UL 1004-7

STANDARD FOR SAFETY

Electronically Protected Motors

UL Standard for Safety for Electronically Protected Motors, UL 1004-7

Third Edition, Dated June 21, 2018

Summary of Topics

This revision of ANSI/UL 1004-7 dated August 10, 2022 is being issued to update the title page to reflect the most recent designation as a Reaffirmed American National Standard (ANS). No technical changes have been made.

Text that has been changed in any manner or impacted by UL's electronic publishing system is marked with a vertical line in the margin.

The requirements are substantially in accordance with Proposal(s) on this subject dated June 17, 2022.

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UL 1004-7

Standard for Electronically Protected Motors

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This ANSI/UL Standard for Safety consists of the Third Edition including revisions through August 10, 2022.

The most recent designation of ANSI/UL 1004-7 as a Reaffirmed American National Standard (ANS) occurred on August 10, 2022. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at https://csds.ul.com.

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CONTENTS

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INTRODUCTION

1 Scope

1.1 This Standard is intended to be read together with the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1. The requirements in this Standard supplement or amend the requirements in UL 1004-1. The requirements of UL 1004-1 apply unless modified by this Standard.

1.2 Motors covered by this Standard, whose overheating protection is provided by an electronic circuit, shall additionally comply with the requirements contained in the Standard for Thermally Protected Motors, UL 1004-3, with regard to Construction, Performance, Manufacturing and Production Tests, Markings, and Instructions unless modified by this Standard.

1.3 This Standard applies to motors that rely upon an electronic circuit to prevent overheating of the motor.

1.4 The requirements in this Standard are intended to evaluate a specific motor/electronic protector combination. When the motor, the electronic protector, or the motor/electronic protector combination is changed, the combination shall be reevaluated.

1.5 The requirements in this Standard do not cover sealed (hermetic) type compressor motors.

1.6 This Standard does not apply to motors that comply with the Standard for Impedance Protected Motors, UL 1004-2, or the Standard for Thermally Protected Motors, UL 1004-3, independent of the electronic circuit.

2 Components

2.1 Controls used to provide overheating protection for motors covered by this Standard shall comply with the requirements for protective controls contained in the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1, or the applicable requirements in Sections 9 – 17.

3 Glossary

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

3.2 INTENTIONALLY WEAK PART – A part intended to rupture under conditions of abnormal operation to prevent the occurrence of a condition which could impair compliance with this standard.

3.3 LOW-POWER CIRCUIT – A circuit or parts of circuits farther from the supply source than a low-power point.

3.4 LOW-POWER POINT – A point closest to the supply source in an electronic circuit where the maximum available power to an external load at the end of 5 seconds does not exceed 15 watts.

3.5 PROTECTIVE ELECTRONIC CIRCUIT (PEC) – An electronic circuit that prevents a hazardous situation under abnormal operating conditions.

3.6 PROTECTION SCHEME – A combination of sensing and control circuits. Examples include the following:

a) A combination of rotation sensing (i.e., Hall effect sensor) and a control circuit designed to take corrective action (i.e., deenergize the motor in the event that the Hall effect sensor senses a lack of intended motor speed);

b) A combination of current sensing and a control circuit designed to take corrective action in the event that excessive motor current is detected.

Electronic protection circuits may incorporate one or many protection schemes to provide primary or redundant overheating protection for a motor.

4 Application of Requirements

4.1 The protection scheme or schemes relied upon to provide freedom from motor overheating due to the causes described in 6.5 (a) – (c) shall be identified and then validated through test and evaluation to either:

a) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1; or

b) The UL 60335-1 based requirements in Sections 9 – 17.

4.2 Protection scheme(s) provided but not relied upon to provide freedom from motor overheating shall be disabled during evaluation and testing of the scheme(s) described in 4.1.

4.3 The circuitry associated with those scheme(s) described in 4.2, that are not relied upon to provide freedom from motor overheating, shall only be evaluated as operating circuits not as protective circuits.

CONSTRUCTION

5 Spacings

5.1 Spacings at an electronic protector terminal intended to be used as a field-wiring terminal shall not be less than those specified in Table 18.1 or Table 18.2 of UL 1004-1, as appropriate.

5.2 The adequacy of spacings shall reflect the actual levels of voltage involved, which in the case of electronically protected motors may be significantly greater or less than the nominal power line voltage.

PERFORMANCE

6 Application of UL 60730-1 to Controls used to Provide Overtemperature Protection for Motors

6.1 With reference to 2.1, all performance testing required by the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1, on the control is to be performed with the control connected as intended to the motor.

6.2 Any test conducted on the control that does not result in an obvious inability of the motor to operate as intended, characterized by a cessation of rotation, shall not result in a temperature of the motor windings in excess of the values specified in Table 32.1 of UL 1004-1. Cessation of rotation is considered to be independent of an inability to start.

6.3 Any test conducted on the control that results in an obvious inability of the motor to operate as intended, characterized by a cessation of rotation, shall not result in a temperature of the motor windings in excess of the values specified in Table 8.1 of UL 1004-3. Cessation of rotation is considered to be independent of an inability to start.

Exception: Any test conducted on the control used within a motor intended for field installation shall not result in a temperature of the motor windings in excess of the values specified in Table 32.1 of UL 1004-1.

6.4 Any abnormal test conducted on the electronic protection circuit that terminates as a result of a component failure, that failure mode shall be evaluated in a manner consistent with the requirements of UL 60730-1 to ensure that the result is reliable and consistent.

6.5 Controls evaluated to provide required motor overtemperature protection shall provide the following required safety functions when evaluated to the requirements of UL 60730-1:

a) Locked rotor protection – The control shall not allow motor temperatures in excess of the applicable values specified in Table 8.1 of UL 1004-3 under any test condition required by UL 60730-1.

b) Loss of phase (power supply phase not motor phase):

1) Where loss of a power supply phase does not result in a cessation of rotation, the temperature of the motor windings shall not exceed the applicable values specified in Table 10.1 of UL 1004-3.

2) Where loss of a power supply phase results in a cessation of rotation, the temperature of the motor windings shall not exceed the applicable values specified in Table 8.1 of UL 1004-3.

c) Running heating (at manufacturer's option and declaration) – The control shall not allow motor temperature in excess of those specified in Table 10.1 of UL 1004-3 under any test condition required by UL 60730-1.

Exception: Controls used in motors to address (a), (b), and (c) and intended for field installation shall not allow motor temperatures in excess the values specified in Table 32.1 of UL 1004-1.

6.6 Compliance of controls to the requirements of UL 60730-1 shall be achieved through declarations by the control manufacturer. The information required is specified in Table 1DV of UL 60730-1. Table 6.1 specifies the declarations necessary for a motor control evaluated to the requirements of this Standard.

Table 6.1
Motor Control Correlation Table

UL 60730-1 Table 1DV item number	Information	Motor control requirement
6	Purpose of control	Protective control (temperature)
7	Type of load controlled	AC motor load
29	Type of disconnection or interruption	Any defined
39	Type 1 or Type 2 action	Type 2
40	Additional features	Must be declared as automatic or manual reset
49	Pollution degree	Pollution degree to be determined by reference to UL 1004-1, 18.8.
52	The minimum parameters of any heat dissipater (heat sink) not provided with an electronic control but essential to its correct operation	Must be specified
58a	Required protection/immunity from mains borne perturbations, magnetic and electromagnetic disturbances	Required[a]
60	Surge immunity	IEC 61000-4-5 installation Class 3. Overvoltage category to be determined by reference to UL 1004-1, 18.8.
69	Software Class	Software Class A. Software specifically used to meet 6.5 (a), (b), or (c) shall meet Software Class B requirements.
74	External load and emission control measures to be used for test purposes	Intended motor

[a] For the purpose of the tests specified in Annex H, Section 26 of UL 60730-1, the products covered by this Standard should be considered as:

a) Installation Class 3 (See Annex R, UL 60730-1);

b) Overvoltage Category III for controls intended to be permanently wired;

c) Overvoltage Category II for controls intended to be cord connected; or

d) Test Level 3.

7 Test Method on Controls used to Provide Overtemperature Protection for Motors

7.1 With reference to 1.2, motors with associated protection circuits shall be evaluated to the requirements of UL 1004-2 or UL 1004-3 in accordance with the operating functionality that is emulated by the control, i.e., that a circuit that operates in a manner similar to an automatically reset protector shall be tested and evaluated to the requirements contained in UL 1004-3 for automatically reset protection as an over-temperature protection means.

7.2 For those electronically protected motors that, at the manufacturer's option, are evaluated and tested for running heating protection in addition to locked rotor protection, if the maximum temperature recorded during the Running Heating Temperature Test is higher than that recorded during the Locked Rotor Temperature Test, then the Running Heating Endurance Test of Section 8, shall be conducted in lieu of the Locked Rotor Endurance Test.

7.3 If the maximum temperatures recorded during both the Running Heating Temperature Test (if conducted) and the Locked Rotor Temperature Test do not exceed the maximum normal temperature for the relevant insulation Class then neither endurance test need be conducted.

8 Running Heating Endurance Test

8.1 Immediately following the Running Heating Temperature Test, the motor is to be re-energized in the overload condition causing the maximum stabilized winding temperature for a test period of 15 days.

8.2 If the Running Heating Endurance Test is interrupted prior to its completion, the manufacturer is to be given the option of restarting the test from the beginning with a new sample or continuing the test, with the original motor, at the point where it was interrupted, and resuming the 15-day timing when the motor has reached the stabilized target temperature, until the test has been completed. If the test is restarted and the motor complies with the acceptance criteria specified in 8.4, then the results are considered acceptable. If the motor fails to meet one or more of the criteria, then, at the manufacturer's discretion, the test may be repeated with a new sample.

8.3 A circulating air oven may be used to facilitate the Running Heating Endurance Test but not to provide the sole means of motor heating. The motor must be energized and loaded for the entire 15 days.

8.4 At the conclusion of the test, the motor shall comply with the following:

a) There shall be no flaming as evidenced by the cheesecloth.

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.

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

e) A secondary protector shall not have operated.

f) A branch circuit overcurrent protective device shall not have operated.

8.5 Immediately following the conclusion of the Running Heating Endurance Test, and while still in a heated state, a motor shall withstand application of a potential of twice the marked rated voltage of the motor between the windings and the frame.

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

UL 60335-1 BASED REQUIREMENTS FOR MOTORS USED IN APPLIANCES

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9 General

9.1 The requirements in Sections 9 – 17 are intended to apply to electronically protected motors intended to be installed in appliances as defined in the Standard for Safety of Household and Similar Electrical Appliances, Part 1: General Requirements, UL 60335-1.

9.2 The pollution degree and overvoltage category shall be as detailed in Table 6.1.

10 Components

10.1 Capacitors

10.1.1 A capacitor connected between two line conductors in a primary circuit, or between one line conductor and the neutral conductor or between primary and accessible secondary circuits or between the primary circuit and protective earth (equipment grounding conductor connection) shall comply with one of the subclasses of the Standard for Fixed Capacitors for Use in Electronic Equipment – Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains, UL 60384-14, and shall be used in accordance with its rating. (Details for the damp heat, steady state test can be found in IEC 60384-14.)

10.2 Isolation devices

10.2.1 An optical isolator that is relied upon to provide isolation between primary and secondary circuits or between other circuits as required by this Standard shall be constructed in accordance with the Standard for Optical Isolators, UL 1577, and shall be able to withstand for 1 minute, without breakdown, an ac dielectric voltage withstand potential equal to the applicable test voltage in Table 4, Voltage for Electric Strength Test, of IEC 60335-1 for reinforced insulation.

10.2.2 A power switching semiconductor device that is relied upon to provide isolation to ground shall be constructed in accordance with the Standard for Electrically Isolated Semiconductor Devices, UL 1557. The dielectric voltage withstand tests required by UL 1557 shall be conducted at a dielectric potential voltage withstand equal to the applicable test voltage in Table 4, Voltage for Electric Strength Test, of IEC 60335-1 for reinforced insulation.

10.3 Switch mode power supplies

10.3.1 Components connected between the primary and secondary circuits of an isolating device such as a switching transformer or between primary and secondary earth reference points shall be evaluated to provide the specified level of isolation for the application under normal and abnormal (single component fault) conditions.

10.3.2 A capacitor connected between primary and accessible secondary circuits shall comply with the requirements for capacitors in 10.1. This shall consist of a single Class Y1 capacitor or two Class Y2 capacitors connected in series.

10.3.3 Insulation used within a transformer of switch mode power supply shall comply one of the following:

a) The Standard for Systems of Insulating Materials – General, UL 1446, for the specified temperature class of the insulation system or the Standard for Single- and Multi-Layer Insulated Winding Wire, UL 2353; or

b) The requirements in Table 22.1, Performance Levels, of the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1, and the applicable RTI measured during normal operation on major insulating components (e.g. bobbin).

Exception: This requirement may be waived if the control is tested with the component(s) shorted and the test results comply with 11.4.

10.4 Temperature sensing, thermistor devices

10.4.1 A temperature sensing device, such as a positive temperature coefficient (PTC) thermistor and a negative temperature coefficient (NTC) thermistor, that is used in combination with an electronic control and that together with the control manages a safety critical function shall comply with the Standard for Thermistor-Type Devices, UL 1434.

10.5 Transformers

10.5.1 General-purpose transformers shall comply with the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1, and the Low Voltage Transformers – Part 2: General Purpose Transformers, UL 5085-2.

Exception: A transformer that complies with the Standard for Transformers and Motor Transformers for Use in Audio-, Radio-, and Television-Type Appliances, UL 1411, and that is used in a circuit involving an audio or video component, complies with the intent of this requirement.

11 Evaluation of the Motor Protection Scheme

11.1 The electronic motor protection scheme shall be evaluated to provide freedom from overheating from the events specified in 6.5.

11.2 Testing shall be in accordance with the Standard for Thermally Protected Motors, UL 1004-3.

11.3 All circuits, whether providing the motor protection scheme being relied upon, shall be evaluated to determine the effects of electronic circuit faults.

11.4 When the applicable component/hardware faults specified in 14.6 are imposed one at a time, they shall not result in:

a) The motor presenting a risk of fire, electric shock, or mechanical hazard; or

b) The loss of the motor protection scheme function.

11.5 The risk of electrically generated fire from the faults of Section 14, Abnormal Operation and Fault Tests, is considered to be mitigated in low-power circuits.

11.6 Electronic motor protection circuits shall incorporate measures to control the fault/error conditions that would impair the safety functions.

11.7 The evaluation of the programmable component shall be in accordance with Annex R, Software Evaluation, of the Standard for Safety of Household and Similar Electrical Appliances, Part 1: General Requirements, UL 60335-1.

11.8 Electronic motor protection circuits that rely upon a programmable component for one or more of its safety functions shall be subjected to the test of the Programmable Component Reduced Supply Voltage Test, Section 16, unless restarting at any point in the operating cycle after interruption of operation due to a supply voltage dip does not result in a hazard. The test is to be carried out after removal of all batteries and other components intended to maintain the programmable component supply voltage during mains supply voltage dips, interruptions, and variations.

11.9 Electronic motor protection circuits shall maintain their required functions when subjected to the EMC related stresses specified in the Electromagnetic Compatibility (EMC) Requirements – Immunity, Section 17.

11.10 The tests of Section 17, Electromagnetic Compatibility (EMC) Requirements – Immunity, are to be carried out with surge protective devices disconnected, unless they incorporate spark gaps.

12 General Conditions for the Tests

12.1 Details

12.1.1 An electronic control shall be tested in the motor under the performance test conditions of the Standard for Thermally Protected Motors, UL 1004-3.

Exception: Except as noted elsewhere, upon the agreement of the manufacturer and with due consideration of the relevant compliance criteria, an electronic control may be tested outside of the appliance.

12.1.2 Cumulative stress resulting from successive tests on electronic circuits is to be avoided. It may be necessary to replace components or to use additional samples.

12.2 Intentionally weak parts

12.2.1 If a conductor of a printed circuit board or other component becomes open-circuited, the appliance is considered to have withstood the particular test, provided the following conditions are met:

a) The base material of the printed circuit board withstands the test in Annex E, Needle-Flame Test, of the Standard for Safety of Household and Similar Electrical Appliances, Part 1: General Requirements, UL 60335-1;

b) Any loosened conductor does not reduce electrical spacings (clearances or creepage distances) between live parts and accessible metal parts below the values specified in this Standard; and

c) The same result is obtained when the test is run three times.

Exception: The base material of the printed-wiring board need not comply with the Needle-Flame Test of (a) if the base material has a flammability rating of V-0 and a CTI of minimum 100.

12.2.2 Fuses other than as noted in 12.3.2 are considered to be intentionally weak parts.

12.3 Test results determined by overcurrent protection operation

12.3.1 If compliance with these requirements under any of the fault conditions depends on the operation of an overcurrent device incorporated within the electronic control, the fuse and/or circuit breaker shall comply with the requirements for that component.

12.3.2 If compliance with the requirements of this Standard depends upon the operation of a miniature fuse-link complying with IEC 60127-1, Miniature Fuses – Part 1: Definitions for miniature fuses and general requirements for miniature fuse-links, during any of the fault conditions specified in Section 14, Abnormal Operation and Fault Tests, the test is to be repeated but with the miniature fuse-link replaced by an ammeter. If the current measured:

a) Does not exceed 2.1 times the rated current of the fuse-link, the circuit is not considered to be adequately protected and the test is to be carried out with the fuse-link short-circuited;

b) Is at least 2.75 times the rated current of the fuse-link, the circuit is considered to be adequately protected;

c) Is between 2.1 times and 2.75 times the rated current of the fuse-link, the fuse link is to be short-circuited and the test is to be carried out:

1) For the relevant period or for 30 minutes, whichever is the shorter, for quick acting fuselinks;

2) For the relevant period or for 2 minutes, whichever is the shorter, for time lag fuse-links.

12.3.3 In case of doubt, the maximum resistance of the fuse-link is to be taken into account when determining the current.

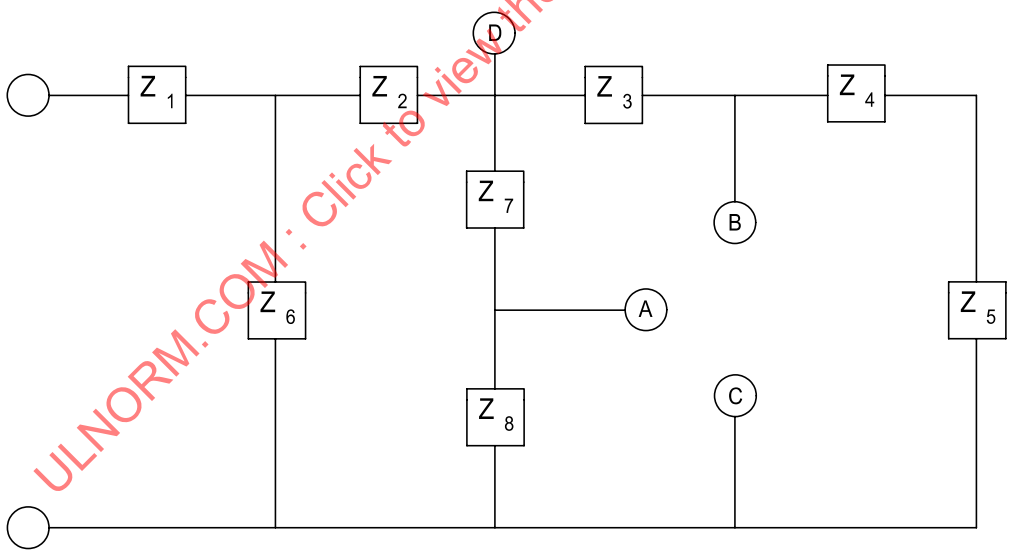
12.3.4 The verification whether the fuse-link acts as a protective device is to be based on the fusing characteristics specified in IEC 60127-1, which also specifies the information necessary to calculate the maximum resistance of the fuse-link.

13 Low-Power Circuits

13.1 The motor is to be supplied at rated voltage and a variable resistor, adjusted to its maximum resistance, is to be connected between the point to be investigated and the opposite pole of the supply source. The resistance is to be decreased until the power consumed by the resistor reaches a maximum. Points closest to the supply source at which the maximum power delivered to this resistor does not exceed 15 W at the end of 5 seconds are called low-power points. The part of the circuit farther from the supply source than a low-power point is considered to be a low-power circuit. See Figure 13.1.

Figure 13.1

Example of an electronic circuit with low-power points



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D is a point farthest from the supply source where the maximum power delivered to the external load exceeds 15 W.

A and B are points closest to the supply source where the maximum power delivered to the external load does not exceed 15 W. These are low-power points.

13.2 The measurements are to be made from only one pole of the supply source, preferably the one that gives the fewest low-power points.