UL 1004-1

STANDARD FOR SAFETY

Rotating Electrical Machines – General Requirements

UL Standard for Safety for Rotating Electrical Machines – General Requirements, UL 1004-1

Second Edition, Dated September 19, 2012

Summary of Topics

This revision of ANSI/UL 1004-1 dated November 5, 2020 includes the following changes in requirements:

Replaced Reference to UL 508C with UL 61800-5-1; 7.1

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 revised requirements are substantially in accordance with Proposal(s) on this subject dated May 29, 2020 and August 28, 2020.

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Standard for Rotating Electrical Machines – General Requirements

First Edition – September, 2008

Second Edition

September 19, 2012

This ANSI/UL Standard for Safety consists of the Second Edition including revisions through November 5, 2020.

The most recent designation of ANSI/UL 1004-1 as an American National Standard (ANSI) occurred on October 22, 2020. 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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INTRODUCTION

1 Scope

1.1 This Standard applies to form wound rotating electrical machines rated less than 460 volts and all other rotating electrical machines and linear motors, both AC and DC, rated 1,000 volts or less.

1.2 This Standard is used to evaluate both motors intended to be field installed as well as those intended to be factory installed. Motors intended to be factory installed need not comply with the requirements in Section 12, Ventilation Openings; Section 13, Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts; 16.9 – 16.16, 16.28, 18.1 – 18.5, 33.1 – 33.3, 33.5 – 33.7, and 34.1.

1.3 For the purposes of this Standard, the term “machine” is representative of and equivalent to the terms rotating electrical machine and rotating machine, and is understood to mean all manner of electric motors and generators covered by the scope of this Standard. The term “machine” is understood to apply to both AC and DC machines.

1.4 These requirements do not cover machines intended for use in hazardous locations as defined in the *National Electrical Code*®, NFPA 70.

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1.5 These requirements do not cover sealed (hermetic type) motor-compressor parts, which are evaluated under the Standard for Household and Similar Electrical Appliances – Safety – Part 2-34: Particular Requirements for Motor-Compressors, UL 60335-2-34.

1.6 If the risk of fire does not exist at a machine, part, or circuit, then the requirements of this Standard and associated parts of this Standard, intended to address the risk of fire shall not apply to that machine, part, or circuit.

1.7 If the risk of electric shock does not exist at a machine, part, or circuit, then the requirements of this Standard and associated parts of this Standard, intended to address the risk of electric shock shall not apply to that machine, part, or circuit.

1.8 The requirements of this Standard and associated parts of this Standard, intended to address the risk of fire do not apply to a motor provided with a metal enclosure in which there are no openings in the enclosure through which molten metal, burning insulation, flaming particles, or other ignited material could fall onto flammable material, or through which a flame could be projected.

2 Components

2.1 Except as indicated in 2.2, a component of a product covered by this Standard shall comply with the requirements for that component. In particular:

a) Positive Temperature Coefficient devices (PTCs) used in self-holding thermal motor protectors shall comply with the Standard for Thermistor-Type Devices, UL 1434.

b) Solid-state controllers shall comply with the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1.

c) Thermal protectors shall comply with the Standard for Automatic Electrical Controls for Household and Similar Use; Part 2 Particular Requirements for Thermal Motor Protectors, UL 60730-2-2.

2.2 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.

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

2.4 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.

3 Units of Measurement

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

4 Undated References

4.1 Any undated reference to a code or standard appearing in the requirements of this standard shall be interpreted as referring to the latest edition of that code or standard.

5 Glossary

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

5.2 AIR-OVER MOTOR – A motor that relies upon a stream of air to cool the motor and is marked in accordance with 44.8.

5.3 ARAMID PAPER – An aromatic polyamide (such as Nomex).

5.4 ARMATURE – The part of a machine that has windings and rotates.

5.5 AUXILIARY SWITCH – A switch that is actuated by motor rotation and intended to control an external load.

5.6 BONDED (BONDING) – The permanent joining of metallic parts to form an electrically conductive path that provides electrical continuity and the capacity to conduct any current likely to be imposed without a risk of electric shock, fire, or injury to persons.

5.7 BONDING CONDUCTOR – A conductor, including a strap or similar part, that is used to provide the required electrical conductivity between metal parts required to be electrically connected.

5.8 BRUSH – A conducting part that provides electrical connection to the armature of a machine through a commutator.

5.9 BRUSH HOLDER – A structure that supports the brush and provides a means to maintain contact with the commutator of the armature.

5.10 CAMBRIC – A varnish-impregnated white linen fabric using an electrical grade resin.

5.11 COMMUTATOR – An assembly of conducting members insulated from one another, against which the brushes bear, that provides electrical connection to the circuits of the armature.

5.12 CONTINUOUS DUTY MOTOR – A motor intended to operate indefinitely at rated load.

5.13 DIRECTLY ACCESSIBLE MACHINE – A machine that can be physically contacted without opening or removing any part, or is located so that it is accessible to contact.

5.14 ELECTRICAL GRADE PAPER – Paper produced from wood pulp formed by wood chips boiled in an alkaline solution containing sodium sulfate.

5.15 ENCLOSED MACHINE – A machine that is totally enclosed in order to prevent the free exchange of air between the inside and outside of the enclosure for the windings. It may not be sufficiently enclosed to be airtight.

5.16 ENCLOSURE – That portion of a unit that:

a) Reduces the accessibility of a part that involves a risk of fire, electric shock, or injury to persons; or

b) Reduces the risk of propagation of flame, sparks, and molten metal initiated by an electrical disturbance occurring within.

5.17 END SHIELD – A part of the machine used to protect the windings and to support the bearing, but does not include either part. It is secured to the frame. Also called an end bell, end cap, or bracket.

5.18 FACTORY INSTALLATION – The act of wiring and mounting a rotating electric machine in a manufacturing environment under controlled conditions by trained personnel.

5.19 FIELD INSTALLATION – The act of wiring and mounting a rotating electric machine outside of a manufacturing environment where the installation is subject to the requirements of the *National Electrical Code*®, NFPA 70.

5.20 FIELD TERMINAL COMPARTMENT – Where the outgoing power is connected to the machine at the field installation site and the connection is a wire-to-terminal connection.

5.21 FIELD WIRING COMPARTMENT – Where the outgoing power is connected to the machine at the field installation site and the connection is a wire-to-wire connection.

5.22 FIXED – Equipment that is intended to be permanently connected electrically to the wiring system.

5.23 GROUND – A conducting connection, whether intentional or accidental, between an electrical circuit or equipment and the earth or to some conducting body that serves in place of the earth.

5.24 GROUNDING CONDUCTOR – An equipment or circuit conductor that is intentionally connected between that electrical circuit or equipment and the earth or to some conducting body that serves in place of the earth.

5.25 HORSEPOWER – A measure of mechanical output. In the context of this Standard, one horsepower is defined as, and shall be used interchangeably with, 0.746 kilowatts of output power.

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

5.27 INDIRECTLY ACCESSIBLE MACHINE – A machine that is accessible only by opening or removing a part of the outer enclosure, such as a guard or panel, that can be opened or removed without the aid of a tool, or is located at such a height or is otherwise guarded or enclosed so that it is unlikely to be contacted.

5.28 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 windings are considered part of the system.

5.29 INTERMITTENT DUTY MOTOR – A motor intended to be connected to a load and that is intended to operate for no longer than a specified time period or for a specified duty-cycle.

5.30 LINEAR MOTOR – An electric motor that produces linear (as opposed to rotary) motion when supplied by a suitable source of electric power.

5.31 MAJOR COMPONENTS – The components of an insulation system that are relied upon to prevent a risk of electric shock or fire. Examples of this type of insulation include ground, interwinding, turn, and encapsulant. See the Major and Minor Component Table in the Standard for Systems of Insulating Materials – General, UL 1446.

5.32 MICA – Small pieces of aluminum silicate materials held in place by electrical grade resin.

5.33 MINOR COMPONENTS – The components of an insulation system that are used typically in mechanical or thermal conduction capacities, and are not relied upon to prevent risk of fire or electric shock. Examples of minor components are balancing compound, crossover insulation, and lead wire. See the Major and Minor Component Table in the Standard for Systems of Insulating Materials – General, UL 1446.

5.34 MULTI-SPEED MOTOR – A motor with separate windings, reconfigured windings, or tapped windings provided for each speed.

5.35 NON-METALLIC FUNCTIONAL PART – A non-metallic, typically, but not necessarily, polymeric, part that is required for the safe operation of the machine (that is, not a trim part). The removal or absence of the part would either render the machine inoperative or unable to satisfy the remaining requirements of this Standard with regard to safe operation. The failure of the part (typically through deformation) would result in a risk of fire, shock, or injury. Polymeric impellers as part of a motor intended to move air for the purposes of cooling are not considered non-metallic functional parts if they do not contact bare live parts.

5.36 OIL IMMERSED MACHINE – A machine having its windings immersed in oil and relying on the oil as a cooling medium.

5.37 OPERATING CONTROL – A device or circuit the operation of which starts or regulates the rotating machine during normal operation.

5.38 PORTABLE – Equipment that is easily carried or conveyed by hand, and is provided with a power-supply cord for connection to the supply circuit.

5.39 PROTECTIVE CONTROL – A device or circuit the operation of which is intended to prevent a hazardous situation during abnormal operation of the machine or equipment. In the context of this Standard, a protective control is one that is relied upon to provide overtemperature protection for a rotating machine.

5.40 RISK OF ELECTRIC SHOCK – A risk of electric shock is considered to exist at any part if:

a) The potential between the part and earth ground or any other simultaneously accessible part is more than 42.4 V peak for alternating current potentials or 60 volts for direct current potentials; and

b) The continuous current flow through a 1500-ohm resistor connected across the potential exceeds 0.5 mA.

5.41 RISK OF FIRE – A risk of fire is considered to exist if the open-circuit voltage between any two points is equal to or greater than 2500 volts peak, or if power of more than 15 watts can be delivered into an external resistor connected between the two points.

5.42 ROTOR – A rotating part of a rotating electric machine that does not have windings.

5.43 SERVICE FACTOR – A multiplier that, when applied to the rated output of a machine, indicates a permissible loading that can be carried continuously at the rated voltage and frequency.

5.44 SIMULTANEOUSLY ACCESSIBLE – Parts are considered to be simultaneously accessible when they are no further than 2 m apart.

5.45 SIZE – The outside diameter of the machine measured in the plane of the laminations, of the circle circumscribing the stator frame (or rotor frame, in the case of an outer rotor motor), excluding lugs, fins, boxes, or the like, used solely for machine mounting, cooling, assembly, or connection.

5.46 SHEET METAL SCREW – A screw with a thread pitch that exceeds the thickness of the sheet metal and is designed to engage an unextruded, unthreaded hole in the metal.

5.47 SINGLE-OPERATION DEVICE – A device that incorporates a bimetal assembly 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.

5.48 SMALL PARTS – Materials that do not exceed 2 cm^3 (0.12 in^3) in volume and 3 cm (1.18 in) in maximum dimension, and are located such that they cannot propagate flame from one area to another or act as a bridge between a possible source of ignition and other ignitable parts.

5.49 START SWITCH – A switch used for the connection and disconnection of the start winding of a motor.

5.50 STATIONARY – Equipment that is intended to be fastened in place or located in a dedicated space, and is provided with a power-supply cord for connection to the supply circuit.

5.51 STATOR – The stationary part of a machine that includes the stationary windings about or within which a rotor or armature turns or rotates.

5.52 TERMINAL COMPARTMENT – An enclosure where the outgoing power is connected to the machine and the connection is a wire-to-terminal connection.

5.53 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.

5.53.1 THERMAL STABILIZATION – Thermal stabilization is considered to have been attained when the temperature does not vary by more than 2°C (3.6°F) in 30 minutes.

5.54 TRACTION MOTOR – An electric motor used for propulsion that exerts a tractive force through a vehicle's wheels.

5.55 TREATED CLOTH – A varnish-impregnated material using an electrical grade resin.

5.56 VOLTAGE REGULATOR – An electrical or mechanical device that, within performance limits, maintains a constant voltage output when supplied by a varying voltage input.

5.57 VULCANIZED FIBER – A term used in this outline to denote a material normally used as electrical insulation. Vulcanized fiber is made by combining layers of chemically gelled paper. The zinc chloride used in gelling the paper is subsequently removed by a water leaching treatment, and the resultant product, after being dried and finished by calendaring, is a dense material of partially, regenerated cellulose where the fibrous structure is retained in varying degrees, depending upon the grade of fiber. Cellulose fiberboard, pressboard, fullerboard, or cardboard are not acceptable as the equivalent of fiber. Fishpaper is a designation commonly used in the trade to refer to thin sheets of electrical grade vulcanized fiber.

5.58 WIRING COMPARTMENT – Where the incoming/outgoing power is connected to the machine and the connection is a wire-to-wire connection.

CONSTRUCTION

6 Current and Horsepower Relation

6.1 In the application of requirements based on horsepower to a motor not rated in horsepower, use shall be made of the appropriate tables of the *National Electrical Code*®, NFPA 70, (Table 6.1 – Table 6.4 of this standard) that gives the relationships between horsepower and full-load currents for motors. For a universal motor, the table applying to a single-phase, alternating-current motors, Table 6.2, shall be used when the motor is marked for use on alternating current only; otherwise, the table applying to direct-current motors, Table 6.1, shall be used.

Table 6.1
Full-load current in amperes, direct current motors

HP	Armature voltage rating[a]					
	90 V	120 V	180 V	240 V	500 V	550 V
1/4	4.0	3.1	2.0	1.6		
1/3	5.2	4.1	2.6	2.0		
1/2	6.8	5.4	3.4	2.7		
3/4	9.6	7.6	4.8	3.8		
1	12.2	9.5	6.1	4.7		
1-1/2		13.2	8.3	6.6		
2		17	10.8	8.5		
3		25	16	12.2		
5		40	27	20		
7-1/2		58		29	13.6	12.2
10		76		38	18	16
15				55	27	24
20				72	34	31
25				89	43	38
30				106	51	46
40				140	67	61
50				173	83	75

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Table 6.1 Continued

HP	Armature voltage rating[a]					
	90 V	120 V	180 V	240 V	500 V	550 V
60				206	99	90
75				255	123	111
100				341	164	148
125				425	205	185
150				506	246	222
200				675	330	294

[a] These are average direct-current quantities.

NOTE – Linear interpolation may be used to calculate motor currents for motors whose rated voltage does not appear in this Table.

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Table 6.2
Full-load currents in amperes single-phase alternating-current motors

HP	115 V	200 V	208 V	230 V
1/6	4.4	2.5	2.4	2.2
1/4	5.8	3.3	3.2	2.9
1/3	7.2	4.1	4.0	3.6
1/2	9.8	5.6	5.4	4.9
3/4	13.8	7.9	7.6	6.9
1	16	9.2	8.8	8
1-1/2	20	11.5	11	10
2	24	13.8	13.2	12
3	34	19.6	18.7	17
5	56	32.2	30.8	28
7-1/2	80	46	44	40
10	100	57.5	55	50

NOTES:

(1) – The values in this table are full-load currents for motors running at usual speeds and motors with normal torque characteristics. Motors built for especially low speeds or high torques may have higher full-load currents, and multispeed motors will have full-load current varying with speed, in which case the nameplate current ratings shall be used. The voltages listed are rated motor voltages. The currents listed shall be permitted for system voltage ranges of 110 – 120, and 220 – 240 volts.

(2) – Linear interpolation may be used to calculate motor currents for motors whose rated voltage does not appear in this Table.

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Table 6.3
Full-load current two-phase alternating-current motors (4-wire)

HP	Induction type squirrel-cage and wound-rotor amperes				
	115 V	230 V	460 V	575 V	2300 V
1/2	4	2	1	0.8	
3/4	4.8	2.4	1.2	1.0	
1	6.4	3.2	1.6	1.3	
1-1/2	9	4.5	2.3	1.8	
2	11.8	5.9	3	2.4	
3		8.3	4.2	3.3	
5		13.2	6.6	5.3	
7-1/2		19	9	8	
10		24	12	10	
15		36	18	14	
20		47	23	19	
25		59	29	24	
30		69	35	28	
40		90	45	36	
50		113	56	45	
60		133	67	53	14
75		166	83	66	18
100		218	109	87	23
125		270	135	108	28
150		312	156	125	32
200		416	208	167	43

NOTES:

(1) – The values in the table for full-load current are for motors running at speeds usual for belted motors and motors with normal torque characteristics. Motors built for especially low speeds or high torques may require more running current, and multispeed motors will have full-load current varying with speed, in which case the nameplate current rating shall be used. Current in the common conductor of a 2-phase, 3-wire system will be 1.41 times the values given. The voltages listed are rated motor voltages. The currents listed shall be permitted for system voltage ranges of 110 – 120, 220 – 240, 440 – 480, and 550 – 600 volts.

(2) – Linear interpolation may be used to calculate motor currents for motors whose rated voltage does not appear in this Table.

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Table 6.4
Full-load current three-phase alternating-current motors

HP	Induction type squirrel-cage and wound-rotor amperes							Synchronous type unity power factor[a] amperes			
	115 V	200 V	208 V	230 V	460 V	575 V	2300 V	230 V	460 V	575 V	2300 V
1/2	4.4	2.5	2.4	2.2	1.1	0.9					
3/4	6.4	3.7	3.5	3.2	1.6	1.3					
1	8.4	4.8	4.6	4.2	2.1	1.7					
1-1/2	12.0	6.9	6.6	6.0	3.0	2.4					

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