UL 1004

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Electric Motors

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UL Standard for Safety for Electric Motors, UL 1004

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Revisions: This Standard contains revisions through and including March 10, 2006.

Summary of Topics

These editorial revisions to UL 1004 replace all references to UL 1020, the Standard for Thermal Cutoffs for Use in Electrical Appliances and Components, with reference to UL 60691, the Standard for Thermal-Links – Requirements and Application Guide. UL 1020 was withdrawn and superseded by UL 60691.

Announcement Bulletin(s): This Standard contains the announcement bulletin(s) dated November 21, 1997 . The announcement bulletin is located at the end of the Standard (after the adoption bulletin(s)).

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Text that has been changed in any manner is marked with a vertical line in the margin. Changes in requirements are marked with a vertical line in the margin and are followed by an effective date note indicating the date of publication or the date on which the changed requirement becomes effective.

The revisions dated March 10, 2006 include a reprinted title page (page1) for this Standard.

The revisions dated March 10, 2006 editorially replace all references to UL 1020 with the reference to UL 60691.

The revisions dated November 24, 1999 were issued to reflect changes in requirements to motor insulation systems and correct editorial discrepancies.

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

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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 Listing, 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:

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UL 1004

Standard for Electric Motors

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Second Edition – February, 1977
Third Edition – May, 1984
Fourth Edition – May, 1989

Fifth Edition

June 3, 1994

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

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

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INTRODUCTION

1 Scope

1.1 These requirements cover motors intended for use in appliances and equipment that comply with the requirements for such appliances and equipment.

1.2 These requirements cover commutator motors of the series, shunt, compound, and permanent-magnet-field types rated 5 horsepower (3.7 kW) or less, 250 volts or less, alternating current or direct current.

1.3 These requirements cover electric motors other than those specified in 1.2 rated 7200 volts or less, including commutator motors of the repulsion type only.

1.3 revised February 7, 2001

1.4 The requirements cover both open and totally-enclosed motors.

1.5 These requirements cover motor parts and combinations of such parts.

1.6 These requirements do not cover:

a) Thermal protectors and impedance requirements for impedance-protected motors, which are judged under the Standard for Overheating Protection for Motors, UL 2111;

b) Other motor protection that is dependent upon requirements for the end-use equipment in which the motor is to be installed; or

c) Sealed (hermetic type) motor-compressor parts, which are judged under the Standard for Hermetic Refrigerant Motor-Compressors, UL 984.

1.6 revised December 26, 1997

1.7 These requirements do not cover motors for use in hazardous locations as defined in the National Electrical Code, NFPA 70.

1.8 These requirements do not include performance requirements that depend upon application in the end-use equipment. Such features as current rating, temperature rise during normal and abnormal operation, motor protection, internal wiring and insulation, and similar features are evaluated in the end-use application.

1.8 revised December 26, 1997

1.9 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.

1.9 revised February 7, 2001

2 References

2.1 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.

2.1 revised February 7, 2001

2A Glossary

2A.1 For the purpose of this standard, the following definitions apply.

2A.1 added November 24, 1999

2A.1.1 ARAMID PAPER – An aromatic polyamide (such as nylon).

2A.1.1 added February 7, 2001

2A.1.2 ARMATURE – The part of an electric motor that has windings and rotates.

2A.1.2 added February 7, 2001

2A.1.3 BRUSH – A conducting part that provides electrical connection to the armature of a motor through the commutator.

2A.1.3 added February 7, 2001

2A.1.4 BRUSH HOLDER – A structure that supports the brush and provides a means to maintain contact with the commutator of the armature.

2A.1.4 added February 7, 2001

2A.1.5 CAMBRIC – A varnish-impregnated white linen fabric using an electrical grade resin.

2A.1.5 added February 7, 2001

2A.1.6 COMMUTATOR – An assembly of conducting members insultated from one another, against which the brushes bear, that provides electrical connection to the circuits of the armature.

2A.1.6 added February 7, 2001

2A.1.7 ELECTRICAL GRADE PAPER – Paper produced from wood pulp formed by wood chips boiled in an alkaline solution containing sodium sulfate.

2A.1.7 added February 7, 2001

2A.1.8 ENCLOSED MOTOR – A motor 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.

2A.1.8 added February 7, 2001

2A.1.9 END SHIELD – A part of the motor 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 or bracket.

2A.1.9 added February 7, 2001

2A.1.10 FIELD TERMINAL COMPARTMENT – Where the incoming power is connected to the motor at the field installation site and the connection is a wire-to-terminal connection.

2A.1.10 added February 7, 2001

2A.1.11 FIELD WIRING COMPARTMENT – Where the incoming power is connected to the motor at the field installation site and the connection is a wire-to-wire connection.

2A.1.11 added February 7, 2001

2A.1.12 FIXED APPLIANCE – Any equipment or appliance that is intended to be permanently connected electrically to the wiring system.

2A.1.12 added February 7, 2001

2A.1.13 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.

2A.1.13 added February 7, 2001

2A.2 MAJOR COMPONENTS – The components of an insulation system that are relied upon to prevent a risk of electric shock or fire. Examples of this type of insulation include ground, interwinding, turn, encapsulant, and varnish. See Table 4.2 in UL 1446, Standard for Systems of Insulating Materials – General.

2A.2 added November 24, 1999

2A.3 MICA– Small pieces of inorganic mineral containing muscovite or philogopite held in place by electrical grade resin.

2A.3 added February 7, 2001

2A.4 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 Table 4.2 in UL 1446, Standard for Systems of Insulating Materials – General.

2A.4 added November 24, 1999

2A.5 OPEN MOTOR– A motor having ventilation openings that permits the passage of air between, over, and around the windings.

2A.5 added February 7, 2001

2A.6 PORTABLE APPLIANCE– An appliance that is easily carried or conveyed by hand, and is provided with a power-supply cord for connection to the supply circuit.

2A.6 added February 7, 2001

2A.7 ROTOR– A rotating part of a motor that does not have windings.

2A.7 added February 7, 2001

2A.8 SERVO MOTOR– A motor that employs feedback and has a characteristic of producing mechanical power to perform the desired motion of the servo mechanism.

2A.8 added February 7, 2001

2A.9 SIZE– The diameter of the motor measured in the plane of the laminations, of the circle circumscribing the stator frame, excluding lugs, fins, boxes, or the like, used solely for motor mounting, cooling, assembly, or connection.

2A.9 added February 7, 2001

2A.10 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.

2A.10 added February 7, 2001

2A.11 STATIONARY APPLIANCE– Any equipment or appliance 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.

2A.11 added February 7, 2001

2A.12 STATOR– The stationary part of a motor about which a rotor or armature turns.

2A.12 added February 7, 2001

2A.13 STEPPER MOTOR– A motor employing a device that accepts the translated electrical current and converts it to actual incremental motion.

2A.13 added February 7, 2001

2A.14 TERMINAL COMPARTMENT– Where the incoming power is connected to the motor in a factory and the connection is a wire-to-terminal connection.

2A.14 added February 7, 2001

2A.15 TREATED CLOTH– A varnish-impregnated material using an electrical grade resin.

2A.15 added February 7, 2001

2A.16 UNIVERSAL MOTOR– A series-wound or compensated series-wound motor designed to operate at the same speed and output on either direct-current or single-phase alternating-current with a specified frequency and at the same root-mean-square voltage.

2A.16 added February 7, 2001

2A.17 VULCANIZED FIBER– A term used in this standard 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 calendering, 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.

2A.17 added February 7, 2001

2A.18 WIRING COMPARTMENT– Where the incoming power is connected to the motor in a factory and the connection is a wire-to-wire connection.

2A.18 added February 7, 2001

3 Components

3.1 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.

3.2 If the manufacturer assigns a rating or an intended use to a component of a motor – for example, an integral auxiliary switch intended to control an external circuit – the component is to be evaluated for that rating or use or both.

4 Units of Measurement

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

4.1 revised February 7, 2001

5 Current/Horsepower Relation

5.1 For the purpose of this standard and unless otherwise indicated, the size of a motor refers to the diameter of the motor, that is, the diameter measured in the plane of the laminations, of the circle circumscribing the stator frame, excluding lugs, fins, boxes, or the like, used solely for motor mounting, cooling, assembly, or connection.

5.2 Deleted February 7, 2001

5.3 Deleted February 7, 2001

5.4 In the application of requirements based on horsepower to a motor not rated in horsepower, use shall be made of the appropriate tables (Tables 430-147 – 430-150) of the National Electrical Code, ANSI/NFPA 70-1999, (Tables 5.1 – 5.4 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 motor shall be used when the motor is marked for use on alternating-current only; otherwise, the table applying to direct-current motors shall be used.

5.4 revised November 24, 1999

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Table 5.1
Full-load current in amperes, direct current motors

Table 5.1 added March 26, 1996

HP	Armature voltage rating[a]					
	90V	120V	180V	240V	500V	550V
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
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.

Table 5.2
Full-load currents in amperes single-phase alternating-current motors

Table 5.2 added March 26, 1996

HP	115V	200V	208V	230V
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

NOTE – 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 100 – 120, and 220 – 240 volts.

Table 5.3
Full-load current two-phase alternating-current motors (4-wire)

Table 5.3 added March 26, 1996

HP	Induction type squirrel-cage and wound-rotor amperes				
	115V	230V	460V	575V	2300V
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

NOTE – 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.

Table 5.4
Full-load current three-phase alternating-current motors

Table 5.4 revised February 14, 1997

HP	Induction type squirrel-cage and wound-rotor amperes							Synchronous type unity power factor[a] amperes			
	115V	200V	208V	230V	460V	575V	2300V	230V	460V	575V	2300V
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					
2	13.6	7.8	7.5	6.8	3.4	2.7					
3		11.0	10.6	9.6	4.8	3.9					
5		17.5	16.7	15.2	7.6	6.1					
7-1/2		25.3	24.2	22	11	9					
10		32.2	30.8	28	14	11					
15		48.3	46.2	42	21	17					
20		62.1	59.4	54	27	22					

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Table 5.4 Continued

HP	Induction type squirrel-cage and wound-rotor amperes							Synchronous type unity power factor[a] amperes			
	115V	200V	208V	230V	460V	575V	2300V	230V	460V	575V	2300V
25		78.2	74.8	68	34	27		53	26	21	
30		92	88	80	40	32		63	32	26	
40		120	114	104	52	41		83	41	33	
50		150	143	130	65	52		104	52	42	
60		177	169	154	77	62	16	123	61	49	12
75		221	211	192	96	77	20	155	78	62	15
100		285	273	248	124	99	26	202	101	81	20
125		359	343	312	156	125	31	253	126	101	25
150		414	396	360	180	144	37	302	151	121	30
200		552	528	480	240	192	49	400	201	161	40
250					302	242	60				
300					361	289	72				
350					414	336	83				
400					477	382	95				
450					515	412	103				
500					590	472	118				

[a] For 90 and 80 percent power factor, the above figures shall be multiplied by 1.1 and 1.25 respectively.

CONSTRUCTION

6 Frame and Enclosure

6.1 A motor shall employ materials that are acceptable for use, and shall be manufactured with the degree of uniformity and grade of workmanship practicable in a well-equipped factory.

6.2 A motor shall be formed and assembled so that it will have the strength and rigidity necessary to resist the abuses to which it is likely to be subjected, without increasing the risk of fire, electric shock, or injury to persons due to total or partial collapse with resulting reduction of spacings, loosening or displacement of parts, or other serious defects.

6.3 For unreinforced, flat surfaces in general, cast metal shall not be less than 1/8 inch (3.2 mm) thick, except that malleable iron may be not less than 3/32 inch (2.4 mm) and die-cast metal may be not less than 5/64 inch (2.0 mm) thick. See 9.1.6. Corresponding thicknesses of not less than 3/32, 1/16, and 3/64 inch (2.4, 1.6, and 1.2 mm), respectively, may be acceptable if the surface under consideration is curved, ribbed, or otherwise reinforced, or if the shape or size or both of the surface is such that adequate mechanical strength is provided.

6.3 revised November 24, 1999

6.4 An enclosure of sheet metal is judged with respect to its size, shape, thickness of metal, and the particular application, considering the intended use of the motor.

6.5 An enclosure of sheet steel shall not be less than 0.026 inch (0.66 mm) thick if uncoated or less than 0.029 inch (0.74 mm) thick if galvanized. The average thickness of a nonferrous sheet metal enclosure shall not be less than 0.036 inch (0.91 mm). See 9.1.7.

Exception No. 1: Relatively small areas or surfaces that are curved or otherwise reinforced need not be as thick.

Exception No. 2: The enclosure need not be as thick as specified if an investigation shows that the material has sufficient strength for the application.

6.6 Among the factors taken into consideration when the acceptability of an enclosure is being judged are its:

a) Mechanical strength,

b) Resistance to impact,

c) Moisture-absorptive properties,

d) Combustibility,

e) Resistance to corrosion,

f) Resistance to distortion at temperatures to which the enclosure may be subjected under conditions of normal or abnormal use, and

g) Resistance to ignition from electrical sources.

6.7 For a nonmetallic enclosure, 6.6 (a) – (g) are to be evaluated with respect to thermal aging. (See 6.10 for polymeric enclosures or enclosure parts.)

6.7 revised March 26, 1996

6.8 An enclosure that serves as a part of the enclosure of end-use equipment will also be judged under the requirements for the end-use equipment.

6.9 Acceptability of the size, number, and location of openings in an enclosure will depend upon requirements for the end-use equipment. Among the factors that are taken into consideration when the end-use equipment is being judged are:

a) Environment;

b) Degree of exposure;

c) Protection against unintentional contact with live parts, including film-coated wire; and

d) Prevention of expulsion of molten metal, burning insulation, flaming particles and the like onto combustible materials, if applicable.

6.10 A polymeric electrical enclosure or a polymeric part of an electrical enclosure shall comply with the applicable requirements specified in UL 746C, Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, and with the additional requirements specified in this standard. See Table 6.1 for an overview of the evaluation.

Exception: A polymeric plug or other enclosure part less than 1 inch^2(6.45 cm^2) made of a material classified in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, and assembled to a sheet-metal or aluminum frame to form a part of an enclosure is able to be used when the material is rated minimum V-2 or VTM-2, or rated HB and complying with the 3/4-inch or 12 mm Flame Tests as specified in UL 746C.

6.10 revised February 7, 2001

Table 6.1
Tests required on polymeric enclosures

Table 6.1 revised December 26, 1997

Type of equipment	Motor location - totally enclosed in an end product enclosure	Motor location - not totally enclosed in an end product enclosure
Portable	Flame: HB	Flame: V-0, -1, -2; VTM-0, -1, -2
	Locked-rotor cycling in accordance with 25.2	5000 volt dielectric (Section 12)
		Impact (Section 24)
		Locked-rotor cycling in accordance with 25.2
		Severe conditioning (29.1)
		Mold stress (31.1)
		Strain relief in accordance with Section 26
		Volume resistivity (Section 16)
Stationary or fixed	Flame: HB	Flame: 5VA, 5VB
	Locked-rotor cycling in accordance with 25.2	5000 volt dielectric (Section 12)
		Impact (Section 24)
		Crush (23.1)
		Locked-rotor cycling in accordance with 25.2
		Severe conditioning (29.1)
		Mold stress (31.1)
		Conduit connections (UL 508, Standard for Industrial Control Equipment)
		Volume resistivity (Section 16)
		UV exposure (26.1)
		Water exposure (27.1 – 27.3)

References in parentheses, unless otherwise noted, are to UL 746C, Standard for Polymeric Materials – Use in Electrical Equipment Evaluations. In addition, the material shall have the following HAI (Section 13) performance levels.

Flame rating	HAI performance level
HB	1
V-2, VTM-2	2
V-1, VTM-1	2
V-0, VTM-0	3
5VA, 5VB	3

7 Mechanical Assembly

7.1 A motor shall be assembled so that it will not be adversely affected by the vibration of normal operation. Brush caps shall be tightly threaded or otherwise designed to prevent loosening.

7.2 An uninsulated live part shall be secured to the base or mounting surface so that it will be prevented from turning or shifting in position if such motion may result in a reduction of spacings below the minimum acceptable value.

7.3 Friction between surfaces is not acceptable as the sole means to prevent shifting or turning of a live part; but a properly applied lock washer is acceptable for this purpose.

7.4 A switch, a motor-attachment plug, an attachment-plug receptacle or similar component shall be mounted securely and shall be prevented from turning. See 7.5.

Exception: A switch need not be prevented from turning if all of the following conditions are met:

a) The switch is of a plunger or other type that does not tend to rotate when operated. A toggle switch is considered to be subject to forces that tend to turn the switch during the normal operation of the switch.

b) Means for mounting the switch makes it unlikely that operation of the switch will loosen it.

c) Spacings are not reduced below the minimum acceptable values if the switch rotates, and leads or connections are not stressed.

d) Operation of the switch is by mechanical means rather than by direct contact by persons.

7.5 A properly applied lock washer is acceptable as a means to prevent a small stem-mounted switch or other device having a single-hole mounting means from turning.

8 Protection Against Corrosion

8.1 Iron and steel parts shall be protected against corrosion by enameling, galvanizing, plating, or other means if the corrosion of such parts would be likely to result in a risk of fire, electric shock, or injury to persons.

Exception No. 1: Surfaces of sheet steel and cast-iron parts within an enclosure if oxidation of the part due to exposure of the metal to air and moisture is not likely to be appreciable – thickness of metal and temperature also being factors.

Exception No. 2: Bearings, laminations, or minor parts of iron or steel, such as washers, screws, and the like need not be protected from corrosion.

9 Supply Connections

9.1 Permanently connected motors

9.1.1 The requirements in 9.1.2 – 9.1.34 and 19.1 apply to a motor having power-supply, control, or equipment-grounding connections that are intended to be made to the motor in the field.

9.1.2 A motor intended for permanent connection to the power supply shall have provision for connection of a wiring system.

9.1.3 A terminal box or compartment in which connections to the power-supply circuit are to be made shall be located so that the connections can be readily inspected after the motor is installed as intended.

9.1.4 A terminal compartment intended for the connection of a supply raceway shall be attached to the motor so as to be prevented from turning.

9.1.5 A terminal or splice compartment attached to the case, end-bell, or frame of a motor shall be complete and shall enclose all field-wiring terminals and all splices to be made in the field.

9.1.6 An enclosure of cast metal to which a wiring system is to be connected in the field shall have a wall thickness not less than 1/8 inch (3.2 mm) at the point of a conduit opening or knockout, and 1/4 inch (6.4 mm) at a tapped hole for conduit.

9.1.7 Sheet metal to which a wiring system is to be connected in the field shall not be less than 0.032 inch (0.81 mm) thick if uncoated steel, not less than 0.034 inch (0.86 mm) thick if galvanized steel, and not less than 0.045 inch (1.14 mm) thick if nonferrous.

9.1.8 The minimum dimension of cover opening and usable volume of a field compartment intended to enclose wire-to-wire connections to be made in the field to a power-supply circuit shall be in accordance with Table 9.1, 9.2, or 9.2A as applicable.

9.1.8 revised February 7, 2001

9.1.8.1 The usable volume of a field compartment intended to enclose wire-to-wire connections to be made in the field to a power-supply circuit shall be verified by any convenient means. When required, the volume of a test sample shall be verified as described in 9.1.8.2 – 9.1.8.5. When the compartment has irregular shape and it is not obvious that the compartment is capable of accommodating the required field wiring conductors, the motor shall be subjected to the Installation Test of Section 27A.

9.1.8.1 revised February 7, 2001

9.1.8.2 All cable clamps, fixture studs, grounding pigtails, internal screws, and other internal accessories are to be removed. Any projections that extend outside the plane of the open face of a box, such as ears for mounting a cover or a flush device, are to be ground flush with the face of the box.

Added 9.1.8.2 effective February 15, 1999

9.1.8.3 All large openings are to be closed by flat, rigid plates clamped in place across the openings. One of the plates is to contain two small holes, one for the entrance of a measuring fluid, the other for venting air.

Added 9.1.8.3 effective February 15, 1999

9.1.8.4 Using modeling clay, putty, glazing compound, or similar material:

a) A hole through the side or bottom of the sample and a hole between the sample and the plate mentioned in 9.1.8.3 are to be filled flush with the inside surface.

b) An internal hub, when tapped through, is to be filled flush with the end of the hub.

c) A bushed opening is to be filled flush with the conduit stop.

Added 9.1.8.4 effective February 15, 1999

9.1.8.5 A clean, graduated vessel (pipette or the equivalent) having a volume equal to or greater than the volume specified for the motor rating in Table 9.1, Table 9.2, or Table 9.2A, as applicable, is to be filled with water at room temperature. The water is then to be transferred from the vessel to the test sample through the hole in the plate specified in 9.1.8.3. The results are acceptable when the test sample holds a volume of water equal to or greater than the required volume specified in Table 9.1, Table 9.2, or Table 9.2A.

Added 9.1.8.5 effective February 15, 1999

Table 9.1
Field wiring compartment for motors 11 inches (279 mm) or less in diameter

Table 9.1 revised July 6, 1999

Rating of motor horsepower (kW)	Field wiring compartment			
	Minimum dimension of field wiring compartment opening, inches (mm)		Minimum usable volume, cubic inches (cm^3)	
1 and smaller[a] (0.75)	1.625	(41)	10.5	(172)
1-1/2, 2, and 3[a] (1.1, 1.5, and 2.2)	1.75	(44)	16.8	(275)
5 and 7-1/2 (3.7 and 5.6)	2	(50)	22.4	(367)
10 and 15 (7.5 and 11.2)	2.5	(64)	36.4	(597)

[a] For a field wiring compartment partially or wholly integral with the frame or end shield, the minimum dimension of cover opening is not specified and the volume of the field wiring compartment per wire-to-wire connection may be not less than 1.1 cubic inch (18 cm^3) for a motor rated 1 horsepower or less, or 1.4 cubic inch (23 cm^3) for a motor rated 1-1/2, 2, and 3 horsepower.

Table 9.2
Field wiring compartment for motors over 11 inches (279 mm) in diameter

Table 9.2 revised July 6, 1999

Maximum full-load current for 3-phase motors with maximum of 12 leads[a]	Minimum dimension of field wiring compartment opening, inches, (mm)		Minimum usable volume, cubic inches (cm^3)	
0 – 45	2.5	(64)	36.4	(597)
46 – 70	3.3	(84)	77	(1262)
71 – 110	4.0	(102)	140	(2295)
111 – 160	5.0	(127)	252	(4130)
161 – 250	6.0	(152)	450	(7376)
251 – 400	7.0	(178)	840	(13768)
401 – 600	8.0	(203)	1540	(25241)

[a] Auxiliary leads for such items as brakes, thermostats, space heaters, or exciting fields are not required to be evaluated when their current-carrying area does not exceed 25 percent of the current-carrying area of the motor power leads.

Table 9.2A
Field wiring compartment for direct-current motors

Table 9.2A revised July 6, 1999

Maximum full-load current for D-C motors with maximum of 6 leads[a]	Minimum dimension of field wiring compartment opening, inches, (mm)		Minimum usable volume, cubic inches (cm^3)	
0 – 68	2.5	(64)	26	(426)
69 – 105	3.3	(84)	55	(901)
106 – 165	4.0	(102)	100	(1639)
166 – 240	5.0	(127)	180	(2950)
241 – 375	6.0	(152)	330	(5409)
376 – 600	7.0	(178)	600	(9834)
601 – 900	8.0	(203)	1100	(18029)

[a] Auxiliary leads for such items as brakes, thermostats, space heaters, or exciting fields are not required to be evaluated when their current-carrying area does not exceed 25 percent of the current-carrying area of the motor power leads.

9.1.9 A terminal compartment that encloses rigidly mounted motor terminals for field connection to a power-supply circuit shall provide room for spacings in accordance with Table 19.1, and usable volume not less than that specified in Table 9.3. When the compartment has irregular shape and it is not obvious that the compartment is capable of accommodating the required field wiring conductors, the motor shall be subjected to the Installation Test of Section 27A.

Revised 9.1.9 effective February 15, 1999

9.1.10 A knockout in a sheet-metal enclosure for connection of a wiring system in the field shall be reliably secured but shall be capable of being removed without undue deformation of the enclosure.

9.1.11 A knockout as specified in 9.1.10 shall be surrounded by a flat surface that will permit proper seating of a conduit bushing, and shall be located so that installation of a bushing at any knockout likely to be used during installation will not result in spacings less than the minimum acceptable values between uninsulated live parts and the bushing.

9.1.12 An integral conduit stop shall be provided at the inner end of a threaded conduit opening, or sufficient room shall be provided inside of the enclosure for attachment of a conduit bushing to the protruding end of the threaded conduit.

9.1.13 An integral conduit stop shall be smooth and rounded and shall have a throat or inner diameter as specified in Table 9.4.

Table 9.3
Field wiring compartments for rigidly mounted motor terminals

Table 9.3 revised July 6, 1999

Power supply conductor size, AWG[a] (mm²)	Minimum usable volume per power supply conductor, cubic inches (cm³)[b]	
14 (2.1) and smaller	1	(16)
12 and 10 (3.3 and 5.3)	1-1/4	(20)
8 and 6 (8.4 and 13.3)	2-1/4	(37)

[a] Based on copper supply conductors having a temperature rating of 60°C (140°F), except that connection of aluminum supply conductors will be assumed if terminals are acceptable for use with aluminum conductors.

[b] The specified volume is not applicable to motors with higher ratings, greater number of leads, or larger wire sizes, or for motors intended to be installed as a part of factory-wired equipment, without additional connection being required at the motor terminal housing during equipment installation, but the terminal housing shall be of ample size to make connections.

Table 9.4
Throat diameter of conduit stop

Trade size of conduit, inches	Throat diameter of conduit stop, inches (mm)			
	Minimum		Maximum	
1/2	0.560	(14.1)	0.622	(15.8)
3/4	0.742	(18.8)	0.824	(20.9)
1	0.944	(24.0)	1.049	(26.6)
1-1/4	1.242	(31.5)	1.380	(35.0)
1-1/2	1.449	(36.8)	1.610	(40.9)
2	1.860	(47.2)	2.067	(52.5)
2-1/2	2.222	(56.4)	2.469	(62.7)
3	2.761	(70.1)	3.068	(77.9)
3-1/2	3.193	(81.1)	3.548	(90.1)
4	3.623	(92.0)	4.026	(102.3)

9.1.14 In a threaded conduit opening not provided with an integral conduit stop, the threads shall be tapered 3/4 inch per foot (1 mm per 16 mm).

9.1.15 Threads in a conduit opening provided with an integral conduit stop may be straight or tapered.

9.1.16 A threaded conduit opening shall be provided with at least 3-1/2 full threads.

9.1.17 If threads for the connection of conduit are tapped all the way through a hole in an enclosure wall there shall not be less than 3-1/2 full threads and not more than the number specified in Table 9.5.

Table 9.5
Maximum number of threads in a conduit opening

Conduit size, inch	Number of threads per inch	Maximum number of threads
1/2, 3/4	14	7
1, 1-1/4, 1-1/2, 2	11-1/2	8
2-1/2, 3, 3-1/2, 4	8	9

9.1.18 A conduit hub not integrally cast with an enclosure shall:

a) Have a wall thickness before threading not less than that of the corresponding trade-size conduit,

b) Not depend upon friction alone to prevent it from turning, and

c) Withstand the torque specified in 27.2.

9.1.19 A conduit nipple used to enclose wiring leads shall fully engage at least 3-1/2 threads in the motor enclosure and be secured against turning, or be secured to the motor enclosure by a solid and continuous weld. The outer end of the nipple shall have at least 3-1/2 full threads.

9.1.20 A field-wiring terminal is considered to be a terminal to which a wire may be connected in the field; however, if the wire and a means of making the connection (a pressure terminal connector, a soldering lug, a solder loop, a crimped eyelet, or the like) is factory assembled to the wire and provided as part of the motor, the terminal is considered to be a factory-wired terminal.

9.1.21 A permanently connected motor shall be provided with field-wiring terminals for the connection of conductors having an ampacity acceptable for the motor; or the motor shall be provided with leads for such connection.

9.1.22 A motor provided with a terminal housing intended to be used for field wiring shall be provided with an equipment-grounding terminal at the motor housing. The terminal shall be provided on housings for wire-to-wire or fixed terminal connections, and may be located either inside or outside the motor terminal housing.

Exception: A means for attaching a terminal for a grounding conductor, such as a screw, a tapped hole, a nut and bolt combination, or the like, may be used provided:

a) The means is not likely to be removed during servicing, and

b) The means is located so that the addition of a terminal will not reduce electrical spacings in the terminal housing to a value less than the applicable value in Table 19.1.

9.1.23 A terminal solely for the connection of an equipment-grounding conductor shall be capable of securing a conductor of a size required for the application. The terminal shall be a pressure connector, clamp, or the equivalent. A connection device or fitting that depends solely on solder shall not be used. A sheet-metal screw shall not be provided for connection of the grounding conductor to enclosures.

Exception No. 1: A No. 10 or larger, wire-binding screw or stud-and-nut combination is able to be employed at a wiring terminal intended to accommodate a No. 10 AWG (5.3 mm^2) or smaller conductor when upturned lugs or the equivalent are provided to hold the wire in position. See 9.1.28.

Exception No. 2: A No. 8 screw or stud-and-nut combination is able to be used at a terminal intended only for the connection of a No. 14 (2.1 mm^2) or No. 12 AWG (3.3 mm^2) conductor.

Exception No. 3: A No. 6 screw or stud-and-nut combination is able to be used at a terminal intended only for the connection of a No. 14 AWG (2.1 mm^2) conductor.

Revised 9.1.23 effective February 15, 1999

9.1.24 A wiring terminal shall be provided with a soldering lug or pressure terminal connector securely fastened in place – for example, firmly bolted or held by a screw.

Exception No. 1: A No. 10 or larger, wire-binding screw or stud-and-nut combination may be employed at a wiring terminal intended to accommodate a No. 10 AWG (5.3 mm^2) or smaller conductor if upturned lugs or the equivalent are provided to hold the wire in position. See 9.1.28.

Exception No. 2: A No. 8 screw or stud-and-nut combination may be used at a terminal intended only for the connection of a No. 14 AWG (2.1 mm^2) conductor.

9.1.25 A wiring terminal shall be prevented from turning.

9.1.26 A terminal plate tapped for a wire-binding screw shall be of metal not less than 0.050 inch (1.27 mm) thick, and there shall be two or more full threads in the metal.

Exception: A plate not less than 0.030 inch (0.76 mm) thick is acceptable provided that the tapped threads have equivalent mechanical strength.

9.1.27 The metal of a terminal plate may be extruded at the tapped hole to provide at least two full threads if the thickness of the unextruded metal is not less than the pitch of the thread.

9.1.28 Upturned lugs or a cupped washer shall be capable of retaining a conductor of the size specified in 9.1.21, but not smaller than No. 14 AWG (2.1 mm^2), under the head of the screw or within the cupped washer.

9.1.29 The free length of a field-connection lead inside a splice box or wiring compartment shall be 6 inches (152 mm) or more.

Exception No. 1: The lead may be less than 6 inches long if it is evident that the use of a longer lead might result in a risk of fire or electric shock.

Exception No. 2: For a motor more than 11 inches (279 mm) in diameter or rated more than 15 horsepower (11 kW), the leads shall be long enough to facilitate proper connections.

9.1.30 A lead to be connected to a power-supply conductor in the field shall not be smaller than No. 18 AWG (0.82 mm^2) and the insulation shall be:

a) Rubber with a braid, neoprene, or thermoplastic, with a wall thickness of at least 1/32 inch (0.8 mm),

b) Cross-linked polyethylene with a wall thickness of at least 1/64 inch (0.4 mm), or

c) Other material having qualities and thickness such that it is at least equally serviceable.

9.1.31 A terminal intended for the connection of a grounded power-supply conductor shall be of, or plated with, metal that is substantially white in color and shall be readily distinguishable from the other terminals; or proper identification of that terminal shall be clearly shown in some other manner, such as on an attached wiring diagram. A lead intended for the connection of a grounded power-supply conductor shall be finished to show a white or natural gray color and no other lead for field connection shall be so identified.

9.1.32 The surface of an insulated lead intended solely for the connection of an equipment-grounding conductor shall be green with or without one or more yellow stripes, and no other lead shall be so identified.

Exception: A lead larger than No. 6 AWG (13.3 mm^2) may have the insulation stripped completely from the exposed length, and be painted or otherwise colored green, or be marked with green tape or green colored adhesive.

9.1.33 For a motor having a frame diameter of 11 inches (279 mm) or less, a wire-binding screw intended for the connection of an equipment-grounding conductor shall have a green colored head that is hexagonal, slotted, or both. A pressure wire connector intended for connection of such a conductor shall be plainly identified, such as by being marked ″G,″ ″GR,″ ″GND,″ ″Ground,″ ″Grounding,″ or similar notation, or by a marking on a wiring diagram provided on the motor. The wire-binding screw or pressure wire connector shall be located so that it is not removed during normal servicing of the motor.

9.1.33 revised March 26, 1996

9.1.34 Each lead or flexible cord provided for wiring to or for interconnection between parts of a motor, for example, motor windings to capacitor, shall be provided with a means to prevent stress from being transmitted to internal connections.

9.2 Cord-connected motors

9.2.1 The requirements in 9.2.2 – 9.2.16 apply to a motor that is intended to be connected to a source of supply in the field by means of a flexible cord and an attachment plug that are provided with the motor.

9.2.2 A flexible cord shall be acceptable for the intended use. It shall be rated for a voltage not less than maximum rated voltage of the motor, and shall have an ampacity, not less than the marked or assigned current rating of the motor.

9.2.3 A general-use attachment plug shall be rated for a current not less than 125 percent of the rated current, and a voltage equal to the rated voltage of the motor.

Exception: A general-use attachment plug on a motor not intended for continuous operation – continuous operation is defined as 3 hours or more – may have a current rating not less than the rated current of the motor.

9.2.4 The attachment plug provided with a motor designed so that it can be adapted for use on two or more different values of voltage by field alteration of internal connections shall be rated for the voltage for which the motor is connected when shipped from the factory.

9.2.5 Unless it is to be provided in the end-use equipment, strain relief shall be provided to prevent a mechanical stress on the flexible cord from being transmitted to terminals, splices, or interior wiring. See 26.1.1.

9.2.6 A metal strain-relief clamp or band is acceptable with Type SP-2 or lighter general-use rubber-insulated cord only if acceptable auxiliary insulation is provided over the cord for mechanical protection.

Exception: The auxiliary insulation may be omitted for Types SV and SVO cord.

9.2.7 Unless investigated for the purpose, a clamp of any material – metal or otherwise – is not acceptable on Types SPT-1, SPT-2, SVT, and SVTO cords, except that a cord protected by varnished-cloth tubing or the equivalent under the clamp may be accepted subject to the investigation described in 26.3.1. For heavier types of thermoplastic-insulated cord, clamps may be employed; in such cases, the auxiliary insulation is not required unless it is judged that the clamp may damage the insulation of the cord.

9.2.8 Unless it is to be provided in the end-use equipment, means shall be provided to prevent the flexible cord from being pushed into the motor through the cord-entry hole if such displacement is likely to subject the cord to mechanical damage or to exposure to a temperature higher than that for which the cord is rated, or is likely to reduce spacings – such as to a metal strain-relief clamp – below the minimum acceptable values.

9.2.9 If a knot in a flexible cord serves as strain relief, a surface with which the knot may contact shall be free from projections, sharp edges, burrs, fins, and the like, that may cause abrasion of the cord jacket or the insulation on the conductors.

9.2.10 At a point where a flexible cord passes through an opening in a wall, barrier, or enclosing case, there shall be a bushing or the equivalent that shall be substantial, and reliably secured in place, or the opening shall have a smooth, rounded surface against which the cord may bear. If Type SP-1, SPT-1, SP-2, SPT-2, or other cord lighter than Type SV is employed, and if the wall or barrier is of metal, an electrical insulating bushing shall be provided.

9.2.11 If the cord-entry hole is in wood, porcelain, phenolic composition, or other nonconducting material, a smooth, rounded surface is considered to be equivalent to a bushing.

9.2.12 Ceramic materials and some molded compositions are generally acceptable for an insulating bushing, but separate bushings of wood or of so-called hot-molded shellac and tar compositions are not acceptable.

9.2.13 Vulcanized fiber or fiber treated to resist moisture absorption may be employed as a bushing if it is not less than 3/64 inch (1.2 mm) thick and if the bushing is formed so that it will be reliably secured in place.

9.2.14 A bushing of any insulating material that has not been found to afford sufficient protection to the cord may be employed at any point in a motor if used with a type of cord for which an insulating bushing is not required. The edges of the hole in which such a bushing is mounted are to be smooth and free of burrs, fins, and the like.

9.2.15 At any point in a motor, a bushing of the same material as, and molded integrally with, the supply cord is acceptable on a Type SP-1 or heavier cord if the built-up section of the bushing is not less than 1/16 inch (1.6 mm) thick at the point where the cord passes through the enclosure.

9.2.16 An insulated metal grommet may be used in place of an insulating bushing if the insulating material is not less than 1/32 inch (0.8 mm) thick and completely fills the space between the grommet and the metal in which it is mounted.

10 Factory Wiring Terminals and Leads

10.1 Among the factors to be considered in judging factory-wiring terminals and leads are the type and size of wire to be connected, ampacity of the terminals, and mechanical protection. These are dependent upon requirements for the end-use equipment.

10.1.1 A factory-provided pigtail lead for equipment grounding connections shall be connected to the motor housing by a fastener that complies with Section 9, Supply Connections, and which is not intended to be removed during servicing, or by means of a rivet. Sheet metal screws shall not be used.

Added 10.1.1 effective February 15, 1999

10.2 Terminals shall be secured to their supporting surfaces by means other than friction between surfaces so that they will be prevented from turning or shifting in position if such motion may result in reduction of spacings to less than the minimum acceptable values.

10.3 An attachment plug intended to facilitate interconnection to an appliance, shall be acceptable for a current not less than the marked or assigned current rating of the motor and for the rated voltage of the motor.

11 Current-Carrying Parts

11.1 A current-carrying part shall be of silver, copper, a copper-alloy, aluminum, or other material acceptable for the particular application.

11.2 Plated iron or steel may be used for a current-carrying part within a motor or associated governor, if acceptable in accordance with 3.1, but unplated iron or steel is not acceptable. The foregoing restriction does not apply to stainless steel or to other corrosion-resistant alloys.

12 Internal Wiring

12.1 Unless it is to be judged as an uninsulated live part, each uninsulated internal conductor, including an equipment-grounding conductor, shall consist of wire of a type that is acceptable for the particular application when considered with respect to:

a) Exposure to oil, grease, cleaning fluid, or other substances likely to have a deleterious effect on the insulation,

b) Exposure to moisture, and

c) The temperature, voltage and other conditions of service to which the wiring is likely to be subjected.

12.2 Except as noted in 12.6 thermoplastic-insulated wire and neoprene-insulated wire shall be standard building wire or appliance wiring material that is acceptable for the purpose.

12.3 Except as noted in 12.4 – 12.6, the wall thickness of insulation shall be at least:

a) For cross-linked polyethylene insulation, 1/64 inch (0.4 mm);

b) For insulation other than cross-linked polyethylene, 1/64 inch if the wire is provided with an outer braid or jacket having a wall thickness of at least 1/64 inch;

c) Except as indicated in (a) and (b), 1/32 inch (0.8 mm).

12.4 Except as noted in 12.5 and 12.6, rubber-insulated wire, excluding neoprene-insulated wire, shall be provided with a braid. The wall thickness of the insulation shall not be less than 1/32 inch (0.8 mm).

12.5 Appliance wiring material having heat-resistant rubber insulation of other than a silicone type at least 3/64 inch (1.2 mm) thick need not be provided with a braid.

12.6 Wire may be insulated with a material other than those specified in 12.2 – 12.5 if it is investigated and found to have qualities and thickness such that it is acceptable for the application.

12.7 Wiring shall be protected from sharp edges – including screw threads – burrs, fins, moving parts, and other agencies that might abrade the insulation on conductors.

12.8 A hole in a metal wall through which insulated wires pass shall be provided with a smoothly rounded bushing, either as described in 9.2.12 and 9.2.13 or of metal, or shall have smooth surfaces, free of burrs, fins, sharp edges, and the like, upon which the wires may bear, to prevent abrasion of the insulation.

12.9 All splices and connections shall be mechanically secure and shall provide adequate and reliable electrical contact.

12.10 A soldered connection shall be made mechanically secure before being soldered.

12.11 A wire inserted into a hole in a terminal is considered to be mechanically secure whether or not it is bent before soldering.

12.12 An internal connection shall be provided with acceptable means to prevent it from becoming loosened due to vibration if such loosening might result in a risk of fire, electric shock, or injury to persons.

12.13 An internal connection terminating in an open-end spade lug is not acceptable unless additional means, such as upturned lugs or the like, are provided to hold the lug in place should the wire-binding screw or nut become slightly loosened. In any case, an open-end lug with a lock washer alone is not acceptable.

12.14 A splice shall be provided with insulation equivalent to that of the wires involved if permanence of spacing between the splice and other metal parts cannot be established.

Exception: A splice within a motor winding need not have insulation equivalent to that of the wires involved.

12.15 A splicing device such as a pressure wire connector that provides adequate mechanical security and insulation acceptable for the voltage to which it is subjected may be employed.

12.16 In evaluating splice insulation consisting of coated fabric, thermoplastic, or other tubing, such factors as its electrical and mechanical properties and its flammability in accordance with the requirements in Section 13, Electrical Insulation are to be evaluated. Thermoplastic tape wrapped over a sharp edge is not able to be used.

Exception: Insulation materials evaluated to the tests in Section 25, Non-Metallic Functional Part Tests, are able to be used.

12.16 revised March 26, 1996

12.17 On a splice where the voltage involved is less than 250 volts, insulation evaluated to the requirements in Section 13, Electrical Insulation, and consisting of two layers of thermoplastic tape is able to be used.

Exception: Insulation materials evaluated to the tests in Section 25, Non-Metallic Functional Part Tests, are able to be used.

12.17 revised March 26, 1996

12.18 Stranded internal wiring shall be connected at a wire-binding screw so that loose strands of wire will be prevented from contacting other uninsulated live parts not always of the same polarity as the wire, and from contacting dead metal parts. This may be accomplished by use of a pressure terminal connector, a soldering lug, a crimped eyelet, soldering all strands of the wire together, or other reliable means.

13 Electrical Insulation Supports

13.1 Material in direct contact with uninsulated live parts other than magnet wire shall be slate, porcelain, phenolic, cold-molded composition, unfilled polycarbonate, unfilled nylon, melamine, melamine-phenolic, urea, or other material investigated and found acceptable in accordance with the requirements covering mechanical/electrical property considerations of the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. These materials shall withstand the most severe conditions likely to be met in service.

Exception: Motor components, such as slot liners and end spiders, that are used only to support the windings of the motor shall comply with Section 14, Insulation Systems.

13.1 revised February 7, 2001

13.2 The material of any part of a base or body shall not introduce a risk of fire or shock by warping, creeping, or distorting under conditions of arcing, temperature, and mechanical stress that are likely to occur in service.

13.3 Material in contact with live parts other than magnet wire shall comply with Table 13.1 with respect to resistance to flame propagation, resistance to arc tracking, resistance to ignition from electrical sources, resistance to moisture absorption, dielectric strength, and mechanical strength. A material shall not display a loss of these properties beyond the minimum required level as a result of aging.

13.3 revised March 26, 1996

Table 13.1
Performance levels

Table 13.1 revised December 26, 1997

Flame rating	Volume resistivity (ohm-cm) (dry/ wet)	Dielectric strength (volts)	CTI (PLC)	HAI (PLC)	HWI (PLC)
HB	50/10 x 10^6	5000	2	1	2
V-2, VTM-2	50/10 x 10^6	5000	2	2	2
V-1, VTM-1	50/10 x 10^6	5000	2	2	3
V-0, VTM-0	50/10 x 10^6	5000	2	3	4

13.4 Material used to support live parts or an insulating barrier shall be acceptable for continuous operation at a temperature specified in Table 13.2.

13.4 revised February 7, 2001

Table 13.2
Temperature Limits of Insulating Materials

Table 13.2 added February 7, 2001

Insulation class	Minimum electrical temperature rating of the material	
	°C	(°F)
A (105 °C)	90	(194)
E (120 °C)	100	(212)
B (130 °C)	110	(230)
F (155 °C)	135	(275)
H (180 °C)	150	(302)

13.5 A small molded part such as a terminal block shall have such mechanical strength and rigidity that it will withstand the stresses of actual service.

13.6 A molded part shall not exhibit softening of the material determined by handling immediately after the condition specified in 25.1.1, nor shall there be shrinkage, warpage, or other distortions as determined after cooling to room temperature that results in any of the following:

a) Reduction of spacings between uninsulated live parts of opposite polarity, uninsulated live parts and accessible dead or grounded metal, and uninsulated live parts and the enclosure below the minimum acceptable values;

b) Uninsulated live parts or internal wiring accessible to contact, or defeating the integrity of the enclosure so that acceptable mechanical protection is not afforded to internal parts of the equipment;

c) A condition in which the motor does not comply with the strain relief test on the power-supply cord, if applicable, as specified in 26.1.1 and 26.1.2; or

d) Interference with the intended operation or servicing of the equipment.

14 Insulation Systems

14.1 The insulation system of a motor shall be rated for a temperature not less than that at which the motor windings are intended to operate in the end-use application under normal conditions. See Figure 14.1 for details on investigations of motor insulation systems or alternate major components and materials.

14.1 revised November 24, 1999

14.2 The test program specified in 14.3 – 14.7 for a Class A insulation system shall consider the end-use of the motor. For instance, a motor for use in attended equipment, products in operation while the user is present, then the 15-Day Abnormal Operation Test, see 7.7, specified in the Standard for Polymeric Materials – Coil Forms, UL 1692, and referenced in 14.7 may not be required. The end product Standard shall be reviewed before developing a test program for the insulation system.

14.2 revised February 7, 2001

Table 14.1
Primary Class A insulating materials and minimum thicknesses

Material	Minimum thickness	
	inches	(mm)
Vulcanized fiber	0.028	(0.8)
Polyethylene terephthalate	0.007	(0.18)
Cambric	0.028	(0.8)
Treated cloth	0.028	(0.8)
Electrical grade paper	0.028	(0.8)
Mica	0.006	(0.15)
Aramid paper	0.010	(0.25)

14.3 Materials in direct contact with uninsulated live parts other than magnet wire shall be a material specified in 13.1 or comply with the Mechanical/Electrical Property Considerations table in UL 746C, Standard for Polymeric Materials – Use in Electrical Equipment Evaluations. Table 13.1 provides the specific performance levels required.

14.3 revised November 24, 1999

14.4 Class E insulation systems or higher shall comply with the requirements specified in UL 1446, Standard for Systems of Insulating Materials – General.

14.4 revised November 24, 1999

14.5 All insulation systems employing integral ground insulation shall comply with the requirements specified in UL 1446, Standard for Systems of Insulating Materials – General.

14.5 revised November 24, 1999

14.6 Class A insulation systems shall consist of a combination of magnet wire and major component insulation materials evaluated and found to operate as intended for this use. Materials in Table 14.1 at the thicknesses specified are able to be used without further evaluation. Wood is able to be used for wedges. Other materials shall comply with 14.7.

14.6 added November 24, 1999

14.7 For Class A insulation systems employing other materials or thinner materials than those indicated in Table 14.1 or a combination of materials, the materials, whether polymeric or not polymeric (treated cloth, for example), shall comply with the requirements specified in UL 1692, Standard for Polymeric Materials – Coil Forms. When reviewing Figure 14.1 for tests related to use of insulating materials in insulating systems of UL 1692, the end-use of the motor shall be considered as indicated in 14.2. Any of the possible tests in UL 1692 are able to be eliminated or adapted to meet a specific end-use application as long as the change is noted in the investigation report. The Locked-Rotor Cycling Test of 25.2, is able to be performed in lieu of the Abnormal Conditioning Test of 7.4, Severe Conditioning Test of 7.5, Overload Burnout Conditioning Test of 7.6, and the 15-Day Abnormal Operation Test of 7.7, in UL 1692.

14.7 revised February 7, 2001

15 Windings

15.1 A motor winding shall be such as to resist the absorption of moisture and shall be formed and assembled in a uniform manner.

15.2 With reference to the requirement in 15.1, film-coated wire is not required to be additionally treated to retard absorption of moisture, but fiber slot liners, cloth coil wrap, and similar moisture-absorptive materials shall be provided with impregnation or otherwise treated to retard the absorption of moisture.

16 Brush Holders

16.1 A brush-holder assembly shall be constructed so that when a brush is worn out – no longer capable of performing its function – the brush, spring, and other parts of the assembly will be retained to the degree necessary to prevent accessible dead metal parts from becoming energized, and to prevent live parts from becoming accessible.

17 Nonmetallic Functional Parts

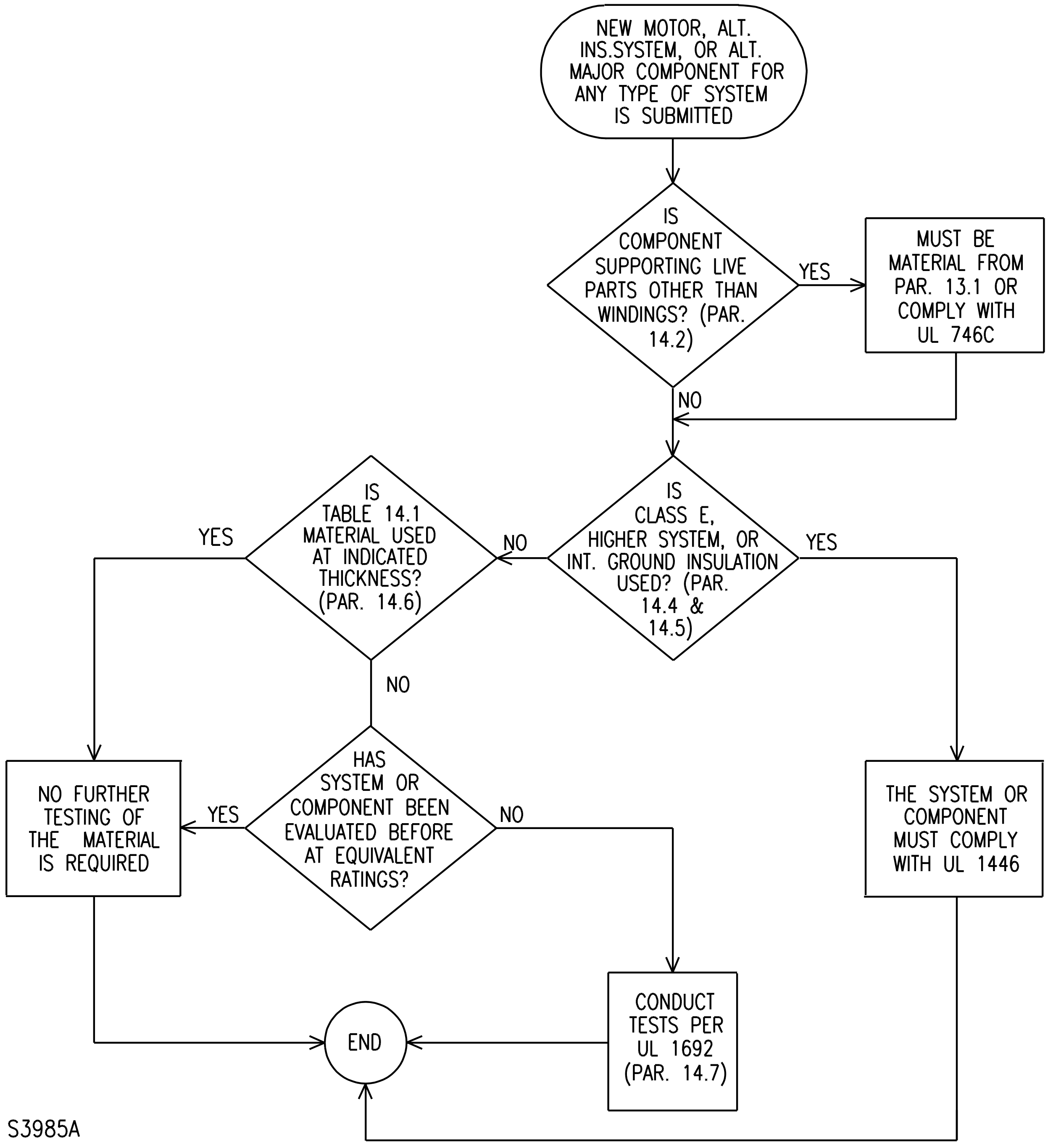
17.1 A non-metallic functional part, the breakdown of which creates a risk of fire, electric shock or injury to persons, shall be subjected to the locked rotor cycling test and the mold stress relief test specified in Section 25, Non-Metallic Functional Part Tests.

Exception: A non-metallic part outside the enclosure of a totally-enclosed motor is not required to be investigated with respect to resistance to ignition from electrical sources.

17.1 revised March 26, 1996

Figure 14.1
Investigation of motor insulation system or alternate major component

Figure 14.1 added November 24, 1999



NOTE – Classification of an insulation component as major or minor shall be determined per the requirements in the Major and Minor Components section of UL 1446, Standard for Systems of Insulating Materials – General.

18 Capacitors

18.0 A capacitor shall comply with the construction requirements in the Standard for Capacitors, UL 810.

Added 18.0 effective February 7, 2003

18.1 A capacitor, mounted on a motor in end-use applications not intended to be totally enclosed, shall be housed within an enclosure that protects the capacitor against mechanical damage and prevents the emission of flame or molten material resulting from malfunction or breakdown of the capacitor. The enclosure shall comply with the requirements in Section 6, Frame and Enclosure.

18.1 revised February 7, 2001

18.2 The individual enclosure of an electrolytic capacitor not provided with means for venting and with an opening more than 1/16 inch (1.6 mm) wide between the capacitor enclosure shall be subjected to the Electrolytic Capacitor Overvoltage Test, Section 27B.

18.2 revised February 7, 2001

18.3 An oil-filled capacitor or a dry-film protected capacitor, not an electrolytic type, employing a dielectric medium more combustible than askarel shall comply with the following:

a) The capacitor shall protect against expulsion of the dielectric medium under both normal and abnormal conditions or use;

b) The capacitor shall be acceptable for a minimum available fault current (AFC) of 5000 amperes; and

c) The capacitor shall comply with the testing requirements of the Standard for Capacitors, UL 810.

18.3 revised February 7, 2001

18A Start Switches

18A.1 A start switch used for the engagement and disengagement of the start winding of a motor shall operate as required for the intended application, and shall comply with the performance requirements in the Start Switch Tests, Section 23A.

18A.1 added May 17, 1996

18A.2 In addition to the requirements in this section, a start switch shall comply with the applicable requirements of this standard.

18A.2 added May 17, 1996

18A.3 When a polymeric material is used to support current in direct contact with carrying parts it shall comply with the applicable requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. See 18A.4 and 18A.5 for details.

18A.3 revised February 7, 2001

18A.4 A material in direct contact with an uninsulated current carrying part, other than magnet wire, shall have a minimum flame rating of V-0, in accordance with UL 94, Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances. The material shall be subjected to the Mold Stress Test described in 25.1. The Relative Thermal Index (RTI) shall be equal to or greater than the temperatures measured during the Temperature Test outlined in 23.5.

Exception: The flame rating of the material is not required to be minimum V-0 when the material is subjected to an end-product flame test in accordance with the Flammability – 12 mm Test or the Flammability – 3/4-Inch Flame Test in UL 746C, Standard for Polymeric Materials – Use in Electrical Equipment Evaluations.

18A.4 revised February 7, 2001

18A.5 When a polymeric material does not have the minimum level of performance as specified in Table 18A.1, then the alternate tests specified in the table for Additional Considerations for Performance Weaknesses in UL 746C, Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, shall be performed.

18A.5 added May 17, 1996

Table 18A.1
Support of live parts

Table 18A.1 added July 6, 1999

Flame	Dielectric	Comparative Tracking Index (CTI)[a]	High Current Arc Ignition (HAI)[a]	Hot Wire Ignition (HWI)[a]
V-0	5000 volts	2	3	4

[a] As determined in accordance with UL 746C, Standard for Polymeric Materials – Use in Electrical Equipment Evaluations.

18B Motors Provided With Controls

18B.1 When a motor is provided with a controller, the control shall comply with:

a) The Standard for Controls for Use in Household or Similar Use, UL 60730-1, when intended only for commercial or residential use; and

b) The Standard for Industrial Control Equipment, UL 508, or the Standard for Power Conversion Equipment, UL 508C, when intended only for industrial applications.

18B.1 added February 7, 2001

18B.2 A motor/control combination shall be subjected to the Temperature Test in 22.7.

18B.2 added February 7, 2001

19 Spacings

19.1 The spacing between field-wiring terminals of opposite polarity, and a spacing between a field-wiring terminal and any other uninsulated metal part – dead or live – not always of the same polarity, shall not be less than that specified in Table 19.1.

19.1.1 The spacing between uninsulated live parts of opposite polarity, and between uninsulated live parts and grounded non-current-carrying metal parts, of circuits greater than 750V, shall not be less than those specified in the Table 19.1A.

19.1.1 added February 7, 2001

Table 19.1
Minimum acceptable spacings at field-wiring terminals for voltages up to 750

Table 19.1 revised February 7, 2001

Potential involved	Minimum spacings through air or over surface	
volts	inch	(mm)[a]
250 or less	1/4	(6.4)
251 – 750	3/8	(9.5)

[a] Applies to the sum of the spacings involved where an isolated dead metal part is interposed. See 19.8.

Table 19.1A
Minimum acceptable spacings at uninsulated live parts for voltages over 750

Table 19.1A added February 7, 2001

Voltage range volts	Minimum spacings			
	Through air		Over surface	
	inches	(mm)	inches	(mm)
751 – 1000	3/8	(10)	1/2	(13)
1001 – 2000	3/4	(19)	1-3/8	(34)
2001 – 3000	1	(25)	2	(50)
3001 – 5000[a]	2-1/2	(63)	3	(75)
3001 – 5000[b]	3-1/4	(82)	4	(100)
5001 – 7200[a]	3	(75)	3-1/2	(88)
5001 – 7200[b]	4	(100)	5	(125)

[a]Between uninsulated live parts and grounded non-current-carrying metal parts.

[b]Between uninsulated live parts of opposite polarity.

19.2 The spacing at a field-wiring terminal is to be measured with wire of the appropriate size for the rating connected to the terminal as in actual service. The connected wire is to be the next larger size than would normally be required if the terminal will accommodate it properly or the device is not marked to restrict its use.

19.3 For an enclosure provided with conduit openings or knockouts, spacings not less than the minimum specified in Table 19.1 shall be provided between uninsulated live parts and a conduit bushing used during installation.

19.4 When measuring a spacing between an uninsulated live part and a bushing installed in a knockout, it is to be assumed that a bushing having the dimensions specified in Table 19.2 is in place, and that a single locknut is installed on the outside of the enclosure.

Table 19.2
Dimensions of bushings

Trade size of conduit, inches	Bushing dimensions, inches (mm)			
	Overall diameter		Height	
1/2	1	(25.4)	3/8	(9.5)
3/4	1-15/64	(31.4)	27/64	(10.7)
1	1-19/32	(40.5)	33/64	(13.1)
1-1/4	1-15/16	(49.2)	9/16	(14.3)
1-1/2	2-13/64	(56.0)	19/32	(15.1)
2	2-45/64	(68.7)	5/8	(15.9)
2-1/2	3-7/32	(51.8)	3/4	(19.0)
3	3-7/8	(98.4)	13/16	(20.6)
3-1/2	4-7/16	(112.7)	15/16	(23.8)
4	4-31/32	(126.2)	1	(25.4)
4-1/2	5-35/64	(140.9)	1-1/16	(27.0)
5	6-7/32	(158.0)	1-3/16	(30.2)
6	7-7/32	(183.4)	1-1/4	(31.8)

19.5 Other than at field-wiring terminals, and as noted in 19.9 and 19.10, the spacing between uninsulated live parts of opposite polarity and between an uninsulated live part and a dead metal part that is exposed to contact by persons or that may be grounded shall not be less than the value specified in Table 19.3.

Exception No. 1: The spacing requirements do not apply to the inherent spacings of a component of the motor, such as a snap switch; such spacings are judged on the basis of the requirements for the component in question. The spacing requirements do not apply between a component live part, such as on a snap switch, and adjacent metal parts.

Exception No. 2: For a repulsion motor, a repulsion-induction motor, or a repulsion-start induction motor, the spacing requirements do not apply to the commutator, the brush assembly, or the jumpers that short-circuit the brushes.

19.6 If an uninsulated live part is not rigidly fixed in position by means other than friction between surfaces or if a movable dead metal part is in proximity to an uninsulated live part, the construction shall be such that the minimum acceptable spacing will be maintained.

19.7 Any uninsulated conductor of the rotor circuit is regarded as a dead metal part with respect to the stator circuit, and the appropriate spacing is required between uninsulated stator and rotor conductors.

19.8 If an isolated dead metal part is interposed between or is in close proximity to live parts of opposite polarity, a live part and an exposed dead metal part, or a live part and a dead metal part that may be grounded, the spacing may be not less than 3/64 inch (1.2 mm) between the isolated dead metal part and any one of the parts previously specified, if the total spacing between the isolated dead metal part and the two other parts is not less than the value specified in Table 19.3.

Table 19.3
Minimum acceptable spacings at other than field-wiring terminals for voltages up to 750

Table 19.3 revised February 7, 2001

Voltage range, volts	Parts involved	Minimum spacings, inch (mm)					
		Motor diameter 7 inches or less[a]		Motor diameter more than 7 inches[a]			
		Over surface and through air		Over surface		Through air	
0 – 125	Commutator or collector rings	1/16	(1.6)	3/16[b]	(4.8)	1/8[b]	(3.2)
	Elsewhere in the motor	3/32[c]	(2.4)	1/4[b, d]	(6.4)	1/8[b, d]	(3.2)
126 – 250	Commutator or collector rings	1/16	(1.6)	3/16[b]	(4.8)	3/16[b]	(4.8)
	Elsewhere in the motor	3/32	(2.4)	1/4[b, d]	(6.4)	1/4[b, d]	(6.4)
251 – 750	Commutator or collector rings and live parts of the brush rigging	1/4[e]	(6.4)	3/8	(9.5)	1/4	(6.4)
	Elsewhere in the motor	1/4[d]	(6.4)	3/8[d, f]	(9.5)	3/8[d,f]	(9.5)

NOTE – For a capacitor such as one described in 19.10, spacings are determined by using Table 19.4.

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

[b] Spacings of not less than 3/32 inch are acceptable throughout a universal motor.

[c] For a motor rated 1/3 horsepower (249 W output) or less, these spacings may be not less than 1/16 inch.

[d] Film-coated wire is considered to be an uninsulated live part. However, a spacing of not less than 3/32 inch, over surface and through air between film-coated wire, rigidly supported and held in place on a coil, and a dead metal part is acceptable.

[e] Through-air spacings involving a collector ring may be not less than 1/8 inch.

[f] For subassemblies mounted on or inside a motor, spacings not less than 1/4 inch are acceptable between live parts and dead metal parts within a subassembly, and between parts in different subassemblies, of the following types only:

a) A terminal board not intended for field wiring;

b) Centrifugally-operated starting, auxiliary, and interlock switches;

c) A starting relay; and

d) A capacitor.

19.9 An insulating liner or barrier of vulcanized fiber or similar material used where a spacing is otherwise less than the minimum required value shall be 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: Other insulating material or insulating material having a thickness less than that specified is able to be used when, upon investigation, it is evaluated for the particular application, in accordance with the Internal Barriers section of UL 746C, Standard for Polymeric Materials – Use in Electrical Equipment Evaluations.

19.9 revised March 26, 1996

19.10 A capacitor, as described in 18.3 , that employs an internal interrupter to protect against expulsion of a flammable dielectric in the event of rupture of the enclosure shall have additional through-air expansion spacings in the axial direction to allow for movement of the terminals. The additional expansion spacing shall be at least 1/2 inch (12.7 mm) through air in addition to the applicable electrical spacings. Examples are provided in Table 19.4.

19.10 revised February 7, 2001

Table 19.4
Minimum acceptable spacings at capacitor terminals

Motor rating, volts	Expansion spacing, inch	(mm)	Electrical spacing,[a] inch	(mm)	Total spacing,[a] inch	(mm)
0 – 300	1/2	(12.7)	1/16	(1.6)	9/16	(14.3)
301 – 600	1/2	(12.7)	1/8	(3.2)	5/8	(15.9)

NOTE – See 19.10.

[a] An insulating liner or barrier as mentioned in 19.9 may be used in lieu of the required electrical spacing; however, at least 1/2 inch expansion spacing shall be provided.

20 Control Devices

20.1 A switch or other control device shall be acceptable for the application, and shall have a rating not less than that of the load that it controls.

20.2 If a rating is assigned to an auxiliary switch – one that functions when motor speed changes – provided as part of a motor and intended to control an external circuit, the switch shall be acceptable for the assigned rating. See 3.2.

20.3 An auxiliary switch or other device that is intended to control a remote motor or a load in a safety circuit shall have ratings not less than the corresponding ratings of the load it is to control and shall be tested for its application.

21 Bonding for Grounding

21.1 Bonding conductor

21.1.1 A bonding conductor shall be of material acceptable for use as an electrical conductor.

21.1.2 A bonding conductor of ferrous metal shall be protected against corrosion by painting, plating, or the equivalent.

21.1.3 The size of the conductor or strap employed to bond an electrical enclosure or motor frame shall be based on the rating of the branch-circuit overcurrent-protective device by which the equipment is intended to be protected. Other than as noted in 21.1.7, the size of the conductor or strap shall be in accordance with Table 21.1.

Table 21.1
Minimum size of bonding wire conductor

Rating of overcurrent-protective device, amperes	Size of bonding conductor[a]	
	Copper wire, AWG	Aluminum or copper-clad aluminum wire, AWG
15	14	12
20	12	10
30	10	8
40	10	8
60	10	8
100	8	6
200	6	4
400	3	1
600	1	2/0

[a] Or equivalent cross-sectional area.

21.1.4 A bonding conductor may be bare.

21.1.5 The surface of the insulation on a bonding conductor shall be green with or without one or more yellow stripes.

21.1.6 A conductor, such as a clamp or strap, used in place of a separate wire conductor shall have a minimum cross-sectional conducting area equivalent to the wire size specified in Table 21.1.

21.1.7 A bonding conductor need not be larger than the motor-circuit conductors. A smaller conductor than required by 21.1.3 may be used if, using a separate sample for each test, neither the bonding conductor nor the connection opens under either of the following conditions:

a) When carrying a current equal to twice the rating or setting of the intended branch-circuit overcurrent-protective device for the time specified in Table 21.2; or

b) When subjected to the limited-short-circuit tests described in 24.3.1 – 24.3.4, 24.3.6, and 24.3.7 in the as-received condition only.

Table 21.2
Duration of overcurrent test

Rating or setting of branch-circuit overcurrent-protective device, amperes	Test time, minutes	
	On 135 percent current	On 200 percent current[a]
0 – 30	60	2
31 – 60	60	4
61 – 100	120	6
101 – 200	120	8
201 – 400	120	10
401 – 600	120	12

[a] If a 600-volt fuse rated 100 amperes or less and plainly marked ″For Use Only on Motor Circuits″ is to be used, test time is to be 8 minutes.

21.2 Connections

21.2.1 Bonding shall be by a positive means, such as by clamping, riveting, bolted or screwed connection, brazing, or welding. The bonding connection shall reliably penetrate nonconductive coatings such as paint.

21.2.2 A bolted or screwed connection that incorporates a star-washer under the screw head, a serrated screw head, or equivalent, is acceptable for penetrating nonconductive coatings if required for compliance with 21.2.1.

21.2.3 If the bonding means depends upon screw threads, two or more screws, or two full threads of a single screw engaging metal, is considered to comply with 21.2.1.

21.2.4 A splice shall not be employed in wire conductors used to bond an electrical enclosure, a motor frame, or other electrical components.

21.3 Resilient rubber mountings

21.3.1 The requirements in 21.3.2 – 21.3.9 apply only to resilient rubber mountings that are depended upon for bonding.

21.3.2 An electrical bonding member across a resilient mounting shall be metal. Conductive rubber compounds – loaded rubber – are not acceptable for bonding.

21.3.3 Electrical bonding shall be such that a path for electric current exists regardless of the manner in which the motor is rotated with respect to the base.

21.3.4 A bonding member shall be welded, clamped, riveted, secured by screws, or the equivalent.

21.3.5 A bonding member shall be secured by a means that will provide retention if a motor is removed from its base. A connection that it is necessary to remove intentionally, such as a screw or a bolt, at one or both ends of a bonding member is considered to comply with this requirement.

21.3.6 A bonding member shall be enclosed, located, or otherwise protected so that it will be unlikely to be damaged during handling or installation.

21.3.7 A metal part of a resilient mounting that also serves as a bonding path shall be inherently resistant to corrosion or shall be plated or finished as protection against corrosion.

21.3.8 Metal parts in a bonding path shall be galvanically compatible so that there will be little or no electrolytic action between dissimilar metals.

21.3.9 A bonding member shall have the flexibility necessary to withstand normal mechanical stress due to vibration.

21A Grounding

21A.1 For a motor provided with an attached grounding-type power-supply cord, electrical continuity shall be provided between all exposed dead-metal parts and the point of connection of the grounding conductor of the power-supply cord of a motor.

21A.1 added March 26, 1996

PERFORMANCE

22 General

22.1 The voltage of the test circuit for the performance tests shall be as specified in Table 22.1.

Exception: A motor having a voltage rating other than those specified in Table 22.1 is to be tested at 100 to 105 percent of rated voltage, but no less than 100 percent. Consideration is to be given to the voltage of the intended source of supply, as this may result in a test at a higher percentage of rated voltage than specified in this Exception.

Table 22.1
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

22.2 Thermocouples are to be applied to the hottest accessible parts to measure the temperature. Thermocouples are to be of wires no larger than No. 24 AWG (0.21 mm^2) and no smaller than No. 30 AWG (0.05 mm^2). Thermocouple wire is to comply with the requirements for special thermocouples in the Standard for Temperature Measurement Thermocouples, ANSI MC96.1-1982(1991).

22.3 A thermocouple junction and adjacent thermocouple lead wire are to be securely held in thermal contact with the surface of the material of which the temperature is being measured. In most cases, adequate thermal contact will result from cementing the thermocouple in place or by any other acceptable means.

22.4 The resistance method for temperature measurement as specified in Table 23.1 consists of the calculation of the temperature rise of a winding using the equation:

$$\Delta T = \frac{r_2}{r_1}(k + t_1) - (k + t_2)$$

in which:

ΔT is the temperature rise of the winding in degrees C;

r_2 is the resistance of the coil at the end of the test in ohms;

r_1 is the resistance of the coil at the beginning of the test in ohms;

t_1 is the room temperature in degrees C at the beginning of the test;

t_2 is the room temperature in degrees C at the end of the test; and

k is 234.5 for copper, 225.0 for electrical conductor grade (EC) aluminum; values of the constant for other conductors are to be determined.

22.5 With respect to 22.4, the value of r_2 measured at shutdown may be determined by taking several resistance measurements at short intervals, beginning as quickly as possible after the instant of shutdown. A curve of the resistance values versus time may be plotted and extrapolated to determine r_2 at shutdown.

22.6 The referee method of measuring the temperature of a coil is the thermocouple method; but temperature measurements by either the thermocouple or resistance method are acceptable; except that the thermocouple method is not to be employed at any point where supplementary insulation is employed. When thermocouples are used in the determination of temperatures in connection with the heating of electrical devices, it is common practice to employ thermocouples consisting of No. 30 AWG (0.05 mm^2) iron and constantan wires and a potentiometer type of instrument. Such equipment is to be used whenever referee temperature measurements by thermocouples are necessary.

22.7 A motor/controller combination shall be subjected to the Temperature Test of 23.5. The motor shall be tested with the load at 25, 50, 75, 100, 125, and 150 percent of rated current. The temperatures in 22.2 shall not be exceeded for loads at or below 100 percent of rated current. When provided, a protective device shall not operate. For loads over 100 percent, there shall be no indication of a risk of fire or shock. When provided, a protective device is allowed to operate. When a speed control is part of the controller, the speed shall be adjusted to 25, 50, 75, and 100 percent of rated speed.

22.7 added February 7, 2001

22A Continuity of Grounding Circuit Test

22A.1 The resistance shall be not more than 0.1 ohm between any point required to be grounded, as specified in 21A.1, and the point to which the grounding conductor of the power-supply is connected.

22A.1 added March 26, 1996

22A.2 The resistance is able to be determined by any convenient method, except that when the results obtained do not meet the intent of the requirement, either a direct- or alternating-current, equal to the current rating of the maximum-current-rated branch-circuit overcurrent-protective device employed with the motor, is to be passed from the equipment grounding terminal to the dead metal part. The resulting drop in potential is to be measured between these two points. The resistance in ohms is to be determined by dividing the drop in potential in volts by the current in amperes passing between the two points.

22A.2 added March 26, 1996

22B Rating

22B.1 A motor shall be loaded to its rated load (horsepower or torque). A motor capable of operating at a range of speeds is to be tested at the lowest possible speed, at an intermediate speed, and at the highest speed.

22B.1 added February 7, 2001

22B.2 The current shall not exceed the maximum rated current marked on the motor by more than 10 percent.

22B.2 added February 7, 2001

23 Auxiliary Switch Tests

23.1 General

23.1.1 The requirements in 23.1.2 – 23.5.1 are to be applied to an auxiliary switch that has been assigned a rating or an intended use by the manufacturer.

23.1.2 The performance of an auxiliary switch having a resistive rating shall be investigated by subjecting a representative sample to the tests described in 23.1.3 – 23.5.1. Unless otherwise specified, one sample shall be used through out all the tests.

23.1.3 The test sequence for an auxiliary switch shall be temperature, overload, endurance and dielectric voltage withstand. The temperature test may be conducted on a separate sample.

23.1.4 During the overload and endurance tests, an auxiliary switch shall be mounted and wired so that actual service conditions will be represented, and shall be connected to a load and to a supply circuit the voltage of which is within 5 percent of the rated voltage of the switch. The capacity of the test circuit shall be such that the potential across the load will have the required value when the switch under test is closed on the circuit with the required test current flowing. The rate of cycling the switch for the overload and endurance tests shall be 6 to 10 cycles of operation per minute except that a different rate may be used if agreeable to those concerned.

23.2 Overload test

23.2.1 An auxiliary switch shall be operated for 50 cycles of operation, making and breaking the required test current. The test current for a switch having a resistive rating shall be 150 percent of the rated current of the switch, and the cycling shall be accomplished by allowing the motor to come to full running speed and then to a complete stop.

23.3 Endurance test

23.3.1 When an auxiliary switch is subjected to the endurance test described in 23.3.2, there shall be no electrical or mechanical breakdown of the switch nor any undue burning or pitting of the contacts. At the conclusion of the test, the switch shall be capable of performing its normal function and shall show no undue wear, loosening of parts, or any other defects that will appreciably diminish the usefulness and reliability of the device.

23.3.2 An auxiliary switch is to be operated by means of the motor actuating member for 6000 cycles, making and breaking rated current of the switch while connected to a load and to a supply circuit the voltage of which is within 5 percent of the rated voltage of the switch. The cycling shall be accomplished by allowing the motor to come to full running speed and then to a complete stop.

23.4 Dielectric voltage-withstand test

23.4.1 An auxiliary switch shall withstand for 1 minute without breakdown the application of a 60 hertz essentially sinusoidal potential between live parts and dead metal parts. The test is to be conducted immediately following the endurance test. The test potential shall be based on either the rating assigned to the switch or the rating of the motor in which it is provided, whichever is higher, and shall be:

a) For a rating of 1/2 horsepower (373 watts) or less, 250 volts or less, 1000 volts; and

b) For any other rating, 1000 volts plus twice the rated voltage.

23.4.2 To determine whether a switch complies with the requirement in 23.4.1, the switch is to be tested by means of a 500 volt-ampere or larger transformer, the output voltage of which is essentially sinusoidal and can be varied. The applied potential is to be increased from zero until the required test value is reached, and is to be held at that value for 1 minute. The increase in the applied potential is to be at a substantially uniform rate and as rapid as is consistent with its value being correctly indicated by a voltmeter.

Exception: A 500 volt-ampere or larger capacity transformer need not be used if the transformer is provided with a voltmeter to measure directly the applied output potential.

23.5 Temperature test

23.5.1 An auxiliary switch shall carry its maximum rated current continuously without exceeding the temperature rises specified in Table 23.1.

Table 23.1
Maximum intended temperature rises

Table 23.1 revised December 26, 1997

Parts	Degrees C	Degrees F
Laminated contacts	50	90
Terminals	50	90
Solid contacts	65	117

23A Start Switch Tests

23A.1 General

23A.1.1 A start switch on a thermally protected motor shall be subjected to the running-heating test, the locked rotor test, and the locked rotor endurance test specified in the Standard for Overheating Protection for Motors, UL 2111. The results are determined to comply when the switch is operational after the test.

Exception: The running-heating test is not required to be performed when the motor is marked "T.P.L." or "Thermally Protected L."

23A.1.1 revised December 26, 1997

23A.2 Temperature test

23A.2.1 One motor sample with the start switch mounted as intended is to be subjected to the start switch test described in 23A.2.2 – 23A.2.4.

23A.2.1 revised November 24, 1999

23A.2.2 Thermocouples are to be attached to the following locations:

a) The motor winding;

b) The start switch components that dissipate maximum heat during operation; and

c) The hottest printed circuit board location, where applicable.

23A.2.2 added May 17, 1996

23A.2.3 The motor is to be energized at a test potential as indicated in Table 22.1 and loaded to the maximum rated load until constant temperatures are obtained.

Exception: The manufacturer is not prohibited from requesting to have the test conducted at a higher temperature, up to the temperature rating of the insulation class used in the motor being tested. When a motor series is being evaluated, the test is to be conducted on the most enclosed model in the motor series.

23A.2.3 added May 17, 1996

23A.2.4 The measured temperatures of components shall not attain a temperature at any point sufficiently high to:

a) Constitute a risk of fire;

b) Adversely affect any materials used in the motor;

c) Exceed the temperature rating of the individual materials or components; or

d) Exceed the maximum temperature rises of mechanical switch components, as specified in Table 23.1.

23A.2.4 added May 17, 1996

23A.3 Solid state start switch component failure test

23A.3.1 The solid state switch is to be mounted on the motor sample as intended in service. The fault condition is to be implemented while the motor is energized and before a single start.

23A.3.1 added May 17, 1996

23A.3.2 The fault condition is to consist of a single capacitor, triac, or other solid state component being short- or open-circuited. Only one condition of simulated malfunction or breakdown is to be imposed at a time.

23A.3.2 added May 17, 1996

23A.3.3 For the purpose of the test, the enclosure is to be connected to ground through a 3-ampere non-time delay fuse.

23A.3.3 added May 17, 1996

23A.3.4 There shall be no emission of flame or molten metal, nor ignition of cotton that is loosely placed around an open motor or over all the openings of a ventilated motor. The 3-ampere fuse connected between the enclosure and ground shall not open during the test.

23A.3.4 added May 17, 1996

23A.4 Start switch endurance test

23A.4.1 One sample of the start switch is to be subjected to a minimum of 100,000 cycles of endurance operation.

23A.4.1 added May 17, 1996

23A.4.2 When a motor is intended for a specific application, the number of cycles is to be increased as necessary.

23A.4.2 added May 17, 1996

23A.4.3 A 3-ampere non-time delay fuse is to be connected between the enclosure and ground.

23A.4.3 added May 17, 1996

23A.4.4 For a group of motors with different ratings, the switch shall be tested based on the ratings of the worst case condition, which includes highest voltage, highest current, and highest horsepower ratings.

Exception: When the switch is restricted for use with a specific motor, it is only required to be tested for use with that motor.

23A.4.4 added May 17, 1996

23A.4.5 The switch is to be cycled once every 10 seconds (1 second ″on,″ and 9 seconds ″off″) or at a rate based on the motor characteristics. Cycle rate is expressed in terms of number of seconds the motor is energized (″on″), versus the number of seconds it is de-energized (″off″).

23A.4.5 added May 17, 1996

23A.4.6 The motor test potential is to be in accordance with Table 22.1.

23A.4.6 added May 17, 1996

23A.4.7 There shall be no electrical or mechanical malfunction and the fuse shall not open during testing.

23A.4.7 added May 17, 1996

24 Resilient Rubber Mounting Tests

24.1 General

24.1.1 A means of electrical bonding that depends upon a resilient motor mounting for reliability shall be sufficiently resistant to deterioration to comply with the requirements in 24.2.1 – 24.7.1. See 24.1.2.

24.1.2 If a motor is intended for use in a specialized application in which weather, atmospheric conditions, contaminants, or the like may cause deterioration of the means for bonding, these factors are to be considered and may necessitate evaluation in addition to that required by 24.1.1.

24.2 Overcurrent test

24.2.1 The requirements in 24.2.2 – 24.2.4 apply if a resilient mounting is relied upon to retain a bonding member in place, whether or not the bonding member is in contact with the resilient material. The test current shall not result in:

a) A voltage drop through the bonding path exceeding the value specified in Table 24.1;

b) Softening or melting of the resilient material or damage to the connection – see 24.2.11; or

c) Molten metal or burning rubber falling on the surface supporting the sample.

24.2.2 The bonding system shall be tested as described in 24.2.4 both before and after the conditioning described in 24.5.2. The results shall comply with the requirements in 24.2.1.

24.2.3 The bonding system shall be tested as described in 24.2.4 after the conditioning described in 24.5.1.

24.2.4 Other than as noted in 24.2.6, a current equal to twice the current rating or setting of the intended branch-circuit overcurrent-protective device shall be passed through the bonding path for the time specified in Table 21.2.

24.2.5 Other than as noted in 24.2.6, if a bonding member is secured by being clamped between a resilient mounting and a metal part, the bonding connection shall comply with the requirement in 24.2.1; and shall also perform acceptably, both before and after being conditioned in accordance with 24.5.2 and 24.6.1, as specified in 24.2.4 and 24.2.11 with a current flowing through the connection equal to:

a) 110 percent of the current rating or setting of the intended branch-circuit overcurrent-protective device – see Table 24.1 – for 7-1/2 hours; and

b) 135 percent of the current rating or setting of the intended branch-circuit overcurrent-protective device – see Table 24.1 – for the time specified in Table 21.2.

24.2.6 If the rating or setting of the intended branch-circuit overcurrent-protective device is less than four times the full-load-current rating of the motor, the test current is to be selected from Table 24.1 using that value in column 1 that is equal to or next greater than four times the full-load-current rating of the motor.

24.2.7 A separate set of three samples is to be subjected to each of the tests required by 24.2.2 – 24.2.5.

24.2.8 The samples are to be supported on a softwood surface that is covered with two layers of white tissue paper.

24.2.9 The tests may be conducted at any convenient voltage, using either an alternating or a direct potential.

Table 24.1
Overcurrent test currents and maximum voltage drops for bonding connections

Ampacity of intended branch-circuit overcurrent-protective device[a,b]	Percent of ampacity of branch-circuit overcurrent-protective device and test current, amperes			Maximum voltage drop
	110	135	200	
15	16.5	20.2	30.0	1.5
20	22.0	27.0	40.0	2.0
25	27.5	33.8	50.0	2.5
30	33.0	40.5	60.0	3.0
35	38.5	47.5	70.0	3.5
40	44.0	54.0	80.0	4.0
45	49.5	60.8	90.0	4.5
50	55.0	67.5	100.0	5.0
60	66.0	81.0	120.0	6.0
70	77.0	94.5	140.0	7.0
80	88.0	108.0	160.0	8.0
90	99.0	121.5	180.0	9.0
100	110.0	135.0	200.0	10.0
110	121.0	148.5	220.0	11.0
125	137.5	168.8	250.0	12.5
150	165.0	202.5	300.0	15.0
175	192.5	236.2	350.0	17.5
200	220.0	270.0	400.0	20.0
225	247.5	303.8	450.0	22.5
250	275.0	337.5	500.0	25.0
300	330.0	405.0	600.0	30.0
350	385.0	472.5	700.0	35.0
400	440.0	540.0	800.0	40.0
450	495.0	607.5	900.0	45.0
500	550.0	675.0	1000.0	50.0
600	660.0	810.0	1200.0	60.0

[a] A bonding connection may also be tested for use with an overcurrent-protective device of higher rating. The maximum acceptable voltage drop is to be calculated by multiplying the rating of the overcurrent-protective device by 0.1 ohm.

[b] The value in column 1 to be used in selecting the test current is to be whichever of the following is higher:

a) The ampacity of the intended branch-circuit overcurrent-protective device, or

b) That value equal to or next higher than four times the current rating of the motor.

24.2.10 The voltage drop through the bonding path is to be measured between a point on the motor frame and a point on the mounting base that are not less than 1/16 inch (1.6 mm) from the connection of the bonding member.

24.2.11 Discoloration is acceptable if there is no loss of mechanical strength of the connection.

24.3 Limited short circuit test

24.3.1 A bonding connection shall withstand the appropriate short-circuit current specified in Table 24.2, both before and after being conditioned in accordance with 24.5.2 and 24.6.1, when tested in series with a fuse as described in 24.3.2. The results of the test are acceptable if there is:

a) No ignition of the cotton described in 24.3.4 or other manifestation of a risk of fire,

b) The bonding member is undamaged, and

c) The connections are found to be intact by means of an ohmmeter or by an equivalent test for continuity.

Table 24.2
Limited-short-circuit-test currents

Horsepower (W output)	Rating of motor in volts and test current in amperes	
	0 – 250	251 – 600
1/2 (373) or less	200	1000
More than 1/2 – 1 (746)	1000	1000
More than 1 – 3 (2238)	2000	5000
More than 3 – 7-1/2 (5595)	3500	5000
More than 7-1/2 – 50 (37300)	5000	5000
More than 50	10000	10000

24.3.2 The test fuse specified in 24.3.1 shall be a nonrenewable cartridge fuse having a current rating at least four times the full-load-current rating of the motor or equal to the current rating setting of the intended branch-circuit overcurrent-protective device, whichever is higher, but shall not be less than 20 amperes for a motor rated 150 volts or less, and not less than 15 amperes for a motor rated 151 – 600 volts. A test fuse rated 15 or 20 amperes shall be a time-delay fuse. A test fuse rated more than 20 amperes shall be a nontime-delay fuse.

24.3.3 The power factor of the test circuit is to be 0.9 – 1.0, unless a lower power factor is agreeable to those concerned. The circuit capacity is to be measured with the bonding connection in the circuit.

24.3.4 The bonding connection is to be loosely draped with untreated surgical cotton.

24.3.5 Three samples of the bonding connection are to be subjected to the limited-short-circuit tests. Each sample is to be tested until ultimate results occur.

24.3.6 With reference to 24.3.1, a fuse of higher rating may be specified by the manufacturer if required for the end-use equipment. In some applications, the combined full-load current of the motor and other simultaneous load or loads may necessitate that the test be conducted using a circuit of higher capacity. Such tests are to be conducted in accordance with 24.3.1 – 24.3.5 except that cheesecloth may replace the cotton indicator specified in 24.3.4. The cheesecloth is to be bleached cotton cloth running 14 – 15 square yards per pound (approximately 26 – 28 square meters per kilogram) and having what is known to the trade as a count of 32 by 28, that is, for any square inch, 32 threads in one direction and 28 threads in the other direction (for any square centimeter, 13 threads in one direction and 11 in the other direction).

24.3.7 Unless a cotton indicator is used for the test described in 24.3.6, it is not considered representative of the tests described in 24.2.9 – 24.3.2 that is required for a motor intended to be used as a single load.

24.4 Humidity conditioning test

24.4.1 After being conditioned as described in 24.4.2, a bonding member shall remain reliably secured in place as determined by visual inspection. See 24.2.3.

24.4.2 Six complete samples of a motor, with resilient mountings assembled in the intended manner, are to be conditioned for 720 hours at a temperature of 35°C (95°F) and a relative humidity of 100 percent.

24.5 Oven conditioning test

24.5.1 After being conditioned as described in 24.5.2 and 24.6.1:

a) A bonding member shall remain reliably secured in place, and

b) A resilient mounting shall not be visibly cracked when examined using 7-power magnification.

24.5.2 A number of samples sufficient for a separate set of three samples to be used for each applicable test required by 24.2.4, 24.2.5, 24.3.1, and 24.3.6 and for the examination required by 24.5.1 are to be conditioned for 720 hours in an air-circulating oven. Each sample is to be complete, and is to have the resilient mounting assembled in the intended manner. The oven is to be maintained at the temperature specified in Table 24.3.

Table 24.3
Temperatures, oven conditioning

Maximum temperature of resilient mounting during normal operation		Conditioning temperature	
°C	°F	°C	°F
60 or less	140 or less	90	194
61 – 80	142 – 176	110	230
81 – 100	178 – 212	130	266
101 – 120	214 – 248	150	302

24.6 Ozone conditioning test

24.6.1 A number of samples sufficient for a separate set of three samples to be used for each applicable test required by 24.2.4, 24.2.5, 24.3.1, and 24.3.6 and for the examination required by 24.5.1 are to be conditioned. Each sample is to be complete, and is to have the resilient mounting assembled in the intended manner. The samples are to be conditioned for 24 hours in an atmosphere free of ozone. They are then to be conditioned for 70 hours in a test chamber regulated to maintain an ozone concentration of 1 part per million and a temperature of 50°C (122°F).

24.7 Oil conditioning test

24.7.1 The material of a resilient mounting shall not swell more than 25 percent or shrink more than 5 percent when samples are immersed for 70 hours at room ambient in IRM immersion oil 903. The change in volume is to be determined in accordance with the Test Method for Rubber Property – Effect of Liquids, ASTM D471-1996.

24.7.1 revised December 26, 1997

25 Non-Metallic Functional Part Tests

25.1 Mold stress relief

25.1.1 One sample of the complete motor or part is to be placed in a full draft circulating air oven maintained at a uniform temperature of 100°C (212°F). The sample is to remain in the oven for 7 hours. After its careful removal from the oven and return to room temperature, the sample is to be investigated for compliance in accordance with 13.6.

Exception: If the maximum temperature measured under actual operating conditions of the complete motor or part under consideration is known to be less than 60°C (140°F), then the oven temperature can be maintained at 70°C (158°F).

25.2 Locked rotor cycling

25.2.1 A motor sample is to be energized at a test potential as indicated in Table 22.1 with the rotor locked. The motor circuit is to be cycled on and off as quickly as the motor allows. The winding temperatures shall reach the maximum temperature and the minimum temperature shown in Table 25.1, as determined with a thermocouple. The test duration is to be for 18 days with the motor at room temperature at the beginning of the test. The motor enclosure is to be connected to ground through a 3-ampere non-time delay cartridge fuse with voltage rating based on the rating of the motor. As a result, there shall be no softening, cracking, warping or other deformation to result in a reduction in spacings of the nonmetallic part being tested, nor shall the fuse open. Protective devices shall be by-passed. When the motor does not function throughout the test, a different motor shall be chosen, and the test started from the beginning. When a part, such as a capacitor, can be replaced in order for the motor to function, then the test may continue.

25.2.1 revised February 7, 2001

Table 25.1
Locking rotor cycling temperature limits

Table 25.1 revised March 26, 1996

Insulation class	Maximum temperature		Minimum temperature	
	°C	°F	°C	°F
A	175	347	125	257
E	190	374	140	284
B	200	392	150	302
F	225	437	175	347
H	250	482	200	392

26 Strain Relief Test

26.1 Power-supply cord

26.1.1 The strain-relief means provided on a flexible cord shall be tested as described in 26.1.2. The strain relief is not acceptable if, at the point of disconnection of the conductors, there is such movement of the cord to indicate that stress would have resulted on the internal connections.

26.1.2 To determine whether a strain relief complies with the requirement in 26.1.1, the cord connections within the motor are to be disconnected. A 35-pound (16-kg) weight is then to be suspended on the cord and supported for 1 minute by the motor so that the strain-relief means will be stressed from any angle that the construction of the motor permits.

26.2 Interconnecting leads

26.2.1 Each lead or flexible cord provided for wiring to or for interconnection between parts of a motor, for example, motor windings to capacitor, shall be subjected to the test described in 26.1.1 and 26.1.2 except that the pull shall be 20 pounds (89 N). Each lead or cord is to be tested with the 20-pound (9-kg) weight.

Exception: The test is to be waived if the cord or leads are not intended to be exposed in the final application and are only handled when the motor is being installed in an appliance.

26.3 Clamps

26.3.1 For the investigation of a clamp for Types SPT-1, SPT-2, SVT, or SVTO cord specified in 9.2.7, six samples of the clamp that are secured to the cord in the intended manner are to be used. Three samples are to be subjected to the dielectric voltage-withstand and strain-relief tests in the as received condition. Three samples are to be conditioned for 168 hours in an air oven. The oven temperature is to be 100°C or 10°C higher than the temperature rating of the insulation of the cord, whichever is higher. The samples are to comply with the dielectric voltage-withstand test requirements in 23.4.1 and 23.4.2, the value of applied potential being based on the rating of the motor. The potential is to be applied between conductors, and if the clamp is metal the potential is also to be applied between the clamp and all conductors spliced together. After cooling to room temperature, the conditioned samples are to comply with the strain-relief requirement in 26.1.1 or 26.2.1 whichever applies.

27 Conduit Hubs

27.1 A conduit hub not integrally cast with a metal enclosure shall not turn in the enclosure and shall not strip any threads when the torque specified in 27.2 is applied.

27.2 To determine whether a conduit hub complies with the requirement in 27.1, the torque is to be applied to a short length of rigid-metal conduit that has been threaded into the hub of the enclosure in the intended manner. The applied torque is to be 800 pound-inches (90 N·m) for 1/2- and 3/4-inch sizes, 1000 pound-inches (113 N·m) for 1- and 1-1/2-inch sizes, and 1600 pound-inches (180 N·m) for 2-inch and larger sizes.

27A Installation Test

27A.1 When required to determine compliance with 9.1.8.1 and 9.1.9, one sample of the motor is to be installed in accordance with the manufacturer's installation instructions. The terminal compartment shall be capable of accommodating all field wiring conductors and connections.

Added 27A.1 effective February 15, 1999

27B Electrolytic Capacitor Overvoltage Test

27B.1 Three samples of the capacitor, mounted in the usual manner and with cotton placed around openings in the capacitor enclosure, are to be subjected to such overvoltage as to cause breakdown or malfunction.

27B.1 added February 7, 2001

27B.2 When the cotton ingites upon breakdown or malfunction of the capacitor, the results are not in compliance.

27B.2 added February 7, 2001

MANUFACTURING AND PRODUCTION TESTS

28 Dielectric Voltage-Withstand

28.1 Each motor shall withstand without electrical breakdown, as a routine production-line test, the application of a potential at a frequency within the range of 40 – 70 hertz, between the primary wiring, including connected components, and accessible dead metal parts that are likely to become energized.

28.2 The production-line test shall be in accordance with either Condition A or Condition B of Table 28.1.

Table 28.1
Production-line test conditions

Motor rating	Condition A		Condition B	
	Potential, volts	Time, seconds	Potential, volts	Time, seconds
250 volts or less and 1/2 horsepower (373 W output) or less	1000	60	1200	1
More than 250 volts or more than 1/2 horsepower	1000+2V[a]	60	1200+2.4V[a]	1

[a] Maximum rated voltage.

28.3 The motor may be in a heated or unheated condition for the test.

28.3.1 When an on-off switch is provided as an integral part of the motor, the production-line test shall be performed with the switch in the ″on″ position.

28.3.1 added March 26, 1996

28.4 The test shall be conducted when the motor is complete – fully assembled. It is not intended that the motor be unwired, modified, or disassembled for the test.

Exception No. 1: Parts, such as snap covers or friction-fit knobs, that would interfere with performance of the test need not be in place.

Exception No. 2: The test may be performed before final assembly if the test represents that for the completed motor.

Exception No. 3: A motor employing a solid-state component that is not relied upon to prevent electric shock and that can be damaged by the dielectric potential may be tested before the component is electrically connected provided that random sampling of each day's production is tested at the potential specified in Table 28.1. The circuitry may be rearranged for the purpose of the test to reduce the likelihood of solid-state-component damage while retaining representative dielectric stress of the circuit.

28.5 The test equipment shall include a transformer having an essentially sinusoidal output, a means of indicating the test potential, an audible or visual indicator of electrical breakdown, and either a manually reset device to restore the equipment after electrical breakdown or an automatic reject feature of any unacceptable unit.

28.6 If the output of the test equipment transformer is less than 500 volt-amperes, the equipment shall include a voltmeter in the output circuit to directly indicate the test potential.

28.7 If the output of the test equipment transformer is 500 volt-amperes or larger, the test potential may be indicated by a voltmeter in the primary circuit or in a tertiary-winding circuit, by a selector switch marked to indicate the test potential, or for equipment having a single test-potential output, by 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.

28.8 Test equipment, other than that described by 28.5 – 28.7, may be used if found to accomplish the intended factory control.

28.9 During the test, the primary switch is to be in the on position, both sides of the primary circuit of the motor are to be connected together and to one terminal of the test equipment, and the second test-equipment terminal is to be connected to the accessible dead metal.

Exception No. 1: A motor having circuitry – resistive, high-impedance winding, or the like – not subject to excessive secondary-voltage build-up in case of electrical breakdown during the test may be tested with a single-pole primary switch, if used, in the off position, or with only one side of the primary circuit connected to the test equipment when the primary switch is in the on position, or when a primary switch is not used.

Exception No. 2: The primary switch is not required to be in the on position if the testing means applies full test potential between primary wiring and dead metal parts with the switch not in the on position.

29 Continuity

29.1 If a resilient mounting is depended upon for bonding, the manufacturer shall employ a production-line test by which it can be determined that electrical continuity exists in the bonding circuit of the motor.

29.2 For the test described in 29.1, the manufacturer shall test each motor or, if agreeable to those concerned, may use statistical sampling methods.

29A Grounding Continuity Test

29A.1 Each motor that has a power-supply cord having a grounding conductor shall be tested to determine the grounding continuity between the grounding blade of the attachment plug and the accessible dead metal parts of the motor that become energized.

29A.1 added March 26, 1996

29A.2 Only a single test is required to be conducted when the accessible metal specified is conductively connected by design to all other accessible metal.

29A.2 added March 26, 1996

29A.3 Any indicating device, such as an ohmmeter, a battery and buzzer combination, or similar device, is able to be used to determine compliance with the grounding-continuity requirement in 29A.1.

29A.3 added March 26, 1996

MARKING

30 Details

30.1 Each motor, each motor part investigated as a single part, and at least one part of each group of motor parts investigated as a combination shall be marked with a model number, catalog number, or similar identifying designation and with the manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the product may be identified so as to:

a) Make it distinguishable from other motors, parts, and combinations of parts; and

b) If it is produced or assembled at more than one factory, identify it as the product of a particular factory.

30.2 A motor shall be marked to indicate:

a) Rated voltage;

b) Full-load input amperes or watts, or both;

c) Rated full-load speed;

d) Rated temperature rise or the insulation system class;

e) Rated ambient temperature;

f) Time rating, or if it is a continuous duty motor then “Continuous” or “CONT”;

g) Rated horsepower when 1/8 horsepower (93 W) or more;

h) Code letter to indicate locked-rotor amperes in accordance with the National Electrical Code, ANSI/NFPA 70-1999, for an alternating-current motor rated 1/2 horsepower (373 W output) or more;

i) Secondary volts and full-load amperes, when a wound-rotor induction motor;

j) Rated frequency – expressed in one of the following terms: hertz, Hz, cycles per second, cps, cycles/second, c/s, ac-dc, (number of cycles)/dc (for example, 60/dc), or ac only – or direct current; and, for a motor intended for use on a polyphase circuit, number of phases;

k) Winding – straight shunt, stabilized shunt, compound, or series, for a direct-current motor; and

l) Amperes and horsepower at each speed, for a multi-speed motor other than a shaded-pole or a permanent-split-capacitor motor.

Exception: A motor having a diameter of 7 inches (178 mm) or less is only required to be marked to indicate:

a) Rated voltage;

b) Rated frequency – expressed in one of the following terms: hertz, Hz, cycles per second, cps, cycles/second, c/s, ac-dc, (number of cycles)/dc (for example, 60/dc), or ac only – or direct current; and, for a motor intended for use on a polyphase circuit, number of phases; and

c) Other information required to be marked on the motor in the end-use application, such as capacitor rating where the capacitor is not supplied with the motor.

30.2 revised February 7, 2001

30.2.1 A stepper or servo motor shall be marked in accordance with 30.2 (b), (c), (d), and (e). In addition, the motor shall be marked with rated continuous torque and the back emf.

30.2.1 added February 7, 2001

30.3 A motor part, and a combination of motor parts need only be marked as required by 30.1.

30.4 A motor provided with a terminal box or wiring compartment that is intended to be wired in the field shall be marked in readily visible location with the following or the equivalent: "Acceptable for field wiring."

Exception: If the marking on the motor on which the compartment is provided will serve as a means for determining whether the compartment is acceptable for field wiring, the information need not be separately marked on the motor.

30.5 The designation of the insulation system shall be on the motor nameplate, motor part, or provided as part of the motor model designation when the insulation is Class E or higher, or has integral ground insulation.

30.5 added March 26, 1996

30.6 A stepper or servo motor shall be marked to indicate the manufacturer and model number or series of the controller used to control the motor.

30.6 added February 7, 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
Overheating Protection for Motors – UL 2111
Polymeric Materials – Short Term Property Evaluations – UL 746A
Polymeric Materials – Long Term Property Evaluations – UL 746B
Polymeric Materials – Use in Electrical Equipment Evaluations – UL 746C
Polymeric Materials – Fabricated Parts – UL 746D
Quick-Connect Terminals, Electrical – UL 310
Terminal Blocks – UL 1059
Thermal-Links – Requirements and Application Guide – UL 60691

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Subjects 1004A(1004)

12 Laboratory Drive
Research Triangle Park, NC 27709

TO: **Industry Advisory Conference of UL for Electric Motors,**
Electrical Council of Underwriters Laboratories Inc.,
Fire Council of Underwriters Laboratories Inc.,
Subscribers to UL's
Standards Service for Electric Motors, Listees to UL's Recognition Service for Electric Motors

SUBJECT: **Announcement of Effective Date for Field Wiring Compartment Size for Fire Pump Motors**

UL 1004 has been updated to correspond with the 1996 National Electric Code revisions which include the revised requirements for field wiring compartments. The revised requirements in UL 1004 have an effective date of February 15, 1999.

An Outline of Investigation, UL 1004A, was created to identify requirements applicable to fire pump motors. The requirements for field wiring compartment sizes are required to comply with the 1996 NEC requirements for terminal housings.

In order to allow for sufficient time for manufacturers to revise their field wiring compartments, UL announces that an effective date of February 15, 1999 has been established for field wiring compartments for Listing Fire Pump Motors to coincide with the effective date for the corresponding changes in UL 1004.

While the field wiring compartment size requirements now have an effective date of February 15, 1999, manufacturers are encouraged to provide a larger compartment than the present standard size in order to help alleviate the concerns that have been expressed.

The effective date for the field wiring compartment size requirements does not have any effect on the requirements in NFPA 20, the Standard for the Installation of Centrifugal Fire Pumps. According to NFPA 20, all fire pump motors will have to be Listed by January 1, 1998.

This bulletin should be kept with your copy of the outline and standard.

Questions regarding interpretation of requirements should be directed to the responsible UL Staff. Please see Appendix A of this bulletin regarding designated responsibility for the subject product category.

UNDERWRITERS LABORATORIES INC.

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SR:JAH

1004ANN.004

APPENDIX A

DESIGNATED RESPONSIBILITY FOR UL

PRODUCT CATEGORY

PRGY2, ELECTRIC MOTORS

The individuals shown in the following table are involved with the investigation of products covered under the subject category. The Primary Designated Engineer **(shown in UPPERCASE letters)** coordinates the establishment and uniform interpretation of UL requirements applicable to the product category. The Designated Engineers **(shown in lowercase letters)** work with the Primary Designated Engineer to interpret requirements and maintain standards.

Should you have questions regarding the requirements that affect your product, you are encouraged to contact the individual at the office to which you normally submit your products.

The Industry Advisory Conference (IAC) Chairman for the subject category is Lee Hewitt at UL's Northbrook office. The IAC Chairman oversees the significant interpretations made by the Primary Designated Engineer and arbitrates any differences regarding interpretation of UL requirements.

CCN	Office/Subsidiary	Responsible Engineer	Extension
PRGY2	Melville	Darrin Conlon	22872
	Northbrook	BRUCE BOHREN	42017
	RTP	Patricia Harding-Paul	11529
	Santa Clara	Anil Patel	32610

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