UL 1812

STANDARD FOR SAFETY

Ducted Heat Recovery Ventilators

UL Standard for Safety for Ducted Heat Recovery Ventilators, UL 1812

Fourth Edition, Dated May 3, 2013

Summary of Topics

This revision to UL 1812 dated May 3, 2022 includes correcting the Impact Test from 5 foot-pounds to 1.5 for non-structural nonmetallic structural parts; 45.10.2

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

The revised requirements are substantially in accordance with Proposal(s) on this subject dated February 21, 2022.

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UL 1812

Standard for Ducted Heat Recovery Ventilators

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Fourth Edition

May 3, 2013

This UL Standard for Safety consists of the Fourth Edition including revisions through May 3, 2022.

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

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INTRODUCTION

1 Scope

1.1 These requirements cover ducted heat recovery ventilators intended to remove air from buildings, replace it with outside air, and in the process transfer heat from the warmer to the colder air. These units are intended to be connected to duct systems that interconnect rooms or spaces within buildings for exhausting the indoor air and/or distributing the outdoor air.

1.2 These requirements cover heat recovery ventilators rated at 600 volts or less, and intended to be installed in ordinary locations in accordance with the National Electrical Code, NFPA 70. These units may also include means for air filtration.

1.3 These requirements apply to heat recovery ventilators employing gas-, oil-, or gas-oil-fired or electric resistance heating means. The requirements for the construction and performance of gas, oil, and gas-oil burners, heat exchangers, electric resistance heaters, and components for the direct control of the utilization of these heating means are to be those included in other applicable standards.

1.4 Heat recovery ventilators are intended for installation in accordance with the Standard for the Installation of Air Conditioning and Ventilating Systems, NFPA 90A, and the Standard for the Installation of Warm Air Heating and Air Conditioning Systems, NFPA 90B.

2 General

2.1 Units of measurement

2.1.1 Unless otherwise indicated, all voltage and current values mentioned in this standard are rms.

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

2.2 Undated references

2.2.1 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.

3 Glossary

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

3.2 BARRIER – A partition for the insulation or isolation of electrical circuits or isolation of electrical arcs.

3.2.1 CAPACITOR, CLASS X – Capacitor or RC unit of a type suitable for use in situations where failure of the capacitor or RC unit would not lead to danger of electrical shock but could result in a risk of fire. Examples would be units connected phase to phase or phase to neutral.

a) X1 capacitors are generally used in circuits of permanently connected appliances. However, if the appliance is provided with a separate surge protective device that limits the impulse voltage to £ 2.5KV, an X2 capacitor is permitted.

b) X2 capacitors are generally used in circuits of cord-connected appliances.

3.2.2 CAPACITOR, CLASS Y – Capacitor or RC unit of a type suitable for use in situations where failure of the capacitor could lead to danger of electric shock. Examples would be capacitors connected across the primary and secondary circuits where electrical isolation is required to prevent an electric shock or between hazardous live parts and accessible parts.

a) Y1 capacitors are used in circuits where the prevention of electric shock is afforded solely by the isolation provided by the capacitor. Two Y2 capacitors connected in series is considered to provide the same level of protection as one Y1 capacitor.

b) Y2 capacitors are used where the prevention of electric shock is provided by the combination of the capacitor and earth ground for circuits operating at voltages ≥ 150V and ≤ 300V.

c) Y4 capacitors are used where the prevention of electric shock is provided by the combination of the capacitor and earth ground for circuits operating at voltages ≤ 150V.

3.3 CONTROL, AUTOMATIC – A control in which at least one aspect is non-manual.

3.4 CONTROL, AUXILIARY – A device or assembly of devices that provides a functional utility, is not relied upon as an operational or protective control, and therefore is not relied upon for safety. For example, an efficiency control not relied upon to reduce the risk of electric shock, fire, or injury to persons during normal or abnormal operation of the end product is considered an auxiliary control.

3.5 CONTROL, MANUAL – A device that requires direct human interaction to activate or rest the control.

3.6 CONTROL, OPERATING – A device or assembly of devices, the operation of which starts or regulates the end product during normal operation. For example, a thermostat, the failure of which a thermal cutout/limiter or another layer of protection would mitigate the potential hazard, is considered an operating control. Operating controls are also referred to as “regulating controls”.

3.7 CONTROL, PROTECTIVE – A device or assembly of devices, the operation of which is intended to reduce the risk of electric shock, fire or injury to persons during normal and reasonably anticipated abnormal operation of the appliance. For example, a thermal cutout/limiter, or any other control/circuit relied upon for normal and abnormal conditions, is considered a protective control. Protective controls are also referred to as “limiting controls” and “safety controls”.

3.8 CONTROL, TYPE 1 – The actuation of an automatic control for which the manufacturing deviation and the drift (tolerance before and after certain conditions) of its operating value, operating time, or operating sequence has not been declared and tested under this standard.

3.9 CONTROL, TYPE 2 – The actuation of an automatic control for which the manufacturing deviation and the drift (tolerance before and after certain conditions) of its operating value, operating time, or operating sequence have been declared and tested under this standard.

3.10 CONTROL CIRCUIT – the circuit that carries the electric signals directing the performance of a controller. A control circuit does not carry the main power current.

3.11 CONTROLLER – A device or group of devices that governs power delivered to a motor or other load in the equipment.

3.12 DIRECT-CONNECTED HIGH-VOLTAGE CONTROL CIRCUIT – A circuit that is supplied from a branch circuit separate from a branch circuit that supplies other loads within the equipment. It is not tapped from the load side of the overcurrent device(s) of the controlled circuit(s) within the equipment.

3.13 ENCLOSURE – That part of a unit which by itself or in conjunction with barriers reduces the risk of contacting all or any parts of the unit that may otherwise present a risk of electric shock or injury to persons and/or prevents propagation of flame initiated by electrical disturbances occurring within.

3.14 FUNCTIONAL PART – A part other than an enclosure or structural part that is necessary for the intended operation of a unit.

3.15 HIGH-VOLTAGE CIRCUIT – A circuit involving a potential of not more than 600 volts and having circuit characteristics in excess of those of a low-voltage circuit.

3.16 LOW-VOLTAGE CIRCUIT – A circuit involving a potential of not more than 30 volts alternating current (42.4 volts peak) or direct current, and supplied by:

a) a primary battery,

b) a Class 2 transformer, or

c) a combination of transformer and fixed impedance which, as a unit, complies with all the performance requirements for a Class 2 transformer.

A circuit derived from a high-voltage circuit by connecting resistance in series with the supply circuit as a means of limiting the voltage and current is not considered to be a low-voltage circuit.

3.17 MANUAL RESET THERMAL PROTECTOR – A device that incorporates a bimetal that is calibrated to open the motor circuit upon reaching a certain temperature and requires manual resetting to reclose the motor circuit.

3.17.1 SAFETY CRITICAL FUNCTION – Control, protection and monitoring functions which are being relied upon to reduce the risk of fire, electric shock or casualty hazards.

3.18 SECONDARY PROTECTION (BACK-UP) PROTECTION – A protector that does not operate under normal running or locked rotor test conditions, without further stress applied to the motor by increased winding temperature, ambient temperature, or voltage.

3.19 SINGLE-OPERATION DEVICE – A device that incorporates a bimetal that is calibrated to open the motor circuit upon reaching a certain temperature and is resettable only by cooling to minus 35°C (minus 31°F), or lower.

3.20 STRUCTURAL PART – A part used in such a manner that failure of the part may present a risk of electric shock or injury to persons.

3.21 TAPPED HIGH-VOLTAGE CONTROL CIRCUIT – A circuit that is tapped within the unit from a circuit supplying one or more loads that are not part of the control circuit.

3.22 THERMAL CUTOFF – A device that incorporates a melting alloy or other material that is calibrated to permanently open the motor circuit upon reaching a certain temperature.

3.23 TOTALLY ENCLOSED MOTOR – A motor that is enclosed to prevent the free exchange of air between the inside and outside of the enclosure for windings but not sufficiently enclosed to be airtight. Drain holes are acceptable.

4 Installation and Operating Instructions

4.1 Installation and operating instructions shall be furnished with units and accessories.

4.2 Instructions are to accompany each unit and accessory, either individually or with each shipment to the installer. If the instructions for the unit do not cover a field installed accessory, instructions are to be furnished with the accessory.

4.3 A copy of the installation and operating instructions or equivalent information is to be furnished with the samples submitted for investigation for use as a guide in the examination and test of the unit. For this purpose, the instructions need not be in final printed form.

4.4 The instructions shall include directions and information deemed by the manufacturer to be adequate for the intended installation, maintenance, and use of the unit, including application information as to mounting. Applicable information as to such quantities as air flow velocity and static pressure shall be made available by the manufacturer.

4.5 If a unit having provision for connection of a fresh air discharge duct does not also have provision for connection of an indoor air intake duct, or if the instructions indicate that an indoor air intake duct need not be connected, the instructions should indicate that applicable installation codes may limit the unit to installation only in a single story residence.

CONSTRUCTION

5 Components

5.1 A component of a product covered by this standard shall:

a) Comply with the requirements for that component;

b) Be used in accordance with its rating(s) established for the intended conditions of use;

c) Be used within its established use limitations or conditions of acceptability; and

d) Additionally comply with the applicable requirements of this end product standard.

Exception No. 1: A component of a product covered by this standard is not required to comply with a specific component requirement that:

a) Involves a feature or characteristic not required in the application of the component in the product,

b) Is superseded by a requirement in this standard, or

c) Is separately investigated when forming part of another component, provided the component is used within its established ratings and limitations.

Exception No. 2: A component complying with a component standard other than those cited in this standard is acceptable if:

a) The component also complies with the applicable component standard; or

b) The component standard:

1) Is compatible with the ampacity and overcurrent protection requirements in the National Electrical Code, NFPA 70, where appropriate;

2) Considers long-term thermal properties of polymeric insulating materials in accordance with the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B, and

3) Any use limitations of the other component standard is identified and appropriately accommodated in the end use application. For example, a component used in a household application, but intended for industrial use and complying with the relevant component standard may assume user expertise not common in household applications.

5.2 Specific components are incomplete in construction features or restricted in performance capabilities. Such components are intended for use only under limited conditions, such as certain temperatures not exceeding specified limits, and shall be used only under those specific conditions.

5.3 A component that is also intended to perform other functions, such as over current protection, ground-fault circuit-interruption, surge suppression, any other similar functions, or any combination thereof, shall comply additionally with the requirements of the applicable standard(s) that cover devices that provide those functions.

Exception: Where these other functions are not required for the application and not identified as part of markings, instructions, or packaging for the appliance, the additional component standard(s) need not be applied.

5.4 A component not anticipated by the requirements of this standard and that involves a potential risk of electric shock, fire, or personal injury, shall be additionally evaluated in accordance with the applicable standard, and shall comply with 5.1(b) – (d).

5.5 With regard to a component being additionally evaluated, reference to construction and performance requirements in another end product standard is appropriate where that standard anticipates normal and abnormal use conditions consistent with the application of this standard.

6 General

6.1 A component of a unit intended to be manually operated or adjusted by the user or that will require periodic servicing by the user, for example, replacement or cleaning, shall be accessible by use of ordinary tools, or without the use of tools. See 6.2.

6.2 With reference to 6.1, ordinary tools are considered to be pliers, flat-bladed and cross-recessed head (Phillips) screwdrivers, and hexagonal-recessed head screw (Allen) wrenches.

6.3 Other than as indicated in 6.4 and 6.5, a unit shall be completely assembled when shipped from the factory.

6.4 If the markings described in 61.8 are provided, a motor, a blower-drive package, a remote or unit mounted control assembly, or a control to be mounted on the outside of the unit may be shipped from the factory separate from the remainder of the unit.

6.5 A louvered panel or grille for indoor air intake or fresh air discharge intended to be installed as part of a unit intended for built-in installation or an enclosure panel that is not required for every intended installation of a unit may be shipped separately if:

a) the unit complies with the performance requirements without the panel or grille installed,

b) markings in accordance with 61.8 are provided, and

c) instructions provided describe installation of the panel or grille.

6.6 Any installation that requires the cutting of wiring or the soldering of connections by the installer is not acceptable. Installations that require cutting, drilling, or welding, are not acceptable in electrical enclosures

and in other areas where such operations may damage electrical components and wiring within the enclosure. In general, a distance of 6 inches (152 mm) from the opening is considered adequate to reduce the risk of damage due to drilling or cutting, but other forms of protection may be acceptable.

6.7 A unit shall be so arranged that condensate from the heat exchanger will not wet uninsulated live parts or film-coated wire.

6.8 A condensate pan shall be designed and located so that overflow due to a blocked drain will not wet uninsulated live parts other than motor windings. See 6.9 and Section 39. Overflowing water also shall not be retained within the enclosure containing electrical parts or wiring.

6.9 A suitably located overflow spout or cutout in the condensate pan may be acceptable for preventing dripping of water on electrical parts.

7 Attachment Plugs, Receptacles, Connectors, and Terminals

7.1 Attachment plugs, receptacles, appliance couplers, appliance inlets (motor attachment plugs), and appliance (flatiron) plugs, shall comply with the requirements in the Standard for Attachment Plugs and Receptacles, UL 498.

Exception: Attachment plugs and appliance couplers integral to cord sets or power supply cords shall comply with the requirements in the Standard for Cord Sets and Power-Supply Cords, UL 817, and need not comply with the Standard for Attachment Plugs and Receptacles, UL 498.

7.2 Quick-connect terminals, both connectors and tabs, for use with one or two 22 – 10 AWG copper conductors, having nominal widths of 0.110, 0.125, 0.187, 0.205, and 0.250 inch (2.8, 3.2, 4.8, 5.2, and 6.3 mm), intended for internal wiring connections in appliances, or for the field termination of conductors to the appliance, shall comply with the requirements in the Standard for Electrical Quick-Connect Terminals, UL 310.

Exception: Other sizes of quick-connect terminals shall be investigated with respect to crimp pull out, insertion-withdrawal, temperature rise, and all tests shall be conducted in accordance with the requirements in the Standard for Electrical Quick-Connection Terminals, UL 310.

7.3 Single and multipole connectors for use in data, signal, control and power applications within and between electrical equipment, and that are intended for factory assembly to copper or copper alloy conductors, or for factory assembly to printed wiring boards, shall comply with the requirements in the Standard for Component Connectors for Use in Data, Signal, Control and Power Applications, UL 1977. See 7.8.

7.4 Wire connectors shall comply with the requirements in the Standard for Wire Connectors, UL 486A-486B.

7.5 Splicing wire connectors shall comply with the requirements in the Standard for Splicing Wire Connectors, UL 486C.

7.6 Equipment wiring terminals for use with all alloys of copper, aluminum, or copper-clad aluminum conductors, shall comply with the requirements in the Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors, UL 486E.

7.7 Terminal blocks shall comply with the requirements in the Standard for Terminal Blocks, UL 1059, and, if used for field wiring connection they shall be rated for field wiring.

7.8 Female devices (such as receptacles, appliance couplers, and connectors) that are intended, or that may be used, to interrupt current in the end product, shall be rated for current interruption of the specific type of load, when evaluated with its mating plug or connector.

8 Protection of Service Personnel

8.1 An uninsulated high-voltage live part and a moving part within the cabinet shall be located, guarded, or enclosed so as to reduce the risk of injury as the result of contact by service personnel performing mechanical service functions that may need to be performed with the unit energized. See 8.2 and 8.3.

8.2 Mechanical service functions that may have to be performed with the unit energized include:

a) adjusting the setting of temperature controls with or without marked dial settings,

b) resetting the control trip mechanism,

c) operating manual switches, and

d) adjusting air flow dampers.

A factory set and sealed control is not considered to be adjustable.

8.3 The requirements in 8.1 are not applicable to mechanical service functions that are not intended to be performed with the equipment energized. Such functions include opening of drain plugs, adjusting or replacing drive belts, replacing components, and the like.

8.4 Other than as indicated in 8.5, an electrical component that may require examination, adjustment, servicing, or maintenance is one of the following: a fuse, an adjustable or resettable overload relay, a manual or magnetic motor controller, a magnetically operated relay, an adjustable or resettable temperature controller, a manual switching device, a clock timer, and an incremental voltage-tap or motor-speed-tap terminals for a variable-speed motor. Such a component in a low-voltage circuit shall comply with the requirements in 8.1 in relation to an uninsulated live part in a high-voltage circuit and to a moving part likely to cause a risk of injury to persons.

8.5 Under certain conditions some of the components referred to in 8.4 are not required to be accessible for service as follows:

a) a nonadjustable magnetic motor controller or a magnetically operated relay that is inaccessible for service while energized because it is located behind subbases and the like and is not visible when the access panel(s) is removed;

b) an enclosed potential or current type single phase motor starting relay; and

c) an incremental voltage tap or a motor speed tap for a variable speed motor that requires contact with a bare live part of the voltage or speed tap to effect the speed or voltage change, such as an uninsulated screw or quick-connect terminal.

8.6 The following are not considered to be uninsulated live parts:

a) coils of controllers, relays, solenoids, and transformer windings, if the coils and windings are provided with insulating overwraps,

b) enclosed motor windings,

c) terminals and splices with insulation, and

d) insulated wire.

9 Enclosures

9.1 General

9.1.1 An enclosure shall be so formed and assembled that it will have the strength and rigidity necessary to resist the abuses to which it may be subjected without total or partial collapse in shipment, installation, and use resulting in reduction of spacings, loosening or displacement of parts, or other defects.

9.1.2 An enclosure for an individual electrical component, an outer enclosure, and a combination of the two are to be considered in determining compliance with the requirement in 9.1.1.

9.1.3 The enclosure of a unit shall be provided with means for mounting in the intended manner. Any unique fittings necessary for such mounting shall be shipped with the unit. Other than as indicated in 9.1.4, a freestanding, floor supported unit need not be provided with mounting means. See also 9.9.2.

9.1.4 A unit designed for installation in a mobile home shall have provision for securing it in place.

9.1.5 The enclosure of a unit shall not have any projections likely to cause persons to trip when walking near the unit after it is installed in the intended manner.

9.1.6 An outer cabinet is to be judged with respect to the size, shape, thickness of metal, and its acceptability for the particular application. Sheet steel having a thickness of less than 0.020 inch (0.51 mm) if uncoated, or 0.023 inch (0.58 mm) if galvanized, or nonferrous sheet metal having a thickness of less than 0.023 inch shall not be used except for relatively small areas or for surfaces that are curved or otherwise reinforced.

9.1.7 Among the factors that are taken into consideration when judging the acceptability of a polymeric enclosure or an enclosure of magnesium are:

a) flame resistance,

b) mechanical strength,

c) resistance to impact,

d) moisture absorptive properties, and

e) resistance to distortion at temperatures to which the material may be subjected under conditions of normal or abnormal usage.

For a polymeric enclosure all of these factors are considered with respect to aging. See Polymeric and Other Nonmetallic Materials, Section 12.

9.2 Enclosure thickness

9.2.1 Sheet metal that serves as an electrical enclosure shall comply with Table 9.1 or Table 9.2, whichever applies, except that if the:

a) location of the enclosure,

b) design and location of components, or

c) the strength and rigidity of the frame and enclosure are adequate to comply with 9.1.1, an enclosure thinner than specified in Table 9.1 and Table 9.2 may be employed. See 9.4.1.

Table 9.1
Minimum thickness of sheet metal for electrical enclosures – carbon steel or stainless steel

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness in inches (mm)			
Maximum width,[b]		Maximum length,[c]		Maximum width,[b]		Maximum length,					
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)	Uncoated (MSG)		Metal coated (GSG)	
4.0	(10.2)	Not limited		6.25	(15.9)	Not limited		0.020[d]	(0.51)	0.023[d]	(0.58)
4.75	(12.1)	5.75	(14.6)	6.75	(17.1)	8.25	(21.0)	(24)		(24)	
6.0	(15.2)	Not limited		9.5	(24.1)	Not limited		0.026[d]	(0.66)	0.029[d]	(0.74)
7.0	(17.8)	8.75	(22.2)	10.0	(25.4)	12.5	(31.8)	(22)		(22)	
8.0	(20.3)	Not limited		12.0	(30.5)	Not limited		0.032	(0.81)	0.034	(0.86)
9.0	(22.9)	11.5	(29.2)	13.0	(33.0)	16.0	(40.6)	(20)		(20)	
12.5	(31.8)	Not limited		19.5	(49.5)	Not limited		0.042	(1.07)	0.045	(1.14)
14.0	(35.6)	18.0	(45.7)	21.0	(53.3)	25.0	(63.5)	(18)		(18)	
18.0	(45.7)	Not limited		27.0	(68.6)	Not limited		0.053	(1.35)	0.056	(1.42)
20.0	(50.8)	25.0	(63.5)	29.0	(73.7)	36.0	(91.4)	(16)		(16)	
22.0	(55.9)	Not limited		33.0	(83.8)	Not limited		0.060	(1.52)	0.063	(1.60)
25.0	(63.5)	31.0	(78.7)	35.0	(88.9)	43.0	(109.2)	(15)		(15)	
25.0	(63.5)	Not limited		39.0	(99.1)	Not limited		0.067	(1.70)	0.070	(1.78)
29.0	(73.7)	36.0	(91.4)	41.0	(104.1)	51.0	(129.5)	(14)		(14)	
33.0	(83.8)	Not limited		51.0	(129.5)	Not limited		0.080	(2.03)	0.084	(2.13)
38.0	(96.5)	47.0	(119.4)	54.0	(137.2)	66.0	(167.6)	(13)		(13)	
42.0	(106.7)	Not limited		64.0	(162.6)	Not limited		0.093	(2.36)	0.097	(2.46)
47.0	(119.4)	59.0	(149.9)	68.0	(172.7)	84.0	(213.4)	(12)		(12)	
52.0	(132.1)	Not limited		80.0	(203.2)	Not limited		0.108	(2.74)	0.111	(2.82)
60.0	(152.4)	74.0	(188.0)	84.0	(213.4)	103.0	(261.6)	(11)		(11)	
63.0	(160.0)	Not limited		97.0	(246.4)	Not limited		0.123	(3.12)	0.126	(3.20)
73.0	(185.4)	90.0	(228.6)	103.0	(261.6)	127.0	(322.6)	(10)		(10)	

[a] A supporting frame is a structure of angle or channel or a folded rigid section of sheet metal which is rigidly attached to and has essentially the same outside dimensions as the enclosure surface and which has sufficient torsional rigidity to resist the bending moments which may be applied via the enclosure surface when it is deflected. Construction that is considered to have equivalent reinforcing may be accomplished by designs that will produce a structure which is as rigid as one built with a frame of angles or channels. Construction considered to be without supporting frame includes:

1. single sheet with single formed flanges (formed edges),
2. a single sheet which is corrugated or ribbed, and
3. an enclosure surface loosely attached to a frame, for example, with spring clips.

[b] The width is the smaller dimension of a rectangular sheet metal piece which is part of an enclosure. Adjacent surfaces of an enclosure may have supports in common and be made of a single sheet.

[c] For panels which are not supported along one side, for example, side panels of boxes, the length of the unsupported side shall be limited to the dimensions specified unless the side in question is provided with a continuous flange at least 1/2 inch (12.7 mm) wide.

[d] Sheet steel for an enclosure intended for outdoor use shall comply with the requirements for Outdoor Use Equipment.

Table 9.2
Minimum thickness of sheet metal for electrical enclosures – aluminum, copper, or brass

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness inches (mm) AWG	
Maximum width[b]		Maximum length[c]		Maximum width[b]		Maximum length			
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)		
3.0	(7.6)	Not limited		7.0	(17.8)	Not limited		0.023[d]	(22)
3.5	(8.9)	4.0	(10.2)	8.5	(21.6)	9.5	(24.1)	(0.58)	
4.0	(10.2)	Not limited		10.0	(25.4)	Not limited		0.029	(20)
5.0	(12.7)	6.0	(15.2)	10.5	(26.7)	13.5	(34.3)	(0.74)	
6.0	(15.2)	Not limited		14.0	(35.6)	Not limited		0.036	(18)
6.5	(16.5)	8.0	(20.3)	15.0	(38.1)	18.0	(45.7)	(0.91)	
8.0	(20.3)	Not limited		19.0	(48.3)	Not limited		0.045	(16)
9.5	(24.1)	11.5	(29.2)	21.0	(53.3)	25.0	(63.5)	(1.14)	
12.0	(30.5)	Not limited		28.0	(71.1)	Not limited		0.058	(14)
14.0	(35.6)	16.0	(40.6)	30.0	(76.2)	37.0	(94.0)	(1.47)	
18.0	(45.7)	Not limited		42.0	(106.7)	Not limited		0.075	(12)
20.0	(50.8)	25.0	(63.5)	45.0	(114.3)	55.0	(139.7)	(1.91)	
25.0	(63.5)	Not limited		60.0	(152.4)	Not limited		0.095	(10)
29.0	(73.7)	36.0	(91.4)	64.0	(162.6)	78.0	(198.1)	(2.41)	
37.0	(94.0)	Not limited		87.0	(221.0)	Not limited		0.122	(8)
42.0	(106.7)	53.0	(134.6)	93.0	(236.2)	114.0	(289.6)	(3.10)	
52.0	(132.1)	Not limited		123.0	(312.4)	Not limited		0.153	(6)
60.0	(152.4)	74.0	(188.0)	130.0	(330.2)	160.0	(406.4)	(3.89)	

[a] A supporting frame is a structure of angle or channel or a folded rigid section of sheet metal which is rigidly attached to and has essentially the same outside dimensions as the enclosure surface and which has sufficient torsional rigidity to resist the bending moments which may be applied via the enclosure surface when it is deflected. Construction that is considered to have equivalent reinforcing may be accomplished by designs that will produce a structure which is a rigid as one built with a frame of angles or channels. Construction considered to be without supporting frame includes:

1. single sheet with single formed flanges (formed edges),
2. a single sheet which is corrugated or ribbed, and
3. an enclosure surface loosely attached to a frame, for example, with spring clips.

[b] The width is the smaller dimension of a rectangular sheet metal piece which is part of an enclosure. Adjacent surfaces of an enclosure may have supports in common and be made of a single sheet.

[c] For panels which are not supported along one side, for example, side panels of boxes, the length of the unsupported side shall be limited to the dimensions specified unless the side in question is provided with a continuous flange at least 1/2 inch (12.7 mm) wide.

[d] Sheet copper, brass, or aluminum for an enclosure intended for outdoor use shall comply with the requirements for Outdoor Use Equipment.

9.2.2 With reference to 9.2.1(a), the surface of an enclosure that will be protected from damage, such as by being mounted against a duct, may not be less than 0.020 inch (0.51 mm) if uncoated steel, not less than 0.023 inch (0.58 mm) if galvanized steel, not less than 0.036 inch (0.91 mm) if aluminum, and not less than 0.033 inch (0.84 mm) if copper or brass, unless a lesser thickness would be acceptable in accordance with Table 9.1 and Table 9.2.

9.2.3 With reference to 9.2.1(b), the surface of an enclosure may be:

a) two gage sizes less than indicated in Table 9.1 and Table 9.2 if the electrical components are located at least 2-1/2 inches (64 mm) from the surface, and

b) four gage sizes less if the components are located at least 5 inches (128 mm) from the surface.

The thickness shall not be less than No. 24 MSG or GSG (steel) or 18 AWG (aluminum, copper, or brass) unless a lesser thickness would be acceptable in accordance with Table 9.1 and Table 9.2. An example of two gage sizes less is No. 18 MSG instead of No. 16 MSG. An example of four gage sizes less is No. 20 MSG instead of No. 16 MSG.

9.2.4 With reference to 9.2.1(c), consideration is to be given to the degree of deflection or distortion that may affect the results contemplated by the requirements in 9.1.1.

9.3 Doors and covers

9.3.1 Except as indicated in 9.3.2 and 9.3.3, the door or cover of an enclosure shall be hinged:

a) if it gives access to any fuse, circuit-breaker handle, or manually resettable lever of a temperature control in other than a low-voltage circuit, and

b) if uninsulated live parts are exposed during the replacement of the fuse or resetting of the manually resettable device.

Such a door or cover shall also be provided with an automatic latch or the equivalent, and, if live parts other than the screw shell of a plug fuseholder are exposed inside the enclosure, shall be provided with a captive screw or equivalent means, requiring the use of a tool to open, and to reliably secure the door or cover in place. See 9.3.4 and 9.3.5.

9.3.2 A hinged cover is not required for a device in which the only fuses enclosed are:

a) control circuit fuses, provided the fuses and control circuit loads (other than a fixed control circuit load, such as a pilot lamp) are within the same enclosure, or

b) an extractor type fuse with its own enclosure that is accessible without exposing live parts other than a fuse contact of the fuseholder.

9.3.3 The removable portion of a fused pullout switch that complies with the requirements in 9.1.1 and 9.1.2, 9.1.6 – 9.2.4, 9.3.7, and 9.3.8 is considered to be an acceptable cover for the fuseholder and need not comply with the requirements in 9.3.1.

9.3.4 A spring latch, a magnetic latch, a dimple, or other mechanical arrangement that will hold the door closed and would require some effort on the user's part to open is considered to provide the "automatic latching means" for holding the door closed as required in 9.3.1.

9.3.5 A cover interlocking mechanism that:

a) must be engaged in the closed position of the cover before any uninsulated live part is energized, and

b) will secure the cover in the closed position, if provided as the sole means for securing the door or cover closed, is considered to comply with the requirement for an automatic latch in 9.3.1.

9.3.6 A screw with a knurled and slotted head (for securing with a screwdriver) and that can be manually turned is not acceptable as a required enclosure securing means.

9.3.7 A door or cover giving direct access to fuses in other than a low-voltage circuit shall shut closely against a 1/4 inch (6.4 mm) rabbet or the equivalent, or shall have either turned flanges for the full length

of four edges or angle strips fastened to it. Flanges and angle strips shall fit closely with the outside of the wall of the box proper and shall overlap the edges of the box no less than 1/2 inch (12.7 mm).

Exception: A construction that affords equivalent protection or a combination of flange and rabbet is acceptable.

9.3.8 A strip used to provide a rabbet and an angle strip fastened to the edges of a door shall be secured:

a) at no less than two points,

b) no more than 1-1/2 inches (38 mm) from each end of each strip, and

c) at points between these end fastenings no more than 6 inches (152 mm) apart.

9.4 Field wiring system connections

9.4.1 Sheet metal to which a wiring system is to be connected in the field shall have a thickness not less than:

a) 0.032 inch (0.81 mm) if uncoated steel,

b) 0.034 inch (0.86 mm) if galvanized steel, and

c) 0.045 inch (1.14 mm) if nonferrous material.

9.4.2 If threads for the connection of conduit are tapped all the way through a hole in an enclosure wall or if an equivalent construction is employed, there shall not be less than three or more than five threads in the metal. The construction of the device shall be such that a conduit bushing can be attached.

9.4.3 If threads for the connection of conduit are not tapped all the way through a hole in an enclosure wall, conduit hub, or the like, there shall not be less than 3-1/2 threads in the metal. There shall be a smooth, rounded inlet hole for the conductors that shall afford protection to the conductors equivalent to that provided by a standard conduit bushing and that shall have an internal diameter approximately the same as that of the corresponding trade size of rigid conduit.

9.4.4 A knockout in a sheet metal enclosure shall be capable of being removed without deformation of the enclosure that would affect the intended attachment of a conduit fitting.

9.4.5 A knockout shall remain in place when a force of 10 pounds (44 N) is applied at right angles to the knockout by a 1/4 inch (6.4 mm) diameter mandrel with a flat end. The mandrel shall be applied at the point most likely to cause movement of the knockout.

9.4.6 A knockout shall be provided with a flat surrounding surface for seating of a conduit bushing and shall be so located that installation of a bushing at any knockout likely to be used during installation will not result in spacings between uninsulated live parts and the bushing less than those specified in Table 34.1 or Table 34.2, as applicable.

9.4.7 In 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 dimension indicated in Table 9.3 is in place, in conjunction with a single locknut on the outside of the enclosure.

Table 9.3
Knockout or hole sizes and dimensions of bushings

Trade size of conduit		Knockout or hole diameter		Bushing dimensions			
				Overall diameter		Height	
Inches	mm OD	Inches	mm	Inches	mm	Inches	mm
1/2	21.3	7/8	22.2	1	25.4	3/8	9.5
3/4	26.7	1-3/32	27.8	1-15/64	31.4	27/64	10.7
1	33.4	1-23/64	34.5	1-19/32	40.5	33/64	13.1
1-1/4	42.3	1-23/32	43.7	1-15/16	49.2	9/16	14.3
1-1/2	48.3	1-31/32	50.0	2-13/64	56.0	19/32	15.1
2	60.3	2-15/32	62.7	2-45/64	68.7	5/8	15.9
2-1/2	73.0	3	76.2	3-7/32	81.8	3/4	19.1
3	88.9	3-5/8	92.1	3-7/8	98.4	13/16	20.6
3-1/2	101.6	4-1/8	104.8	4-7/16	112.7	15/16	23.8
4	114.0	4-5/8	117.5	4-31/32	126.2	1	25.4
4-1/2	127.0	5-1/8	130.2	5-35/64	140.9	1-1/16	27.0
5	141.3	5-5/8	142.9	6-7/32	158.0	1-3/16	30.2
6	168.3	6-3/4	171.5	7-7/32	183.4	1-1/4	31.8

9.5 User servicing

9.5.1 Uninsulated high-voltage live parts of a unit shall be located, guarded, or enclosed so as to reduce the likelihood of unintentional contact by persons performing operations such as oiling motors, replacing filters, or adjusting controls. See 61.1.

9.5.2 A rubber or neoprene boot over the terminal of a motor capacitor that is accessible during user servicing:

a) shall not be less than 1/32 inch (0.8 mm) thick,

b) shall resist thermal degradation, and

c) shall incorporate means to secure the boot in place, such as a molded lip that fits over the flange of the capacitor case.

9.5.3 Fan blades, blower wheels, pulleys, belts, and the like, shall be enclosed or guarded to reduce the risk of injury to persons. See 9.5.4 – 9.5.8.

9.5.4 The degree of protection required in 9.5.3 depends upon the general design and the intended use of the unit. Factors to be taken into consideration in judging the acceptability of protection against contact with moving parts are:

a) the degree of exposure afforded by intended locations in use,

b) the sharpness of the moving parts,

c) the likelihood of unintentional contact with the moving parts,

d) the speed of movement, and

e) the likelihood of fingers, arms, or clothing being drawn into the moving parts (such as at points where gears mesh, where belts travel onto a pulley, or where moving parts close in a pinching or shearing action).

9.5.5 An interlocking mechanism that operates to disconnect power to the drive motor when the cover or panel is removed or opened for access to moving parts is considered to provide the protection required by 9.5.3.

9.5.6 The requirement in 9.5.3 will ordinarily necessitate that an opening in the required guard or enclosure around a moving part comply with Table 9.4.

Table 9.4
Size of openings

Straight line distance to moving part from external plane of opening, inches (mm)		Maximum diameter rod that will pass through the opening, inches (mm)	
2	(50.8) or less	1/4	(6.4)
6	(152) or less (but greater than 2)	1/2	(12.7)
15	(381) or less (but greater than 6)	1	(25.4)

9.5.7 If the starting or restarting of a motor driving a moving part such as described in 9.5.3 is provided by an automatic cycling device such as a thermostat, thermal protector, or the like, a guard shall be provided if the part is exposed when making normal operating adjustments or changing air filters or if the part is accessible without requiring the use of tools.

9.5.8 With reference to 9.5.7, the scroll of a centrifugal blower is an acceptable guard for a blower wheel.

9.6 Electrical components

9.6.1 Other than as indicated in 9.6.2, an opening in the enclosure of a unit or in an externally mounted component shall be located so that it will not vent into a concealed space of a building structure, such as a false ceiling space, a hollow space in the wall, and the like, when installed as intended.

9.6.2 The requirement in 9.6.1 does not apply to an opening for a mounting screw or nail or for a manufacturing operation (such as paint drainage) if the opening has no dimension more than 17/64 inch (6.8 mm) or an area no more than 0.055 square inch (35.5 mm^2).

9.6.3 Other than as noted in 9.6.4, an opening for ventilation in an enclosure, other than in the bottom, shall be provided with one or more baffles to reduce the risk of emission of flame, molten metal, burning insulation, or the like, from the unit.

9.6.4 In a compartment other than one that houses a motor overload relay or overcurrent protective device, such as a fuse or circuit breaker, the baffles mentioned in 9.6.3 may be omitted if:

a) No ventilating opening in a vertical wall is more than 3/8 inch (9.5 mm) in width, or

b) The unit is so constructed that it is suitable for the purpose, as shown by an investigation, including short-circuit tests.

9.6.5 Panelboards shall comply with the requirements in the Standard for Panelboards, UL 67.

9.7 Accessibility of uninsulated live parts, film-coated wire, and moving parts

9.7.1 To reduce the likelihood of unintentional contact that may involve a risk of electric shock from uninsulated live parts or film-coated wire, or injury to persons from a moving part, an opening in the outer enclosure shall comply with either (a) or (b):

a) For an opening that has a minor dimension (see 9.7.5) less than 1 inch (25.4 mm), such a part or wire shall not be contacted by the probe illustrated in Figure 9.1.

b) For an opening that has a minor dimension of 1 inch or more, such a part or wire shall be spaced from the opening as specified in Table 9.5.

Exception: A motor need not comply with these requirements if it complies with the requirements in 9.7.2.

Figure 9.1

Articulate probe with web stop

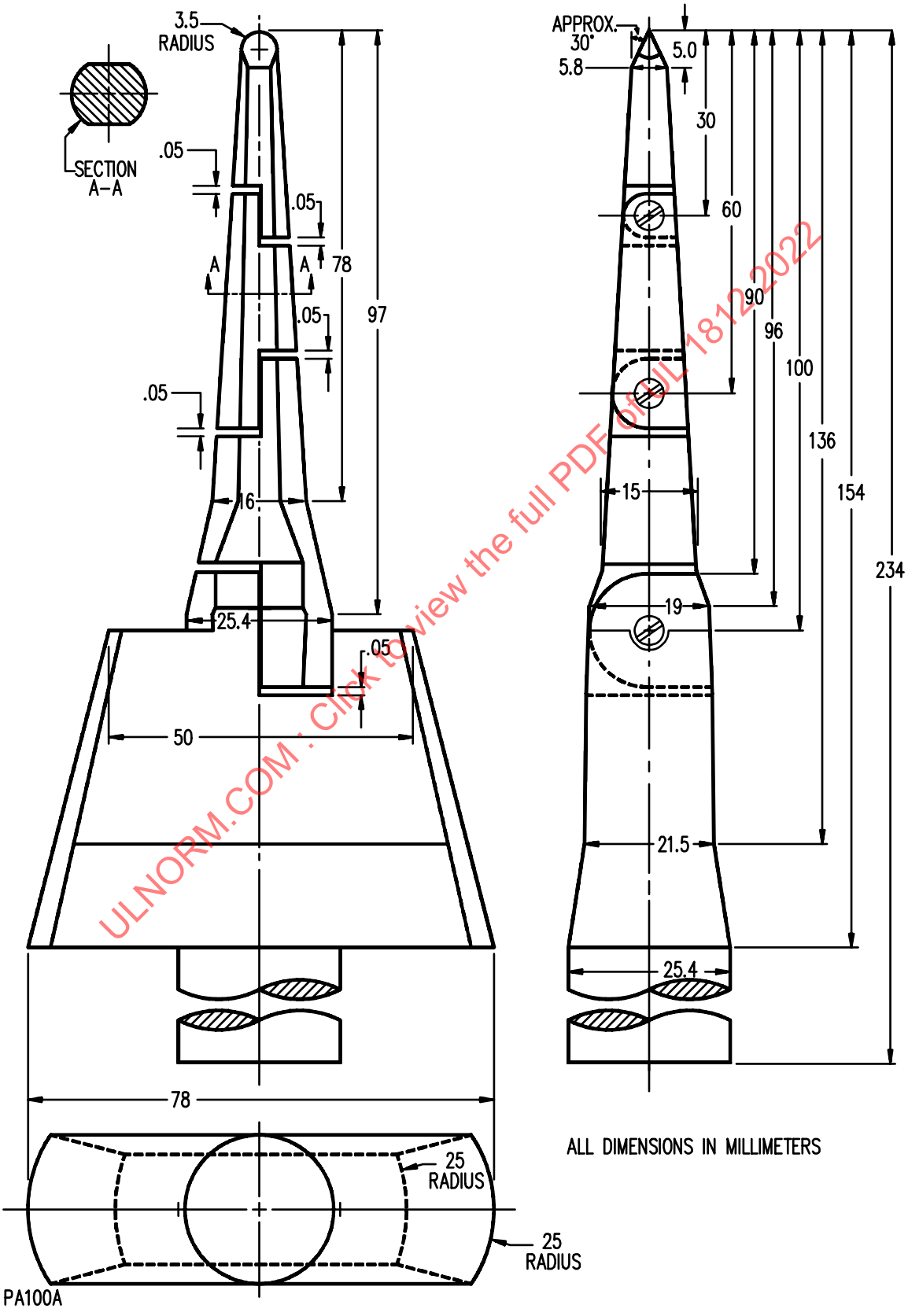


Table 9.5
Minimum acceptable distance from an opening to a part that may involve a risk of electric shock or injury to persons

Minor dimension of opening[a],		Minimum distance from opening to part,	
inches[b]	(mm)[b]	inches[b]	(mm)[b]
3/4[c]	(19.1)	4-1/2	(114.0)
1[c]	(25.4)	6-1/2	(165.0)
1-1/4	(31.8)	7-1/2	(190.0)
1-1/2	(38.1)	12-1/2	(318.0)
1-7/8	(47.6)	15-1/2	(394.0)
2-1/8	(54.0)	17-1/2	(444.0)
d		30	(762.0)

[a] See 9.7.5.
[b] Between 3/4 and 2-1/8 inches, interpolation is to be used to determine a value between values specified in the table.
[c] Any dimension less than 1 inch applies to a motor only.
[d] More than 2-1/8 inches, but not more than 6 inches (152.0 mm).

9.7.2 With respect to a part or wire as mentioned in 9.7.1, in an integral enclosure of a motor as mentioned in the exception to 9.7.1:

a) An opening that has a minor dimension (see 9.7.5) less than 3/4 inch (19.1 mm) is acceptable if:

1) A moving part cannot be contacted by the probe illustrated in Figure 9.2;

2) Film-coated wire cannot be contacted by the probe illustrated in Figure 9.3;

3) In a directly accessible motor (see 9.7.6), an uninsulated live part cannot be contacted by the probe illustrated in Figure 9.4; or

4) In an indirectly accessible motor (see 9.7.6), an uninsulated live part cannot be contacted by the probe illustrated in Figure 9.2.

b) An opening that has a minor dimension of 3/4 inch or more is acceptable if a part or wire is spaced from the opening as specified in Table 9.5.

Figure 9.2

Probe for moving parts and uninsulated live parts

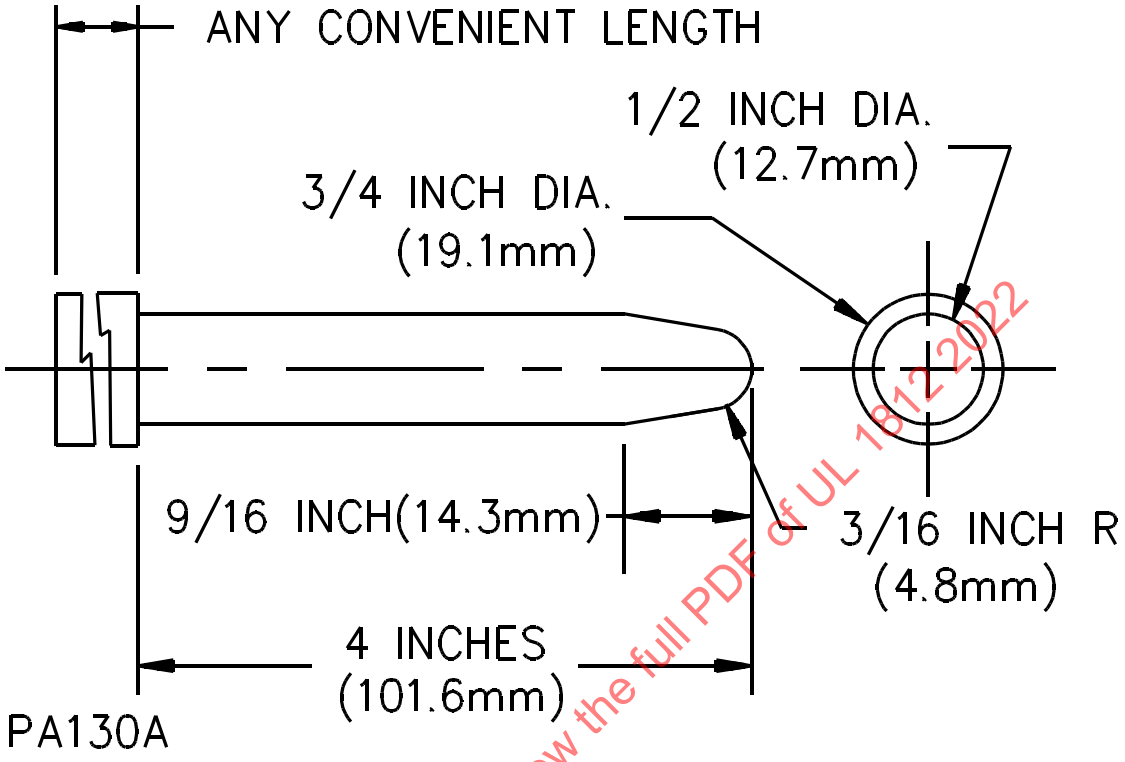


Figure 9.3

Probe for film-coated wire

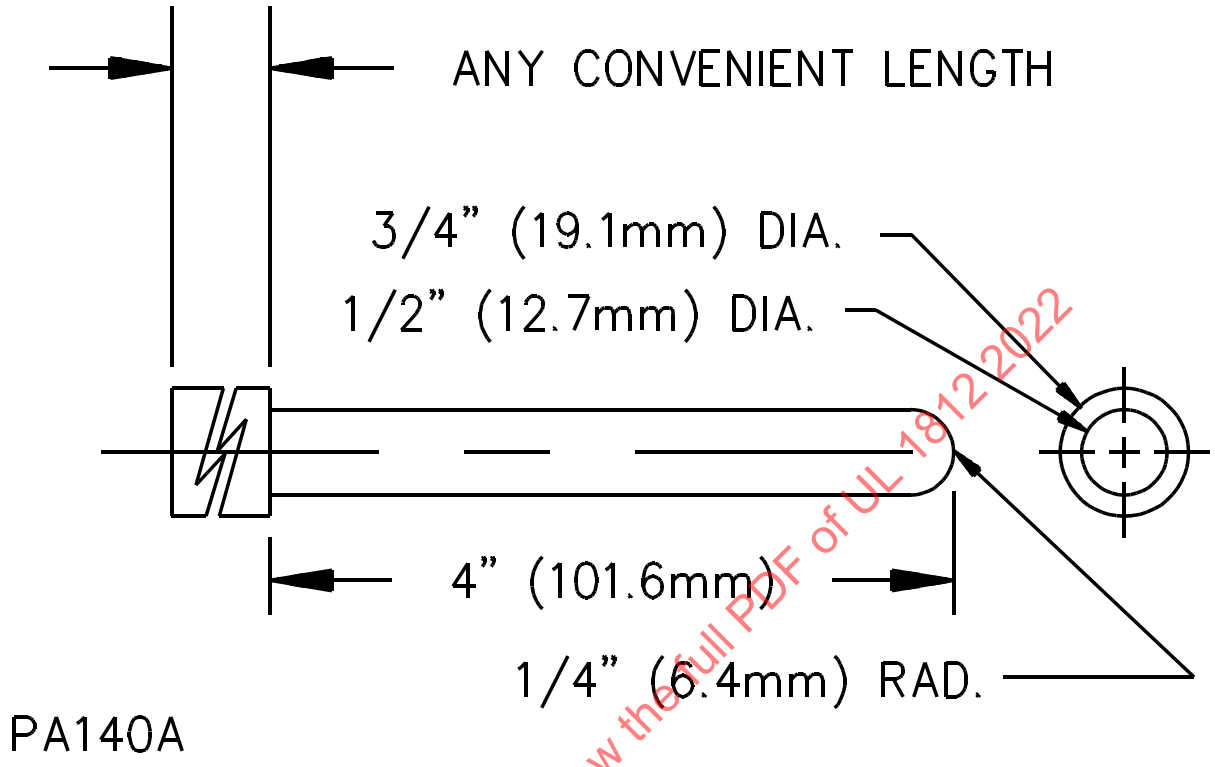
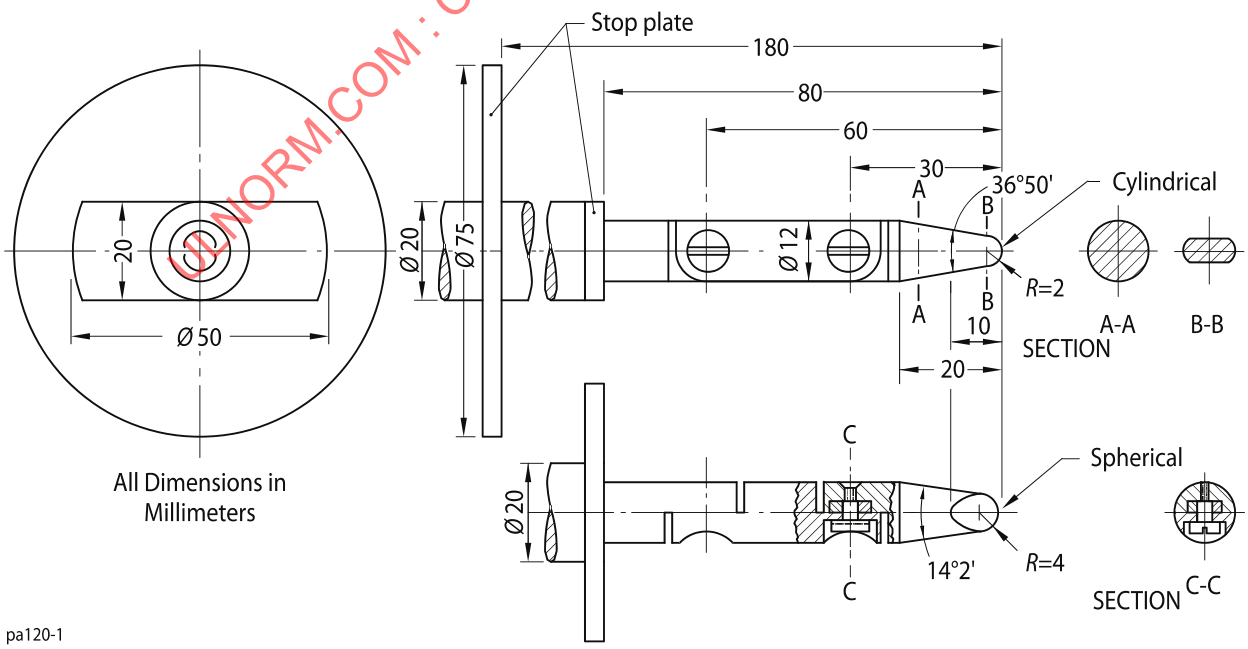


Figure 9.4

IEC articulate probe



9.7.3 The probes mentioned in 9.7.1 and 9.7.2 and illustrated in Figure 9.1 – Figure 9.4 are to be applied to any depth that the opening will permit; and are to be rotated or angled before, during, and after insertion through the opening to any position that is necessary to examine the enclosure. The probes illustrated in Figure 9.1 and Figure 9.4 are to be applied in any possible configuration; and, if necessary, the configuration is to be changed after insertion through the opening.

9.7.4 The probes mentioned in 9.7.1 and 9.7.2 are to be used as measuring instruments to judge the accessibility provided by an opening, and not as instruments to judge the strength of a material; they are to be applied with the minimum force necessary to determine accessibility.

9.7.5 With reference to the requirements in 9.7.1 and 9.7.2, the minor dimension of an opening is the diameter of the largest cylindrical probe having a hemispherical tip that can be inserted through the opening.

9.7.6 With reference to the requirements in 9.7.2, an indirectly accessible motor is a motor:

a) that is accessible only by opening or removing a part of the outer enclosure, such as a guard or panel, that can be opened or removed without using a tool, or

b) that is located at such a height or is otherwise guarded or enclosed so that it is unlikely to be contacted.

A directly accessible motor is a motor that can be contacted without opening or removing any part or that is located so as to be accessible to contact.

9.7.7 During the examination of a product to determine whether it complies with the requirements in 9.7.1 or 9.7.2, an air filter and a part of the enclosure that may be opened or removed by the user without using a tool (to attach an accessory, to make an operating adjustment, or for other reasons) is to be opened or removed.

9.7.8 With reference to the requirements in 9.7.1 and 9.7.2, insulated brush caps are not required to be additionally enclosed.

9.8 Bottom closure

9.8.1 An enclosure shall reduce the risk of molten metal, burning insulation, flaming particles, or the like, from falling onto flammable materials, including the surface upon which a unit is supported. See 9.6.3, 9.6.4, and 9.8.2 – 9.8.8.

9.8.2 All intended mounting positions of a unit are to be considered in determining if the unit complies with the requirements in 9.8.1.

9.8.3 An acceptable bottom closure is considered to be provided if the bottom opening is always intended to be connected to a fresh air discharge duct or an indoor intake air duct and:

a) the unit includes space-heating means (electric, hot water, or steam), or

b) the unit is intended only for nonresidential applications and a marking as specified in 60.13 is provided.

9.8.4 An air filter is not acceptable as part of the bottom closure or as a barrier.

9.8.5 Other than as indicated in 9.8.3, the requirement in 9.8.1 will necessitate that a nonflammable bottom closure with no openings be provided for a unit or a compartment thereof that contains:

a) Opening wiring (that is, wiring that is not separately and immediately enclosed in conduit, metal clad cable, metal raceway, or the like); or

b) An electrical component (other than a motor) that is not individually and completely enclosed, other than terminals.

Exception: This requirement does not apply if it can be shown that failure of the component would not result in a risk of fire.

9.8.6 With reference to 9.8.5(a), a channel or trough under the wiring is acceptable as a bottom closure if:

a) The wires do not project through the plane of the top of the trough or channel; and

b) If judged as film-coated wire, the wiring would be acceptable in accordance with 9.7.1 and 9.7.2.

9.8.7 The requirement in 9.8.1 will necessitate the use of a barrier of metal or a material classed 5V in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, under an open type motor unless:

a) The structural parts of the motor or unit, such as the bottom closure, provide the equivalent of such a barrier;

b) An overload protective device provided with a motor is such that no burning insulation or molten material falls to the surface that supports the unit when the motor is energized under each of the following fault conditions applicable to the motor:

1) Open main winding,

2) Open starting winding,

3) Starting switch short-circuited,

4) Capacitor of a permanent-split-capacitor motor short-circuited, while the rotor is locked; or

c) The motor is provided with a thermal motor protector (a protective device that is sensitive to temperature and current) that will prevent the temperature of the motor windings from exceeding 125°C (257°F) under the maximum load under which the motor will run without causing the protector to cycle, and from exceeding 150°C (302°F) with the rotor of the motor locked.

9.8.8 The barrier specified in 9.8.7 shall:

a) be horizontal,

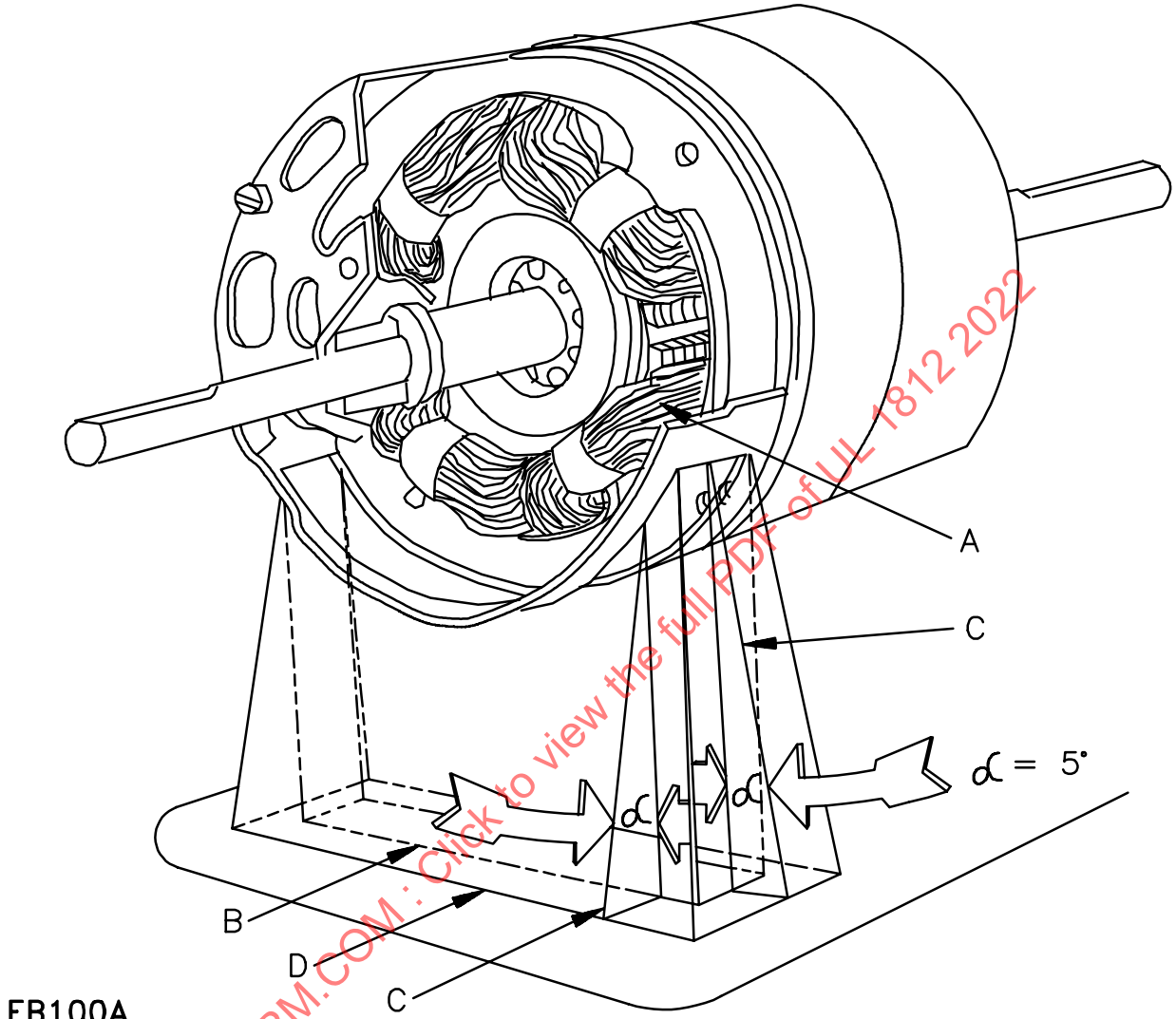
b) be located as indicated in Figure 9.5, and

c) have an area not less than that illustrated in Figure 9.4.

Openings for drainage, ventilation, and the like, may be employed in the barrier, provided that such openings would not permit molten metal, burning insulation, or the like, to fall on flammable material.

Figure 9.5

Location and extent of barrier



A – Motor winding to be shielded by barrier. This is to consist of the entire motor winding if it is not otherwise shielded, and is to consist of the unshielded portion of a motor winding that is partially shielded by the motor enclosure or equivalent.

B – Projection of outline of motor winding on horizontal plane.

C – Inclined line which traces out minimum area of the barrier. When moving, the line is to be always (1) tangent to the motor winding, (2) 5 degrees from the vertical, and (3) so oriented that the area traced out on a horizontal plane is maximum.

D – Location (horizontal) and minimum area for barrier. The area is to be that included inside the line of intersection traced out by the inclined line C and the horizontal plane of the barrier.

9.8.9 The assembly shall be so arranged that fuses can be replaced and manually reset devices can be reset without removing parts other than a service cover or panel.

9.9 Through-the-floor installation

9.9.1 A unit designed for connection to a duct that penetrates the building structure that supports the unit shall be provided with a mounting base of metal or other nonflammable material so designed that after the unit is installed, there will be no open passages through the supporting structure that would permit flame or hot gases from a fire originating in the space below that supporting structure to travel to the space above that structure. If the unit is intended to be installed on a supporting structure of combustible material, the base shall be constructed so that the requisite clearance will be maintained between the supporting structure and the unit, plenum, and attached duct, spacers necessary to provide required clearances shall be integral, attached to the unit mounting base, and shall extend not less than 3 inches (76 mm) below the upper surface of the supporting structure.

Exception: The distance for spacers in a unit intended for use only in a mobile home shall not be less than 3/4 inch (19.1 mm).

9.9.2 The unit mounting base specified in 9.9.1 may be furnished as a separate member or members and need not be shipped with the unit if not needed for every intended installation.

9.9.3 The surface of the unit mounting base in contact with the mounting surface shall have no projections. A screw or rivet that penetrates that surface of the unit shall be flathead or recessed.

9.9.4 If a unit is so designed that it can be installed in the field with an air duct attached at any of several locations (bottom, one or more sides, or the like), a complete enclosure shall be provided except for an opening required at a position where the duct may be attached.

9.9.5 The requirement in 9.9.4 will necessitate provision of either:

a) removable panels that can be moved to obtain the opening at the desired location or

b) an area with complete enclosure that can be cut, as required, to permit attachment of the air duct.

10 Protection Against Corrosion

10.1 Other than as noted in 10.2 and 10.3, a ferrous part shall be protected against corrosion by enameling, galvanizing, plating, or other equivalent means if the deterioration of such an unprotected part would be likely to cause a risk of fire, electric shock, or injury to persons.

10.2 If the oxidation of ferrous metal due to exposure to air and moisture is not likely to be appreciable, thickness or metal and temperature also being factors, surfaces of sheet steel and cast iron parts within an enclosure may not be required to be protected against corrosion.

10.3 The requirement in 10.1 does not apply to bearings, laminations, or minor parts of iron or steel, such as washers, screws, and the like, unless such parts are relied upon to maintain a permanent grounding bond. See Bonding for Grounding, Section 16.

11 Materials in Air-Handling Compartments

11.1 Thermal or acoustic insulating material shall be securely positioned where loosening reduces or blocks air flow that causes temperatures in excess of those acceptable in the temperature test or where loosening results in the reduction of electrical spacings below the required values, short-circuiting, or

grounding. Leading edges of insulation shall be protected against damage from the effects of the velocity of the moving air.

11.2 A mechanical fastener for each square foot (0.093 m^2) of exposed surface is considered to securely position insulating liners to comply with 11.1. Mechanical fasteners shall be bolts, metal clamps, wire rods, or the equivalent. Butting edges of insulation against bulkheads is considered to provide protection for leading edges against damage from the effects of the velocity of moving air. Rigid or semirigid sheets of insulating material shall not require fastening to the extent required for less rigid material or protection of leading edges when the material possesses inherent resistance to damage.

11.3 An adhesive provided to securely position insulating material to comply with the requirement in 11.1 shall retain its adhesive qualities at any temperature attained by the adhesive when the unit is tested under the performance requirements of this standard and at minus 17.8°C (0°F) for indoor use equipment or minus 28.9°C (minus 20°F) for outdoor use equipment.

11.4 The flame spread index of a material in a compartment handling air intended for circulation through a duct system shall not be over 25 and its smoke developed index shall not be over 50 when tested in accordance with the Standard for Test for Surface Burning Characteristics of Building Materials, UL 723. Alternately, the material shall be evaluated and determined to have a peak normalized optical density of 0.5 or less and an average normalized optical density of 0.15 or less and a peak heat release rate of 100 kW or less when tested in accordance with UL 2043, Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces.

Exception: This requirement does not apply to the following:

a) An air filter that meets the test requirements in UL 900, Air Filter Units, drive belt, electrical insulation, paint as applied for corrosion protection, and tubing of material equivalent to one of the types of wire insulation permitted by this standard.

b) Gaskets forming an air or water seal between metal parts.

c) Miscellaneous small parts such as an insulating bushing, a resilient or vibration mount, a wire tie, a clamp, a label, and a drain line fitting with an exposed surface area not exceeding 25 square inches (0.016 m^2).

d) An adhesive that, when tested in combination with the specific insulating material, complies with the requirement.

e) Heat transfer media, polymeric materials, or other nonmetallic materials that meet the requirements in 12.3.1 or have a flame-spread index not over 200 when tested in accordance with the Standard for Test for Surface Burning Characteristics of Building Materials, UL 723 in a unit marked "FOR RESIDENTIAL INSTALLATION ONLY" or equivalent marking.

f) Heat transfer media that complies with the requirements for air filters in the Standard for Air Filter Units, UL 900. When the Flame-Exposure Test is conducted, only two samples of the media are required to be tested.

g) Polymeric materials in such quantities that their total exposed surface area within the compartment does not exceed 0.93 m^2 (10 ft^2) in accordance with the requirements of 11.5.

11.5 Polymeric materials exempted by Item (g) of 11.4 shall have a flame-spread index of not more than 25, or shall comply with the requirements of the vertical burning test for classifying materials 5V in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

11.6 Exposed unimpregnated asbestos material shall not be used in an air handling compartment. The unprotected edge of a gasket sandwiched between two parts is considered to be exposed.

12 Polymeric and Other Nonmetallic Materials

12.1 General

12.1.1 This section specifies the construction requirements applicable to polymeric and other nonmetallic materials used in a unit. Details of the performance requirements are specified in Section 45.

12.1.2 These requirements apply to a unit intended for indoor use only, having a maximum normal operating temperature on the material that does not exceed 100°C (212°F). See Normal temperature test, Section 38.

12.1.3 The acceptability of polymeric material for use in a unit shall be determined for each application. See Table 12.1 for properties to be evaluated depending on use of the material.

Table 12.1
Evaluation of properties of polymeric materials

Characteristics to be evaluated	Enclosures	Structural parts	Thermal and acoustical insulation	Functional parts
Flammability[a]				
Source of ignition				
External	Yes	Yes	Yes[e]	
Internal	Yes	Yes	Yes	Yes
Heat deflection	Yes	Yes		Yes[b]
Water absorption	Yes	Yes[c]		
Environmental exposure	Yes	Yes		
Air oven aging	Yes	Yes		
Tensile and flexural strength	Yes	Yes		
Izod or tensile impact strength	Yes	Yes		
Impact	Yes	Yes		
Volume resistivity	Yes[d]	Yes[d]	Yes[d]	Yes[d]

[a] A material having a flame-spread rating of no more than 25 when tested in accordance with the Standard for Test for Surface Burning Characteristics of Building Materials, UL 723, is acceptable from a flammability standpoint.

[b] When applicable, see 22.2.8.

[c] When applicable.

[d] When applicable, see 12.1.4.

[e] When the thermal and acoustical insulation is employed on the outside of the enclosure.

12.1.4 For the purpose of evaluating electrical spacings between an uninsulated live part and a polymeric material, the material shall be treated as a metal part unless it complies with the requirements of the Volume resistivity test, 45.11.1 and 45.11.2.

12.1.5 Consideration shall be given to the possibility of external ignition of a nonmetallic outer enclosure and of a structural part.

12.2 Polymeric materials and enclosures

12.2.1 Unless otherwise specified in this end product standard, polymeric electrical insulating materials and enclosures shall comply with the applicable requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

12.2.2 Metallized or painted polymeric parts or enclosures shall comply with the applicable requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

Exception: The requirement is not applicable to exterior surfaces of polymeric enclosure materials or parts provided that the metallized coating or paint does not offer a continuous path for an internal flame to propagate externally.

12.3 Material classification

12.3.1 A polymeric material or other nonmetallic material used in a unit shall have flammability classification of 5V, V-0, V-1, V-2, HF-1, HF-2, HBF, or HB as indicated in Table 12.2.

Table 12.2
Acceptable uses of materials based on flammability classifications

Degree of exposure to ignition source	Type of material					
	HB or HBF	HF-1	HF-2	V-2	V-0 or V-1	5V
Not exposed	Yes	Yes	Yes	Yes	Yes	Yes
Exposed, but isolated as shown in Figure 12.1	No	No[c]	No[a,c]	Yes[a]	Yes	Yes
Exposed	No	No[b,c]	No[b,c]	No[b,c]	No[b,c]	Yes

NOTE – The flammability classifications are in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

[a] May not be used in space A illustrated in Figure 12.1 if there are openings in the enclosure bottom in that space.

[b] Vertically oriented material, when laminated between two metal surfaces each no less than 0.010-inch (0.25 mm) thick, may have an exposed vertical surface no more than 3/8-inch (9.5-mm) wide.

[c] May be used if the only ignition sources are flexible cord or appliance wiring material of the types described in 14.1.17.

12.4 Ignition sources

12.4.1 With reference to 12.5.3, Figure 12.1, and Table 12.2, possible ignition sources within the unit are considered to be wiring in a high-voltage circuit, and any other electrical component such as a switch, relay, transformer, or motor winding not completely enclosed in:

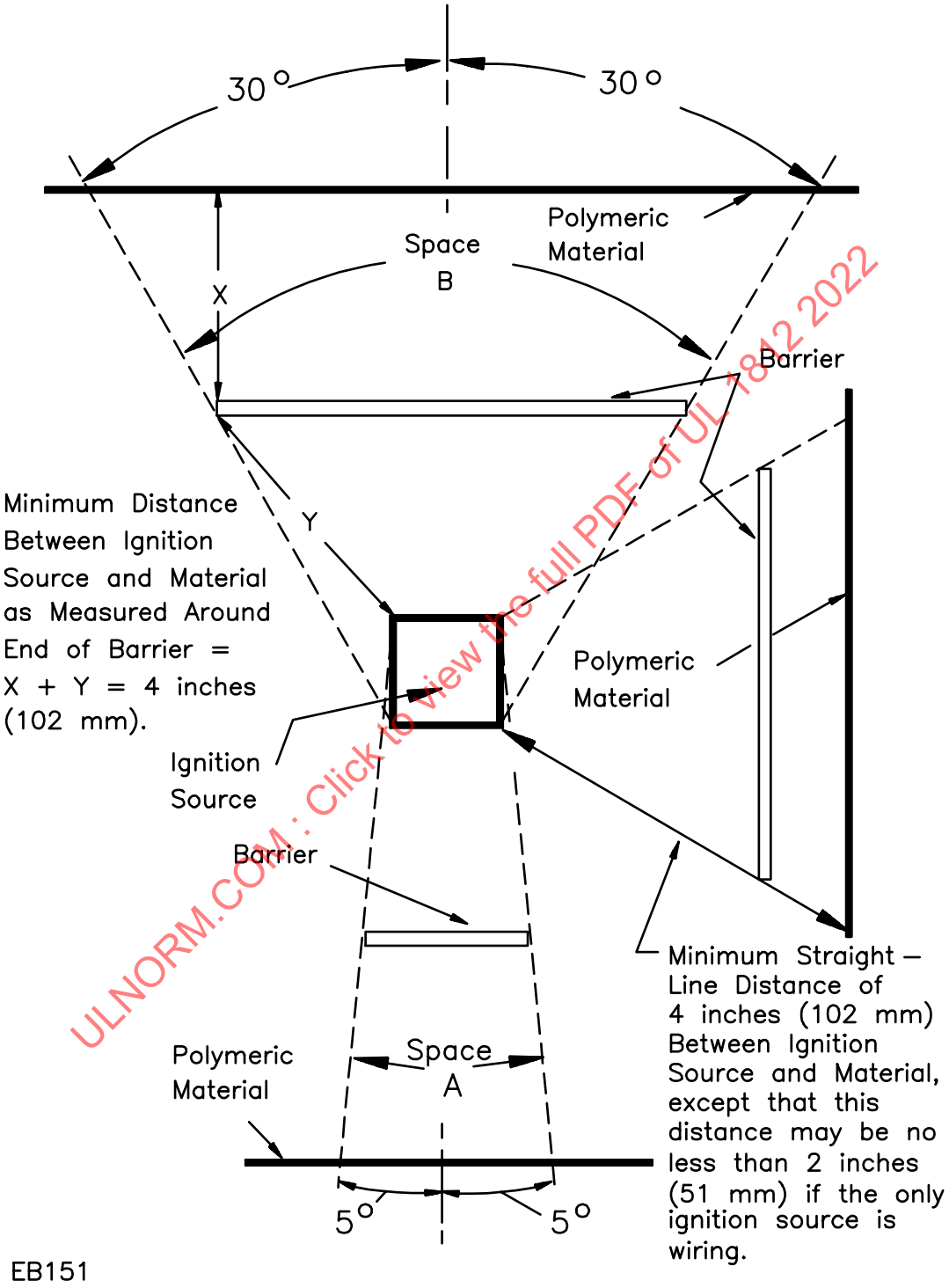
a) metal not less than 0.010 inch (0.25 mm) thick, or

b) 5V polymeric material.

Exception: Wiring need not be isolated as indicated in 12.5.1 – 12.5.4 if it complies with the VW-1 flame test or the vertical flame test described in the Reference Standard for Electrical Wires, Cables, and Flexible Cords, UL 1581.

Figure 12.1

Exposure to ignition source



Space A. Represents the volume below the ignition source determined by a straight line that moves about the ignition source while remaining at an angle of 5 degrees from the vertical and is always so oriented that the volume is a maximum.

Space B. Represents the volume above the ignition source determined in the same manner as Space A, except that the angle is 30 degrees from the vertical.

12.5 Material applications

12.5.1 Material employed for sole or partial support of live parts shall be classed 5V.

12.5.2 A barrier as illustrated in Figure 12.1 shall be of metal or of 5V material, and shall be mechanically secured in place.

12.5.3 The acceptability of an opening in a control compartment, other than that of minimum size for the passage of a control shaft or rod, shall be judged on the basis of the necessity for its existence. On any one surface, the minor dimension of an opening shall not exceed 3/8 inch (9.5 mm) and the maximum area shall not exceed 0.25 square inch (1.61 cm^2) except that this may be increased to a maximum of 1.00 square inch (6.45 cm^2) if a barrier of metal or 5V polymeric material is secured in place and interposed between ignition sources and combustible material. In any case, the maximum aggregate area of all openings in any one surface shall not exceed 1.0 square inch.

12.5.4 With reference to 12.5.3, wiring in the control compartment is to be routed away from any openings that expose the wire to combustible materials. In judging the need for a barrier, consideration is to be given to grouped openings that have an aggregated area exceeding 0.25 square inch (1.61 cm^2).

13 Power Supply Connections

13.1 Permanently connected appliances

13.1.1 An appliance intended for permanent connection to the power supply shall be constructed so that it may be permanently connected electrically to one of the wiring systems that would be acceptable for the appliance in accordance with the National Electrical Code, ANSI/NFPA 70.

13.1.2 In addition to the requirements specified in this standard conduit shall comply with the requirements in the:

a) Standard for Flexible Metal Conduit, UL 1;

b) Standard for Liquid-Tight Flexible Steel Conduit, UL 360;

c) Standard for Electrical Rigid Metal Conduit – Steel, UL 6; or

d) Standard for Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings, UL 651, for conduit, schedule 40 and 80 PVC.

13.1.3 In addition to the requirements specified in this standard fittings for conduit and outlet boxes shall comply with the requirements in the:

a) Standard for Conduit, Tubing and Cable Fittings, UL 514B;

b) Standard for Metallic Outlet Boxes, UL 514A; or

c) Standard for Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers, UL 514C.

13.1.4 In addition to the requirements specified in this standard, electrical metallic tubing – steel (EMT) and elbows for use as a metal raceway for installation of wires and cables shall comply with the requirements in the Standard for Electrical Metallic Tubing – Steel, UL 797.

13.1.5 A knockout, hole, or threaded hub for connection of a conduit field-wiring system to a field-wiring compartment shall accommodate conduit of the trade size determined by applying Table 13.1.

Table 13.1
Trade size of conduit in inches

Wire size		Number of wires				
AWG	(mm^2)	2	3	4	5	6
14	(2.1)	1/2	1/2	1/2	1/2	1/2
12	(3.3)	1/2	1/2	1/2	3/4	3/4
10	(5.3)	1/2	1/2	1/2	3/4	3/4
8	(8.4)	3/4	3/4	1	1	1-1/4
6	(13.3)	3/4	1	1	1-1/4	1-1/4
4	(21.2)	1	1	1-1/4	1-1/4	1-1/2
3	(26.7)	1	1-1/4	1-1/4	1-1/2	1-1/2
2	(33.6)	1	1-1/4	1-1/4	1-1/2	2
1	(42.4)	1-1/4	1-1/4	1-1/2	2	2
1/0	(54.0)	1-1/4	1-1/2	2	2	2-1/2
2/0	(67.0)	1-1/2	1-1/2	2	2	2-1/2
3/0	(85.0)	1-1/2	2	2	2-1/2	2-1/2
4/0	(107.2)	2	2	2-1/2	2-1/2	3
MCM –						
250	(127)	2	2-1/2	2-1/2	3	3
300	(152)	2	2-1/2	3	3	3-1/2
350	(177)	2-1/2	2-1/2	3	3-1/2	3-1/2
400	(203)	2-1/2	3	3	3-1/2	4
500	(253)	3	3	3-1/2	4	4

NOTES –

1. This table is based on the assumption that all conductors will be of the same size and there will be no more than six conductors in the conduit. If more than six conductors will be involved or if all of them are not of the same size, the internal cross-sectional area of the smallest conduit that may be used is determined by multiplying by 2.5 the total cross-sectional area of the wires, based on the cross-sectional area of Type THW wire.

2. Trade size per Standard for Electrical Rigid Steel Conduit, ANSI C80.1.

13.1.6 An opening for the entry of a conductor(s) in a low-voltage circuit shall be provided with an insulating bushing. The bushing may be mounted in place in the opening or may be provided with the unit so that it may be properly mounted when the unit is installed.

13.1.7 A bushing of rubber or rubber-like material provided in accordance with 13.1.6 shall be 1/8 inch (3.2 mm) or more in thickness, however, it may not be less than 3/64 inch (1.2 mm) thick if the metal around the hole is eyeleted or treated to provide smooth edges. A hole in which such a bushing is mounted shall be free from sharp edges, burrs, projections, and the like, that might damage the bushing.

13.1.8 The wiring of a unit may terminate in a length of flexible metal conduit with an outlet box, control box, or equivalent enclosure intended for connection of the appliance to the wiring system specified in 13.1.1. Unless the conduit is terminated in an outlet box, not larger than 4 by 4 by 2 inches (102 by 102 by 51 mm), for splice connections only, locknuts on the fittings are not considered an acceptable means for reducing the risk of loosening of the conduit fittings. A grounding conductor of the size specified by the National Electrical Code, ANSI/NFPA 70, shall be included unless:

a) The total length of flexible metal conduit of any ground return path in the product does not exceed 6 feet (1.82 m);

b) No circuit conductor protected by an overcurrent device rated more than 20 amperes is included; and

c) The conduit is not larger than 3/4 inch trade size, or the fittings are identified as providing grounding.

Exception: The overcurrent device mentioned in (b) may be rated up to 60 amperes if 3/4 to 1-1/4 inch trade size liquidtight flexible metal conduit is used.

13.1.9 With reference to the requirement specified in 13.1.1, an appliance intended for permanent attachment to a building structure or a duct-connected appliance shall be provided with means for permanent electrical connection to the power supply.

Exception: An appliance need not be provided with a means for permanent electrical connection if it is provided with a power-supply cord that:

a) Is at least 18 inches (0.5 m) and not more than 6 feet (1.83 m) long,

b) Has three conductors, one being an equipment-grounding conductor,

c) Is Type S, SJ, SJO, SJT, SO, SP-3, SPT-3, or ST,

d) Is permanently attached to the appliance, and

e) Complies with the requirements in 13.3.1.2 and 13.3.2.1 – 13.3.2.5.

13.1.10 A terminal box or compartment in which power-supply connections are to be made shall be so located that these connections may be inspected after the unit has been installed as intended.

13.1.11 A wiring compartment for power-supply connections is considered to comply with the requirement in 13.1.10 if it is accessible upon the removal of an air filter or of a panel for servicing.

13.1.12 The wiring compartment for power-supply connections on a built-in unit shall be so located that it will not be rendered inaccessible when installed.

13.1.13 An unwired convenience receptacle may be provided on a unit if the unit is legibly marked in the area of the receptacle in accordance with 61.7.

13.1.14 A wiring compartment secured directly to the enclosure of the unit and intended for connection of a supply raceway shall be so attached to the unit as to be prevented from turning with respect thereto.

13.1.15 Adequate space shall be provided in the field-wiring outlet box or compartment for installation of the conductors of the number and size required by 13.2.1 and 13.2.3, using Type TW or THW wire with at least a 6 inch (152 mm) length of each conductor brought into the wiring compartment. If necessary, a trial installation shall be made to determine if the outlet box provides the required space.

Exception: Other types of conductors may be used if specified in the installation instructions.

13.1.16 Nonmetallic-sheathed cables containing two – four thermoplastic-insulated circuit conductors, with a grounding conductor, shall comply with the requirements in the Standard for Nonmetallic-Sheathed Cables, UL 719.

13.2 Leads and terminals

13.2.1 For the purpose of these requirements, field-wiring terminals (or leads) are considered to be the terminals to which power-supply, control, or equipment-grounding connections will be made in the field when the unit is installed. It is to be assumed that 60°C (140°F) wire will be used for connections requiring an ampacity of 100 amperes or less and that 75°C (167°F) wire will be used for connections requiring an ampacity of more than 100 amperes, even if such wire would not be necessary because of the temperatures measured in the temperature test. See 61.14.

13.2.2 Connection of one supply source shall be to a single set of terminals or leads, but the leads to which a field wire may be connected may consist of more than one lead when acceptably grouped and identified.

13.2.3 A unit or remote control assembly shall be provided with field-wiring terminals or leads for connection to the field installed conductors. Other than as indicated in 13.2.7, each such terminal or lead shall be acceptable for connection of a conductor having an ampacity, in accordance with the National Electrical Code, ANSI/NFPA 70, not less than 125 percent of the rated current at that terminal or lead. If a single conductor larger than 500 MCM (253 mm^2) would be required, the unit shall have provision for connection of conductors in parallel.

13.2.4 If a unit or remote control assembly is marked to indicate that it is acceptable for use with either copper, copper-clad aluminum, or aluminum power-supply conductors, a field-wiring terminal shall comply with the requirement in 13.2.3 for a wire of each metal.

13.2.5 A field-wiring terminal shall be provided with a pressure terminal connector securely fastened in place, for example, firmly bolted or held by a screw.

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

Exception No. 2: A soldering lug may be used in place of a pressure terminal connector for a field-wiring terminal intended for connection of other than an equipment-grounding conductor.

13.2.6 A field-wiring terminal shall be prevented from turning or shifting in position by means other than friction between surfaces. This may be accomplished by two screws or rivets; by square shoulders or mortises; by a dowel pin, lug, or offset; by a connecting strap or clip fitted into an adjacent part; or by an equivalent method.

13.2.7 With reference to 13.2.3, a terminal for field connection of a control circuit conductor is acceptable if it is acceptable for the connection of 14 AWG (2.1 mm^2) copper conductor, except that such a terminal in a low-voltage circuit as defined in 3.16, is acceptable if it is acceptable for connection of a 16 AWG (1.3 mm^2) or 18 AWG (0.82 mm^2) copper conductor. With reference to 13.2.8, a lead for field connection of a control circuit conductor may be 16 or 18 AWG copper.

13.2.8 Other than as indicated in 13.2.11, a lead for connection of field wiring other than for connection of an NEC Class 2 low-voltage circuit shall not be more than two standard wire sizes smaller than the branch-circuit power-supply or control circuit conductor (copper) to which it will be connected. In no case shall such a lead be smaller than 18 AWG (0.82 mm^2).

13.2.9 Leads provided for connection to an external high-voltage circuit shall not be connected to wire binding screws or pressure terminal connectors located in the same compartment as the splice unless:

a) the screws or connectors are rendered unusable for field-wiring connections, or

b) the leads are insulated at the unconnected ends and a marking on the unit clearly indicates the use of these leads.

13.2.10 The free end of any lead that may not be used in every installation (such as an equipment-grounding lead) shall be insulated if that end could reduce spacings below the minimum acceptable values indicated in Spacings – General, Section 34.

13.2.11 The lead described in 13.2.8 may be more than two wire sizes smaller than a field-provided copper conductor to which it will be connected, but no smaller than 18 AWG (0.82 mm^2), if more than one factory-provided copper lead is intended for connection to the same field-provided lead, and the construction complies with the following conditions:

a) The wire connector for the splice connection to the field-provided wire is provided as part of the unit or remote control assembly, and the wire connector is suitable for the combination of wires that will be spliced.

b) A marking is included indicating that the provided wire connector is to be used for the field-wiring splice connection. The marking is to be plainly visible in the field-wiring area during installation and inspection. See 61.17.

c) The factory-provided leads are grouped in a manner to prevent stress on an individual lead.

13.2.12 In determining the size of the power-supply conductors in equipment intended for connection to multiple power supplies and in which it is likely that more than six conductors will occupy the same raceway, the additional ampacity deratings given in the National Electrical Code, ANSI/NFPA 70, shall be applied.

13.2.13 Other than as noted in 13.2.14, the free length of a lead inside an outlet box or wiring compartment shall be 6 inches (152 mm) or more if the lead is intended for field connection to an external circuit.

13.2.14 The lead may be less than 6 inches (152 mm) in length if it is evident that a longer lead might result in a risk of fire or electric shock.

13.2.15 A wire binding screw at a field-wiring terminal shall not be smaller than No. 10 (4.8 mm diameter).

Exception No. 1: A No. 8 (4.2 mm diameter) screw may be used at a terminal intended only for the connection of a 14 AWG (2.1 mm^2) conductor.

Exception No. 2: A No. 6 (3.5 mm diameter) screw may be used for the connection of a 16 or 18 AWG (1.3 or 0.82 mm^2) control circuit conductor.

13.2.16 A terminal plate tapped for a wire binding screw shall be of metal not less than 0.050 inch (1.27 mm) thick. There shall be no fewer than two full threads in the metal.

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

13.2.17 A terminal plate may have the metal extruded at the tapped hole to provide two full threads for the wire binding screw.

13.2.18 Upturned lugs or a cupped washer shall be capable of retaining a supply conductor of the size indicated in 13.2.3 under the head of the screw or washer.

13.2.19 A wire binding screw shall thread into metal.

13.2.20 A unit intended for connection to a grounded conductor and employing a single-pole switch or overcurrent-protective device other than an automatic control shall have one terminal or lead identified for the connection of such conductor. The identified terminal or lead shall be the one to which are connected no switches or overcurrent protective devices of the single-pole type, other than automatic controls without a marked off position.

13.2.21 A lead provided for connection of a grounded conductor shall be finished to show a white or gray color and no other leads, other than grounded conductors, shall be so identified. See 13.2.23.

13.2.22 A field-wiring terminal for the connection of a grounded conductor shall be identified by means of a metallic plated coating substantially white in color and shall be readily distinguishable from the other terminals, or proper identification of the terminal for the connection of the grounded conductor shall be clearly shown in some other manner, such as on an attached wiring diagram.

13.2.23 The requirements in 13.2.21 and 16.11 relating to color coding of a lead apply to internal wiring that is visible in a wiring compartment in the area in which field connections are to be made. These requirements do not apply to leads of wiring of low-voltage circuits intended to be field connected to Class 2 wiring and that are separated or segregated from high-voltage circuit field-wiring connections by barriers.

13.2.24 It should be noted that according to the National Electrical Code, ANSI/NFPA 70, 14 AWG (2.1 mm^2) is the smallest conductor that may be used for branch circuit wiring, and thus is the smallest conductor that may be anticipated at a terminal for the connection of a power-supply wire.

13.3 Cord-connected appliances

13.3.1 Cords and plugs

13.3.1.1 In addition to the requirements specified in this standard cords and plugs shall comply with the requirements in the:

a) Standard for Cord Sets and Power-Supply Cords, UL 817; or

b) Standard for Flexible Cords and Cables, UL 62.

13.3.1.2 The length of cord external to the appliance shall be no longer than 6 feet (1.83 m) measured from the face of the attachment plug to the point of attachment to or entry into the enclosure.

13.3.1.3 The supply cord of a heat recovery ventilator intended for use with a power cord greater than 36 inches (0.9 m) to less than or equal to 72 inches (1.83 m) shall be marked in accordance with 60.20.

13.3.1.4 A flexible cord shall be rated for use at a voltage not less than the rated voltage of the appliance, and shall have an ampacity not less than the current rating of the appliance.

13.3.1.5 An attachment plug shall be rated for the current and voltage ratings of the appliance. If an appliance can be adapted for use on two or more different values of voltage by field alteration of internal connections, the attachment plug shall be rated for the voltage for which the appliance is connected when shipped from the factory. Instructions shall be provided to indicate the type of plug that should be used if the appliance is reconnected for the alternative voltage.

13.3.2 Strain relief

13.3.2.1 Strain relief shall be provided so that the mechanical stress on the flexible cord is not transmitted to terminals, splices, or internal wiring. See 55.1.

13.3.2.2 A metal strain-relief clamp or band is acceptable without supplementary protection on a Type SJ, SJO, SJT, SJTO, S, SO, ST, STO, SV, or SVO cord.

13.3.2.3 A strain-relief clamp or band of metal shall not be used on Type SP-2 or lighter rubber-insulated cord or on Type SPT-1, SPT-2, SVT, or SVTO cord unless such a cord is protected by varnished cloth tubing or the equivalent under the clamp, and the construction complies with the requirements specified in 55.4.

13.3.2.4 Means shall be provided to prevent the flexible cord from being pushed into the appliance enclosure through the cord-entry hole if such displacement might subject the cord to mechanical damage or to exposure to a temperature higher than that for which the cord is suitable, or might reduce spacings, such as to a metal strain-relief clamp, below the minimum acceptable values.

13.3.2.5 If a knot in a flexible cord serves as the strain relief, the surfaces that the knot may touch shall be free from projections, sharp edges, burrs, fins, or the like that may damage the conductors.

13.3.3 Bushings

13.3.3.1 A bushing or the equivalent shall be provided at a point where a flexible cord passes through an opening in a wall, barrier, or enclosing case. The bushing shall be substantial, secured in place, and shall have a smooth, well-rounded surface against which the cord may bear. An insulating bushing shall be provided if:

a) the cord is Type S, SJ, SJO, SJT, SO, SP-3, SPT-3, ST, SP-1, or heavier cord,

b) the wall or barrier is of metal, and

c) the construction is such that the cord may be subjected to stress or motion.

Exception: For a cord hole in wood, porcelain, phenolic composition, or other acceptable nonconductive material, a smoothly rounded surface is considered to be the equivalent of a bushing.

13.3.3.2 Ceramic materials and some molded compositions are acceptable for insulating bushings.

13.3.3.3 Vulcanized fiber may be employed if the bushing is not less than 3/64 inch (1.2 mm) thick, and if formed and secured in place so that it will not be damaged by conditions of ordinary moisture.

13.3.3.4 A separate soft-rubber, neoprene, or polyvinyl chloride bushing may be employed in a fan or in the frame of a motor if the bushing is:

a) Not less than 3/64 inch (1.2 mm) thick.

b) Located so that it will not be exposed to oil, grease, oily vapor, or other substances that may deteriorate the compound employed.

13.3.3.5 A bushing of a material specified in 13.3.3.4 may be employed at any point in an appliance only if used in conjunction with a type of cord for which an insulating bushing is not required.

13.3.3.6 If a bushing of a material specified in 13.3.3.4 is used, the hole in which the bushing is mounted shall be smooth and free from sharp edges.

13.3.3.7 A bushing of the same material as, and molded integrally with the supply cord is acceptable on Type S, SJ, SJO, SJT, SO, SP-3, SPT-3, ST, SP-1, or heavier cord, if the built-up section is not less than 1/16 inch (1.6 mm) thick at the point where the cord passes through the enclosure.

13.3.3.8 An insulated metal grommet is acceptable 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.

13.4 Power Supplies

13.4.1 A Class 2 power supply shall comply with the requirements in the:

a) Standard for Class 2 Power Units, UL 1310;

b) Standard for Information Technology Equipment Safety – Part 1: General Requirements, UL 60950-1, with an output marked "Class 2", or

c) Standard for Information Technology Equipment Safety – Part 1: General Requirements, UL 60950-1, with an output that complies with the limited power source (LPS) requirements and is marked "LPS".

13.4.2 A non-Class 2 power supply shall comply with the requirements in the:

a) Standard for Power Units Other Than Class 2, UL 1012; or

b) Standard for Information Technology Equipment Safety – Part 1: General Requirements, UL 60950-1.

14 Internal Wiring

14.1 General

14.1.1 The requirements in this section apply to all internal wiring except that which is located in a low-voltage nonsafety circuit.

14.1.2 For the purpose of these requirements, the internal wiring of a unit is considered to be all the interconnecting wiring beyond the wiring terminals or leads for field-wiring connections, even though some of it:

a) may not be completely enclosed, or

b) may be in the form of flexible cord or equivalent appliance wiring material.

14.1.3 No temperature limit is applicable to a conductor (except as noted in Subitem 7 of Item B of Table 38.1) provided with beads of noncarbonizable material or the equivalent.

14.1.4 The wiring and connections between parts of a unit not enclosed within the entire enclosure shall be protected by use of conduit, electrical metallic tubing, or metal clad cable with appropriate fittings, or by other equivalent means (including the enclosure of the unit). See 9.8.5.

14.1.5 Internal wiring that is exposed through an opening in the enclosure of a unit is considered to be protected as required in 14.1.4 if, when judged as though it were film-coated wire, the wiring would be

acceptable according to 9.7.1 and 9.7.2. Internal wiring that can be touched with the probe is acceptable if it is so protected or guarded that it cannot be grasped or hooked in a manner that would subject the wire to stress.

14.1.6 The internal wiring shall consist of wires of a type(s) that are rated for the particular application, when considered with respect to:

a) The temperature and voltage to which the wiring is likely to be subjected,

b) Its exposure to oil or grease, and

c) Other conditions of service to which it is likely to be subjected.

14.1.7 Building wires acceptable for internal wiring include thermoset-insulated conductors such as Types RH, RHH, and RHW; thermoplastic-insulated conductors such as Types TW, THHN, THW, THWN, and MTW.

14.1.8 Fixture wires acceptable for internal wiring include thermoset-insulated conductors such as Types RFH-2, SF-2, SFF-2, and FFH-2; and thermoplastic insulated conductors such as Types TF, TFF, TFN, and TFFN.

14.1.9 In addition to the requirements specified in this standard, building and fixture wire shall comply with the requirements in the Standard for:

a) Standard for Thermoset-Insulated Wires and Cables, UL 44;

b) Standard for Thermoplastic-Insulated Wires and Cables, UL 83; or

c) Standard for Machine-Tool Wires and Cables, UL 1063.

14.1.10 Flexible cords acceptable for internal wiring include Types HPN, HS, HSJ, HSJO, HSO, S, SJ, SJO, SJT, SJTO, SO, ST, STO, SP-2, SP-3, SPT-2, and SPT-3.

14.1.11 Appliance wiring material having thermoplastic insulation not less than 2/64 inch (0.8 mm) thick for 18 – 10 AWG (0.82 – 5.3 mm^2), 3/64 inch (1.2 mm) thick for 8 AWG (8.4 mm^2), and 4/64 inch (1.6 mm) thick for 6 – 2 AWG (13.3 – 33.6 mm^2) is acceptable for internal wiring.

14.1.12 Appliance wiring material having rubber, neoprene, or thermoplastic insulation with properties equivalent to the jacket of Types SJ, SJO, SJTO, or SJT cord, with an insulation thickness not less than 4/64 inch (1.6 mm) for 18 – 16 AWG (0.82 – 1.3 mm^2) and 5/64 inch (1.9 mm) for 14 – 10 AWG (2.1 – 5.3 mm^2) is acceptable for internal wiring where permitted by 14.1.21.

14.1.13 Wiring that may be subject to moisture, such as condensation, shall be of a type that is rated for use in moist locations.

14.1.14 If wiring is located so that it may be in proximity to combustible material, it shall be metal clad cable, or shall be enclosed in conduit, electrical metallic tubing, metal raceway, or equivalent. See 14.1.15.

14.1.15 With reference to 14.1.14, wiring that is adjacent to an opening in an enclosure that, after installation of the unit, will abut a building structure, and wiring in a compartment containing thermal insulation or other material that is not self-extinguishing are considered to be in proximity to combustible material.

14.1.16 Other than as noted in 14.1.17, wiring that is located so as to be subject to physical damage (such as in the compartment where plumbing connections must be made) or that is in a duct-connected assembly, shall be enclosed as described in 14.1.14.

14.1.17 With reference to the requirement in 14.1.16, if the wiring is cord such as Type SO, ST, SPT-3, SJO, or SJT, or single or multiple conductor appliance wiring material having an insulation wall thickness not less than 1/16 inch (1.6 mm) for 18 or 16 AWG (0.82 or 1.3 mm^2) or 5/64 inch (2.0 mm) for 14 – 10 AWG (2.1 – 5.3 mm^2) and is rated for refrigeration or air conditioning use, it need not be so enclosed.

14.1.18 Other than as indicated in 14.1.19 – 14.1.21, wiring in a compartment through which air to or from the conditioned space is circulated shall be in metal-clad cable, or in rigid metal conduit, electrical metallic tubing, or other metal raceway.

14.1.19 The requirement in 14.1.18 does not apply to wiring in a control compartment through which bypass air is circulated; that is, a portion of the total air that is taken from within the unit, passes through openings in the compartment, and returned within the unit. The total area of openings for bypass air in any surface of a control compartment shall not exceed 10 percent of the total area of that surface.

14.1.20 Other than as noted in 14.1.21, lengths not exceeding 4 inches (102 mm) of unenclosed wiring of the types specified in 14.1.7, 14.1.8, and 14.1.11, or equivalent, may be employed if enclosed within the unit cabinet and supported to prevent damage from air movement.

14.1.21 Types SJO, SJT, SJTO, SO, ST, STO, or SPT-3 flexible cords or equivalent single or multiple conductor appliance wiring material, see 14.1.12, without limitation on length, may be employed if protected as described in 14.1.20.

14.1.22 Unenclosed wiring of the types described in 14.1.11, without limitation on the length, may be employed within the unit cabinet, if:

a) the unit cabinet has no openings other than duct openings,

b) the wiring is secured and supported to prevent damage from air movement, and

c) no combustible material other than electrical insulation or an air filter is located within the unit cabinet unless the wiring complies with the exception to 12.4.1.

14.1.23 A fan motor may be provided with a cord and attachment plug to permit removal for servicing, if the cord is Type SO, ST, STO, SPT-3, SJO, SJT, or SJTO, or the equivalent.

14.2 Methods

14.2.1 Strain relief intended to prevent mechanical stress from being transmitted to terminals, splices, and the like, shall be provided on wiring that is likely to be moved during installation and user servicing.

14.2.2 Wires within an enclosure, compartment, raceway, or the like shall be so disposed or protected that no damage to conductor insulation can result from contact with any rough, sharp, or moving part or from air movement.

14.2.3 A hole by which insulated wires pass through a sheet-metal wall within the overall enclosure shall be provided with a smoothly rounded bushing or shall have smooth, rounded surfaces upon which the wires may bear, to prevent abrasion of the insulation.

14.2.4 Insulated wires may be bunched and passed through a single opening in a metal wall within the enclosure.

14.2.5 If relative motion between asbestos-insulated wire and the metal surrounding the opening through which the wire passes is likely because of expansion and contraction of the metal resulting from changes in temperature, the opening shall be fitted with an insulating bushing or the equivalent.

14.2.6 Splices and connections shall be mechanically secure and bonded electrically. A soldered connection shall be made mechanically secure before being soldered.

14.2.7 A splice in an air handling compartment shall be in a separate enclosure unless normal air motion in the compartment is not likely to cause movement of the splice or conductors.

14.2.8 A splice shall be provided with insulation equivalent to that of the wires involved if spacing between the splice and other metal parts can be unintentionally reduced.

14.2.9 Insulation consisting of two layers of thermoplastic tape, or of one layer of friction tape on top of one layer of rubber tape, is acceptable on a splice if the voltage involved is less than 250 volts. In determining if splice insulation consisting of coated fabric, thermoplastic, or other tubing is acceptable, consideration is given to such factors as its dielectric properties, and heat resistant and moisture resistant characteristics. Thermoplastic tape wrapped over a sharp edge is not acceptable.

14.2.10 Loose strands of stranded internal wiring connected to a wire binding screw shall be prevented from contacting uninsulated live parts that are not always of the same polarity as the wire and from contacting dead metal parts. This may be accomplished by use of pressure terminal connectors, soldering lugs, crimped eyelets, soldering all strands of the wire together, or other equivalent means.

14.2.11 Other than as indicated in 14.2.12, conductors of motor circuits having two or more thermal- or overcurrent-protected motors or one or more such motors in combination with an electric resistance heater wired for connection to one supply line shall withstand short-circuit and ground-fault conditions when tested in accordance with the Short-Circuit Tests, Section 46.

14.2.12 With reference to 14.2.11, conductors are considered acceptable without test if:

a) The conductors have an ampacity of not less than one-third the ampacity of the supply conductors as determined in accordance with 13.2.1 and 13.2.3. Ampacities are to be determined from the ampacity tables in the National Electrical Code, ANSI/NFPA 70, for the type of wire or cord employed, or for the wire or cord equivalent to appliance wiring material;

b) The conductors including those enclosed in raceways, are 18 AWG (0.82 mm^2) or larger, and not more than 4 feet (1.22 m) long, and the circuit will be protected by a fuse or circuit breaker that is rated 60 amperes or less as specified on the unit nameplate or that is provided as part of the unit and acceptable for branch-circuit protection;

c) The conductor is a jumper lead between controls and is not longer than 3 inches (76 mm), unless the conductor is located in a control panel; or

d) The conductor is connected between two fixed impedances that reduce the risk of a high vault current within the conductor (examples of two such impedances are a motor-running capacitor and a start winding of a permanent-split-capacitor motor).

15 Separation of Circuits

15.1 Conductors of different circuits in internal wiring, including insulated wires in a wiring compartment, shall be:

a) provided with insulation rated for the highest voltage involved, or

b) separated by a barrier or otherwise segregated from an uninsulated live part connected to a different circuit.

15.2 With reference to the requirement in 15.1, low-voltage and high-voltage circuits, for example, are considered to be different circuits.

15.3 Segregation of insulated conductors may be accomplished by clamping, routing, or an equivalent means that provides permanent separation from insulated and uninsulated live parts of a different circuit.

15.4 Other than as noted in 15.6 and 15.7, barriers shall be provided to separate conductors that will be field installed, from:

a) Conductors of any other circuit that will be field installed;

b) Conductors of any other circuit that are factory installed;

c) Uninsulated live parts of any other circuit; and

d) Uninsulated live parts of the same circuit, if short-circuiting of the live parts may result in a risk of fire, electric shock, or injury to persons.

Exception No. 1: The barriers required in 15.4(a) and (b) may be omitted if the conductors involved are insulated for the maximum voltage of either circuit.

Exception No. 2: The barriers required in 15.4(c) and (d) may be omitted if the field installed conductors will have a voltage rating not less than the potential on the uninsulated live part.

15.5 With respect to 15.4(a) and (b), a removable barrier or one having openings for the passage of conductors may be employed, if:

a) instructions for the use of the barrier are given in a permanent manner on the unit, and

b) use of the barrier does not require any manipulation of factory-installed leads (other than pigtails provided for field-wiring connections).

Exception: A removable barrier or one having openings for the passage of conductors may be omitted if complete instructions, in conjunction with a wiring diagram, will provide for the acceptable separation of the high-voltage and low-voltage circuits.

15.6 Segregation of field installed conductors from other field installed conductors and from uninsulated live parts of the unit connected to different circuits may be accomplished by arranging the location of the openings in the enclosure for the various conductors, with respect to the terminals or other uninsulated live parts, so that there is no likelihood of the intermingling of the conductors or parts of different circuits.

a) If the number of openings in the enclosure does not exceed the minimum required for the proper wiring of the unit and if each such opening is located opposite a set of terminals, it is to be assumed, for the purpose of determining compliance with 15.4, that the conductors entering an opening will be connected to the terminals opposite that opening.

b) If more than the minimum number of openings are provided, there shall be no likelihood of a conductor that enters at a point other than opposite the terminals to which it is intended to be connected, contacting insulated conductors or uninsulated live parts connected to a different circuit.

c) To determine if a unit complies with the requirement in 15.4, it is to be wired as it would be in service. In so doing, slack is to be left in each conductor within the enclosure, and this slack is to be stowed in the wiring compartment.

15.7 Unclosed openings in a barrier for the passage of conductors shall not be larger in diameter than 1/4 inch (6.4 mm) and shall not exceed in number, on the basis of one opening per conductor, the number of wires that will need to pass through the barrier. The closure for any other opening shall present a smooth surface wherever an insulated wire may be in contact with it; and the area of any such opening, with the closure removed, shall not be larger than required for the passage of the necessary wires.

15.8 A metal barrier shall have a thickness of at least 0.020 inch (0.51 mm) if uncoated steel, 0.023 inch (0.58 mm) if galvanized steel, and 0.023 inch (0.58 mm) if nonferrous metal. A barrier of insulating material shall be no less than 1/32 inch (0.8 mm) in nominal thickness [minimum 0.028 inch (0.71 mm)] and shall be of greater thickness if its deformation may be readily accomplished so as to defeat its purpose.

15.9 The output of a transformer device supplying a NEC Class 2 low-voltage circuit shall not be interconnected with the output of another such transformer device provided as part of the equipment unless the voltage and current measurements at the output terminals of the interconnected devices do not exceed the limits for a single Class 2, 30-volt or less, transformer device.

15.10 Two or more transformer devices supplying circuits classified as low-voltage circuits and provided as a part of the equipment shall be treated as separate circuits unless the devices are interconnected as permitted in 15.9. If more than one such circuit is to be field wired, the several circuits shall be separated by barriers in accordance with 15.4, and the field wiring connection point of each circuit shall be marked to warn that the separation shall be maintained.

16 Bonding for Grounding

16.1 Electrical continuity shall be provided between all exposed dead metal parts and all dead metal parts within the enclosure that are exposed to contact during any user-servicing operation and that can become energized and:

a) The equipment-grounding terminal or lead, and to the metal surrounding the knockout, hole, or bushing provided for field power-supply connection for an appliance intended for permanent electrical connection; or

b) The point of connection of the equipment-grounding conductor of the power-supply cord for an appliance equipped with a power-supply cord of the grounding type. See 16.7.

16.2 In addition to the requirements specified in this standard equipment used for grounding and bonding shall comply with the requirements in the Standard for Grounding and Bonding Equipment, UL 467.

16.3 Other than as indicated in 16.4 and 16.5, a field-wiring terminal or lead for connection of an equipment-grounding conductor shall be provided as follows:

a) The equipment-grounding terminal or lead shall be located in the field-wiring compartment and shall be identified in accordance with 16.10 and 16.11.

b) The equipment-grounding terminal or lead shall be acceptable for connection of an equipment-grounding conductor of at least the size required by the National Electrical Code, ANSI/NFPA 70, Table 250-95, based on the size of the overcurrent device protecting the circuit.

c) If more than one circuit is to be connected to the equipment, the terminal or lead provided for field connection of an equipment-grounding conductor shall be acceptable for connection of a separate grounding conductor for each circuit.

d) If there is provision for connection of two or more power-supply conductors in parallel at each terminal as specified in 13.2.3, provision shall be made for connection of an equal number of equipment-grounding conductors. The size of each of these equipment-grounding conductors shall comply with (b) above, except that it need be no larger than one of the power-supply conductors.

16.4 The equipment-grounding terminal or lead specified in 16.3 is not required for a low-voltage (National Electrical Code – Class 2) control circuit connection, and may be omitted for a high-voltage circuit connection if:

a) The rating of the product is such that the power-supply conductors are likely to be larger than 2 AWG (33.6 mm^2), see 16.5;

b) The construction is such that a terminal can be acceptably installed in the field, for example, the terminal can be secured without a drilling or cutting operation upon installation, and acceptable space for the equipment-grounding conductor is provided; and

c) The product is marked as required in 61.22.

16.5 With reference to 16.4(a), a field-wiring power-supply conductor is likely to be larger than 2 AWG (33.6 mm^2) if:

a) The marked minimum circuit ampacity for the circuit under consideration is more than 95.5 amperes for copper conductors, or 75.5 amperes for aluminum or copper-clad aluminum conductors;

b) A minimum circuit ampacity is not required to be marked (see 60.8) and if the rated current is more than 76.4 amperes for copper conductors or more than 60.4 amperes for aluminum or copper-clad aluminum conductors; or

c) Any marking on the product indicates use of a conductor larger than 2 AWG (33.6 mm^2). See 61.15.

16.6 With reference to 16.3(c) and (d), an individual terminal or lead for each field wired equipment-grounding conductor may be provided. A single terminal for connection of all such conductors may be employed if acceptable for the application. A lead for connection of an equipment-grounding conductor may serve for connection of more than one circuit.

16.7 A power-supply cord of an appliance shall include an equipment-grounding conductor.

16.8 An equipment-grounding conductor of a flexible cord shall be:

a) Finished to show a green color with or without one or more yellow stripes;

b) Connected to the grounding member of an attachment plug of the grounding type; and

c) Connected to the dead metal parts mentioned in 16.1 by a screw or other acceptable means not likely to be removed during servicing. Solder alone is not acceptable for making this connection.

16.9 The screw mentioned in 16.8(c) shall be of corrosion-resistant metal, or shall be adequately protected against corrosion. A lock washer or equivalent means shall be employed to prevent the screw from becoming loosened by vibration. The screw shall have a green-colored head that is hexagonal, slotted, or both, and shall be located so that it is not likely to be removed during intended servicing of the appliance.

16.10 A wire binding screw intended for the connection of an equipment-grounding conductor shall have a green colored head that is hexagonal-shaped, slotted, or both. A pressure wire connector intended for

connection of such a conductor shall be plainly identified, such as by an adjacent marking "G," "GR," "Ground," "Grounding," by being colored green, by the symbol ⏚ or the equivalent, or by a marking on a wiring diagram provided on the unit. The wire binding screw or pressure wire connector shall be so located that it is not necessary to be removed during servicing of the unit.

16.11 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 lead visible to the installer other than grounding conductors shall be so identified except in a separate low-voltage NEC Class 2 wiring compartment. See 13.2.23.

16.12 Splices shall not be employed in wire conductors used to bond electrical enclosures, motor frames, or other electrical components.

16.13 A bonding conductor shall be of material acceptable for use as an electrical conductor. If of ferrous metal, it shall be protected against corrosion by painting, plating, or the equivalent. The conductor shall be of acceptable size. A separate bonding conductor shall be installed so that it is protected from mechanical damage. See 14.1.14.

16.14 Bonding shall be by a positive means, such as by a clamped, riveted, bolted, or screw-secured connection, by brazing, or by welding. The bonding connections shall reliably penetrate nonconductive coatings such as paint.

16.15 A bolted or screw-secured connection that incorporates a star washer or serrations under the screwhead is acceptable for penetrating nonconductive coatings if required for compliance with 16.14.

16.16 If the bonding means depends upon screw threads, two or more screws, or two full threads of a single screw engaging metal, shall comply with the requirement in 16.14.

16.17 Metal-to-metal hinge-bearing members for a door or cover are considered to be a means for bonding the door or cover for grounding if a multiple-bearing pin-type hinge is employed.

16.18 A motor frame shall be bonded for grounding. A motor frame bonding connection shall be secured by riveting, bolting, or by welding, soldering, or brazing with material having a softening or melting point greater than 454°C (849°F), or equivalent positive means. Other than as indicated in 16.19, a connection that depends upon the clamping action of rubber or similar material is not acceptable.

16.19 A connection that depends upon the clamping action exerted by rubber or similar material shall comply with the requirements for:

a) the Grounding Means Overload Test, Section 50, and

b) the Short-Circuit Tests, Section 46, under any degree of compression permitted by a variable clamping device, and after exposure to the effects of oil, grease, moisture, and thermal degradation likely to occur in service.

The effect of assembling and disassembling such a clamping device, as for maintenance purposes, is also to be considered with particular emphasis on the likelihood of the clamp being reassembled in its intended fashion.

16.20 A separate conductor employed to bond an electrical enclosure, motor frame, or the like, shall:

a) Be a copper or aluminum conductor at least as large as specified in Table 16.1, based on the rating of the branch-circuit overcurrent device by which the unit or section of the unit will be protected;

b) Be at least as large as the conductors supplying the component being bonded; or

c) Comply with the requirements for:

1) the Grounding Means Overload Test, Section 50, and

2) the Short-Circuit Tests, Section 46.

Exception: The short-circuit tests may be waived if the conductor is a 18 AWG (0.82 mm^2) or larger copper conductor, not more than 4 feet (1.22 m) long, and connected in a circuit that will be protected by a fuse or circuit breaker rated 60 amperes or less.

Table 16.1
Bonding-wire conductor size

Rating of overcurrent device, amperes	Size of bonding conductor[a]			
	Copper wire		Aluminum wire	
	AWG	(mm^2)	AWG	(mm^2)
15	14	2.1	12	3.3
20	12	3.3	10	5.3
30	10	5.3	8	8.4
40	10	5.3	8	8.4
60	10	5.3	8	8.4
100	8	8.4	6	13.3

[a] Or equivalent cross-sectional area.

ELECTRICAL COMPONENTS

17 Mounting of Components

17.1 A switch, a lampholder, an attachment-plug receptacle, a motor attachment plug, or similar component shall be mounted securely and, other than as noted in 17.2 and 17.3, shall be prevented from turning. See 17.4.

17.2 The requirement that a switch be prevented from turning may be waived if all of the following conditions are met:

a) The switch is to be 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 operation of the switch;

b) The means for mounting the switch is not subject to loosening as the result of its operation;

c) The spacings are not to be reduced below the minimum required values if the switch rotates; and

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

17.3 A lampholder of a type in which the lamp cannot be replaced, such as a neon pilot or indicator light in which the lamp is sealed in a nonremovable jewel, need not be prevented from turning if rotation cannot reduce spacings below the minimum acceptable values.

17.4 The means for preventing the turning indicated in 17.1 shall consist of more than friction between surfaces. A toothed lock washer that provides both spring takeup and mechanical interference is

acceptable as the means for preventing a small stem-mounted switch or other small device having a single hole mounting means from turning.

17.5 An uninsulated live part and a part that supports a live part shall be so secured to the base or mounting surface 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 values shown in Table 34.1 and Table 34.2.

17.6 Friction between surfaces is not acceptable as a means to prevent shifting or turning of a live part as indicated in 17.5, but a lock washer as described in 17.4 is acceptable.

18 Printed Wiring Boards

18.1 Printed wiring boards, including the coatings, shall comply with the requirements in the Standard for Printed Wiring Boards, UL 796.

Exception: A printed-wiring board in a Class 2 nonsafety circuit is not required to comply with the bonding requirements in the Standard for Printed-Wiring Boards, UL 796, if the board is separated from parts of other circuits such that loosening of the bond between the foil conductor and the base material will not result in the foil conductors or components coming in contact with parts of other circuits of the control or of the end-use product.

19 Live Parts

19.1 Metal employed for a current-carrying part shall be acceptable for the application. Plated iron or steel may be used for current-carrying parts whose temperature during intended operation is more than 100°C (212°F). Regardless of the temperature attained, unplated iron or steel shall not be used; but stainless steel and other corrosion resistant alloys may be used.

19.2 With reference to 19.1, ordinary iron or steel, if provided with a corrosion resistant coating, may be used for a current-carrying part:

a) if permitted in accordance with 5.1, or

b) within a motor.

20 Electrical Insulating Material

20.1 Material for the mounting of uninsulated live parts shall be porcelain, phenolic composition, cold-molded composition, or a material having equivalent electrical and physical properties. See 20.2.

20.2 Vulcanized fiber may be used for insulating bushings, washers, separators, and barriers, but not as the sole support for uninsulated live parts. Polymeric materials may be used for the sole support of uninsulated live parts, if found to have mechanical strength and rigidity, dielectric withstand, resistance to heat, flame propagation, arcing, creep, and moisture, and other properties required for the application without displaying a loss of these properties beyond the minimum acceptable level as a result of aging.

21 Supplemental Insulation, Insulating Bushings, and Assembly Aids

21.1 The requirements for supplemental insulation (e.g. tape, sleeving or tubing) are not specified unless the insulation or device is required to fulfill 14.2.9 or a performance requirement of this standard.

21.2 In accordance with 21.1, supplemental insulation shall comply with the following:

a) Insulating tape shall comply with the requirements in the Standard for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape, UL 510;

b) Sleeving shall comply with the requirements in the Standard for Coated Electrical Sleeving, UL 1441;

c) Tubing shall comply with the requirements in the Standard for Extruded Insulating Tubing, UL 224; and

d) Electrical insulation systems shall comply with requirements in the Standard for Systems of Insulating Materials – General, UL 1446.

21.3 Wire positioning devices shall comply with the requirements in Bonding for Grounding, Section 16, and Live Parts, Section 19.

Exception: A device that complies with the requirements in the Standard for Positioning Devices, UL 1565, is considered to fulfill this requirement.

21.4 Insulating bushings that comply with Components, Section 5, of this end product standard, and the requirements in the Standard for Insulating Bushings, UL 635, are considered to fulfill the requirements of this Standard. Tests specified in this Standard (e.g. Strain Relief Test) may still need to be performed to confirm that the combination of the insulating bushing and the supporting part comply with the performance requirements.

22 Motors and Motor Protection

22.1 General

22.1.1 A motor shall handle the maximum intended load of the unit without resulting in a risk of fire, electric shock, or injury to persons.

22.1.2 A motor winding shall resist the absorption of moisture.

22.1.3 With reference to the requirements in 22.1.2, film-coated wire is not required to be additionally treated to prevent absorption of moisture, but fiber slot liners, cloth coil wrap, and similar moisture absorptive materials should be impregnated or otherwise treated to resist moisture absorption.

22.2 Overload protection

22.2.1 Other than as specified in 22.2.2, 22.2.7, and 22.2.9, each motor shall be protected by:

a) an integral thermal protector that provides running and locked rotor protection in accordance with:

1) *Deleted*

2) The Standard for Rotating Electrical Machines – General Requirements, UL 1004-1 and the Standard for Thermally Protected Motors, UL 1004-3; or

3) Electronic protection that meets the test requirements of the Standard for Electronically Protected Motors, UL 1004-7 and the circuits requirements of Controls – End Product Test Parameters, Section 57.

b) an overcurrent protective device rated or set in accordance with the National Electrical Code, ANSI/NFPA 70.

The protection for a motor rated at 15 horsepower (11.2 kW output) or less and protected in accordance with (b) shall also comply with the requirement in 40.1.

22.2.2 The overload protection of a single speed, continuous-duty blower motor having a marked rating over 1 horsepower (746 Watts output) need not be provided as part of a unit if:

a) The motor is outside the air stream;

Exception: If the motor is totally enclosed, it may be in the air stream.

b) The motor is to be field-wired to a separate circuit that does not supply any other loads within the unit; and

Exception: A Class 2 power supply provided as part of the unit and protected in accordance with Overcurrent Protection, Article 240, Parts I through VII per Article 430.53 (C)(6) of the National Electrical Code, NFPA 70, need not be supplied by a separate circuit.

c) The motor overload protection is part of separate field-provided motor control equipment that does not require wiring interconnection to the unit, other than for the motor circuit (see 22.2.3 and 60.5), and

d) Energization of electric heaters, if any, does not occur without motor operation or evidence of air flow.

22.2.3 A separate motor protection device must be installed for each motor in this unit, and must be marked with output voltage, phase, HP or Watts output, and FLA not exceeding the motor ratings on this unit nameplate. See 22.2.4.

22.2.4 A separate overload device which combines the functions of overload and overcurrent protection and is responsive to motor current rated or set at values not greater than the percentages of the motor nameplate full-load current rating as specified Table 22.1. Such a device shall be capable of fully protecting the circuit and motor both under overload and short circuit conditions. If the marked service factor of a motor is less than 1.15, or if the service factor or service factor current is not marked on the motor, the rating or setting of separate overload devices, if used, shall not exceed 115% of the full load current of the motor.

Table 22.1
Protective device activation level

Motor nameplate marking	Maximum percentage full-load current rating protection	
	A	B
Motor with marked service factor no less than 1.15	125	140
Motor with marked temperature rise no more than 40°C (72°F)	125	140
Any other motor	115	130

22.2.5 For a multispeed motor that employs a separate overcurrent protective device to provide running protection, the protection is to be effective at all speeds at which the motor is intended to operate.

22.2.6 A 3-phase motor shall be provided with overcurrent protection as follows:

a) Three overcurrent units (see 22.2.1), or

b) Thermal protectors, combinations of thermal protectors and overcurrent units, or other methods of protection where the specific protective arrangement has been investigated and found to provide

protection under primary single-phase failure conditions when supplied from transformers connected wye-delta or delta-wye. Assemblies so investigated shall be marked to indicate that the motor is protected under primary single-phasing conditions. This marking may be on a paper sticker or decal, or may be on a permanently attached wiring diagram, and shall be located where it is accessible after installation. See 61.3.

22.2.7 A direct drive fan motor provided with an integral protector complying with:

a) *Deleted*

b) The Standard for Rotating Electrical Machines – General Requirements, UL 1004-1 and the Standard for Thermally Protected Motors, UL 1004-3; exclusive of temperature requirements applying to running overload conditions, is considered to comply with the requirements in 22.2.1; or

c) Electronic protection that meets the test requirements of the Standard for Electronically Protected Motors, UL 1004-7 and the circuits requirements of Controls – End Product Test Parameters, Section 57.

22.2.8 A direct drive fan motor, other than an impedance-protected motor as described in 22.2.9, employed with nonmetallic parts, such as fans, scrolls, or shaft supports, shall have running overload protection as described in 22.2.1 or the nonmetallic part shall comply with the requirements for the heat deflection test in 45.3.1 and 45.3.2.

22.2.9 A motor with impedance protection that:

a) under conditions of use in the application, including such factors as evaluated ambient temperatures and any restricted ventilation, complies with the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1 and the Standard for Impedance Protected Motors, UL 1004-2; and

b) does not generate smoke with the rotor of the motor locked under any required test condition for the unit, is considered to comply with the requirements in 22.2.1.

22.2.10 An electronically protected motor shall comply with the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1 and the Standard for Electronically Protected Motors, UL 1004-7.

22.2.11 A fuse may be used to provide the necessary overload protection if compliance with the requirements will be provided by the largest ampere-rated fuse that can be mounted in the fuseholder or if a noninterchangeable fuse is used. The fuse used to provide this protection may be of the supplementary type (need not be acceptable for branch circuit protection) provided the fuse has a short-circuit rating acceptable for the circuit in which it is used. See Table 46.1. If a supplementary type fuse is used, the equipment shall be marked in accordance with the requirements in 61.20.

22.2.12 Electronically protected motor circuits shall comply with the Standard for Tests for Safety-Related Controls Employing Solid State Devices, UL 991. When the electronic circuit is relying on software as a protective component, it shall comply with all of the requirements in the Standard for Software in Programmable Components, UL 1998. If software is relied upon to perform a safety function, it shall be considered software class 1.

Exception: Compliance with UL 991 and UL 1998 is not required for an electronically protected motor circuit if:

a) There is no risk of fire, electric shock or casualty noted during Abnormal testing with the motor electronic circuit rendered ineffective (open or short circuited),

b) It complies with the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1 and the Standard for Automatic Electrical Controls – Part 2-9: Particular Requirements for Temperature Sensing Controls, UL 60730-2-9. When the electronic circuit is relying on software as a protective component, it shall comply with all of the requirements in clause H.11.12 of UL 60730-1, if software is relied upon to perform a safety function, it shall be considered software class B, or

c) It is a power conversion controller incorporating overcurrent protection complying with the Standard for Adjustable Speed Electrical Power Drive Systems – Part 5-1: Safety Requirements – Electrical, Thermal and Energy, UL 61800-5-1 and is rated or set to trip at not more than the 115 percent of the motor nameplate full-load current rating.

22.2.13 The requirements in Table 22.2 are among the factors to be used in evaluating the protective circuit.

Table 22.2
Application of UL 991 and UL 1998 or UL 60730-1 and UL 60730-2-9

	Application of UL 991 and UL 1998	Application of UL 60730-1, and UL 60730-2-9
1)	Conduct a failure-mode and effect analysis (FMEA) – for the protective circuit identified in 22.2.12.	Conduct a failure-mode and effect analysis (FMEA) – for the protective circuit identified in 22.2.12.
2)	A control becoming permanently inoperative and disconnecting power meets the criteria for electrical supervision of critical components and trouble indication.	A control becoming permanently inoperative and disconnecting power meets the criteria for electrical supervision of critical components and trouble indication.
3)	Assumed temperature ranges are as follows: a) Indoor Use: 0.0 ±2°C (32.0 ±3.6°F) and 40.0 ±2°C (104 ±3.6°F), b) Outdoor Use: -35.0 ±2°C (−31.0 ±3.6°F).	Assumed temperature ranges are as follows: a) Indoor Use: 0.0 ±2°C (32.0 ±3.6°F) and 40.0 ±2°C (104 ±3.6°F), b) Outdoor Use: -35.0 ±2°C (−31.0 ±3.6°F).
4)	Cycling test duration shall be 14 days.	Cycling test duration shall be 14 days.
5)	Endurance test duration shall be 100,000 cycles.	Endurance test duration shall be 100,000 cycles.
6)	Radio-frequency electromagnetic field immunity: a) Immunity to conducted disturbances - Test level 3 shall be used, b) Immunity to radiated electromagnetic fields - field strength of 3 V/m shall be used.	Radio-frequency electromagnetic field immunity: a) Immunity to conducted disturbances - Test level 3 shall be used, b) Immunity to radiated electromagnetic fields - field strength of 3 V/m shall be used.
7)	For exposure to humidity, the following conditions shall apply: a) Indoor Use: 21.1 to 26.7°C (70 to 80°F) and minimum 50 percent relative humidity, b) Outdoor Use: minimum 98 percent relative humidity.	For exposure to humidity, the following conditions shall apply: a) Indoor Use: 21.1 to 26.7°C (70 to 80°F) and minimum 50 percent relative humidity, b) Outdoor Use: minimum 98 percent relative humidity.
8)		Surge immunity test - Test with installation Class 3 used for other than outdoor use protective devices. Class 4 shall be used for protective devices intended for outdoor use.
9)	Electrical fast transient/burst immunity such that a test level 3 shall be used for all equipment other than outdoor use equipment. Test level 4 shall be used for outdoor use equipment.	Electrical fast transient/burst immunity such that a test level 3 shall be used for all equipment other than outdoor use equipment. Test level 4 shall be used for outdoor use equipment.
10)		Electrostatic Discharge Test with a Severity Level of 3 having Contact Discharge at 6 kV for accessible metal parts and air discharge at 8 kV for accessible parts of insulating material.

22.3 Short-circuit protection

22.3.1 A motor circuit shall be protected against short-circuit and ground-fault conditions by an overcurrent protective device conforming with the National Electrical Code, ANSI/NFPA 70.

22.3.2 Other than as indicated in 22.3.3, a motor overload protective device in a unit having more than one motor wired for connection to one supply circuit shall withstand short-circuit and ground-fault conditions without a risk of fire or electric shock when tested in accordance with the Short-Circuit Tests, Section 46. These tests need not be conducted if the device is rated for the conditions specified in Section 46.

22.3.3 The short-circuit test for risk of fire specified in 22.3.2 may be waived if:

a) A thermally protected motor or a separately enclosed motor-overload protective device is within a cabinet of a product or section of a product;

b) The motor or device is intended to be protected by a fuse or circuit breaker as specified on the unit nameplate or provided as part of the product and is acceptable for branch-circuit protection;

c) The assembly is constructed so that flame and molten metal will be confined within the cabinet; and

d) Combustible material, except electrical insulation or an air filter, is not located below the motor and has the characteristics specified in 12.3.1.

However, if short-circuiting of live parts of different circuits may result, the test shall not be waived.

23 Motors For Use In Unattended Areas

23.1 General

23.1.1 In addition to any other motor requirements specified in UL 1812, the requirements specified in Section 23 apply to any motor used in fan products which operate unattended or in situations in which the operator may not detect a locked rotor condition. Examples include: wall-insert HRV's, through-wall HRV's, ceiling-insert HRV's, attic HRV's, whole house HRV's, and ducted HRV's.

Exception No. 1: These requirements do not apply to motors employing a single-operation device, a thermal cutoff, or a manual reset thermal protector when the device opens during the normal locked rotor testing in accordance with:

a) Deleted

b) The Standard for Rotating Electrical Machines – General Requirements, UL 1004-1 and the Standard for Thermally Protected Motors, UL 1004-3.

Exception No. 2: These requirements do not apply to a motor in which there are no openings in the enclosure through which molten metal, burning insulation, flaming particles, or other ignited material could fall onto flammable material, or through which a flame could be projected, such as a totally enclosed motor.

23.1.2 There shall be no increased risk of fire as evidenced by the burning of cotton. All cotton used for this test is to be sterile or surgical 100 percent cotton.

23.1.3 A motor shall be tested in accordance with this Section at each speed and rated voltage. A motor with a single tapped winding is required to only be tested at high speed.

23.2 Performance

23.2.1 Test preparation – fan motor failure mode analysis

23.2.1.1 The test procedure specified in this Section is to be conducted on either ten samples of a complete fan or ten samples of the motor.

Exception: For a motor employing a thermal cutoff or a manual reset thermal protector as a secondary or "back-up" protection, only three samples are to be tested. See 3.17, 3.18, and 3.22.

23.2.1.2 For the purpose of this test, motor samples are to be provided without an automatic reset thermal protector. A "back-up" protector is to remain in the circuit.

23.2.1.3 A thermocouple is to be attached to the motor winding to verify constant temperature rise (motor heating) during the test. The rotor is to be locked.

23.2.1.4 Each sample of a complete fan is to be oriented as intended in the application. One layer of cotton is to be loosely draped around the area of the motor and any other area of the fan where flame or molten metal is emitted. When a barrier or guard is provided for the purpose of preventing flames or molten metal from escaping from the motor area, the cotton is to be loosely draped around the barrier or guard.

23.2.1.5 Each sample of a fan motor is to be placed on one layer of cotton on a wood surface. Each motor is then to be surrounded with one layer of loosely draped cotton.

23.2.2 Test procedure – fan motor failure mode analysis

23.2.2.1 The supply circuit is to be provided with a 20 amp slow blow fuse. If the fuse opens during the test procedure, it is to be replaced with the largest standard size fuse needed to continue the test.

23.2.2.2 The fan motor is to be energized in a room ambient temperature of 10 to 40°C (50 to 104°F) initially at the rated voltage of the fan until the winding temperature stabilizes.

23.2.2.3 Following stabilization, the voltage is to be gradually increased to achieve a maximum 10°C temperature rise per minute until ultimate results are observed (opening of motor winding, opening of a or "back-up" protection, or ignition of the cotton).

23.2.2.4 Cotton ignition on one of the samples during the test is considered a failure.

24 Capacitors

24.1 A capacitor shall comply with the Standard for Capacitors, UL 810.

24.2 A capacitor employing a liquid dielectric medium more combustible than askarel shall be protected against expulsion of the dielectric medium when tested in accordance with the applicable performance requirements of this standard, including faulted overcurrent conditions based on the circuit in which it is used. See Table 46.1.

Exception No. 1: If the available fault current is limited by other components in the circuit, such as a motor start winding, the capacitor may be tested using a fault current less than the test current specified in Table 46.1 but not less than the current established by dividing the circuit voltage by the impedance of the other component(s).

Exception No. 2: Electromagnetic interference filters with integral enclosures that comply with the requirements in the Standard for Electromagnetic Interference Filters, UL 1283, are considered to fulfill the requirements.

25 Circuit Breakers and Fuseholders

25.1 A circuit breaker used to protect a circuit having more than one ungrounded conductor and no grounded neutral shall be of the multipole common trip type arranged to open all ungrounded conductors. The use of an external handle tie does not in itself constitute a common trip mechanism.

25.2 A fuseholder shall be designed, installed, or protected so that adjacent uninsulated high-voltage live parts, other than the screw shell of a plug fuseholder, cartridge fuse clips, or wiring terminals to the fuseholder, will not be exposed to contact by persons removing or replacing fuses.

Exception: Live parts disconnected by an interlock switch are exempted from this requirement.

25.3 In addition to the requirements specified in this standard, fuseholders shall comply with the requirements in the Standard for Fuseholders – Part 1: General Requirements, UL 4248-1 and

a) The Standard for Fuseholders – Part 4: Class CC, UL 4248-4;

b) The Standard for Fuseholders – Part 5: Class G, UL 4248-5;

c) The Standard for Fuseholders – Part 6: Class H, UL 4248-6;

d) The Standard for Fuseholders – Part 8: Class J, UL 4248-8;

e) The Standard for Fuseholders – Part 9: Class K, UL 4248-9;

f) The Standard for Fuseholders – Part 11: Class C (Edison Base) and Type S Plug Fuse, UL 4248-11;

g) The Standard for Fuseholders – Part 12 : Class R, UL 4248-12; or

h) The Standard for Fuseholders – Part 15: Class T, UL 4248-15.

25.4 With reference to 25.2, a separation less than 4 inches (102 mm) from the insulating body of a fuse is considered to be adjacent.

26 Overcurrent Protection, General

26.1 The overcurrent protection specified in 26.2 and 26.3 shall be circuit breakers, cartridge fuses, or Type S plug fuses of a type and rating acceptable for branch-circuit protection for the circuit involved, in accordance with the requirements of the National Electrical Code, ANSI/NFPA 70.

26.2 Overcurrent protection at not more than 20 amperes shall be provided by a circuit breaker or fuses, as a part of the unit:

a) for each general-use duplex receptacle circuit, and

b) for each lampholder circuit, independent of a heating element, unless the unit would be connected in accordance with the National Electrical Code, ANSI/NFPA 70, to a branch circuit rated at 20 amperes or less.

Exception No. 1: A neon pilot lamp that is integral with the lampholder is not required to have overcurrent protection at 20 amperes or less.

Exception No. 2: A receptacle circuit in a unit marked in accordance with 61.7 is exempted from this requirement.

26.3 Overcurrent protection at no more than 15 amperes shall be provided by a fuse or circuit breaker for each general use single receptacle, unless the unit would be connected in accordance with the National Electrical Code, ANSI/NFPA 70, to a branch circuit rated at 15 amperes or less.

Exception: A receptacle in a unit marked in accordance with 61.7 is exempted from this requirement.

26.4 If a fuseholder is incorporated in a unit, the fuses shall be shipped with the unit by the manufacturer, but need not be mounted in the fuseholder.

27 Overcurrent Protection, High-Voltage Control Circuit Conductors

27.1 General

27.1.1 If a control circuit is supplied through a transformer provided as part of the equipment, see Transformer Protection, Section 28, for additional requirements.

27.2 Direct-connected high-voltage control circuits

27.2.1 A unit employing a direct-connected high-voltage control circuit shall be marked in accordance with 61.23.

27.3 Tapped high-voltage control circuits

27.3.1 Tapped high-voltage control circuit conductors shall be provided with overcurrent protection. The rating of the overcurrent protective device(s) shall not exceed the applicable value specified in Table 27.1.

Exception No. 1: 18, 16, and 14 AWG (0.82, 1.3, and 2.1 mm^2, respectively) conductors that do not exceed 4 feet (1.2 m) in length between points of opposite polarity may be protected by fuses or circuit breakers rated 60 amperes or less.

Exception No. 2: An overcurrent protective device of a higher rating may be provided if the conductors withstand short-circuiting when tested as specified in the Short-Circuit Tests, Section 46.

Exception No. 3: A lead 12 inches (305 mm) or less in length need not be provided with overcurrent protection.

Exception No. 4: A control circuit conductor, supplied from the secondary of a single-phase transformer that is connected so that only a 2-wire (single voltage) secondary is used, may be protected by an overcurrent device(s) located on the primary side of the transformer provided:

a) this protection complies with requirements specified in Transformer Protection, Section 28, and

b) the protection does not exceed the applicable value specified in Table 27.1 multiplied by the ratio of secondary-to-primary rated transformer voltage.

Exception No. 5: A control circuit conductor that is tapped from the main power circuit at a point outside of the control equipment enclosure shall be protected as specified in Column A of Table 430-72(b) of the National Electrical Code, ANSI/NFPA 70.

Table 27.1
Overcurrent protective device rating for control circuit conductors

Tapped control-circuit conductor size AWG (mm^2)		Maximum rating of overcurrent protective device, amperes			
		Conductors contained in control equipment enclosure		Conductors extending beyond control equipment enclosure	
		Copper	Aluminum[a]	Copper	Aluminum[a]
18	(0.82)	25	–	7	–
16	(1.3)	40	–	10	–
14	(2.1)	100	–	45	–
12	(3.3)	120	100	60	45
10	(5.3)	160	140	90	75
Larger than 10		b	b	c	c

[a] Includes copper-clad aluminum.

[b] 400 percent of value specified for 60°C conductors in Table 310-17 of the National Electrical Code, ANSI/NFPA 70.

[c] 300 percent of value specified for 60°C conductors in Table 310-16 of the National Electrical Code, ANSI/NFPA 70.

27.4 Overcurrent protective devices

27.4.1 Overcurrent protection for a tapped high-voltage control circuit conductor, as required by 27.3.1, shall be provided as part of the equipment.

Exception: The overcurrent device(s) need not be provided as part of the equipment if, based on the marked rating(s) of the equipment, the rating of the branch circuit overcurrent protective device(s) does not exceed the values specified in Table 27.1.

27.4.2 A control circuit overcurrent protective device(s) shall:

a) be provided for all ungrounded conductors,

b) be sized in accordance with requirements in 28.1.2.1, and

c) have a voltage rating not less than the circuit in which it is used.

The device(s) shall be a circuit breaker acceptable for branch circuit protection, or a fuse acceptable for branch circuit protection, such as a Class CC, G, H, J, K, L, R, or T cartridge fuse or Type S plug fuse.

Exception: A device used for overcurrent protection of a tapped control circuit may be of the supplementary type if it has a short-circuit rating acceptable for the circuit in which it is used. See Table 46.1. If the supplementary type device used is a fuse, the equipment shall be marked in accordance with 61.20.

28 Transformer Protection

28.1 High-voltage transformer

28.1.1 General

28.1.1.1 A transformer (including an autotransformer), other than one as described in 28.2.1 and 28.2.2, is considered a high-voltage transformer and shall:

a) Be provided with thermal overload protection in accordance with the requirements in 28.1.2.1,

b) Be protected by an overcurrent device in accordance with requirements in Section 28.1.3, or

c) Be provided with electronic protection that meets the test requirements of Section 28.1.2 and the circuits requirements of the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1, or

d) Comply with the Burnout Test – High-Voltage Transformer, Section 49

Exception: A transformer rated less than 50 volt-amperes supplying only a motor control circuit and located in the same enclosure as the motor controller.

28.1.2 Thermal protection

28.1.2.1 If a high-voltage transformer is provided with a thermal overload protective device, the device shall be arranged to interrupt primary current and shall limit temperatures of the transformer windings, under overload conditions, to that permitted for the class of insulation employed in the windings. See Overload Test – High-Voltage Transformer, Section 48.

Exception: If the thermal protective device provided is a nonrenewable thermal cutoff, a burnout test is to be conducted in place of the overload test. See Burnout Test – High-Voltage Transformer, Section 49.

28.1.2.2 Thermal cutoffs shall comply with the Standard for Thermal-Links – Requirements and Application Guide, UL 60691. A manual or automatic resetting thermal protector shall have an endurance rating of not less than 6000 cycles and shall comply with the requirements pertaining to the calibration of temperature limiting controls specified in the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1 and the Standard for Automatic Electrical Controls – Part 2-9: Particular Requirements for Temperature Sensing Controls, UL 60730-2-9.

28.1.3 Overcurrent protection

28.1.3.1 If a high-voltage transformer is protected by an overcurrent device, such protection shall comply with the requirements specified in 28.1.3.2, 28.1.3.3, and 28.3.1 – 28.3.3.

28.1.3.2 Other than as noted in 28.1.3.3, a high-voltage transformer shall be protected by an overcurrent device(s) located in the primary circuit and rated or set as indicated in Table 28.1. See 28.2.2.

Exception: If the rated primary current of the transformer is 9 amperes or more and 125 percent of this current does not correspond to a standard rating of fuse or circuit breaker, the next higher standard rating of protective device may be used. Standard ratings of protective devices are specified in Section 240-6 of the National Electrical Code, ANSI/NFPA 70.

Table 28.1
Rating of overcurrent devices

Rated primary current, amperes	Maximum rating of overcurrent device, percent of transformer primary current rating
Less than 2	300[a]
2 or more less than 9	167
9 or more	125

[a] Does not apply to an autotransformer. May be increased to 500 percent if transformer supplies a motor control circuit.

28.1.3.3 If the circuit supplying a transformer other than an autotransformer is provided with overcurrent protection rated or set at not more than 250 percent of the rated primary current of the transformer,

additional overcurrent protection is not required in the primary circuit provided the secondary circuit is protected at not more than 125 percent of the rated secondary current of the transformer. See 28.3.2.

Exception No. 1: If the rated secondary current of the transformer is 9 amperes or more and 125 percent of this current does not correspond to a standard rating of fuse or circuit breaker, the next higher standard rating of protective device may be used in the secondary circuit. Standard ratings of protective devices are specified in Section 240-6 of the National Electrical Code, ANSI/NFPA 70.

Exception No. 2: If the rated secondary current of the transformer is less than 9 amperes, the overcurrent device(s) in the secondary circuit may be rated or set at not more than 167 percent of the rated secondary current.

28.2 Low-voltage transformers

28.2.1 Other than as indicated in 28.2.2, a transformer having a rated output of not more than 30 volts and 1000 volt-amperes (National Electrical Code, ANSI/NFPA 70, Class 1, power-limited circuit) shall be protected by an overcurrent device located in the primary circuit. The overcurrent device shall be rated or set at not more than 167 percent of the primary current rating of the transformer. See 28.3.1.

28.2.2 A transformer that directly supplies a National Electrical Code, ANSI/NFPA 70, Class 2 circuit shall, in accordance with the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1 and the Standard for Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3, either limit the output current (inherently limited transformer) or be equipped with an overcurrent device (not inherently limited transformer), and need not comply with the requirements in 28.2.1.

28.3 Overcurrent protective device

28.3.1 Overcurrent protection in the primary circuit of a transformer, as described in 28.1.3.2 and 28.2.1, need not be provided as part of the equipment if, based on the marked rating(s) of the equipment, the rating of the branch circuit overcurrent protective device(s) does not exceed the applicable value specified in 28.1.3.2 or 28.2.1.

28.3.2 Overcurrent protection in the secondary circuit of a transformer, as required by 28.1.3.3, shall be provided as part of the equipment.

28.3.3 A required transformer overcurrent protective device provided as part of a unit shall:

a) be provided for each ungrounded conductor,

b) be sized in accordance with the requirements in 28.1.3.2 – 28.2.1, as applicable, and

c) have a voltage rating not less than the circuit in which it is used.

The device shall be a circuit breaker acceptable for branch circuit protection, or fuses acceptable for branch circuit protection, such as a Class CC, G, H, J, K, L, R, or T cartridge fuse or a Type S plug fuse.

Exception: If a transformer supply is tapped from a circuit supplying other loads in the unit, a fuse used for overcurrent protection may be of the supplementary type [a type other than indicated in 28.3.3] provided the fuse has a short-circuit rating acceptable for the circuit in which it is used. See Table 46.1. The unit shall be marked in accordance with the requirements specified in 61.20.

28.3.4 In addition to the requirements specified in this Standard fuses shall comply with the requirements in the Standard for Low-Voltage Fuses – Part 1: General Requirements, UL 248-1 and,

a) Standard for Low-Voltage Fuses – Part 2: Class C Fuses, UL 248-2;

b) Standard for Low-Voltage Fuses – Part 4: Class CC Fuses, UL 248-4;

c) Standard for Low-Voltage Fuses – Part 5: Class G Fuses, UL 248-5;

d) Standard for Low-Voltage Fuses – Part 6: Class H Non-Renewable Fuses, UL 248-6;

e) Standard for Low-Voltage Fuses – Part 7: Class H Renewable Fuses, UL 248-7;

f) Standard for Low-Voltage Fuses – Part 8: Class J Fuses, UL 248-8;

g) Standard for Low-Voltage Fuses – Part 9: Class K Fuses, UL 248-9;

h) Standard for Low-Voltage Fuses – Part 10: Class L Fuses, UL 248-10;

i) Standard for Low-Voltage Fuses – Part 11: Plug Fuses, UL 248-11;

j) Standard for Low-Voltage Fuses – Part 12: Class R Fuses, UL 248-12; or

k) Standard for Low-Voltage Fuses – Part 15: Class T Fuses, UL 248-15.

29 Switches and Controllers

29.1 A switch or other control device shall have a rating not less than that of the load that it controls.

29.2 In addition to the requirements specified in this standard switches shall comply with the requirements in the:

a) Standard for Clock-Operated Switches, UL 917;

b) Standard for Enclosed and Dead-Front Switches, UL 98;

c) Standard for General-Use Snap Switches, UL 20; or

d) *Deleted*

e) Standard for Switches for Appliances – Part 1: General Requirements, UL 61058-1.

Exception: Switches used in extra-low-voltage non-safety circuits, that will not cause a risk of injury.

29.3 With reference to the requirement in 29.1, the ampere rating of a switch that controls an inductive load, such as a transformer, shall not be less than twice the rated full load current of the inductive load unless the switch is rated for the particular application.

29.4 A switch shall be so located or protected that it will not be subjected to mechanical damage in its intended use.

29.5 A switch or other device that controls a motor of a unit, unless rated for the application, shall perform acceptably when subjected to an overload test in accordance with the Switch Overload Test, Section 41.

29.6 A switching device such as a contactor, controlled by a remote thermostat having a marked on or off position, is not required to disconnect all ungrounded conductors of the power supply circuit.

29.7 If a manual switch in a unit or separate control assembly has a marked off position or the equivalent, there shall be no exposed live parts when the switch is in the off position and when the access panel(s) or cover(s) to the unit or control assembly is opened.

Exception: This requirement does not apply to:

a) A switch in a unit that is clearly marked to indicate that a remote disconnect shall be opened before the access panel(s) or cover(s) is opened; or

b) A switch that has its operating handle located behind a panel or cover that serves as the required enclosure for live parts.

29.8 A shield or barrier used to cover supply wiring terminals that may be live when a switch as specified in 29.6 is in the off position, shall comply with 15.7 and 15.8 and shall be marked in accordance with 61.18.

29.9 More than one switch may be used to comply with the requirements in 29.7, provided the manual switches are grouped and identified. A cover interlock switch, with terminals independently covered, may be used to disconnect some conductors, such as control circuit conductors, from a supply separate from the main power supply.

29.10 If an appliance provided with a power-supply cord and an attachment plug employs a motor rated more than 1/3 horsepower (250 W output), a motor controller – a device for starting and stopping the motor – shall be provided in the appliance.

29.11 A motor controller complying with the following is considered to fulfill the construction and rating for the application requirements of this Standard:

a) The Standard for Industrial Control Equipment, UL 508,

b) The Standard for Adjustable Speed Electrical Power Drive Systems – Part 5-1: Safety Requirements – Electrical, Thermal and Energy, UL 61800-5-1,

c) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1 and the Standard for Automatic Electrical Controls – Part 2-9: Particular Requirements for Temperature Sensing Controls, UL 60730-2-9, or

d) *Deleted*

30 Controls

30.1 General

30.1.1 Auxiliary controls shall be evaluated using the applicable requirements of this end product standard and the parameters in Controls – End Product Test Parameters, Section 57.

Exception: This requirement does not apply to circuits that comply with the requirements in Section 57.

30.1.2 Operating (regulating) controls shall be evaluated using the applicable component standard requirements specified in 30.2 – 30.4, and if applicable, the parameters in Controls – End Product Test Parameters, Section 57, unless otherwise specified in this end product standard.

Exception: This requirement does not apply to circuits that comply with the requirements in Section 57.

30.1.3 Operating controls that rely upon software for the normal operation of the end product where deviation or drift of the control may result in a risk of safety, such as a speed control unexpectedly changing its output, shall comply with the requirements in the:

Operating controls that rely upon software for the normal operation of the end product where deviation or drift of the control may result in a risk of safety, such as a speed control unexpectedly changing its output, shall comply with the requirements in the:

a) Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991; and the Standard for Software in Programmable Components, UL 1998; or

b) Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1.

c) The alternate circuits requirements of Section 57.

30.1.4 Protective (limiting) controls shall be evaluated using the applicable component standard requirements specified in 30.2 – 30.4, and if applicable, the parameters in Controls – End Product Test Parameters, Section 57, unless otherwise specified in this end product standard.

Exception: This requirement does not apply to circuits that comply with the requirements in Section 57.

30.1.5 Solid-state protective controls that do not rely upon software as a protective component shall comply with the requirements in the:

a) Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991; or

b) Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1, except Controls using software, Clause H.11.12.

c) The alternate circuits requirements of Section 57.

30.1.6 Protective controls that rely upon software as a protective component shall comply with the requirements in the:

a) Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991; and Standard for Software in Programmable Components, UL 1998; or

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

c) The alternate circuits requirements of Section 57.

30.2 Electromechanical and electronic controls

30.2.1 A control, other than as specified in 30.3 – 30.4, shall comply with the requirements in the:

a) *Deleted*

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

c) Standard for Programmable Controllers – Part 2: Equipment Requirements and Tests, UL 61131-2, or

d) The alternate circuits requirements of Section 57.

30.3 Motor and speed controls

30.3.1 A control used to start, stop, regulate or control the speed of a motor shall comply with the requirements in the:

a) *Deleted*

b) Standard for Industrial Control Equipment, UL 508;

c) Standard for Adjustable Speed Electrical Power Drive Systems – Part 5-1: Safety Requirements – Electrical, Thermal and Energy, UL 61800-5-1;

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

e) Standard for Solid-State Fan Speed Controls, UL 1917; or

f) Standard for Solid-State Controls for Appliances, UL 244A.

g) The alternate circuits requirements of Section 57.

30.4 Temperature controls

30.4.1 A temperature control shall comply with the requirements in the:

a) *Deleted*

b) Standard for Industrial Control Equipment, UL 508; or

c) Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1; and the Standard for Automatic Electrical Controls – Part 2-9: Particular Requirements for Temperature Sensing Controls, UL 60730-2-9.

d) The alternate circuits requirements of Section 57.

30.4.2 A temperature sensing positive temperature coefficient (PTC) or negative temperature coefficient (NTC) thermistor, that performs the same function as an operating or protective control shall comply with the requirements in the Standard for Thermistor-Type Devices, UL 1434.

31 Valves (Electrically Operated) and Solenoids

31.1 Electrically operated valves shall comply with the requirements in the:

a) Standard for Electrically Operated Valves, UL 429; or

b) Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1; and the Standard for Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Electrically Operated Water Valves, Including Mechanical Requirements, UL 60730-2-8.

32 Light Sources and Associated Components

32.1 Lampholders and indicating lamps shall comply with the requirements in the Standard for Lampholders, UL 496.

Exception: Lampholders forming part of a luminaire that complies with the requirements in the Standard for Luminaires, UL 1598, are considered to fulfill this requirement.

32.2 Lighting ballasts shall comply with the requirements in the:

a) Standard for Fluorescent-Lamp Ballasts, UL 935; or

b) Standard for High-Intensity Discharge Lamp Ballasts, UL 1029.

Exception: Ballasts forming part of a luminaire that complies with the requirements in the Standard for Luminaires, UL 1598, are considered to fulfill this requirement.

32.3 Light emitting diode (LED) light sources shall comply with the requirements in the Standard for Light Emitting Diode (LED) Equipment For Use In Lighting Products, UL 8750.

33 Safety Devices

33.1 The terminals of a safety device within the enclosure of a unit shall be located or further enclosed so that they will be protected against unintentional short-circuiting or damage.

33.2 The bulb, capillary tubing, or other sensing element of a temperature limiting control that is depended upon to reduce the risk of fire, electric shock, or injury to persons shall be located or guarded so as to be protected from mechanical damage during installation and use of the unit.

33.3 In connection with the requirement in 33.1, particular attention is to be paid to a unit that, when being installed, requires partial disassembly or permits rearrangement of internal parts.

33.4 A safety control device or a temperature limiting control (one designed to reduce the likelihood of operation that may result in a risk of fire, electric shock, or injury to persons) shall be operative whenever the unit is connected to its power supply.

33.5 A component, such as a pilot light, capacitor, or resistor, shall not be connected across the contact terminals of a safety control or a limit control.

33.6 A solid state safety control shall comply with the requirements in the Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991.

Exception No. 1: A control that complies with temperature limiter, thermal cutout or protective control, as appropriate, requirements of the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1 and the Standard for Automatic Electrical Controls – Part 2-9: Particular Requirements for Temperature Sensing Controls, UL 60730-2-9 are considered to fulfill the requirements of the Safety Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991.

Exception No. 2: This requirement does not apply to circuits that comply with the requirements in Section 57.

SPACINGS

34 General

34.1 The spacings at field-wiring terminals, fuseholders, and thermal cutoffs shall not be less than the value specified in Table 34.1. See 13.2.1.

Table 34.1
Spacings at field wiring terminals at fuseholders, and at thermal cutoffs

Potential involved in volts	Between parts mentioned above through air, or over surface,		Between parts mentioned above and other uninsulated metal parts not always of the same polarity[a]				Between parts mentioned above and enclosure (shortest distance),	
			Over surface,		Through air,			
	inches	(mm)	inches	(mm)	inches	(mm)	inches	(mm)
250 or less (0 – 2000 volt-amperes)	1/4	(6.4)	1/4	(6.4)	1/4	(6.4)	1/4	(6.4)
250 or less (more than 2000 volt-amperes)	1/4	(6.4)	3/8	(9.5)	1/4	(6.4)	1/2	(12.7)
251 – 600	1/2[b]	(12.7)	1/2[b]	(12.7)	3/8	(9.5)	1/2	(12.7)

NOTES –

1 These spacings do not apply to connecting straps or busses extending away from wiring terminals, from fuseholders or from thermal cutoffs. Such spacings are judged under Table 34.2.

2 These spacings apply with fuses installed in the fuseholders.

3 Spacings in low-voltage nonsafety circuits are not specified.

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

[b] A spacing of no less than 3/8 inch (9.5 mm), though air and over surface, is acceptable at wiring terminals in a wiring compartment or terminal box if the compartment or terminal box is integral with a motor.

34.2 Other than as noted in 34.1, 34.3, 34.4, and 34.6, the spacings between uninsulated live parts of opposite polarity and between an uninsulated live part and a dead metal part shall not be less than the value specified in Table 34.2.

Table 34.2
Spacings other than at field wiring terminals, at fuseholders, and at thermal cutoffs

Rating[a]		Minimum spacings in inches (mm)					
Volt-amperes	Volts	Through air		Over surface		To enclosure	
0 – 2000	250[b] or less	1/8	(3.2)	1/4	(6.4)	1/4	(6.4)
	0 – 125	1/8	(3.2)	1/4	(6.4)	1/2	(12.7)
	126 – 250	1/4	(6.4)	3/8	(9.5)	1/2	(12.7)
More than 2000	251 – 600	3/8	(9.5)	1/2	(12.7)	1/2	(12.7)

NOTE – Spacings in low-voltage nonsafety circuits are not specified.

[a] The spacings at an individual component are to be judged on the basis of the total volt-ampere load of the circuit in which the component is installed.

[b] If more than 250 volts, spacings in final line of table apply.

34.3 At closed in points only, such as the screw and washer construction of an insulated terminal mounted in metal, a spacing of 3/64 inch (1.2 mm) is acceptable if the potential involved is 250 volts or less, and a spacing not less than 1/4 inch (6.4 mm) is acceptable if the potential involved is 251 – 600 volts.

34.4 The spacing requirements indicated in Table 34.2 are not applicable to the inherent spacings of a component such as a motor or a snap switch; such spacings are judged on the basis of the requirements for the component. However, the electrical clearances resulting from the assembly of the component into the complete unit, including clearances to dead metal or an enclosure, shall not be less than those specified in Table 34.2.

34.5 Uninsulated live parts connected to different circuits shall be spaced from one another as though they are parts of opposite polarity in accordance with the requirements specified in 34.1 and 34.2 and shall be judged on the basis of the highest voltage involved.

34.6 The spacings "To Enclosure" as specified in Table 34.2 are not to be applied to an individual enclosure of a component that is within an outer enclosure or cabinet.

34.7 An insulating liner or barrier of vulcanized fiber, varnished cloth, mica, phenolic composition, or other moisture resistant material employed in addition to a through air spacing where the total spacing would otherwise be less than the minimum acceptable values shall not be less than 0.028 inch (0.71 mm) thick; except that a liner or barrier not less than 0.013 inch (0.33 mm) thick may be used in addition to an air spacing of not less than one-half of the through air spacing required. The liner shall be located so that it will not be affected adversely by arcing.

Exception: Insulating material having a thickness less than that specified may be used if it has equivalent insulating, physical, and flammability properties.

34.8 The spacings within a motor connected across a portion of a resistance element or in series with a reactor or an autotransformer shall be those specified for the full rated voltage of the circuit in which the motor is connected.

34A Clearance and Creepage Distances

34A.1 As an alternative approach to the spacing requirements specified in Spacings, 34, and other than as noted in Section 34A clearances and creepage distances may be evaluated in accordance with the requirements in the Standard for Insulation Coordination Including Clearance and Creepage Distances for Electrical Equipment, UL 840, as described in 34A.3.

34A.2 The clearance and creepage distance at field wiring terminals shall be in accordance with the requirements in Spacings, 34.

34A.3 In conducting evaluations in accordance with the requirements in the Standard for Insulation Coordination Including Clearance and Creepage Distances for Electrical Equipment, UL 840, the following guidelines in Table 57.1 – Table 57.3 shall be used.

PERFORMANCE

35 Installation

35.1 General

35.1.1 A unit is to be mounted in accordance with the manufacturer's installation instructions. If it is intended for mounting in two or more different positions, the unit is to be tested for installation in each such position. If a unit has optional air inlet and/or outlet openings, it is to be tested for each of the optional opening arrangements.

35.1.2 Inlet and outlet grilles, louvers, and filters intended for use with the unit are to be in place during the test.

35.1.3 Other than as indicated in 35.1.4, a unit that is intended to be mounted in a recess in a building structure or completely enclosed by the building structure is to be mounted inside a complete enclosure for the tests.

35.1.4 The enclosure specified in 35.1.3 is to be in accordance with the manufacturer's installation instructions and is to be complete, except that any surface that is not intended to be covered when the unit is installed (such as the exposed side of a recessed unit, an air inlet or discharge opening, or the like) is to remain exposed. An outlet box or control compartment is to be enclosed.

35.1.5 If operating the unit without restricting the duct connection openings will result in the most severe operating conditions, the tests may be conducted with no ducts attached if agreeable to those concerned. Otherwise, short lengths of duct of the same size as the opening to which they are attached, or as otherwise specified in the installation instructions, shall be provided as necessary with an adjustable means to restrict the airflow uniformly across the duct area.

35.1.6 If necessary because of the requirement in 38.3, a means is to be provided for measuring the static pressure in the outlet duct. The means is to consist of a hole 0.040 inch (1.02 mm) in diameter at the center point of at least one of the side walls of the outlet duct.

35.1.7 The inner surface of the wall adjacent to the hole is to be smooth and free from irregularities, and a metal tube having an internal diameter of 3/16 inch (4.8 mm) or larger is to be soldered, centered over the hole, to the outside surface of the duct. Connection of this tube to the manometer gauge is to be made by rubber tubing or the equivalent.

35.1.8 Panels representing a building structural part, such as a floor, wall, or duct or unit enclosure, are to be 5/8 inch (15.9 mm) minimum thickness plywood. The panels are to be painted black on the side toward the unit or duct, and all joints are to be sealed.

35.1.9 The lengths and widths of the panels specified in 35.1.8 are to be such that they extend not less than 2 feet (610 mm) beyond the extremities of the unit if the panels do not enclose the unit and ducts completely. The unit and ducts are to be as close to the panels as their configuration will permit.

35.1.10 A 1-inch (25.4-mm) thick insulating blanket having a density not less than 1 pound per cubic foot (1.6 kg/m^3) may be substituted for the wooden enclosure specified in 35.1.8 and 35.1.9 over surfaces intended for zero clearance to combustible materials.

35.1.11 External thermal insulation, such as glass fiber or mineral wool, is to be removed from the unit before installation in the enclosure or insulating blanket.

35.1.12 If a clearance is specified for a unit intended for installation as described in 35.1.3, temperatures are to be measured on the inside surfaces of the wooden test enclosure. Otherwise, temperatures are to be measured by thermocouples soldered, brazed, or welded to the metal surfaces of the equipment.

35.2 Supply connections

35.2.1 All tests are to be conducted with the unit and any accompanying electrical accessories intended to function with the operation of the unit electrically connected in accordance with the manufacturer's instructions.

35.3 Assembly, leveling, and adjustable features

35.3.1 All tests are to be conducted with the unit completely assembled, and with all components mechanically connected in accordance with the instructions. If a unit is intended to employ one or more air filters, all filters are to be in place and are to be of the largest size that the unit will accommodate.

35.3.2 All tests are to be conducted with the unit level. Detachable leveling means are to be removed, and any leveling means that are not detachable are to be so adjusted that the base of the unit will be the minimum distance from the floor.

35.3.3 If a unit employs a fan or blower whose speed can be varied and is intended to be set only by the installer, all tests are to be conducted with the fan speed adjusted to give approximately the rated air delivery. See 35.3.4.

35.3.4 If a unit employs an adjustable component that is intended to be regulated by the user, and if its setting could affect temperature test results, all tests are to be conducted with the component adjustment most likely to produce maximum temperatures or develop faulty performance.

36 Test voltage

36.1 Unless otherwise specified, a unit is to be tested at rated frequency at the potentials indicated in Table 36.1 as detailed in the paragraphs describing the test.

Table 36.1
Test voltages

Rated voltage (volts)	Normal test voltage (volts)	Overvoltage volts	Undervoltage volts
110 – 120	120	132	102
200 – 208	208	229	177
220 – 240	240	264	204
254 – 277	277	305	235
440 – 480	480	528	408
550 – 600	600	660	510
Other	Rated	110 percent Rated	85 percent Rated

37 Input Test

37.1 The current input to a unit shall not be more than 110 percent of the rated value when the unit is operated under the conditions specified in the Normal Temperature Test, Section 38, and the unit is connected to a supply circuit of rated frequency at the applicable voltage specified in Table 36.1.

38 Normal Temperature Test

38.1 When tested as described in this section, the observed temperature rise at any designated point and on any particular material shall not exceed those indicated in Table 38.1. A temperature, overload, or overcurrent protective device shall not open the circuit during the tests.

Table 38.1
Maximum temperature rises

Device or material	Degrees C	Degrees F
A. Motors[a]		
1. Class A insulation systems on coil windings of alternating-current motors having a frame diameter of 7 inches (178 mm) or less (not including universal motors).		
a. In open motors –		
Thermocouple or resistance method	75	135
b. In totally enclosed motors–		

Table 38.1 Continued on Next Page

Table 38.1 Continued

Device or material	Degrees C	Degrees F
Thermocouple or resistance method	80	144
2. Class A insulation systems on coil windings of alternating-current motors having a frame diameter of more than 7 inches (178 mm) and of direct-current motors and universal motors.		
a. In open motors –		
Thermocouple method	65	117
Resistance method	75	135
b. In totally enclosed motors–		
Thermocouple method	70	126
Resistance method	80	144
3. Class B insulation systems on coil windings of alternating-current motors having a frame diameter of 7 inches (178 mm) or less (not including universal motors).		
a. In open motors –		
Thermocouple or resistance method	95	171
b. In totally enclosed motors –		
Thermocouple or resistance method	100	180
4. Class B insulation systems on coil windings of alternating-current motors having a frame diameter of more than 7 inches (178 mm) and of direct-current motors and universal motors.		
a. In open motors –	85	153
	95	171
Thermocouple method	85	153
Resistance method	95	171
b. In totally enclosed motors –		
Thermocouple method	90	162
Resistance method	100	180
B Other Electrical Components		
1. Field wiring		
Any point within a wiring compartment in which field-installed conductors are to be connected including such conductors themselves, unless the unit is marked in accordance with 61.14.	35	63
2. Relay, solenoid, and other coils with:		
a. Class 105 insulated windings –		
Thermocouple method	65	117
Resistance method	85	153
b. Class 130 insulated windings–		
Thermocouple method	85	153
Resistance method	105	189
3. Sealing compounds[c]	40°C (104°F) less than its melting point	
4. Fuses[e]	65	117
5. Transformer, relay, and solenoid windings		
Class 155 insulations;		
Class 2 transformers		

Table 38.1 Continued on Next Page

Table 38.1 Continued

Device or material	Degrees C	Degrees F
Thermocouple method	95	171
Resistance method	115	207
Power transformers, relays, and solenoids		
Thermocouple method	110	198
Resistance method	115	207
6. Transformer, relay, and solenoid windings		
Class 180 insulation;		
Class 2 transformers		
Thermocouple method	115	207
Resistance method	135	243
Power transformers, relays, and solenoids		
Thermocouple method	125	225
Resistance method	135	243
7. Copper conductor, bare, or insulated, without tinning, nickel coating, or silver plating, except as noted in item B8.	175	315
8. Termination of copper conductor in a pressure terminal connector, unless both are tinned, nickel-coated, or silver-plated.	125	225
C. Insulated Conductors[b,d]	25°C (77°F) less than its temperature rating	
D. Electrical Insulation – General		
1. Fiber used as electrical insulation or cord bushings	65	117
2. Phenolic composition used as electrical insulation or as parts where failure will result in a risk of fire or electric shock[b]	125	225
3. Thermoplastic material[b]	25°C (77°F) less than its temperature rating	
4. Varnished cloth insulation	60	108
E. General		
1. Any point on a test enclosure surface at designated clearances from the unit or attached duct and plenums and a surface of a unit or attached ducts and plenums at the point of contact with the test-enclosure surface	65	117
2. Unit air filter	65	117
3. Wood or other combustible material which is a part of the unit	65	117

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

[b] The limitations on phenolic composition and on rubber and thermoplastic insulation do not apply to compounds that have been investigated and found to be acceptable for higher temperatures than those specified in Table 38.1.

[c] This is a maximum temperature rise.

[d] Inside a unit, the temperature rise on a wire or cord may be greater than the specified maximum rise provided that the insulation on each individual conductor is protected by supplementary insulation (such as a braid, wrap, tape, or close-fitting tubing) which is acceptable for the temperature and type of insulation involved.

[e] Includes both casing and ferrule. However, a temperature not more than 20°C (36°F) higher than the values indicated in the table is acceptable on the casing (not ferrule) of a Class G, J, T, or L fuse.

38.2 A unit is to be installed in accordance with Section 35 and supplied by test voltages in accordance with Section 36. The unit is to be operated continuously until temperatures stabilize.

38.3 A unit is to be tested in accordance with the manufacturer's recommendation as to static pressure and at other intended conditions as necessary to determine maximum temperatures.

38.4 A unit intended only for direct discharge of the conditioned air is to be tested accordingly.

38.5 A unit intended for either duct connection or direct discharge is to be tested under the condition or conditions that result in maximum temperatures.

38.6 Ordinarily, a thermocouple is to be used for determining the temperature of a coil or winding if it can be mounted, without removal of encapsulating compound or the like:

a) on the integrally applied insulation of a coil without a wrap, or

b) on the outer surface of a wrap that is no more than 1/32 inch (0.8 mm) thick and consists of cotton, paper, rayon, or the like but not of asbestos or similar thermal insulation.

The change-of-resistance method is to be used if the thermocouple measurement cannot be conducted in accordance with the foregoing considerations. For a thermocouple-measured temperature of a motor coil as mentioned in subitem 1 of item A and subitem 3 of item A of Table 38.1, the thermocouple is to be mounted on the integrally applied insulation on the conductor.

38.7 At a point on the surface of a coil where the temperature is affected by an external source of heat, the temperature rise as measured by means of a thermocouple may be 5°C (9°F) for item (a) of subitem 1 of item A of Table 38.1, 15°C (27°F) for item (a) of subitem 2 of item A of Table 38.1, and item (a) of subitem 2 of item B of Table 38.1, 10°C (18°F) for item (a) of subitem 3 of item A of Table 38.1, and 20°C (36°F) for item 1 of subitem 4 of item A of Table 38.1, more than the indicated maximum, provided that the temperature rise of the coil, as measured by the resistance method, is no more than that specified in the table.

38.8 Temperatures are to be measured by thermocouples consisting of 24 – 30 AWG (0.21 – 0.05 mm^2) wires, except that a coil temperature may be determined by the change-of-resistance method if the coil is inaccessible for mounting thermocouples. When the thermocouples are used in determining temperatures in electrical equipment, it is standard practice to employ thermocouples consisting of 30 AWG iron and constantan wire and a potentiometer type instrument; and such equipment is to be used whenever referee temperature measurements by thermocouples are necessary. The thermocouple wire is to conform with the requirements as listed in the Tolerances on Initial Values of EMF versus Temperature tables in the Standard Specification and Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples, ANSI/ASTM E230/E230M.

38.9 A temperature is considered to be constant when three successive readings, taken at intervals of 10 percent of the previously elapsed duration of the test (but no less than 5-minute intervals), indicate no change.

38.10 A thermocouple junction is to be securely held in thermal contact with the surface of the material whose temperature is being measured, and the adjacent thermocouple lead wire is to be secured to prevent movement. In most cases, thermal contact will result from securely taping or cementing the thermocouple in place but, if a metal surface is involved, brazing or soldering the thermocouple to the metal may be necessary.

38.11 The values in Table 38.1 are based on an assumed ambient-air temperature of 25°C (77°F), but a test may be conducted at any ambient-air temperature within the range of 10 – 40°C (50 – 104°F). However, if the operation of an automatic thermal control during the test limits the temperatures under observation, no observed temperature higher than 25°C plus the specified maximum rise is acceptable.

38.12 Flexible cord inside a motor terminal box may be exposed to a temperature higher than its rated value if supplementary heat-resistant insulation of adequate dielectric strength is employed on the individual conductors of the cord to reduce the risk of deterioration of the conductor insulation.

39 Overflow Tests

39.1 If a test is considered necessary to determine if a unit complies with the requirement in 6.8, it is to be performed as follows. The unit is to be leveled in any intended mounting position likely to cause wetting of electrical components. All drain lines are to be blocked and water added to the drain pan at a rate of not less than 1 pint per minute for each 1000 cubic feet per minute (16.7 milliliters per second for each cubic meter per second) of airflow, until water drains onto the floor around the unit. The test is to be conducted with the fan motor energized.

40 Motor Overload Tests

40.1 A motor overcurrent protective device as described in 22.2.1 (b) shall protect a motor rated 15 horsepower (11.2 kW output) or less. The motor shall not burn out and there shall not be other evidence of a risk of fire when tested in accordance with 40.2 – 40.5.

Exception: Tests in accordance with 40.2 – 40.5 are not required if all of the following conditions exist:

a) The motor is rated over 1 horsepower (746 W output).

b) The motor is located where it is not affected by an external source of heat.

c) The overload relay is selected to trip at not more than 125 percent of the motor full-load current rating for a motor with a marked service factor not less than 1.15 or with a marked temperature rise not over 40°C (72°F), and 115 percent for any other motor.

40.2 The motor and protective device combination is to be connected to a supply circuit of voltage as indicated in Table 36.1. Temperatures are to be measured by thermocouples on the surface of coils of the motor.

40.3 The motor and protective device shall be tested in the ambient encountered in normal operation, as determined during the Normal Temperature Test, Section 38.

Exception No. 1: A motor that is subjected to an ambient higher than normal room ambient, 25 – 26°C (77 – 79°F), in normal operation may be tested in a lower ambient with the maximum allowable temperatures specified in 40.4 and 40.5 reduced by the difference between the ambient encountered in normal operation and the test ambient.

Exception No. 2: An ambient compensated protective device may be tested in any ambient from 25 – 50°C (77 – 122°F).

40.4 When a motor is operating under the maximum overload that it can carry without causing the protective device to function, the maximum acceptable temperature on a Class A insulated motor winding is 140°C (284°F) and is 165°C (329°F) for a Class B insulated motor.

Exception: This requirement does not apply to a motor moving air only by means of a fan or blower directly attached to the motor shaft.

40.5 When the rotor of a motor is locked, the maximum acceptable temperature on a Class A insulated motor winding is 200°C (392°F) during the first hour of operation and is 175°C (347°F) thereafter. After the first hour of operation, the average temperature, that is, the average of:

a) the arithmetic mean of the maximum temperatures and

b) the arithmetic mean of the minimum temperatures is not acceptable if it is higher than 150°C (302°F).

For a motor employing Class B insulation, the corresponding temperatures are 225°C (437°F) for the first hour, 200°C after the first hour, and 175°C for the mean temperature.

40.6 The locked rotor test on a manually reset device is to be continued for four operations of the protective device, with the device being reset as quickly as possible after it is opened. For an automatically reset device, the locked rotor test is to be continued for 72 hours unless the unit includes other controls (such as a timer) that will demonstrably limit the duration of the operation to a shorter interval.

41 Switch Overload Test

41.1 If it is necessary to conduct this test to comply with the requirement in 29.5, there shall be no electrical or mechanical failure of the device nor pitting or burning of the contacts to an extent affecting its intended functioning.

41.2 In a test to determine if the switch or other control device is capable of performing acceptably in the overload test mentioned in 41.1, the unit is to be connected to a grounded supply circuit of rated frequency and normal test voltage, see Table 36.1, with the rotor of the motor locked in position. During the test, exposed dead metal parts of the unit are to be connected to ground through a 3-ampere fuse, and the connection is to be such that any single pole, current-rupturing device will be located in the ungrounded conductor of the supply circuit. If the unit is intended for use on direct current, the exposed dead metal parts of the unit are to be connected so as to be positive with respect to a single pole, current rupturing control device. The device is to be operated for 50 cycles at a rate of 6 – 10 cycles per minute; however, a faster rate of operation may be employed if agreeable to those concerned. The performance is unacceptable if the fuse in the grounding connection is blown during the test.

42 Dielectric Voltage-Withstand Test

42.1 A unit shall withstand without breakdown for 1 minute the application of a DC potential or an AC 60-hertz potential between high-voltage live parts and dead metal parts, and between live parts of high-voltage and low-voltage circuits. The test potential shall be as shown in Table 42.1:

Table 42.1
Dielectric Voltage Withstand Voltages

Unit under test	Test potential V AC	Test potential V DC
Low-voltage circuit	500	700
Motors rated at not more than 1/2 horsepower (373 W output) and not more than 250 volts	1000	1400
Secondary circuit of a transformer or autotransformer that operates at 250 volts or less	1000	1400
Secondary circuit of a transformer or autotransformer that operates at 251 – 600 volts	1000 + 2V[a]	1400 + 2.8V[a]
Other than noted in the previous lines	1000 + 2V[a]	1400 + 2.8V[a]
[a] Maximum marked voltage.		

42.2 To determine if a unit complies with the requirement in 42.1, it is to be tested by means of a 500 volt-ampere or larger transformer, the output voltage of which can be varied. Starting at zero, the applied potential is to be increased gradually to the required test value, and is to be held at that value for 1 minute. The requirement that the transformer be rated at 500 volt-amperes or more can be waived if the high potential testing equipment used is such that it maintains the specified high potential voltage at the equipment for the duration of the test and it can be demonstrated that the test equipment will detect a breakdown.

43 Insulation Resistance Test

43.1 A unit employing:

a) thermal or acoustical insulation, such as mineral wool or other material, in contact with uninsulated live parts or

b) electrical insulating material that is likely to be affected adversely by moisture under the conditions of intended use,

shall have an insulation resistance not less than 50,000 ohms after exposure for 24 hours to moist air having a relative humidity of 85 ±5 percent at a temperature of 32 ±2°C (90 ±4°F). See 20.2.

43.2 Insulation resistance may be measured by means of a voltmeter having an internal resistance of 30,000 ohms and a 250-volt direct current circuit or by an equivalent method.

44 Overvoltage and Undervoltage Tests

44.1 Other than as indicated in 44.2 and 44.3, an electromagnet as employed on a relay or solenoid in a low-voltage circuit shall withstand 10 percent above the normal test voltage without damage and shall operate successfully at 15 percent below the normal test voltage, see Table 36.1, when tested as described in 44.4 or 44.5, whichever applies.

44.2 If limits of operating voltage that may be marked on the unit nameplate in addition to the rated voltage extend beyond the overvoltage and undervoltage values specified in Table 36.1, the test potential for the Overvoltage and/or Undervoltage Test is to be such marked operating voltage limit.

44.3 A relay or solenoid that is rated for the voltage and operating conditions involved, including ambient-temperature conditions, is not required to be tested in the unit to determine if it complies with the requirement in 44.1. See 5.1 – 5.2.

44.4 The primary of a low-voltage transformer provided as part of the equipment and supplying continuous duty relays and solenoids is to be connected to a supply source and maintained at the indicated overvoltage until the coils of the relays and solenoids reach constant temperature. The potential is then to be reduced to the normal test voltage. Each relay and solenoid is to operate properly at the normal test voltage. The potential is to be maintained at the normal test voltage until the coils reach constant temperatures. The potential is then to be reduced to the indicated undervoltage condition. Each relay and solenoid is to operate properly under the undervoltage test condition.

44.5 If the low-voltage transformer is not provided as part of the equipment, the normal test voltage is the voltage rating of the low-voltage circuit, and the overvoltage and undervoltage potentials applied to the relays or solenoids are 110 and 85 percent, respectively, of the voltage rating. A relay or solenoid that will not be subject to continuous operation is to be energized at the specified overvoltage and at the normal test voltage for the maximum time permitted by its duty cycle or until it reaches constant temperature, whichever occurs first.

45 Tests for Polymeric Materials

45.1 General

45.1.1 The tests for polymeric materials in this section are to be conducted as indicated in Table 12.1.

45.1.2 Materials shall be classed 5V, V-0, V-1, V-2, HF-1, HF-2, HBF, or HB by the burning tests described in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94. The tests may be conducted on specimens cut from the finished part.

Exception: A material is to be considered equivalent to 5V if the finished part complies with the requirements in 45.2.1 – 45.2.3.

45.2 Flammability – 5 inch flame

45.2.1 The test is to be conducted employing the apparatus and test method described for the Vertical Burning Test for Classifying Materials 5V in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, except that samples of the complete finished part or sections obtained from the finished part are to be tested with the flame applied to areas of the part judged to be most critical with respect to ignition.

45.2.2 Sets of at least three samples each are to be provided for test. One set is tested in the "as received" condition, and the other sets are tested after aging:

a) as detailed in the air oven aging exposure if the polymeric material is used as an enclosure or a structural part, or

b) at 90°C (194°F) for 168 hours if the material is used as thermal or acoustical insulation or as a functional part.

If a polymeric material is used as indicated in both (a) and (b) above, it is to be aged at the more severe set of conditions.

Exception: The test may be conducted on only three unconditioned test samples if both of the following conditions are met:

a) The material used as the enclosure does not exhibit a reduction in its flame-resistance properties as a result of long-term thermal aging.

b) The thermal-aging program used for such determination included specimens having a thickness equal to or less than the wall thickness of the polymeric enclosure.

45.2.3 Two of the three samples from each set shall show acceptable performance as follows: samples shall not continue to flame or exhibit consuming combustion for more than 1 minute after the fifth application of the test flame. Particles shall not drip from the specimen at any time during the test. The performance is not acceptable if the material is destroyed in the area of the test flame to such an extent as to produce a condition that could result in a risk of fire, electric shock, or injury to persons.

45.3 Heat deflection test

45.3.1 The heat deflection temperature of a polymeric material shall not be less than 10°C (18°F) higher than the maximum intended operating temperature, but not less than 70°C (158°F) in any case.

45.3.2 The heat deflection temperature is to be measured in accordance with the requirements for Deflection Temperature of Polymeric Materials Under Load in the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A, at a loading of 66 psi (455 kPa) fiber stress.

45.4 Water absorption test

45.4.1 The percentage of water absorption by weight of a polymeric part shall not exceed 1-1/2 percent.

Exception: If dimensional changes in any measurable direction on the sample tested do not exceed 1/10 of 1 percent, the percentage of water absorption by weight may be not more than 2 percent.

45.4.2 Three samples approximately 1 by 2 by 1/8 inch (25.4 by 51 by 3.2 mm), obtained from the finished molding are to be used. In each case, the sample is to be dried in a calcium chloride desiccator for 24 hours, then weighed, and next immersed in distilled water at 20 – 30°C (68 – 86°F) for 24 hours. The samples are then removed from water and wiped dry of excess moisture and reweighed immediately. The percentage increase in weight is to be calculated.

45.5 Air-oven aging

45.5.1 Specimens of a polymeric part are to be aged in a full-draft, circulating air-oven at the aging temperature and time determined by the intended use of the finished part in accordance with Table 45.1.

Table 45.1
Aging temperature and time

Intended use[a]	Maximum normal operating temperature degrees C (F)[b]		Aging temperature degrees C	(F)	Aging time, hours
Enclosure (indoor only)	65	(149)	90	(194)	168
Enclosure	75	(167)	90	(194)	1440
Enclosure	85	(185)	95	(203)	1440
Enclosure	95	(203)	105	(221)	1440
Enclosure	100	(212)	121	(250)	1440
Structural	50	(122)	75	(167)	1440
Structural	75	(167)	100	(212)	1440
Structural	100	(212)	121	(250)	1440

[a] If a material is used as both an enclosure and a structural part, it is to be subjected to the aging condition shown for structural parts.

[b] If normal operating temperature is between two values shown in table, the higher of these two values is used in determining the aging conditions.

45.5.2 Following the air-oven aging, the specimens are to be subjected to the Flammability Test required for the material application and to the Tensile-Strength, Flexural-Strength, Izod Impact, or Tensile-Impact Tests, if required for the material application. See Table 12.1 and Table 12.2 and the applicable tests described in this section.

45.6 Tensile-strength test

45.6.1 The tensile strength of a polymeric part after air-oven aging:

a) shall not decrease more than 50 percent and

b) shall be essentially stabilized.

45.6.2 The tensile strength is to be determined in accordance with the procedures of Standard Test Methods for Tensile Properties of Plastics, ASTM D638, on samples in the "as-received" condition and after the appropriate air-oven aging.

45.7 Flexural-strength test

45.7.1 The flexural strength of a polymeric part after air-oven aging:

a) shall not decrease more than 50 percent and

b) shall be essentially stabilized.

45.7.2 The test is to be conducted in accordance with the procedure of Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials, ASTM D790, on appropriate samples in the "as received" condition and after air-oven aging.

45.8 Izod impact test

45.8.1 The Izod impact strength of a polymeric part after air-oven aging:

a) shall not decrease more than 50 percent and

b) shall be essentially stabilized.

45.8.2 The test is to be conducted on samples obtained form the finished part and is to be conducted in accordance with the procedure of Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics, ASTM D256.

45.8.3 If the Izod Impact Test is not considered appropriate on the basis of the material and the thickness of the part involved, Tensile Impact Tests, as specified in 45.9.1, are to be conducted in lieu of the Izod Impact Test. See 45.9.1.

45.9 Tensile-impact test

45.9.1 The tensile impact strength of a polymeric part after air-oven aging:

a) shall not decrease more than 50 percent, and

b) shall be essentially stabilized.

45.9.2 The test is to be conducted on samples obtained from the finished part and is to be conducted in accordance with the procedure of Standard Test Method for Tensile-Impact Energy to Break Plastics and Electrical Insulating Materials, ASTM D1822.

45.10 Impact test

45.10.1 A nonmetallic outer enclosure or base pan shall withstand an impact of 5 foot-pounds (6.9 J) without breakdown or cracking in a manner which results in exposed uninsulated live parts or which defeats its intended use.

45.10.2 A nonmetallic structural part located within the unit enclosure shall withstand an impact of 1.5 foot-pounds (2.0 J) without breaking or cracking.

45.10.3 A decorative part not necessary for the operation of the unit and which does not serve as the enclosure of uninsulated live parts need not comply with the requirements of 45.10.1 or 45.10.2.

45.10.4 The complete part is to be employed for the test. The impact force applied is to be obtained from a solid, smooth, steel sphere 2 inches (51 mm) in diameter and weighing approximately 1.18 pounds

(0.535 kg). The sphere is to be allowed to fall freely from rest through the distance required to cause it to strike the surface of the sample with the specified impact. For surfaces other than horizontal, the sphere is to be suspended by a suitable cord and allowed to fall as a pendulum through the vertical distance required to cause it to strike the surface with the specified impact. If the pendulum-type impact force is used, the test sample is to be so placed that the surface to be tested is vertical and in the same vertical plane as the point of support of the pendulum.

45.11 Volume resistivity tests

45.11.1 To be considered as insulating material, a polymeric material shall have a resistance per unit volume of not less than 50 megohms-cm in the "as received" condition and not less than 10 megohms-cm after exposure to moist air having a relative humidity of 85 ±5 percent at a temperature of 32 ±3°C (90 ±5°F) for 96 hours.

45.11.2 The test is to be conducted in accordance with the procedure of Tests for D-C Resistance or Conductance of Insulating Materials in the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A, on samples measuring 2 inches (51 mm) in diameter and in the minimum thickness of the finished part.

46 Short-Circuit Tests

46.1 Devices and conductors as referenced in 14.2.11, 16.19, 16.20 and 22.3.1 shall withstand short-circuit and ground-fault conditions when protected by either:

a) a device that is acceptable for branch-circuit protection and located in the product,

b) a branch-circuit protective device of the type and maximum rating specified on the product nameplate, or

c) a fuse as specified in 46.3.

Specifically, there shall be no damage to conductors or their terminations, no ignition of cheesecloth surrounding the enclosure housing of the components under test, and no arc-over between line-voltage and low-voltage circuits.

46.2 For the purpose of these tests:

a) Circuit breakers and fuses are not considered to be interchangeable,

b) Fuses of the same rating are considered to be interchangeable,

c) Circuit breakers of the same rating are considered to be interchangeable, and

d) Other types of circuit breakers are not considered to be interchangeable with each other or with circuit breakers.

46.3 If a branch-circuit protective device is not specified on the product nameplate, a fuse of the maximum rating permitted by the National Electrical Code, ANSI/NFPA 70, to protect the circuit involved may be used. However, the rating is to be not less than 20 amperes for a voltage rating of 150 volts or less or not less than 15 amperes for a voltage rating of 151 – 600 volts. A test fuse rated at 15 or 20 amperes is to be of the time-delay type.

46.4 The device or conductor is to be connected in a circuit having a capacity based on the rated current and voltage of the product in accordance with Table 46.1. Each concurrent-load condition is to be considered separately, and the maximum resulting current employed as the basis of selection of the

capacity of the test circuit. The voltage source for the test circuit is to be an alternating voltage and the circuit capacity is to be measured without devices or conductors in the circuit. The power factor is to be 0.9 – 1.0 unless a lower power factor is agreeable to all concerned.

Table 46.1
Short-circuit test currents

Product ratings, amperes				Circuit capacity amperes
	Single phase			
110 – 120 V	200 – 208 V	220 – 240 V	254 – 277 V	
9.8 or less	5.4 or less	4.9 or less	–	200
9.9 – 16.0	5.5 – 8.8	5.0 – 8.0	6.65 or less	1000
16.1 – 34.0	8.9 – 18.6	8.1 – 17.0	–	2000
34.1 – 80.0	18.7 – 44.0	17.1 – 40.0	–	3500
Over 80.0	Over 44.0	Over 40.0	Over 6.65	5000
	Three phase			
200 – 208V	220 – 240 V	440 – 480 V	550 – 600 V	Circuit Capacity Amperes
2.12 or less	2.0 or less	–	–	200
2.13 – 3.7	2.1 – 3.5	1.8 or less	1.4 or less	1000
3.8 – 9.5	3.6 – 9.0	–	–	2000
9.6 – 23.3	9.1 – 22.0	–	–	3500
Over 23.3	Over 22.0	Over 1.8	Over 1.4	5000

46.5 Three samples of each component under test are to be subjected to each test condition and a new protective device is to be used for each test. Consideration is to be given to both short-circuit and ground-fault conditions.

47 Starting Test

47.1 The test is to be conducted on any product marked to specify a maximum size of supply-circuit overcurrent protection that is less than the sum of:

a) four times the rating of the largest motor (or 2.25 times that rating if time-delay fuses are specified) and

b) the total rating of all other loads.

The ratings referenced are to be those specified on the product nameplate. See 60.12.

47.2 The product and four fuses of the type and rating specified on the product nameplate are to be connected in series. The product is to be operated for 1/2 hour under the conditions specified in 37.1 and then is to be stopped. The product is to be restarted immediately after the fan stops. If one of the four fuses opens on the restart, it is to be shorted out of the circuit and the test repeated. If one of three remaining fuses opens, the results are not acceptable. An automatic-reset motor overload protective device may open on the restart, but the product shall ultimately restart and run as intended without continuing operation of automatic-reset motor overload protective devices and without opening of a manual-reset motor overload protective device.

48 Overload Test – High-Voltage Transformer

48.1 This test applied to a high-voltage transformer provided with thermal protection of other than the nonrenewable thermal cutoff type. See 28.1.2.1.

48.2 Temperatures measured on the surface of the windings of a thermally protected high-voltage transformer shall not exceed the insulation temperature rating when the transformer is tested as indicated in 48.3 and 48.4. Insulation temperature rating is defined as the rating for the class of insulation; such as 105°C for Class 105 insulation, 130°C for Class 130 insulation, and the like.

48.3 A variable resistance load is to be connected to the output terminals and the transformer operated continuously at the normal test voltage indicated in Table 36.1. If the protective device controls a switching device that, in turn, interrupts primary current to the transformer, the switching device is to be in the circuit. The test ambient temperature is to be approximately 25°C (77°F). The resistance load is to be adjusted so that the transformer winding is brought to a stabilized temperature of approximately 10°C (18°F) below its insulation rating. The load is then to be gradually increased until operation of the protector occurs.

48.4 Three samples of the transformer-protector combination are to be tested. Average temperatures of the three samples shall not exceed the winding insulation rating and the temperature of any one sample shall not exceed the insulation rating by more than 5°C (9°F).

48.5 The transformer shall comply with the Dielectric Voltage-Withstand Test, Section 42, following the test specified in 48.3 and 48.4.

49 Burnout Test – High-Voltage Transformer

49.1 When a high-voltage transformer is tested as described in 49.2 and 49.3, there shall be:

a) no emission of flame or molten metal from the unit enclosure, and

b) no emission of smoke into an air handling compartment.

Exception: This test does not apply to a high-voltage transformer that is provided with thermal overload protection of other than the nonrenewable thermal cutoff type (see 28.1.2.1) or that is protected by overcurrent devices in accordance with the requirements in 28.1.3.1.

49.2 Three samples of the transformer are to be tested at the normal test voltage specified in Table 36.1 and at rated frequency with the enclosure grounded. The test ambient temperature is to be 25°C (77°F) and operation is to be continued until constant temperatures are indicated by a thermocouple on the transformer enclosure, unless burnout occurs earlier.

49.3 The load connected to the output terminals is to be the highest of the following and is to be readjusted to the specified value after 2 minutes of operation, if necessary, with no further readjustment during the test.

a) A resistance load to provide a current equal to three times the full rated transformer secondary current;

b) If the transformer supplies a motor with or without additional loads, a resistance load to provide a current equal to the motor locked-rotor current plus any additional loads; or

c) If the transformer supplies an inductive load (other than a motor), such as the coils of relays, solenoids, and the like, a resistance load to provide a current equal to the sum of such loads with the armature of the largest blocked open.

Exception: The test may be conducted with the output terminals short-circuited if this results in less than three times rated secondary current.

50 Grounding Means Overload Test

50.1 The test specified in 50.2 is to be conducted only if required by 16.19 or 16.20(c).

50.2 The bonding connection and conductor shall not open when carrying a current equal to twice the rating of the circuit overcurrent protective device for the time interval indicated in Table 50.1.

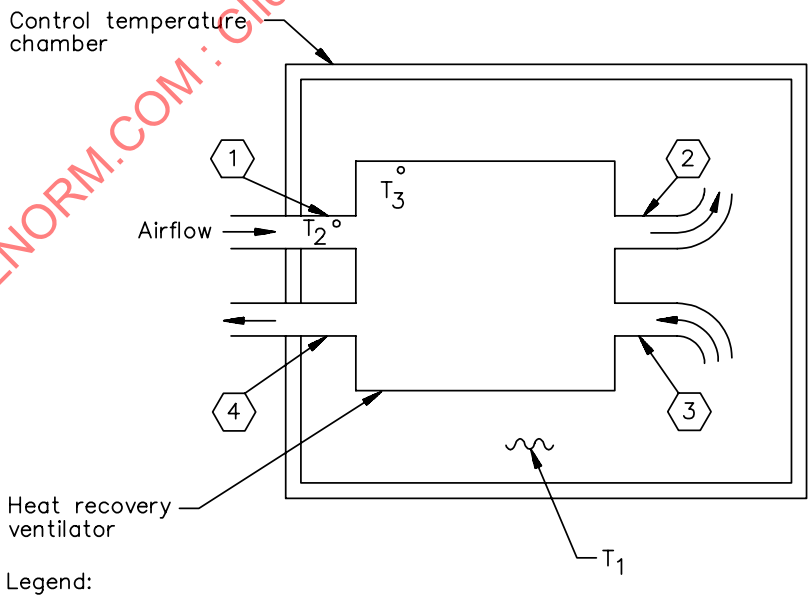
Table 50.1
Duration of current flow, bonding conductor test

Rating of overcurrent protection device, amperes	Minimum duration of current flow, minutes
30 or less	2
31 – 60	4
61 – 100	6
101 – 200	8

51 Condensation Test

51.1 An appliance operating under the conditions described in 51.2 and 51.3 shall have a surface temperature on all live electrical components exposed to ambient air or the warm exhaust air (Station 3, Figure 51.1), greater than the minimum permissible temperature as determined in 51.4.

Figure 51.1
Condensation test



Legend:

1 = Station 1 – supply air from outside
2 = Station 2 – supply air to test chamber
3 = Station 3 – exhaust air from test chamber
4 = Station 4 – exhaust air to outside

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51.2 The appliance shall be installed in a test facility as shown in Figure 51.1. Test chamber air temperature shall be maintained at 20 ±1°C (36 ±2°F) above the air temperature entering the appliance (Station 1). The airflow rate entering the equipment shall be adjusted to the manufacturer's maximum recommended value.

51.3 The temperature shall be considered constant when three successive readings taken at 10 minute intervals indicate no change, but not less than 1 hour elapsed duration of the test.

51.4 The minimum permissible temperature shall be computed by means of the formula:

$$T_3 = 0.8\,T_1 + 0.2\,T_2$$

in which:

T_1 is the air temperature of test chamber, degrees C,

T_2 is the air temperature entering the heat recovery ventilator, degrees C, and

T_3 is the minimum permissible temperature, degrees C.

52 Leakage Current Test

52.1 A cord-connected appliance rated for a nominal 240 volt or less supply shall be tested in accordance with 52.3 – 52.6. The leakage current shall not exceed:

a) 0.5 milliampere for an ungrounded 2-wire product,

b) 0.5 milliampere for a grounded, 3-wire, portable product, and

c) 0.75 milliampere for a grounded, 3-wire, product:

1) employing a standard attachment plug rated 20 amperes or less and

2) intended to be fastened in place or located in a dedicated space.

Exception: The leakage current shall be no more than 3.5 mA under the following conditions:

a) The product is rated 20 A or less,

b) The product requires electromagnetic field suppression filtering for compliance with EMI regulations; and

c) The product is equipped with a grounding-type power supply cord and plug.

52.2 Leakage current refers to all currents, including capacitively coupled currents, that may be conveyed between exposed conductive surfaces of an appliance and ground or other exposed conductive surfaces of an appliance.

52.3 Currents from these surfaces are to be measured to the grounded supply conductor individually as well as collectively where simultaneously accessible. Parts are considered to be exposed surfaces unless guarded by an enclosure considered acceptable for reducing the risk of electric shock as determined in accordance with 9.5.1 – 9.7.8. Surfaces are considered to be simultaneously accessible if they can be readily contacted by one or both hands of a person at the same time. These measurements do not apply to terminals operating at voltages that are not considered to involve a risk of electric shock. If all accessible

surfaces are bonded together and connected to the grounded conductor of the power-supply cord, the leakage current can be measured between the grounding conductor and the grounded supply conductor.

52.4 If a conductive surface other than metal is used for the enclosure or part of the enclosure, the leakage current is to be measured using metal foil having an area of 10 by 20 centimeters in contact with the surface. If the surface has an area of less than 10 by 20 centimeters, the metal foil is to be the same size as the surface. The metal foil is not to remain in place long enough to affect the temperature of the appliance.

52.5 The measurement circuit for leakage current is to be as illustrated in Figure 52.1. The measurement instrument is defined in (a) – (d). The meter that is actually used for a measurement need only indicate the same numerical value for a particular measurement as would the defined instrument. The meter used need not have all the attributes of the defined instrument.

a) The meter is to have an input impedance of 1500 ohms resistive shunted by a capacitance of 0.15 microfarad.

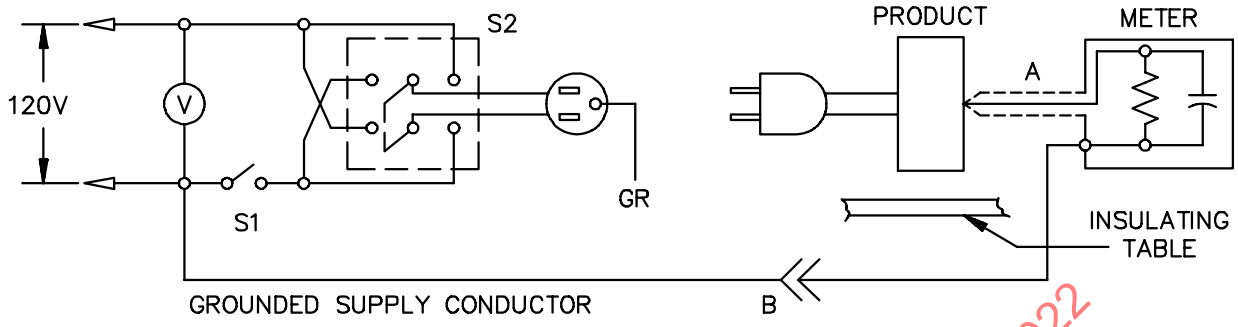
b) The meter is to indicate 1.11 times the average of the full-wave rectified composite waveform of the voltage across the resistor or current through the resistor.

c) Over a frequency range of 0 – 100 kilohertz, the measurement circuitry is to have a frequency response – ratio of indicated to actual value of current – equal to the ratio of the impedance of a 1500-ohm resistor shunted by a 0.15-microfarad capacitor to 1500 ohms. At an indication of 0.5 milliampere, the measurement is not to have an error of more than 5 percent at 60 hertz.

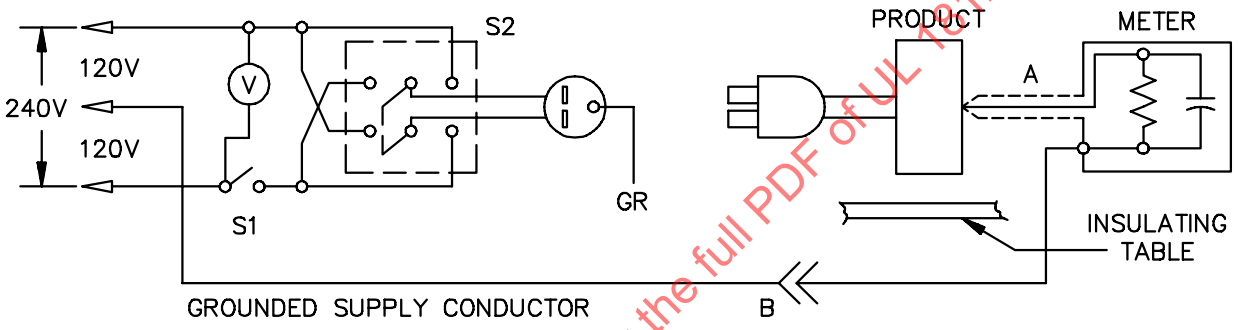
d) Unless the meter is being used to measure leakage from one part of an appliance to another, the meter is to be connected between the accessible parts and the grounded supply conductor.

Figure 52.1

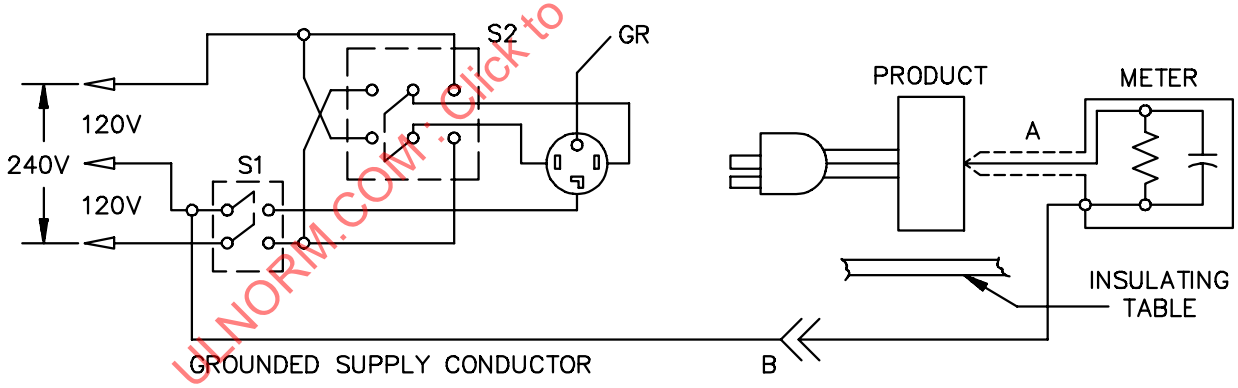
Leakage current measurement circuits



Product intended for connection to a 120–volt power supply, as illustrated above.



Product intended for connection to a 3–wire, grounded neutral power supply, as illustrated above.



Product intended for connection to a 3–wire, grounded neutral power supply, as illustrated above.

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Notes:

A – Probe with shielded lead.

B – Separated and used as clip when measuring currents from one part of product to another.

52.6 A sample of the appliance is to be tested for leakage current in the as-received condition, without prior energization except as may occur as part of the production-line testing, but with the grounding conductor, if any, open at the attachment plug. The supply voltage is to be adjusted to the applicable values specified in Test voltage, Section 36. The test sequence, with reference to the measuring circuit, Figure 52.1, is to be as follows:

a) With the switch S1 open, the appliance is to be connected to the measuring circuit. Leakage current is to be measured using both positions of switch S2, and with the unit switching devices in all their normal operating positions.

b) Switch S1 is then to be closed, energizing the appliance, and within 5 seconds, the leakage current is to be measured using both positions of switch S2 and with the unit switching devices in all their normal operating positions.

c) The leakage current is to be monitored until thermal stabilization. Both positions of switch S2 are to be used in determining this measurement. Thermal stabilization is to be obtained by operation as in the normal temperature test.

52.7 Normally the complete leakage current test, as described in 52.6, is to be conducted without interruption for other tests. However, with the concurrence of those concerned, the leakage current test may be interrupted to conduct other nondestructive tests.

53 Continuity of Grounding Circuit Test

53.1 The resistance shall not be more than 0.1 ohm between any point required to be grounded, as specified in 16.1, and:

a) For an appliance intended for permanent electrical connection, the point on the enclosure at which the power-supply system will be connected.

b) For a cord-connected appliance employing a grounding conductor in the cord, the point to which the grounding conductor of the power-supply cord is connected.

54 Humidity Conditioning Test

54.1 After conditioning as specified in 54.2 a cord-connected appliance:

a) Shall comply with the Dielectric voltage-withstand requirements in Section 42; and

b) For an appliance rated 240 volts or less, the leakage current shall not be more than the applicable value in 52.1.

54.2 For the conditioning mentioned in 54.1, a sample of the appliance is to be heated to a temperature just above 34°C (93°F) to reduce the likelihood of condensation of moisture during conditioning. The heated sample is then to be placed in the humidity chamber and conditioned for 48 hours in air having a relative humidity of 88 ±2 percent and a temperature of 32 ±2°C (90 ±4°F). Following the conditioning:

a) The appliance is to be tested unenergized as specified in 52.6(a). Then, either while the sample is still in the humidity chamber or within 1 minute of removal from the chamber, the sample is to be energized and tested as specified in 52.6(b) and (c). The test is to be discontinued when the leakage current stabilizes or decreases.

b) An appliance shall comply with the dielectric voltage-withstand requirements in 42.1.

54.3 Insulation resistance is to be measured by means of a high-resistance voltmeter using a 250-volt, direct current circuit.

55 Strain Relief Test

55.1 The strain relief means provided on a flexible cord shall withstand for 1 minute without displacement a direct pull of 35 pounds (156 N) applied to the cord with the connections within the appliance disconnected. The strain relief is not acceptable if, at the point of disconnection of the conductors, there is such movement of the cord as to indicate that stress on the connections would have resulted.

Exception: As provided in 55.3.

55.2 A 35-pound (16-kg) weight is to be suspended from the cord and supported by the appliance so that the strain-relief means will be stressed from any angle the construction of the appliance permits.

55.3 The strain relief means provided in a through cord switch shall withstand for 1 minute a direct pull of 30 pounds (133 N). The strain relief is not acceptable if a conductor is detached from a terminal or an uninsulated conductor of the cord is exposed.

55.4 For the construction mentioned in 13.3.2.3, six samples of the clamp that have been secured to the cord in the intended manner are to be used. Three samples are to be subjected to the Dielectric voltage withstand test specified in Section 42 and shall then comply with the strain-relief tests specified in 55.1, in the as-received condition. Three samples shall comply with the requirements specified in 55.1 after being subjected to the following procedures:

a) The samples are to be placed for 168 hours in a forced-draft air-circulating oven maintained at a temperature of 70°C (158°F) or 10°C (18°F) higher than the temperature recorded on the clamp during the Temperature Test, Section 38, whichever is greater.

b) The samples are then to be subjected to the Dielectric voltage withstand test specified in Section 42 with the value of the applied potential based on the rating of the appliance. 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.

c) The conditioned samples then are to be cooled at room temperature.

56 Push-Back Test

56.1 The supply cord shall be prevented from being pushed into the product through the cord entry hole when such displacement is likely to:

a) Subject the cord to mechanical damage or to exposure to a temperature higher than that for which the cord is rated;

b) Reduce spacings (such as to a metal strain relief clamp) below the minimum intended values, or

c) Damage internal connectors or components.

56.2 The supply cord is to be held 1 inch (25.4 mm) from the point where the cord emerges from the product and is then to be pushed back into the product. The cord is to be pushed back into the product in 1 inch (25.4 m) increments until the cord buckles or the force to push the cord into the product exceed 6 pounds-force (26.7 N) The supply cord, within the product, is to be manipulated to the worst case position during the test to determine compliance with 56.1.

57 Controls – End Product Test Parameters

57.1 General

57.1.1 Spacings of controls shall comply with the electrical spacing, or clearances and clearance distance requirements of the applicable control standard as determined in Controls, Section 30.

57.1.2 Where reference is made to declared deviation and drift, this indicates the manufacturer's declaration of the control's tolerance before and after certain conditioning tests.

57.2 Auxiliary controls

57.2.1 Auxiliary controls shall not introduce a risk of electric shock, fire, or personal injury.

57.2.2 Auxiliary controls shall comply with the requirements of this end product standard.

57.3 Operating controls(regulating controls)

57.3.1 The following test parameters shall be among the items considered when judging the acceptability of an operating control investigated using the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1:

a) Control Types 1 or 2;

b) Unless otherwise specified in this standard, manual and automatic controls shall be tested for 6,000 cycles with under maximum normal load conditions, and 50 cycles under overload conditions;

c) Installation Class 2 per Electromagnetic Compatibility (EMC) – Part 4-5: Testing Measurement Techniques – Surge Immunity Test, IEC 61000-4-5;

d) For the applicable Overvoltage Category, see Table 57.1;

e) For the applicable Material Group, see Table 57.2;

f) For the applicable Pollution Degree, see Table 57.3.

Appendix B provides more examples of controls intended to be used as operating controls.

Table 57.1
Overvoltage categories

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