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] (mm^2)	Minimum usable volume per power supply conductor, cubic inches (cm^3)[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	$50/10 \times 10^6$	5000	2	1	2
V-2, VTM-2	$50/10 \times 10^6$	5000	2	2	2
V-1, VTM-1	$50/10 \times 10^6$	5000	2	2	3
V-0, VTM-0	$50/10 \times 10^6$	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

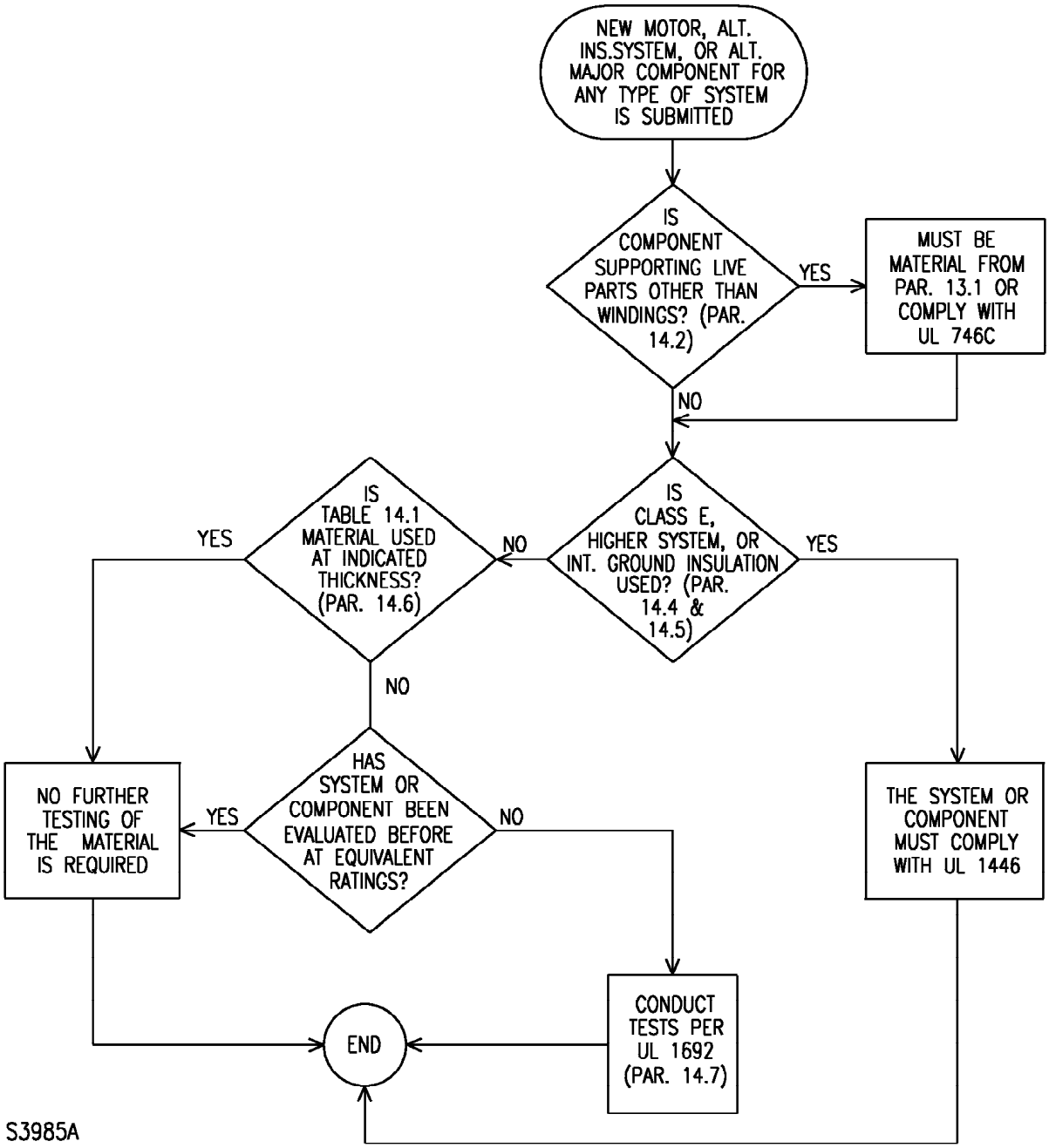
17.1 A non-metallic functional part, the breakdown of which creates a risk of fire, electric shock or injury to persons, shall be subjected to the locked rotor cycling test and the mold stress relief test specified in Section 25, Non-Metallic Functional Part Tests.

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	Minimum spacings			
volts	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.