002.

UL Standards for Safety are developed and maintained in the Standard Generalized Markup Language (SGML). SGML -- an international standard (ISO 8879-1986) -- is a descriptive markup language that describes a document's structure and purpose, rather than its physical appearance on a page. Due to formatting differences resulting from the use of UL's new electronic publishing system, please note that additional pages (on which no requirements have been changed) may be included in revision pages due to relocation of existing text and reformatting of the Standard. **Due to the new publishing system and the relocation of Sections 20 – 23, page numbers 29 and 30 have been deleted in the revisions dated March 28, 2001. The text has been relocated to other Sections in the Standard. Remove pages 29 and 30 from your paper copy of the Standard.**

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 following table lists the future effective dates with the corresponding reference.

Future Effective Dates	References
March 28, 2003	Paragraphs 4.2, 6.1, and 10.1

The revised requirements are substantially in accordance with UL's Bulletin(s) on this subject dated September 21, 2001. The bulletin(s) is now obsolete and may be discarded.

The revisions dated March 14, 2002 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.

The master for this Standard at UL's Northbrook Office is the official document insofar as it relates to a UL service and the compliance of a product with respect to the requirements for that product and service, or if there are questions regarding the accuracy of this Standard.

Revisions of UL Standards for Safety are issued from time to time. A UL Standard for Safety is current only if it incorporates the most recently adopted revisions.

UL provides this Standard ″as is″ without warranty of any kind, either expressed or implied, including but not limited to, the implied warranties of merchantability or fitness for any purpose.

In no event will UL be liable for any special, incidental, consequential, indirect or similar damages, including loss of profits, lost savings, loss of data, or any other damages arising out of the use of or the inability to use this Standard, even if UL or an authorized UL representative has been advised of the possibility of such damage. In no event shall UL's liability for any damage ever exceed the price paid for this Standard, regardless of the form of the claim.

UL will attempt to answer support requests concerning electronic versions of its Standards. However, this support service is offered on a reasonable efforts basis only, and UL may not be able to resolve every support request. UL supports the electronic versions of its Standards only if they are used under the conditions and operating systems for which it is intended. UL's support policies may change from time-to-time without notification.

UL reserves the right to change the format, presentation, file types and formats, delivery methods and formats, and the like of both its printed and electronic Standards without prior notice.

Purchasers of the electronic versions of UL's Standards for Safety agree to defend, indemnify, and hold UL harmless from and against any loss, expense, liability, damage, claim, or judgement (including reasonable attorney's fees) resulting from any error or deviation introduced while purchaser is storing an electronic Standard on the purchaser's computer system.

If a single-user version electronic Standard was purchased, one copy of this Standard may be stored on the hard disk of a single personal computer, or on a single LAN file-server or the permanent storage device of a multiple-user computer in such a manner that this Standard may only be accessed by one user at a time and for which there is no possibility of multiple concurrent access.

If a multiple-user version electronic Standard was purchased, one copy of the Standard may be stored on a single LAN file-server, or on the permanent storage device of a multiple-user computer, or on an Intranet server. The number of concurrent users shall not exceed the number of users authorized.

Electronic Standards are intended for on-line use, such as for viewing the requirements of a Standard, conducting a word search, and the like. Only one copy of the Standard may be printed from each single-user version of an electronic Standard. Only one copy of the Standard may be printed for each authorized user of a multiple-user version of an electronic Standard. Because of differences in the computer/software/printer setup used by UL and those of electronic Standards purchasers, the printed copy obtained by a purchaser may not look exactly like the on-line screen view or the printed Standard.

An employee of an organization purchasing a UL Standard can make a copy of the page or pages being viewed for their own fair and/or practical internal use.

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

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.

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

No Text on This Page

American National Standard

MARCH 28, 1997 **ANSI/UL 2111-2002**

(Title Page Reprinted: March 14, 2002)

1

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 March 14, 2002, 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 the UL-RTP Standards Department, 12 Laboratory Dr., PO Box 13995, Research Triangle Park, NC 27709-3995.

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.

ISBN 0-7629-0166-7

No Text on This Page

CONTENTS

No Text on This Page

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 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.

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 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 UL 1020, Standard for Thermal Cutoffs for Use in Electrical Appliances and Components.

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

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

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

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

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

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

5.9.1 When determining the ″worst-case″ operating condition(s) for the Locked-Rotor Tests, a motor is to be operated at each condition (see 5.9) until the motor has stabilized, but not less than two hours. Stabilization occurs when the cycle rate is constant for a motor with a protective device, and the maximum temperature is no longer rising and the temperature does not vary by more than 2°C (3.6°F). Following this, the condition(s) determined to be ″worst-case″ are to be subjected to the full Locked-Rotor Temperature, Section 7 and Endurance Test, Section 9 for Impedance Protected Motors; and the full Locked-Rotor Temperature, Section 14 and Endurance Test, Section 16 for Thermal Device Protected Motors.

5.9.1 added March 28, 2001

5.10 For all locked rotor tests, Sections7, 9, 14, and 16, the frame of the motor is to be grounded through a 3-ampere non-time-delay fuse.

5.11 For each test, the motor is to be mounted on wood or other material of low thermal conductivity. Blades or other load attachments are to be removed from the motor. Integral mounting brackets are to be left in place.

5.12 A motor is to be mounted accordingly when the motor has:

a) A permanently attached, fixed, or rigid base;

b) Instructions for mounting marked on the motor; or

c) A construction feature, such as an oil hole, indicating a mounting position.

A motor without one of these features shall be tested with the protector in the maximum possible down position. A motor with one of these features is able to be tested with the protector in the maximum possible down position when agreeable to those concerned.

5.13 A motor under locked-rotor conditions for which a protector does not open under any operating conditions (speed, direction) shall be identified as impedance-protected. At the manufacturer's request, informational testing is to be conducted under conditions causing the protector to operate to determine compliance with Part III requirements.

5.14 A motor for which a protector opens under at least one operating condition shall be identified as thermally-protected and shall comply with the requirements of Part III at each condition that results in a protector opening. At each condition that does not result in the protector opening, tests in Part II are performed when the measured constant temperature at the condition(s) where the protector does not open exceeds the average after first hour temperature in Table 14.1 for the Class of insulation in the motor.

5.14 revised March 14, 2002

5.15 A motor that complies with the requirements for a lower insulation class is not required to be re-tested for compliance to higher insulation class limits when the insulation materials are the same. The motor shall still be limited to the lower insulation class temperature limits unless the motor is retested. For instance, when a Class A system on a motor is investigated and becomes a Class B system, no additional testing is required, but the motor is still limited to the Class A abnormal temperature limits.

5.15 revised March 28, 2001

5.16 An evaluation of the motor performance shall be required when there is a change in the major components of the motor insulation system.

5.16 added March 28, 2001

5A Dielectric Voltage-Withstand Test

5A.1 Each production-line motor shall withstand, without electric breakdown, a potential between live parts (including the windings and connected components) and accessible dead metal parts that risk becoming energized.

20.1 relocated as 5A.1 March 28, 2001

5A.2 The potential and test duration shall be in accordance with Condition A or Condition B, as specified in Table 5A.1. The potential shall be at a frequency within the range of 40 – 70 hertz.

20.2 revised and relocated as 5A.2 March 28, 2001

Table 5A.1
Production-line test conditions

Table 20.1 relocated as Table 5A.1 March 28, 2001

Motor rating	Condition A		Condition B	
	Potential (volts)	Time (sec)	Potential (volts)	Time (sec)
250 volts or less or 1/2 hp or less	1000	60	1200	1
More than 250 volts or 1/2 hp	1000 + 2 V[a]	60	1200 + 2.4 V[a]	1

NOTE – When a dc potential is required, the values specified in this Table are to be multiplied by 1.414.

[a]Maximum rated voltage.

5A.3 The motor is not prohibited from being in a heated or unheated condition for the test.

20.3 relocated as 5A.3 March 28, 2001

5A.4 The test is to be conducted on a fully assembled motor. It is not intended that the motor be unwired, modified, or disassembled for the test.

Exception No. 1: A part, such as a snap cover or a friction-fit knob that has a risk of interfering with the performance of the test is not required to be in place.

Exception No. 2: The test is able to be performed before final assembly when the test represents the completed motor.

20.4 relocated as 5A.4 March 28, 2001

5A.5 For the test, all power leads are to be connected to one test-equipment terminal and the second test-equipment terminal is to be connected to the accessible dead metal. A motor having all circuits internally interconnected is to be tested with at least one lead of each circuit connected to one terminal of the test equipment and the second terminal is to be connected to the accessible dead metal.

20.5 revised and relocated as 5A.5 March 28, 2001

5A.6 A motor employing a solid-state or other component that is not relied upon to reduce the risk of electric shock and that is capable of being damaged by the dielectric potential is to be tested before the component is electrically connected when a random sampling of each day's production is tested at the potential specified in Table 5A.1. The circuitry is to be rearranged for the purpose of the test to reduce the risk of solid-state-component damage while retaining representative dielectric stress of the circuit. A dc potential is able to be used when an ac potential is capable of damaging solid-state or other components.

20.6 revised and relocated as 5A.6 March 28, 2001

5A.7 The test equipment shall include a transformer having an sinusoidal adequate output, a means of indicating the test potential, an audible or visible indicator of electrical breakdown and either a manually reset device to restore the equipment after electrical breakdown or an automatic feature that rejects any unit that does not meet the requirements.

20.7 revised and relocated as 5A.7 March 28, 2001

5A.8 When the output of the test-equipment transformer is less than 500 volt-amperes, the equipment shall include a voltmeter in the output circuit that indicates the test potential directly.

20.8 relocated as 5A.8 March 28, 2001

5A.9 When the output of the test-equipment is 500 volt-amperes or more, the test potential is able to be indicated by:

a) A voltmeter in the primary circuit or in a tertiary-winding circuit;

b) A selector switch marked to indicate the test potential; or

c) For equipment having a single test-potential output, a marking in a readily visible location to indicate the test potential.

When marking is used without an indicating voltmeter, the equipment shall include a positive means, such as an indicator lamp, to indicate that the manually reset switch has been reset following a dielectric breakdown.

20.9 relocated as 5A.9 March 28, 2001

5A.10 Test equipment, or a test procedure, other than as described in this section is not prohibited from use when found to accomplish the intended factory control.

20.10 relocated as 5A.10 March 28, 2001

PART II – IMPEDANCE-PROTECTED MOTORS

CONSTRUCTION

6 General

6.1 Deleted effective March 28, 2003

6.2 An unenclosed motor that uses multiple types of outerwrap tape shall have each construction subjected to the Locked Rotor Test (Sections 7 and 9). Following the test, the tape shall not shift to result in a reduction of spacings or expose uninsulated live parts.

6.3 A secondary protector shall not operate during the tests in Section 7 and Section 9.

6.3 revised March 28, 2001

PERFORMANCE

7 Locked-Rotor Temperature Test

7.1 Three motors are to be stalled, and the locked rotor wattage of each measured. The highest wattage sample is then to be locked in a stationary position using a low means of thermal conductivity.

7.2 Testing of a permanent-split capacitor motor is to be conducted with the capacitor either properly connected in the circuit or short-circuited, whichever results in the higher temperature.

Exception No. 1: A motor that employs an integrally mounted and enclosed capacitor is not required to be tested with the capacitor short-circuited.

Exception No. 2: A motor that employs a capacitor evaluated to the construction and testing requirements in UL 810, Standard for Capacitors, is not required to be tested with the capacitor short-circuited.

7.2 revised March 28, 2001

7.3 Temperatures are to be measured:

a) With thermocouples on the enclosure for a totally enclosed motor or for a motor with an encapsulated coil complying with the requirements for a non-metallic enclosure in UL 1004, Standard for Electric Motors;

b) By the change-in-resistance method for a motor with an encapsulated coil other than as noted in (a); or

c) With a thermocouple applied directly to the actual conductor material, integrally applied conductor insulation, or coil wrap, as applicable, for any other type of motor.

7.4 Starting at room temperature, the motor is to be energized continuously for 72 hours, during which the winding temperatures are to be monitored.

Exception: The test is able to be discontinued when the winding temperatures stabilize at a constant temperature not exceeding 100°C (212°F). The Endurance Test, Section 9, is not required to be performed.

7.4 revised March 28, 2001

7.5 During the 72 hours, the motor shall comply with the following:

a) The frame or coil temperature shall not exceed the temperature limits specified in Table 7.1.

b) The fuse in the grounding conductor shall not open.

c) The motor shall still be capable of operating electrically. For example, a bearing failure is considered in compliance.

d) There shall be no flaming or severe or prolonged smoking.

e) There shall be no flaking, embrittlement or charring of the insulation. Simple discoloration of the insulation meets the intent of the requirement, and charring or embrittlement to the extent that the insulation flakes off or material is removed when the windings are rubbed with the thumb does not meet the intent of the requirement.

f) There shall be no electrical or mechanical malfunction of any associated component parts such as capacitors.

7.5 revised March 28, 2001

Table 7.1
Maximum temperatures

Motor insulation system	Maximum temperature	
	°C	°F
Class A	150	302
Class B	175	347
Class F	200	392
Class H	225	437

7.6 At the request of the manufacturer, the above test is to be conducted under such conditions that result in the motor coils operating at the maximum temperature for the insulation class specified in Table 7.1. The maximum temperature is to be obtained by:

a) Increasing the test voltage;

b) Increasing the ambient temperature;

c) Using test samples constructed so that they maintain the maximum temperature; or

d) Any other equivalent means.

This test shall not be conducted by increasing the voltage for motors with the capacitor shorted.

7.7 When a ″worst-case″ condition is not evident (such as high speed for a tapped winding) a motor shall be tested at each condition until thermal stabilization. The condition resulting in the highest operating temperature is then to be subjected to the full Locked Rotor Temperature, Section 7 and Endurance Tests, Section 9.

8 Dielectric Voltage Withstand Test

8.1 Immediately following the conclusion of the Locked-Rotor Temperature Test, Section 7, a motor shall withstand a 1 minute application of a 60-hertz sinusoidal potential between live parts and dead metal parts that are grounded or that are exposed to contact. The potential shall be 1000 volts for a motor rated 250 volts or less; or 1000 volts plus twice the voltage rating of the motor for all other motors.

8.1 revised March 28, 2001

8.2 To determine whether a motor complies with the requirements in 8.1, the motor is to be tested by means of a 500 volt-ampere or larger capacity transformer, the output voltage of which is sinusoidal and is able to be varied. The applied potential is to be increased from zero until the required test level is reached and is to be held at that level for 1 minute. The applied potential is to be increased at a substantially uniform rate as rapid as is consistent with correct indication of the potential by a voltmeter. The capacity of the transformer is able to be less than 500 volt-amperes when the test equipment used maintains the specified test potential at the output terminals for the duration of the test.

9 Locked-Rotor Endurance Test

9.1 Immediately following the Dielectric Voltage Withstand Test, Section 8, a motor is to be re-energized under the conditions of the Locked-Rotor Temperature Test, Section 7, for an additional 15 days.

9.2 At the conclusion of the 15 days, the motor shall comply with the following:

a) There shall be no evidence of excessive deterioration of the insulation. Simple discoloration of the insulation meets the intent of the requirement, and charring or embrittlement to the extent that the insulation flakes off or material is removed when the windings are rubbed with the thumb does not meet the intent of the requirement.

b) The fuse in the grounding conductor shall not open.

c) The motor shall still electrically operate. For example, a bearing failure is considered in compliance.

9.2 revised March 28, 2001

9.3 In addition, there shall be no dielectric breakdown as the result of a one minute application of a potential of twice the marked rated voltage of the motor between the windings and the frame.

MARKINGS

9A Details

9A.1 Each motor shall be marked in a readily visible location on the outside of the motor with the following:

a) Name, tradename, or trademark of the company or other descriptive marking by which the company is identified;

b) The complete electrical rating;

c) The insulation class when higher than Class A;

d) A distinctive identifying catalog or model number or the equivalent; and

e) At least the month and year of manufacture. Date coding, serial numbers, or equivalent means are not prohibited from being used.

9A.1 added March 28, 2001

9A.2 The complete electrical rating as required in 5A.1(b), consists of the following:

a) Rated voltage;

b) Rated frequency, specified with one of the following: hertz, Hz, dc or equivalent;

c) Full-load or locked-rotor input amperage, full-load or locked-rotor input watts, or output horsepower or watts. Ratings shall be provided at each speed provided unless the motor is of the shaded-pole or permanent-split-capacitor type; and

d) Other information as required by an intended end-use product.

21.2 revised and relocated as 9A.2 March 28, 2001

9A.3 A distinctive factory identifying marking shall be provided on a motor manufactured at more than one factory.

21.3 relocated as 9A.3 March 28, 2001

9A.4 The words ″Impedance-Protected″ shall be marked on the outside of the motor where visible.

Exception: A motor having a rated input of 100 watts or less is not prohibited from being marked ″Z.P.″ instead of ″Impedance-Protected″.

9A.4 added March 28, 2001

PART III – THERMAL-DEVICE-PROTECTED MOTORS

CONSTRUCTION

10 General

10.1 Deleted effective March 28, 2003

10.2 A re-evaluation of the motor/protector combination performance shall be required when there is a change in the protector or protector insulation. For a solid-state circuitry-protected motor, an evaluation of the motor/circuitry combination shall be required when the protection circuitry, software, or firmware is changed.

10.2 revised March 28, 2001

10.3 The electrical insulation system of a motor rated for a temperature class other than Class A shall comply with the requirements for the insulation class specified in UL 1446, Standard for Systems of Insulating Materials – General.

10.3.1 For motors with higher than Class A insulation system, any protector insulation in contact with the windings material shall be covered in the manufacturer's previously evaluated insulation system, or be investigated in accordance with UL 1446, Standard for Systems of Insulating Material – General, to determine compatibility with the insulation system.

10.3.1 added March 28, 2001

10.4 Any electrical insulation system that is an integral ground system, such as an epoxy resin coating, shall comply with the requirements for such systems in UL 1446, Standard for Systems of Insulating Materials – General.

10.5 An open motor that uses multiple types of outerwrap shall have each construction subjected to an 18-day or 60-cycle locked rotor endurance test as specified in this standard. As a result, the outerwrap tape shall not shift to result in a reduction of spacings, adversely affect the protector securement, or expose uninsulated live parts.

10.6 Any protector employed within a motor shall comply with the requirements of Part IV.

10.7 A fuseholder shall be constructed and installed so that no uninsulated live part other than the screw shell or clips is exposed to contact by persons removing or replacing fuses.

10.7 added March 28, 2001

10.8 A fuse that requires replacement after it opens shall be readily accessible.

10.8 added March 28, 2001

11 Spacings

11.1 Spacings at a protector terminal intended to be used as a field-wiring terminal shall not be less than those specified in Table 11.1. For a protector mounted within a motor enclosure, spacings between protector parts and other parts of the motor specified shall not be less than specified in Table 11.2. For a protector mounted outside a motor enclosure, the spacings shall not be less than specified in Table 11.3.

Table 11.1
Minimum spacings at field-wiring terminals within a motor enclosure

Potential involved	Minimum spacing between wiring terminals and between terminals and other uninsulated metal parts not always of the same polarity[a], through air or over surface	
Volts	Inch	(mm)
250 or less	1/4	(6.4)
More than 250	3/8	(9.5)

[a] Applies to the sum of the spacings involved where an isolated dead part is interposed. See 11.2.

No Text on This Page

Table 11.2
Minimum spacings at other than field-wiring terminals of a protector mounted within a motor enclosure

Potential involved	Minimum spacing between uninsulated live parts of opposite polarity, and an uninsulated live part and an exposed dead metal part, including the enclosure inch (mm)[a]							
	Motor diameter 7 inches (180 mm) or less[b]				Motor diameter more than 7 inches (180 mm)[b]			
Volts	Over surface		Through air		Over surface		Through air	
0 – 150	3/32[c]	(2.4)	3/32	(2.4)	1/4	(6.4)	1/8	(3.2)
151 – 300	3/32	(2.4)	3/32	(2.4)	1/4	(6.4)	1/4	(6.4)
301 – 600	1/4	(6.4)	1/4	(4.4)	3/8	(9.5)	3/8	(9.5)

[a] Film coated wire is an uninsulated live part.

[b] This is the diameter, measured in the plane of the laminations, of the circle circumscribing the stator frame, excluding lugs, fins, and boxes, used solely for motor mounting, cooling, assembly, or connection.

[c] For a motor rated 1/3 horsepower (249 watts) or less, these spacings are not to be less than 1/16 inch (1.6 mm).

Table 11.3
Minimum spacings at other than field-wiring terminals of a protector mounted outside of a motor enclosure

Potential involved	Minimum spacing between an uninsulated live part and a metal enclosure							
	Motor diameter 7 inches (180 mm) or less[a]				Motor diameter more than 7 inches (180 mm)[a]			
Volts	Over surface		Through air		Over surface		Through air	
0 – 300	1/4	(6.4)	1/8	(3.2)	1/4	(6.4)	1/4	(6.4)
301 – 600	3/8	(9.5)	1/4	(6.4)	3/8	(9.5)	3/8	(9.5)

[a] This is the diameter, measured in the plane of the laminations, of the circle circumscribing the stator frame, excluding lugs, fins, and boxes, used solely for motor mounting, cooling, assembly, or connection.

11.2 For an isolated dead metal part that is interposed between or is in close proximity to:

a) Live parts of opposite polarity;

b) A live part and an exposed dead metal part; or

c) A live part and a dead metal part that is capable of being grounded;

the spacing is to be a minimum of 3/64 inch (1.2 mm) between the isolated dead metal part and any one of the parts previously specified, when the total spacing between the isolated dead metal part and the two other parts is not less than the value specified in Table 11.2.

11.3 An insulating liner or barrier of vulcanized fiber or similar material is capable of being used where a spacing is otherwise less than the minimum intended value when the material is no less than 1/32 inch (0.8 mm) thick, and shall be so located or of such material that it is not adversely affected by arcing.

Exception No. 1: Vulcanized fiber no less than 1/64 inch (0.4 mm) thick is able to be used with an air spacing of no less than 50 percent of the minimum required through-air spacing.

Exception No. 2: Insulating materials having a thickness less than that specified or other insulating materials are able to be used when they comply with the requirements specified in 17.2 and 17.3.

11.3 revised March 28, 2001

11A Solid-State Circuitry-Protected Motors

11A.1 A reliability study for electronic circuit components in a solid-state protector shall be made in accordance with the requirements for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991.

11A.1 added March 28, 2001

11A.2 Limiting impedance circuit requirements

11A.2.1 A limiting impedance circuit shall be supplied by an impedance in which the calculated power dissipation of the impedance does not exceed the power rating of the impedance and is less than 15 watts. The calculated power dissipation of the impedance is the result of a direct short applied across the circuit downstream of the impedance.

Exception: A limiting impedance circuit is not prohibited from being supplied by an impedance in which the calculated power dissipation of the impedance exceeds the power rating of the impedance and is less than 15 watts when the impedance does not open or short when subjected to the effects of a direct short applied across the circuit downstream of the impedance. The method for setting up this limiting impedance test is the same as the method for setting up the Component breakdown test, Sub-Section 12A.2.

11A.2.1 added March 28, 2001

11A.2.2 The limiting impedance shall be able to function under single component fault conditions.

Exception: The limiting impedance is not required to function under single component fault conditions when the limiting impedance circuit is enclosed.

11A.2.2 added March 28, 2001

11A.2.3 A single resistor serving as limiting impedance complies with 11A.2.2 without further investigation. A single capacitor serving as a limiting impedance complies with 11A.2.2 without further investigation when the capacitor complies with the Standard for Capacitors and Suppressors for Radio- and Television-Type Appliances, UL 1414.

11A.2.3 added March 28, 2001

11A.2.4 A printed-wiring board containing circuitry other than low voltage limited energy shall be capable of direct support of live parts.

11A.2.4 added March 28, 2001

11A.2.5 The spacings on printed-wiring boards within low voltage limited energy circuits are not specified.

11A.2.5 added March 28, 2001

11A.3 Clearances and creepage distances

11A.3.1 As an alternative to the specified spacing requirements of the Standard for Motors, UL 1004, the spacing requirements in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, are able to be used for spacings on printed wiring boards. The spacing requirements in UL 840 are not to be used for field wiring terminals and spacings to a dead metal enclosure. In determining the pollution degree and overvoltage category, the end-use application is to be identified and is to modify those characteristics given in 11A.3.2 – 11A.3.5, as appropriate.

11A.3.1 added March 28, 2001

11A.3.2 When applying specific requirements from the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, it is anticipated that the degree of pollution expected or controlled will be as indicated in Table 11A.1.

11A.3.2 added March 28, 2001

11A.3.3 When applying specific requirements from the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, it is anticipated that the equipment will be identified by overvoltage categories as indicated in Table 11A.2.

11A.3.3 added March 28, 2001

11A.3.4 In order to evaluate clearances where the levels of overvoltage are controlled, control of overvoltage shall be achieved by providing an overvoltage device or system as an integral part of the product or by devices specified for use with end products. The equipment is to be evaluated for the rated impulse withstand voltage specified in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840.

11A.3.4 added March 28, 2001

Table 11A.1
Degrees of Pollution

Table 11A.1 added March 28, 2001

Equipment	Pollution Degree
Hermetically sealed or encapsulated equipment without contaminating influences or printed wiring boards with a protective coating.	1
Totally enclosed motors without brushes or internal lubrication systems.	2
Open motors for use in equipment for ordinary locations and indoor use, such as: a) Residential appliances; and b) Commercial appliances for use in a clean environment	2
Motors for use in equipment for outdoor use, and equipment influenced by surrounding environment, such as industrial use.	3
Motors with graphite brushes, internal lubrication systems, or other contaminating influences.	4

Table 11A.2
Overvoltage Categories

Table 11A.2 added March 28, 2001

Equipment	Overvoltage category
Intended for fixed wiring connection	III
Portable and stationary cord-connected	II
Power-limited and safety low voltage	I
NOTE – Applicable to low-voltage circuits if a short circuit between the parts involved may result in operation of the controlled equipment that would a increase the risk of fire or electric shock.	

11A.3.5 Printed-wiring boards constructed of Types XXXP, XXXPC, G-10, FR-2, FR-3, FR-4, FR-5, CEM-1, CEM-3, GPO-2, or GPO-3 industrial laminates in accordance with the Standard for Polymeric Materials – Industrial Laminates, Filament Wound Tubing, Vulcanized Fiber, and Materials Used in Printed-Wiring Boards, UL 746E, are determined to have a minimum comparative tracking index of 100 without further investigation.

11A.3.5 added March 28, 2001

PERFORMANCE

12 General

12.1 Deleted March 28, 2001

12.2 The Running Heating Test, Section 13, shall be conducted only at the manufacturer's request, or in accordance with an end-use standard. A motor that has been tested for running heating protection only shall be marked in accordance with 16A.5.

12.2 revised March 28, 2001

12.3 All protectors shall comply with the Limited Short Circuit Test, Section 18, and when required, the Protector Insulation Test, Section 19.

12.4 The performance tests are to be conducted on representative samples of motor/protector combinations. The number of samples specified are to be in accordance with the range of motors to be protected.

12.5 A protector calibrated to have a tolerance in excess of ±5°C (9°F) of the nominal opening temperature or ±15°C (27°F) of the closing temperature, shall be tested in accordance with 12.6 to determine that the wider tolerance protector has an intended locked-rotor cycling life.

12.6 As required by 12.5, the following motor/protector combinations are to be tested to all temperature and endurance tests:

a) One sample protector calibrated to open at the maximum temperature is to be subjected to all tests required in this standard; and

b) One sample calibrated to open at the minimum temperature and close at the maximum temperature is to be subjected to the Locked-Rotor Endurance Test, Section 16, except the duration is to be 18 days.

12.6 revised March 28, 2001

12.7 Thermocouples are to be placed on the surfaces of coils of all windings and on parts, other than a commutator, exposed in the interior of the motor. A thermocouple on a coil is to be applied to the actual conductor material, or it is to be separated from that material by not more than the integrally applied conductor insulation.

12.8 Testing is to be conducted on individual or multiple samples of a motor/protector combination. When individual samples are used, then the tests shall be conducted in the sequence presented in the following sections.

12.9 When a secondary or back-up protector is provided, it shall be removed or shunted so that only the primary protector is being tested.

12.9 revised March 28, 2001

12.10 Polyphase motors shall be provided with protectors so that each phase winding is protected from overheating.

12.11 A single-operation device shall not reset itself at a temperature higher than minus 35°C (minus 31°F).

12.12 A motor that employs an insulation system greater than Class A shall not be prohibited from being protected to the temperature limits for one insulation class lower than the insulation class marked on the motor for the locked-rotor tests. The running heating test would still comply with the temperature limit of the insulation class marked on the motor. For example, during the running overload test, a motor with a Class B insulation system would be allowed to trip at or below 165 °C (a Class B limit). For the locked-rotor test, the maximum temperature limit will be 200°C (a Class A limit) during the first hour and 175°C (a Class A limit) after the first hour.

12.12 added March 28, 2001

12.13 The Solid State Motor Protection Test described in the Standard for Power Conversion Equipment, UL 508C, is to be conducted only at the manufacturer's request, or in accordance with an end-use standard.

12.13 added March 28, 2001

12.14 During the tests, the current is to be monitored and recorded at key events such as when the load is increased during the Running Heating Temperature Test, Section 13, or when the protector trips during the Locked-Rotor Temperature Test, Section 14.

Exception: The current is not required to be monitored during the Locked-Rotor Endurance Test, Section 16.

12.14 added March 28, 2001

12.15 The primary protector shall operate during testing.

12.15 added March 28, 2001

12.16 At the manufacturer's request, informational testing is to be conducted under conditions that cause the backup protection means to operate to determine compliance with Part II or III requirements.

12.16 added March 28, 2001

12A Solid-State Circuitry-Protected Motors Tests

12A.1 Normal temperature test

12A.1.1 A motor shall be tested in accordance with Section 5, General, and 12A.1.2 – 12A.1.6 and shall not reach a temperature at any point high enough to cause a risk of fire, to damage any materials in the motor, or to exceed the temperature rises specified in Table 12A.1.

12A.1.1 added March 28, 2001

12A.1.2 A protective device shall not open the circuit during the temperature test.

12A.1.2 added March 28, 2001

12A.1.3 All values of temperature rise in Table 12A.1 are based on an assumed ambient temperature of 25°C (77°F). Tests are to be conducted at any ambient temperature within the range of 10 – 40°C (50 – 104°F).

12A.1.3 added March 28, 2001

12A.1.4 For a motor that is not intended for continuous operation, the intermittent or short-time operation of the motor is to be taken into consideration when conducting the temperature test.

12A.1.4 added March 28, 2001

12A.1.5 Constant temperatures are attained when three successive readings taken at intervals of 30 minutes indicate no change greater than 1°C (1.8°F) and temperatures are not still rising.

12A.1.5 added March 28, 2001

12A.1.6 The motor shall be tested at the following load levels:

a) 25 percent of rated horsepower;

b) 50 percent of rated horsepower;

c) 75 percent of rated horsepower; and

d) 100 percent of rated horsepower.

12A.1.6 added March 28, 2001

Table 12A.1
Maximum temperature rises

Table 12A.1 added March 28, 2001

Materials and Components	°C	°F
1. Capacitors[a]:		
Electrolytic[b]	40	72
Other types	65	117
2. Fuses		
A. Class G, J, L, T, and CC		
Tube	100	180
Ferrule or blade	85	153
B. Other[c]	65	117
3. Fiber employed as electrical insulation:	65	117
4. At any point within a terminal box or wiring compartment of a permanently connected appliance in which power-supply conductors are to be connected, including such conductors themselves, unless the appliance is marked in accordance with the Standard for Electric Motors, UL 1004.	35	63
5. A surface upon which an appliance may be fastened in place and surfaces that may be adjacent	65	117
6. Class A (105)[d]		
Thermocouple method	65	117
Resistance method	75	135
7. Class E (120)[d]		
Thermocouple method	75	135
Resistance method	85	153
8. Class B (130)[d]		
Thermocouple method	85	153
Resistance method	95	171
9. Class F (155)[d]		
Thermocouple method	110	198
Resistance method	120	216
10. Class H (180)[d]		
Thermocouple method	125	225
Resistance method	135	243
11. Phenolic composition employed as electrical insulation or as a part the deterioration of which would result in a risk of fire or electric shock.[e]	125	225
12. Rubber- or thermoplastic-insulated wire and cord.[e, f, g]	35	63
13. Sealing compound (less than melting point)	40	104
14. Varnished-cloth insulation	60	108
15. Wood and other combustible material	65	117
16. Current carrying parts		
A. Copper or copper alloy	175	315
B. Aluminum	175	315
C. Stainless steel, monel, nickel plated copper	225	405
17. Other components	h	h

[a]A capacitor that operates at a temperature rise of more than 65°C (117°F) may be judged on the basis of its marked temperature limit.

[b]The temperature rise on insulating material integral with the enclosure of an electrolytic capacitor that is physically integral with or attached to a motor shall not be more than 65°C (117°F).

[c]A fuse that has been investigated and found usable at a higher temperature is able to be used at that temperature.

Table 12A.1 Continued on Next Page

Table 12A.1 Continued

Materials and Components	°C	°F
[d]A totally enclosed motor is able to have a winding temperature 5°C (9°F) higher than those stated.		
[e]The limitations on phenolic composition and on rubber and thermoplastic insulation do not apply to compounds that have been investigated and found usable at higher temperatures.		
[f]Rubber-insulated conductors within a Class A insulated motor, rubber-insulated motor leads, and a rubber-insulated flexible cord entering a motor may be subjected to a temperature rise of more than 35°C (63°F), when a braid is employed on the conductor of other than a flexible cord. However, this does not apply to thermoplastic-insulated wires or cords.		
[g]A short length of rubber- or thermoplastic-insulated flexible cord exposed to a temperature of more than 60°C (140°F), such as at terminals, is acceptable if supplementary heat-resistant insulation of adequate dielectric strength is employed on the individual conductors of the cord to protect the conductor insulation against deterioration.		
[h]The temperature on other components shall not exceed the temperature of the component.		

12A.2 Component breakdown test

12A.2.1 General

12A.2.1.1 Solid state motor protection circuitry shall be subjected to the tests described in 12A.2.1.2 – 12A.2.1.5.

12A.2.1.1 added March 28, 2001

12A.2.1.2 With reference to the requirement in 12A.2.1.3, a risk of fire or electric shock is determined to exist when any of the following occur:

a) Glowing, charring, or flaming of the surgical cotton or tissue paper as specified in 12A.2.2.1;

b) Opening of the 3-ampere fuse specified in 12A.2.2.2;

c) Emission of flame, sparks, or molten metal from the enclosure;

d) Development of an opening in the overall enclosure that exposes live parts involving a risk of electric shock to contact by persons; or

e) Loss of structural integrity to a degree that the equipment collapses or experiences such displacement of parts that may lead to short-circuiting or grounding of live parts.

12A.2.1.2 added March 28, 2001

12A.2.1.3 Malfunction of components that have not been investigated for reliability, or have been investigated to be reliable, but could result in a risk of fire or electric shock are to have their fault simulated. These types of components include diodes; transistors; thyristors; electrolytic capacitors; integrated circuits; optical isolators that do not comply with the Standard for Optical Isolators, UL 1577; or other solid-state device (a device whose operation is dependent upon any combination of optical, electrical, or magnetic phenomena within a solid). The circuit between any two terminals of such a device is to be opened or shorted. Only one of the simulated fault conditions is to be imposed at one time. For a multi-terminal device, only two terminals are to be short-circuited at a time. It is allowable to use simulated circuits, but if the tests performed on simulated circuits indicate likely damage to other parts of the equipment to the extent that the safety of the equipment may be affected; the test shall be repeated on the equipment with the fault imposed on the component under test.

Exception No. 1: A component located in the following circuits is not required to be open- or short-circuited:

a) A limiting impedance or low-voltage circuit as defined in 3.4(c) and 3.4(e);

b) A circuit that has been investigated for reliability and determined to be reliable;

c) A circuit that would not involve a risk of fire or electric shock if a component malfunction was to occur; or

d) Where circuit analysis indicates that no other component or portion of the circuit is able to be overloaded.

Exception No. 2: The test is not required for optical isolators that comply with the requirements in the Standard for Optical Isolators, UL 1577.

12A.2.1.3 added March 28, 2001

12A.2.1.4 Each test is to be conducted on a separate sample unless it is agreeable to those concerned that more than one test be conducted on the same sample.

12A.2.1.4 added March 28, 2001

12A.2.1.5 A part of equipment that is removed during routine operation or maintenance is to be omitted when it results in a more severe test, and the part is:

a) Not necessary for the functioning of the equipment;

b) Not exposed to view during intended operation; and

c) Not captivated.

12A.2.1.5 added March 28, 2001

12A.2.2 Test method

12A.2.2.1 During the tests of 12A.2.2.2 – 12A.2.2.7, the sample is to be placed on a softwood surface covered with white tissue paper, and a single layer of surgical cotton is to be draped loosely over the entire enclosure.

Exception No. 1: Controls not having any bottom openings are not required to be placed on a softwood surface covered with tissue paper.

Exception No. 2: When it is impractical to drape the entire enclosure, surgical cotton shall be placed only over all ventilating openings.

12A.2.2.1 added March 28, 2001

12A.2.2.2 During each test, exposed dead-metal parts of the sample are to be connected to earth ground through a 3-ampere, nontime-delay fuse.

12A.2.2.2 added March 28, 2001

12A.2.2.3 The supply circuit is to have branch circuit overcurrent protection. The size of which equals 125 percent of the input current rating (20-ampere minimum). Where this value does not correspond with the standard rating of a fuse or a circuit breaker, the next higher standard device rating shall be used. The test voltage is to be adjusted to the value specified in 5.1.

Exception: When a marking on the product indicates the use of branch circuit protection exceeding 125 percent of the input current, such protection shall be used.

12A.2.2.3 added March 28, 2001

12A.2.2.4 A fuse that is replaced during routine maintenance is to be effectively defeated unless marked in accordance with 19A.3. A fuse that is soldered in place, or is located such that it is accessible only to qualified service personnel, and marked in accordance with 19A.3, and any other overcurrent protective device not subject to replacement during routine maintenance is to be left in the circuit.

12A.2.2.4 added March 28, 2001

12A.2.2.5 The test is to be conducted for 7 hours or until one or more of the following results are observed:

a) A risk of fire or electric shock develops (See 12A.2.1.2);.

b) The branch-circuit fuse opens;

c) The equipment protective device opens;

d) Any other circuit component opens; or

e) A minimum of one hour elapses, circuit conditions stabilize, and there is no further evidence of overheating of parts.

12A.2.2.5 added March 28, 2001

12A.2.2.6 The overheating of parts referred to in 12A.2.1.2(e) is to be detected by an indicator such as an odor, smoke, discoloration, cracking of materials, charring, flaming, glowing, arcing, changes in circuit current through the applied fault, or any similar phenomenon.

12A.2.2.6 added March 28, 2001

12A.2.2.7 When a fault condition is terminated by opening of a circuit component as specified in 12A.2.1.2(d), the test is to be conducted two more times using new components for each test.

12A.2.2.7 added March 28, 2001

12A.3 Abnormal tests

12A.3.1 The tests described in Section 13 – 16 shall be performed. The specific method is to be determined based on the process used in the circuit. For instance, if a fuse is relied upon, then the products is to be treated as a one shot protector.

12A.3.1 added March 28, 2001

13 Running Heating Temperature Test

13.1 Continuous duty motors

13.1.1 General

13.1.1.1 A continuous-duty motor is to be operated under load at its nameplate current and at the applicable test voltage until the motor winding temperature becomes constant. The protector shall not open when operating at the nameplate current. The load is then to be increased in small increments to the maximum load that does not result in the protector opening.

Exception: This is not required for fan duty motors.

13.1.1.2 When a motor-protector combination is running with the maximum load it is capable of carrying without resulting in the protector opening the circuit, the stabilized winding temperature under maximum load shall not exceed the values specified in Table 13.1.

Table 13.1
Maximum winding temperatures

Motor insulation system	Maximum winding temperature	
	°C	°F
Class A	140	284
Class B	165	329
Class F	190	374
Class H	215	419

13.1.2 Polyphase motors

13.1.2.1 A continuous-duty polyphase motor is to be tested under both the normal polyphase operation and under single-phasing conditions.

Exception: Fan duty motors are not required to be tested under single phase conditions.

13.1.2.1 revised March 28, 2001

13.1.2.2 For the single phase test, the motor is to be energized and the load adjusted so that the motor operates at the rated current. One motor supply conductor is to be opened. The motor winding temperature is to stabilize before beginning to load the motor. After opening the supply conductor, the motor is able to stall or continue to operate for a short time before the protector opens. This meets the intent of the requirement when the winding temperatures do not exceed the locked-rotor limits specified in Table 14.1. The single-phasing running heating test is to be discontinued at this point.

13.1.2.2 revised March 28, 2001

13.1.3 Ultimate trip current

13.1.3.1 The ultimate trip current of a protector in a motor rated more than 1 horsepower (746 W) shall not exceed the percentage of motor full-load current specified in Table 13.2. The full-load current of a motor is to be one of the values specified in either Table 18.3 or 18.4, not the marked nameplate value. When requested by the manufacturer, the ultimate trip current shall be determined at a 40°C (104°F) referee ambient.

Table 13.2
Maximum ultimate trip current

Full-load current[a] Amperes	Ultimate trip current: Maximum percentage of full-load current[b]
9.0 or less	170
9.1 to 20.0	156
20.1 or more	140

[a] See 13.1.3.1.
[b] See 13.1.3.3.

13.1.3.2 A motor shall comply with the requirements of 13.1.3.1 at each voltage and speed connection.

Exception: This requirement does not apply to the lower speeds of a multi-speed motor marked 1 horsepower or less on the lower speeds.

13.1.3.3 Table 13.2 does not apply to a polyphase motor operating under single-phasing conditions.

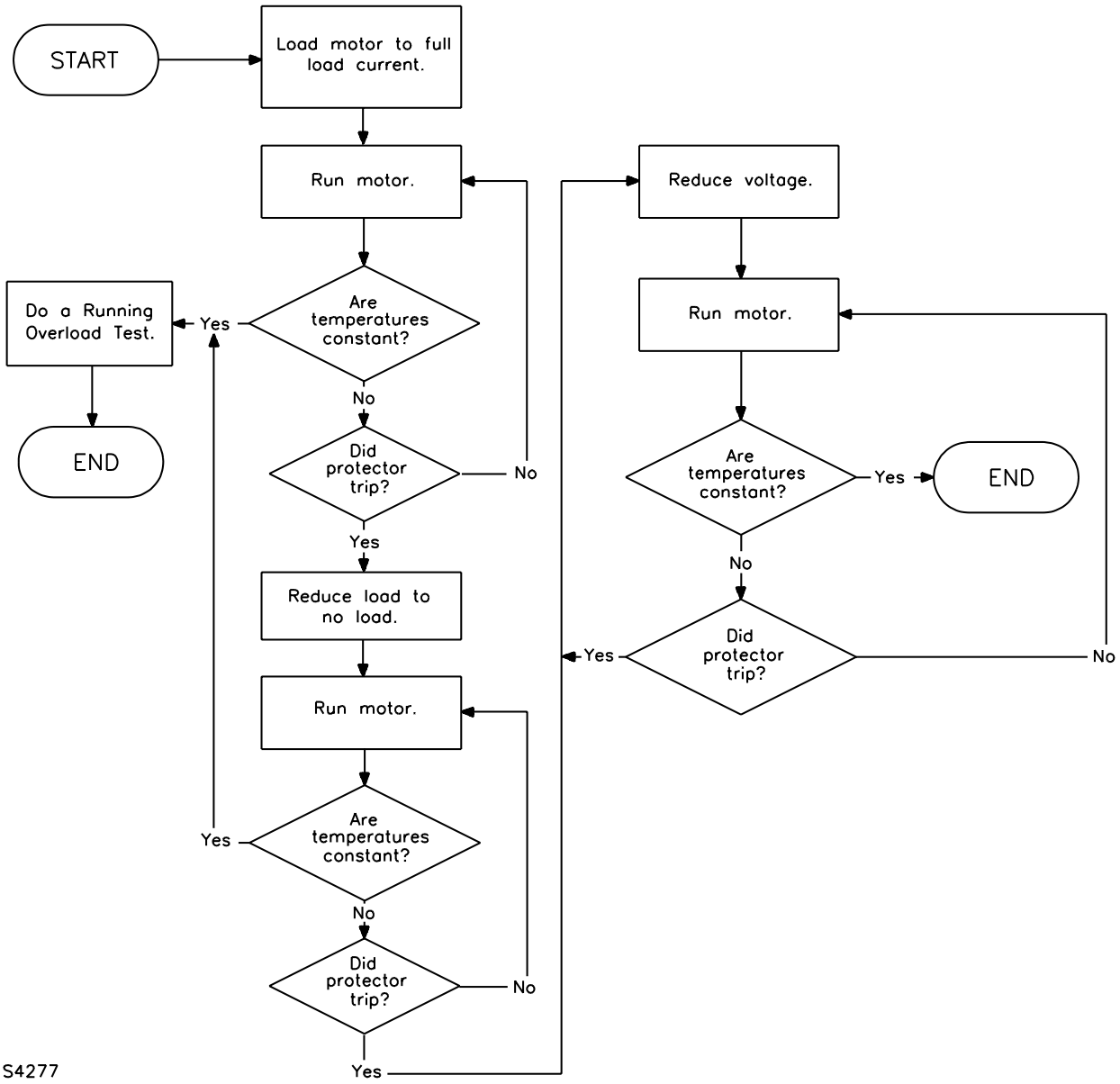
13.2 Intermittent duty motors

13.2.1 An intermittent-duty motor is to be operated under load at its nameplate current and at the applicable test voltage. The load and/or voltage is to be adjusted until the motor is able to operate without the protector tripping. See Figure 13.1.

13.2.1 revised March 28, 2001

Figure 13.1
Intermittent duty test method

Figure 13.1 added March 28, 2001



13.2.2 Following the procedure of 13.2.1, the stabilized winding temperature under maximum load shall not exceed the values specified in Table 13.1.

13.2.3 Polyphase motors are to be tested only under polyphase conditions.

13.3 Fan duty motors

13.3.1 A motor that is to be directly coupled to a fan-blade or blower-wheel load is to be operated at the applicable test voltage and under no-fan, no-load conditions with the shaft running free.

a) When the protector does not open the circuit the winding temperature at thermal equilibrium shall not exceed the temperature limits specified in Table 7.1; or

b) When the protector opens the circuit, the winding temperature shall not exceed the values specified in Table 14.1.

13.3.1 revised March 28, 2001

13.3.2 Polyphase motors are to tested only under polyphase conditions.

14 Locked-Rotor Temperature Test

14.1 General

14.1.1 The rotor is to be locked in a stationary position using means of low thermal conductivity.

14.1.2 As a result of this test, a motor shall comply with the following:

a) The coil temperature shall not exceed the values specified in Table 14.1.

b) The fuse in the grounding conductor shall not open.

c) There shall be no flaming or severe or prolonged smoking;

d) There shall be no flaking, embrittlement or charring of the insulation. Simple discoloration of the insulation meets the intent of the requirement, and charring or embrittlement to the extent that the insulation flakes off or material is removed when the windings are rubbed with the thumb does not meet the intent of the requirement;

e) There shall be no electrical or mechanical malfunction of any associated component parts such as capacitors or starting relays.

f) The motor shall still be capable of operating electrically. For example, a bearing failure is considered in compliance.

When examination of the motor windings requires disassembly of the motor, the examination shall be conducted after the Locked-Rotor Endurance Test, Section 16.

14.1.2 revised March 28, 2001

Table 14.1
Maximum locked-rotor temperature limits

Motor insulation class:	A		B		F		H	
Protector type	**°C**	**°F**	**°C**	**°F**	**°C**	**°F**	**°C**	**°F**
1. Automatically reset:								
a) During 1st hour	200	392	225	437	250	482	275	527
b) After 1st hour[a]	175	347	200	392	225	437	250	482
c)Average[b]	150	302	175	347	200	392	225	437
2. Manually reset, single operation;	200	392	225	437	250	482	275	527
3. Thermal cutoff:								
a) During 1st hour	200	392	225	437	250	482	275	527
b) After 1st hour	150	302	175	347	200	392	225	437

[a] The temperatures are to be recorded for:

a) The second hour of operation or until the temperatures stabilize, whichever is longer, and

b) The seventy-second hour of the test.

Stabilized temperatures are obtained when the maximum temperatures readings of three successive cycles are within 2°C (3.6°F) of each other and are not showing a successive increase or a successive decrease in temperature.

[b] Refer to 14.1.3.

14.1.3 The average temperature referenced in Table 14.1 is to be determined for both the second and seventy-second hours. For each of these periods, the average temperature is to be determined by taking the arithmetic mean of the trip temperature and reset temperature. The temperatures of the hottest thermocouple are to be used.

14.1.3 revised March 28, 2001

14.1.4 Deleted March 28, 2001

14.2 Automatically reset protectors

14.2.1 Starting at room temperature, a motor provided with an automatically reset protector is to be energized continuously for 72 hours, during which the winding temperatures are to be monitored.

14.2.2 A polyphase motor that is not provided with a 3-phase protector shall also be tested under single-phasing conditions. Each open conductor shall be tested. The motor is to be locked and energized with one supply-conductor opened. The test duration shall be such that the first and second hour winding temperatures are recorded or until temperatures stabilize, whichever is longer.

14.2.2 revised March 28, 2001

14.3 Manually reset protectors

14.3.1 Starting at room temperature, a motor provided with a manually reset protector is to be energized for 10 cycles of protector operation, with the protector being reset quickly after it has opened the circuit.

14.3.2 A polyphase motor shall also be tested under single-phasing conditions with one supply-conductor opened. Each open conductor shall be tested.

14.4 Thermal cutoffs

14.4.1 Starting at room temperature, three samples of a motor provided with a thermal cutoff protector are to be energized continuously until the thermal cutoff opens the circuit.

14.5 Single-operation devices

14.5.1 Starting at room temperature, three samples of a motor provided with a single-operation device are to be energized continuously until the protector opens the circuit.

15 Dielectric Voltage-Withstand Test

15.1 Immediately following the conclusion of the Locked-Rotor Temperature Test, Section 14, a motor shall withstand a 1 minute application of a 60-hertz sinusoidal potential. The potential shall be between live parts and dead metal parts that are grounded or that are exposed to contact. The potential shall be 1000 volts for a motor rated 1/2 horsepower (373 W) or less and 250 volts or less; or 1000 volts plus twice the voltage rating of the motor for all other motors.

15.1 revised March 28, 2001

15.2 To determine whether a motor complies with the requirements in 15.1, the motor is to be tested by means of a 500 volt-ampere or larger capacity transformer, the output voltage of which is sinusoidal and able to be varied. The applied potential is to be increased from zero until the required test level is reached and is to be held at that level for 1 minute. The applied potential is to be increased at a substantially uniform rate as rapid as is consistent with correct indication of the potential by a voltmeter. The capacity of the transformer is able to be less than 500 volt-amperes when the test equipment used maintains the specified test potential at the output terminals for the duration of the test.

16 Locked-Rotor Endurance Test

16.1 General

16.1.1 Immediately following the Dielectric Voltage Withstand Test, Section 15, a motor is to be re-energized under the conditions of the Locked-Rotor Temperature Test, Section 14.

16.1.2 At the conclusion of the test, the motor shall comply with the requirements of 14.1.2 (b) – (f).

16.1.2 revised March 28, 2001

16.1.3 In addition to 16.1.2, there shall be no dielectric breakdown as the result of a one minute application of a potential of twice the marked rated voltage of the motor between the windings and the frame.

16.1.4 Polyphase motors are only to be tested under polyphase conditions.

16.1.5 For multiple voltage motors, the Locked-Rotor Endurance Test is to be conducted at each voltage. A different sample is able to be used for each test.

16.2 Automatically reset protectors

16.2.1 A motor is to be tested for an additional 15 days.

16.2.2 A protector in a motor rated more than 1 horsepower (746 W) shall operate a minimum of 2000 cycles during the 18 day locked-rotor period. When required, the Locked-Rotor Endurance Test is to continue beyond 15 days until 2000 cycles have been completed.

16.2.3 The automatically reset protector shall not open the circuit permanently prior to the completion of 15 days unless:

a) It is specifically intended to do so; and

b) Testing of three samples shows that it is capable of doing so consistently and reliably without permanent damage to the motor.

16.2.4 Deleted March 28, 2001

16.2.5 For dual rotation and multi-speed motors, the Locked-Rotor Endurance Test is to be conducted only at the condition resulting in the highest current. When the currents are similar, the condition with the fastest protector cycling rate is to be tested. When the cycling rates are also similar, the condition with the highest temperature is to be tested.

16.3 Manually reset protectors

16.3.1 A motor is to be tested for an additional 50 cycles.

MARKINGS

16A Details

16A.1 Name, tradename, or trademark of the protector manufacturer or other descriptive marking by which the manufacturer is identified, and protector model number or type designation shall be marked on the outside of the motor where visible.

Exception: When the motor marking also serves as a means of identifying the manufacturer and model of protector, the information required are not required to be separately marked.

22.1 revised and relocated as 16A.1 March 28, 2001

16A.2 The complete electrical rating required in 9A.1(b) consists of the following:

a) Rated voltage;

b) Rated frequency, specified with hertz, Hz, cycles per second, cps, cycles/second, c/s, ac-dc, (number of cycles)/dc (for example, 60/dc);

c) Full-load input amperage, locked-rotor input amperage, full-load input wattage, locked-rotor input wattage, output horsepower, or output wattage. Ratings shall be provided at each speed provided unless the motor is of the shaded-pole or permanent-split-capacitor type;

d) Number of phases when intended for use on a polyphase circuit; and

e) Other information as required by an intended end-use product.

Exception: A motor rated 1/8 horsepower or less is not prohibited from being marked with locked-rotor amperage, full-load amperage, rated wattage, or locked-rotor wattage.

22.2 revised and relocated as 16A.2 March 28, 2001

16A.3 A motor that has been tested for running-heating and locked-rotor protection shall be marked ″Thermally-Protected″.

Exception: A motor 1/8 horsepower or less, or 100 watts or less, is not prohibited from being marked ″T.P.″.

22.4 relocated as 16A.3 March 28, 2001

16A.4 A motor that has been tested for locked-rotor protection only shall be marked ″Thermally-Protected L″.

Exception: A motor rated 1/8 horsepower or less, or 100 watts or less, is not prohibited from being marked ″T.P.L.″.

22.5 relocated as 16A.4 March 28, 2001

16A.5 A motor that has been tested for running heating protection only shall be marked ″Thermally-Protected R″ or ″T.P.R.″.

Exception: A motor rated 1/8 horsepower or less, or 100 watts or less, is not prohibited from being marked ″T.P.R.″.

22.6 relocated as 16A.5 March 28, 2001

16A.6 A motor rated for short-time or intermittent duty shall be marked on the nameplate with the words ″intermittent duty″ or ″int. duty″ or with a time rating in minutes or hours or a combination of minutes and hours. The rating is able to be for ″On″ time only or include specifications for both ″On″ and ″Off″ periods.

22.7 relocated as 16A.6 March 28, 2001

16A.7 Instructions shall be provided for manual reset operation, when not self-evident.

22.8 relocated as 16A.7 March 28, 2001

PART IV – THERMAL PROTECTORS

CONSTRUCTION

17 General

17.1 A thermal cutoff shall comply with the requirements in UL 1020, Standard for Thermal Cutoffs for Use in Electrical Products and Components, in addition to the requirements of this standard.

17.2 Insulation for a protector intended for use in a Class A or Class B insulated motor shall be:

a) 1/32 inch (0.8 mm) [0.028 inch (0.7 mm)] minimum thickness treated fiber;

b) 0.004 inch (0.1 mm) minimum thickness polyethylene terepthalate (PETP);

c) 0.015 inch (0.4 mm) minimum thickness silicone-impregnated fiberglass;

d) 0.017 inch (0.4 mm) minimum thickness isocyanate-resin-impregnated fiberglass; or

e) 0.006 inch (0.152 mm) minimum thickness aramid paper.

Exception: Other materials are capable of being used when they comply with the protector insulation test requirements in the Protector Insulation Test, Section 19, or the equivalent, and with the traceability requirements specified in UL 746A, Standard for Polymeric Materials – Short Term Property Evaluations.

17.2 revised March 28, 2001

17.3 Any insulation for a protector intended for use in a Class F or higher insulated motor shall comply with Protector Insulation Test, Section 19 and with the traceability requirements specified in UL 746A, Standard for Polymeric Materials – Short Term Property Evaluations.

17.4 Deleted March 28, 2001

17.5 Current-carrying parts of a protector shall be metal inherently resistant to corrosion or shall be treated to resist corrosion. Iron and steel parts shall be protected by enameling, galvanizing, plating or other means when the corrosion of such parts results in risk of electric shock, fire, or injury to persons.

Exception: Multimetallic thermal elements and heater elements are not required to be protected.

17.6 Protector components, such as wiring or polymeric materials, shall be rated for the maximum protector calibration temperature plus the tolerance.

17.7 Automatic tripping of a manually reset protector shall be independent of the position or manipulation of the reset handle or button. That is:

a) The bimetal shall open the circuit regardless of the handle or button position or manipulation; and

b) Manipulation of the handle or button shall not reset the protector until the bimetal closes the circuit again.

17.8 The construction of a protector shall be such that it reduces the risk of substitution of a protector or thermal element of higher calibration than the protector or element originally provided.

17.9 A protector shall be mounted in place and shall employ materials of such strength, rigidity, and insulating properties as to be capable of withstanding the stresses to which there is a risk of it being subjected.

17.10 A polyphase protector shall comply with the spacing requirements of Table 11.2.

PERFORMANCE

18 Limited Short Circuit Test

18.1 Three samples of a motor protector shall be subjected to a short-circuit-current as determined by Table 18.1.

Exception: Protectors connected in the common point of a wye-connected polyphase motor are not subjected to this test.

Table 18.1
Limited short circuit test current

Motor horsepower (kW)[a]	Motor voltage	Test current, amperes
1/2 (0.373) or less	250 or less	200
More than 1/2 (0.373) up to 1 (0.746)	250 or less	1000
1 (0.746) or less	More than 250	1000
More than 1 (0.746) up to 3 (2.24)	250 or less	2000
More than 3 (2.24) up to 7-1/2 (5.60)	250 or less	3500
More than 7-1/2 (5.60)	250 or less	5000
More than 1 (0.746)	More than 250	5000

[a] For the purpose of determining the circuit capacity of a motor not marked in horsepower (watts), a horsepower rating is to be assumed on the basis of the marked full-load amperes in accordance with Tables 18.3 and 18.4.

18.2 A protector is to be tested:

a) Within the motor it is intended to protect; or

b) Positioned between two copper bars to simulate the motor enclosure within which it is intended to be used.

18.2 revised March 28, 2001

18.2.1 A live case protector shall be provided with suitable insulation (see 10.3.1, 17.2, and 17.3):

a) Within the motor it is intended to protect; or

b) Positioned between two copper bars to simulate the motor enclosure within which it is intended to be used.

18.2.1 added March 28, 2001

18.3 A protector that is tested within a motor shall not be connected to the motor windings.

18.4 The protector is to be connected in series with a non-renewable non-time-delay cartridge fuse rated not less than four times the rated full-load current marked on the motor with which it is intended to be used. The fuse rating is to be not less than 20 amperes for a device rated 150 volts or less, and is to be not less than 15 amperes for a device rated more than 150 volts and not more than 600 volts.

18.5 The test voltage is to be in accordance with Table 18.2.

Table 18.2
Test voltages

Motor nameplate		Nominal test
Rating,	Volts	Voltage, volts
110	120	120
200	208	240
220	240	240
254	277	277
440	480	480
550	600	600

18.6 When requested, the test is to be conducted at a higher voltage, current or fuse size than specified to represent lower values.

18.7 The power factor is to be 0.9 – 1.0, unless a lower power factor is agreeable to those concerned. The circuit capacity is to be measured without the protector in the circuit.

18.8 The enclosure of the protector is to be connected, without a fuse, to the same test terminal as the protector-switched side of the line.

18.9 The protector or overall enclosure is to be wrapped in surgical cotton.

18.9 revised March 28, 2001

18.10 As a result of this test, the cotton shall not ignite. When the protector cycles, the test is to be continued until the protector or fuse permanently opens the circuit.

18.11 One of the three tests for a manually reset protector is to be conducted by closing the protector on the short circuit.

Table 18.3
Full-load motor-running currents in amperes corresponding to various alternating-current horsepower (wattage) ratings

Horse-power	(kW)	110 – 120 Volts			220 – 240 Volts[a,b]			440 – 480 Volts			550 – 600 Volts		
		Single phase	Two phase	Three phase	Single phase	Two phase	Three phase	Single phase	Two phase	Three phase	Single phase	Two phase	Three phase
1/6	(0.124)	4.4	–	–	2.2	–	–	–	–	–	–	–	–
1/4	(0.187)	5.8	–	–	2.9	–	–	–	–	–	–	–	–
1/3	(0.249)	7.2	–	–	3.6	–	–	–	–	–	–	–	–
1/2	(0.373)	9.8	4.0	4.4	4.9	2.0	2.2	2.5	1.0	1.1	2.0	0.8	0.9
3/4	(0.560)	13.8	4.8	6.4	6.9	2.4	3.2	3.5	1.2	1.6	2.8	1.0	1.3
1	(0.746)	16	6.4	8.4	8	3.2	4.2	4.0	1.6	2.1	3.2	1.3	1.7
1-1/2	(1.12)	20	9.0	12.0	10	4.5	6.0	5.0	2.3	3.0	4.0	1.8	2.4
2	(1.49)	24	11.8	13.6	12	5.9	6.8	6.0	3.0	3.4	4.8	2.4	2.7
3	(2.24)	34	16.6	19.2	17	8.3	9.6	8.5	4.2	4.8	6.8	3.3	3.9
5	(3.73)	56	26.4	30.4	28	13.2	15.2	14	6.6	7.6	11.2	5.3	6.1
7-1/2	(5.60)	80	38	44	40	19	22	20	9	11	16	8	9
10	(7.46)	100	48	56	50	24	28	25	12	14	20	10	11
15	(11.19)	135	72	84	68	36	42	34	18	21	27	14	17

Table 18.3 Continued on Next Page

Table 18.3 Continued

Horse-power	(kW)	110 – 120 Volts			220 – 240 Volts[a,b]			440 – 480 Volts			550 – 600 Volts		
		Single phase	Two phase	Three phase	Single phase	Two phase	Three phase	Single phase	Two phase	Three phase	Single phase	Two phase	Three phase

[a] To obtain full-load currents for 200- and 208-volt motors, increase corresponding 220 – 240 volt ratings by 15 to 10 percent respectively.

[b] To obtain full-load currents for the 265- and 277-volt motors, decrease the corresponding 220 – 240 volt ratings by 13 and 17 percent respectively.

Table 18.4
Full-load motor-running currents in amperes corresponding to various direct-current horsepower (wattage) ratings

Horsepower	(kW)	110 – 120 Volts	220 – 240 Volts	550 – 600 Volts
1/4	(0.187)	3.1	1.6	–
1/3	(0.249)	4.1	2.0	–
1/2	(0.373)	5.4	2.7	–
3/4	(0.560)	7.6	3.8	1.6
1	(0.746)	9.5	4.7	2.0
1-1/2	(1.12)	13.2	6.6	2.7
2	(1.49)	17	8.5	3.6
3	(2.24)	25	12.2	5.2
5	(3.73)	40	20	8.3
7-1/2	(5.60)	58	29	12.2
10	(7.46)	76	38	16
15	(11.19)	110	55	24

19 Protector Insulation Test

19.1 Eighteen samples of the tubular style insulation are to be conditioned in accordance with Table 19.1. Three samples are to be installed on metal mandrels representative of the size and shape of the protector to be insulated and submitted to the 18-day test described in Table 19.1. Fifteen samples are to be 4 inches (102 mm) diameter or square in the minimum thickness used or is to be of a size representative of the end-use and subjected to the other tests in Table 19.1.

19.1 revised March 28, 2001

Table 19.1
Protector insulation conditioning

No. of samples	Conditioning
5	As received
5	Oven exposure at 100 ±2°C (212 ±3.6°F) for 72 hours
5	Exposure to moist air at a temperature of 30 ±2°C (86 ±3.6°F) for 24 hours
3	18-day oven temperature cycling per 19.4 – 19.6

19.2 Following the conditioning, each sample is to be subjected to a dielectric voltage within a test chamber. For the 15.4 inch samples, the electrodes of the dielectric equipment shall be placed on opposite sides and in the center of the sample. For the 3 samples on the mandrel, one electrode shall be connected to the mandrel and the other should be on the opposite side of the insulation sleeve in the center of the sleeve.The voltage is to be applied at a uniform rate of 500 volts per second until breakdown occurs. When physical evidence of dielectric breakdown is not apparent, the voltage is to be reapplied until a more positive indication is produced.

19.2 revised March 28, 2001

19.3 As a result of this test, the average breakdown value for each set of samples shall be no less than 5000 volts. In addition, the average breakdown value for all 13 conditioned samples shall be no less than one-half the value of the as-received samples. For example, when the as-received samples had a breakdown of 15000 volts, then the conditioned samples shall not have a breakdown less than 7500 volts.

19.3 revised March 28, 2001

19.4 The samples to be subjected to 18 days of oven temperature are to be suspended vertically in an air-circulating oven. The oven temperature is to be cycled as specified in Table 19.2. This Table is based upon the maximum temperature – see Table 14.1 – that meets the requirements for the insulation class and a minimum temperature such that the average of the minimum and maximum temperatures equals the maximum average temperature for the insulation class as specified in Table 14.1.

19.4 revised March 28, 2001

Table 19.2
Oven cycling temperature limits

	Maximum temperature		Minimum temperature	
Insulation class	°C	°F	°C	°F
A	175	347	125	257
B	200	392	150	302
F	225	437	175	347
H	250	482	200	392

19.5 The cycle rate shall be such that at least 2000 cycles are completed within a minimum 18-day duration to represent the full locked-rotor test period.

19.6 As an alternate to using an oven as described in 19.4, motor samples with an insulated protector are to be cycled such that the temperatures in Table 19.2 are observed.

19.6 revised March 28, 2001

MARKINGS

19A Details

19A.1 A protector shall be marked with the following:

a) Name, tradename, or trademark of the manufacturer or other descriptive marking by which the manufacturer is able to be identified;

b) A distinctive type identification that is indicative of the design and electrical rating; and

c) Opening temperature; and, for an automatically reset protector, closing temperature.

Exception: A protector for which the catalog number identifies the temperature ratings is not required to be marked with the temperature ratings when the complete catalog number is marked on the protector.

23.1 relocated as 19A.1 March 28, 2001

19A.2 A distinctive factory identifying marking shall be provided on a protector manufactured at more than one factory.

23.2 relocated as 19A.2 March 28, 2001

19A.3 A fuse replacement marking shall be:

a) Provided adjacent to a fuse or fuseholder or in another location provided that it is obvious to which fuseholder the marking applies, if the fuse is used to meet the requirements of this standard; and

b) Located where readily visible during replacement of the fuse.

The marking shall specify the ampere rating, and the voltage rating if higher than 125 V, of the fuse to be used for replacement. Where fuses with special fusing characteristics such as time delay are necessary, the type shall also be included.

19A.3 added March 28, 2001

PART V – MOTOR MANUFACTURING AND PRODUCTION LINE TESTS

20 Dielectric Voltage-Withstand Test

Section 20 revised and relocated as Section 5A March 28, 2001

PART VI – MARKINGS

21 Impedance-Protected Motors (Part I)

Section 21 revised and relocated as Section 9A March 28, 2001

22 Thermal-Device-Protected Motors (Part II)

Section 22 revised and relocated as Section 16A March 28, 2001

23 Thermal Protectors (Part III)

Section 23 revised and relocated as Section 19A March 28, 2001

APPENDIX A

Standards for Components

Standards under which components of the products covered by this standard are evaluated include the following:

Title of Standard − UL Standard Designation

Capacitors – UL 810
Industrial Control Equipment – UL 508
Insulating Materials – General, Systems of – UL 1446
Marking and Labeling Systems – UL 969
Motors, Electric – UL 1004
Polymeric Materials – Short Term Property Evaluations – UL 746A
Polymeric Materials – Long Term Property Evaluations – UL 746B
Polymeric Materials – Use in Electrical Equipment – UL 746C
Polymeric Materials – Fabricated Parts – UL 746D
Power Conversion Equipment – UL 508C
Quick-Connect Terminals, Electrical – UL 310
Terminal Blocks – UL 1059
Thermal Cutoffs for Use in Electrical Products and Components – UL 1020

No Text on This Page

Superseded requirements for
the Standard for
Overheating Protection for Motors,

UL 2111, First Edition

The requirements shown are the current requirements that have been superseded by requirements in revisions issued for this Standard. To retain the current requirements, do not discard the following requirements until the future effective dates are reached.

6.1 An impedance-protected motor shall comply with the requirements in UL 1004, Standard for Electric Motors.

10.1 A thermally-protected motor is not required to comply with the requirements in UL 1004, Standard for Electric Motors.

No Text on This Page