UL 1812

STANDARD FOR SAFETY

Ducted Heat Recovery Ventilators

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

Fifth Edition, Dated April 1, 2025

Summary of Topics

This new Fifth edition of UL 1812 dated April 1, 2025 incorporates editorial changes including renumbering and reformatting to align with current style.

The new requirements are substantially in accordance with Proposal(s) on this subject dated November 1, 2024 and January 16, 2025.

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Standard for Ducted Heat Recovery Ventilators

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

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PART 1 – ALL EQUIPMENT

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 Components

2.1 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 the requirements in a component standard other than those cited in this Standard is acceptable if:

a) The component also complies with the requirements in 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 UL 746B; and

3) Any use limitations of the other component standard are 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 requirements in the relevant component standard may assume user expertise not common in household applications.

2.2 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.

2.3 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) are not required to be applied.

2.4 A component not described 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 2.1 (b) – (d).

2.5 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.

3 Units of Measurement

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

3.2 Unless otherwise indicated, all voltage and current values mentioned in this Standard are rms.

4 Referenced Publications

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

4.2 The following publications are referenced in this Standard:

ASHRAE 34, *Designation and Safety Classification of Refrigerants*

ASME B94.11M, *Twist Drills*

ASTM A90/A90M, *Standard Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings*

ASTM A653/A653M, *Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process*

ASTM D256, *Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics*

ASTM D638, *Standard Test Method for Tensile Properties of Plastics*

ASTM D790, *Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials*

ASTM D1822, *Standard Test Method for Determining the Tensile-Impact Resistance of Plastics*

ASTM E230/E230M, *Standard Specification for Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples*

CSA B51, *Boiler, Pressure Vessel, And Pressure Piping Code*

IEC 61000-4-5, *Electromagnetic Compatibility (EMC) – Part 4-5: Testing and Measurement Techniques – Surge Immunity Test*

NEMA C80.1, *Electrical Rigid Steel Conduit (ERSC)*

NFPA 70, *National Electrical Code*

NFPA 90A, *Installation of Air-Conditioning and Ventilating Systems*

NFPA 90B, *Installation of Warm Air Heating and Air-Conditioning Systems*

UL 1, *Flexible Metal Conduit*

UL 6, *Electrical Rigid Metal Conduit – Steel*

UL 20, *General-Use Snap Switches*

UL 44, *Thermoset-Insulated Wires and Cables*

UL 62, *Flexible Cords and Cables*

UL 67, *Panelboards*

UL 83, *Thermoplastic-Insulated Wires and Cables*

UL 94, *Tests for Flammability of Plastic Materials for Parts in Devices and Appliances*

UL 98, *Enclosed and Dead-Front Switches*

UL 207, *Refrigerant-Containing Components and Accessories, Nonelectrical*

UL 224, *Extruded Insulating Tubing*

UL 244A, *Solid-State Controls for Appliances*

UL 248-1, *Low-Voltage Fuses – Part 1: General Requirements*

UL 248-2, *Low-Voltage Fuses – Part 2: Class C Fuses*

UL 248-4, *Low-Voltage Fuses – Part 4: Class CC Fuses*

UL 248-5, *Low-Voltage Fuses – Part 5: Class G Fuses*

UL 248-6, *Low-Voltage Fuses – Part 6: Class H Non-Renewable Fuses*

UL 248-7, *Low-Voltage Fuses – Part 7: Class H Renewable Fuses*

UL 248-8, *Low-Voltage Fuses – Part 8: Class J Fuses*

UL 248-9, *Low-Voltage Fuses – Part 9: Class K Fuses*

UL 248-10, *Low-Voltage Fuses – Part 10: Class L Fuses*

UL 248-11, *Low-Voltage Fuses – Part 11: Plug Fuses*

UL 248-12, *Low-Voltage Fuses – Part 12: Class R Fuses*

UL 248-15, *Low-Voltage Fuses – Part 15: Class T Fuses*

UL 310, *Electrical Quick-Connect Terminals*

UL 353, *Limit Controls*

UL 360, *Liquid-Tight Flexible Metal Conduit*

UL 429, *Electrically Operated Valves*

UL 467, *Grounding and Bonding Equipment*

UL 486A-486B, *Wire Connectors*

UL 486C, *Splicing Wire Connectors*

UL 486E, *Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors*

UL 496, *Lampholders*

UL 498, *Attachment Plugs and Receptacles*

UL 508, *Industrial Control Equipment*

UL 508C, *Power Conversion Equipment*

UL 510, *Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape*

UL 514A, *Metallic Outlet Boxes*

UL 514B, *Conduit, Tubing, and Cable Fittings*

UL 514C, *Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers*

UL 635, *Insulating Bushings*

UL 651, *Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings*

UL 719, *Nonmetallic-Sheathed Cables*

UL 723, *Test for Surface Burning Characteristics of Building Materials*

UL 746A, *Polymeric Materials – Short Term Property Evaluations*

UL 746B, *Polymeric Materials – Long Term Property Evaluations*

UL 746C, *Polymeric Materials – Use in Electrical Equipment Evaluations*

UL 796, *Printed Wiring Boards*

UL 797, *Electrical Metallic Tubing – Steel*

UL 810, *Capacitors*

UL 817, *Cord Sets and Power-Supply Cords*

UL 840, *Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment*

UL 867, *Electrostatic Air Cleaners*

UL 900, *Air Filter Units*

UL 917, *Clock-Operated Switches*

UL 935, *Fluorescent-Lamp Ballasts*

UL 969, *Marking and Labeling Systems*

UL 991, *Tests for Safety-Related Controls Employing Solid-State Devices*

UL 1004-1, *Rotating Electrical Machines – General Requirements*

UL 1004-2, *Impedance Protected Motors*

UL 1004-3, *Thermally Protected Motors*

UL 1004-7, *Electronically Protected Motors*

UL 1012, *Power Units Other Than Class 2*

UL 1029, *High-Intensity-Discharge Lamp Ballasts*

UL 1059, *Terminal Blocks*

UL 1063, *Machine-Tool Wires and Cables*

UL 1097, *Double Insulation Systems for Use in Electrical Equipment*

UL 1283, *Electromagnetic Interference Filters*

UL 1310, *Class 2 Power Units*

UL 1434, *Thermistor-Type Devices*

UL 1441, *Coated Electrical Sleeving*

UL 1446, *Systems of Insulating Materials – General*

UL 1565, *Positioning Devices*

UL 1581, *Reference Standard for Electrical Wires, Cables, and Flexible Cords*

UL 1598, *Luminaires*

UL 1917, *Solid-State Fan Speed Controls*

UL 1977, *Component Connectors for Use in Data, Signal, Control and Power Applications*

UL 1998, *Software in Programmable Components*

UL 2043, *Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces*

UL 4248-1, *Fuseholders – Part 1: General Requirements*

UL 4248-4, *Fuseholders – Part 4: Class CC*

UL 4248-5, *Fuseholders – Part 5: Class G*

UL 4248-6, *Fuseholders – Part 6: Class H*

UL 4248-8, *Fuseholders – Part 8: Class J*

UL 4248-9, *Fuseholders – Part 9: Class K*

UL 4248-11, *Fuseholders – Part 11: Type C (Edison Base) and Type S Plug Fuse*

UL 4248-12, *Fuseholders – Part 12: Class R*

UL 4248-15, *Fuseholders – Part 15: Class T*

UL 5085-1, *Low Voltage Transformers – Part 1: General Requirements*

UL 5085-3, *Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers*

UL 8750, *Light Emitting Diode (LED) Equipment for Use in Lighting Products*

UL 60335-2-40, *Household and Similar Electrical Appliances – Safety – Part 2-40: Particular Requirements for Electrical Heat Pumps, Air-Conditioners and Dehumidifiers*

UL 60691, *Thermal-Links – Requirements and Application Guide*

UL 60730-1, *Automatic Electrical Controls – Part 1: General Requirements*

UL 60730-2-8, *Automatic Electrical Controls - Part 2-8: Particular Requirements for Electrically Operated Water Valves, Including Mechanical Requirements*

UL 60730-2-9, *Automatic Electrical Controls - Part 2-9: Particular Requirements for Temperature Sensing Controls*

UL 60950-1, *Information Technology Equipment – Safety – Part 1: General Requirements*

UL 61058-1, *Switches for Appliances – Part 1: General Requirements*

UL 61131-2, *Programmable Controllers – Part 2: Equipment Requirements and Tests*

UL 61800-5-1, *Adjustable Speed Electrical Power Drive Systems – Part 5-1: Safety Requirements – Electrical, Thermal and Energy*

UL 62368-1, *Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements*

5 Glossary

5.1 For the purpose of this Standard the following definitions apply.

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

5.3 AUXILIARY CONTROL – 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.

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

5.5 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.

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

5.7 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.

5.8 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.

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

5.10 HEATER ASSEMBLY – A complete or partial assembly of the heating element, electrical insulation (for example, refractory or mica), metal sheath, thermal insulation, and frame or adaptor for holding the assembly together and fastening it in the heater enclosure; and leads and terminal connections, or both.

5.11 HEATING ELEMENT – The electrical conducting medium that is intended to be heated by an electric current.

5.12 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.

5.13 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.

5.14 MANUAL CONTROL – A device that requires direct human interaction to activate or reset the control.

5.15 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.

5.16 OPERATING CONTROL – 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".

5.17 PROTECTIVE CONTROL – 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".

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

5.19 SECONDARY (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.

5.20 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.

5.21 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.

5.22 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.

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

5.24 THERMAL MOTOR PROTECTOR – A protective device that acts automatically to de-energize the windings of a motor and is sensitive to temperature and current of the windings.

5.25 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.

5.26 TYPE 1 CONTROL – 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 not been declared and tested under this Standard.

5.27 TYPE 2 CONTROL – 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.

CONSTRUCTION

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 (e.g. 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 76.8 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 76.8 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 42, Overflow Tests. 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.

6.10 Each ducted heat-recovery ventilator incorporating electrostatic air cleaning functions shall be constructed and tested in accordance with UL 867.

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 UL 498.

Exception: Attachment plugs and appliance couplers integral to cord sets or power supply cords shall comply with the requirements in UL 817 and are not required to comply with UL 498.

7.2 The attachment plug of the power supply cord of an appliance provided with a 15- or 20-ampere general-use convenience receptacle shall be of the 3-wire grounding type. The attachment plug of the power supply cord of all other appliances not required to be grounded shall be polarized or of the grounding type.

7.3 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 UL 310.

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

7.4 Single and multipole connectors that are 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 to printed wiring boards shall comply with the requirements in UL 1977. See 7.9.

7.5 Wire connectors shall comply with the requirements in UL 486A-486B.

7.6 Splicing wire connectors shall comply with the requirements in UL 486C.

7.7 Equipment wiring terminals for use with all alloys of copper, aluminum, or copper-clad aluminum conductors shall comply with the requirements in UL 486E.

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

7.9 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) A fuse;

b) An adjustable or resettable overload relay;

c) A manual or magnetic motor controller;

d) A magnetically operated relay;

e) An adjustable or resettable temperature controller;

f) A manual switching device;

g) A clock timer; and

h) 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. These components are 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 affect 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 requirements 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 is not required to 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 and nonferrous sheet metal having a thickness of less than 0.023 inch (0.58 mm) 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 these factors are considered with respect to aging. See Section 12, Polymeric and Other Nonmetallic Materials.

9.2 Enclosure thickness

9.2.1 Sheet metal that serves as an electrical enclosure shall comply with the requirements in Table 9.1 or Table 9.2, whichever applies.

Exception No. 1: If the location of the enclosure is adequate to comply with the requirements in 9.1.1, an enclosure thinner than specified in Table 9.1 and Table 9.2 may be employed. See 9.4.1.

Exception No. 2: If the design and location of components are adequate to comply with the requirements in 9.1.1, an enclosure thinner than specified in Table 9.1 and Table 9.2 may be employed. See 9.4.1.

Exception No. 3: If the strength and rigidity of the frame and enclosure are adequate to comply with the requirements in 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		Uncoated (MSG)		Metal coated (GSG)	
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)				
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)

Table 9.1 Continued on Next Page

Table 9.1 Continued

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		Uncoated (MSG)	Metal coated (GSG)
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)		
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:

a) A single sheet with single formed flanges (formed edges);

b) A single sheet which is corrugated or ribbed; and

c) An enclosure surface loosely attached to a frame (e.g. 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 (e.g. 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)	

Table 9.2 Continued on Next Page

Table 9.2 Continued

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)	

[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:

a) A single sheet with single formed flanges (formed edges);

b) A single sheet which is corrugated or ribbed; and

c) An enclosure surface loosely attached to a frame (e.g. 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 (e.g. 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 Exception No. 1 to 9.2.1, 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, less than 0.023 inch (0.58 mm) if galvanized steel, less than 0.036 inch (0.91 mm) if aluminum, and 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 Exception No. 2 to 9.2.1, 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 (63.5 mm) from the surface; and

b) Four gage sizes less if the components are located at least 5 inches (127 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 Exception No. 3 to 9.2.1, 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 if:

a) The door or cover 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) Replacement of the fuse or resetting of the manually resettable device exposes uninsulated live parts.

Such a door or cover shall also be provided with an automatic latch or the equivalent. If live parts other than the screw shell of a plug fuseholder are exposed inside the enclosure, such a door or cover shall also

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 is not required to comply with the requirements in 9.3.1.

9.3.4 A spring latch, a magnetic latch, a dimple, or any 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 is considered to comply with the requirements for an automatic latch in 9.3.1 if:

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

b) It will secure the cover in the closed position, if provided as the sole means for securing the door or cover closed.

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 by 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 (38.1 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 35.1 or Table 35.2, 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	(102)	4-1/8	(105)	4-7/16	(113)	15/16	(23.8)
4	(114)	4-5/8	(118)	4-31/32	(126)	1	(25.4)
4-1/2	(127)	5-1/8	(130)	5-35/64	(141)	1-1/16	(27.0)
5	(141)	5-5/8	(143)	6-7/32	(158)	1-3/16	(30.2)
6	(168)	6-3/4	(172)	7-7/32	(183)	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 76.1.

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

a) Not be less than 1/32 inch (0.8 mm) thick;

b) Resist thermal degradation; and

c) 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 requirements in 9.5.3 will ordinarily necessitate that an opening in the required guard or enclosure around a moving part comply with the requirements in Table 9.4.

Table 9.4
Size of Openings

Straight line distance to moving part from external plane of opening		Maximum diameter rod that will pass through the opening	
inches	(mm)	inches	(mm)
≤ 2	(≤ 50.8)	1/4	(6.4)
> 2 and ≤ 6	(> 50.8 and ≤ 152)	1/2	(12.7)
> 6 and ≤ 15	(> 152 and ≤ 381)	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 requirements in 9.6.1 do 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 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 a risk of injury to persons from a moving part, an opening in the outer enclosure shall comply with one of the following requirements:

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; or

b) For an opening that has a minor dimension (see 9.7.5) of 1 inch (25.4 mm) or more, such a part or wire shall be spaced from the opening as specified in Table 9.5.

Exception: A motor complying with the requirements in 9.7.2 is not required to comply with these requirements.

Figure 9.1

Articulate Probe with Web Stop

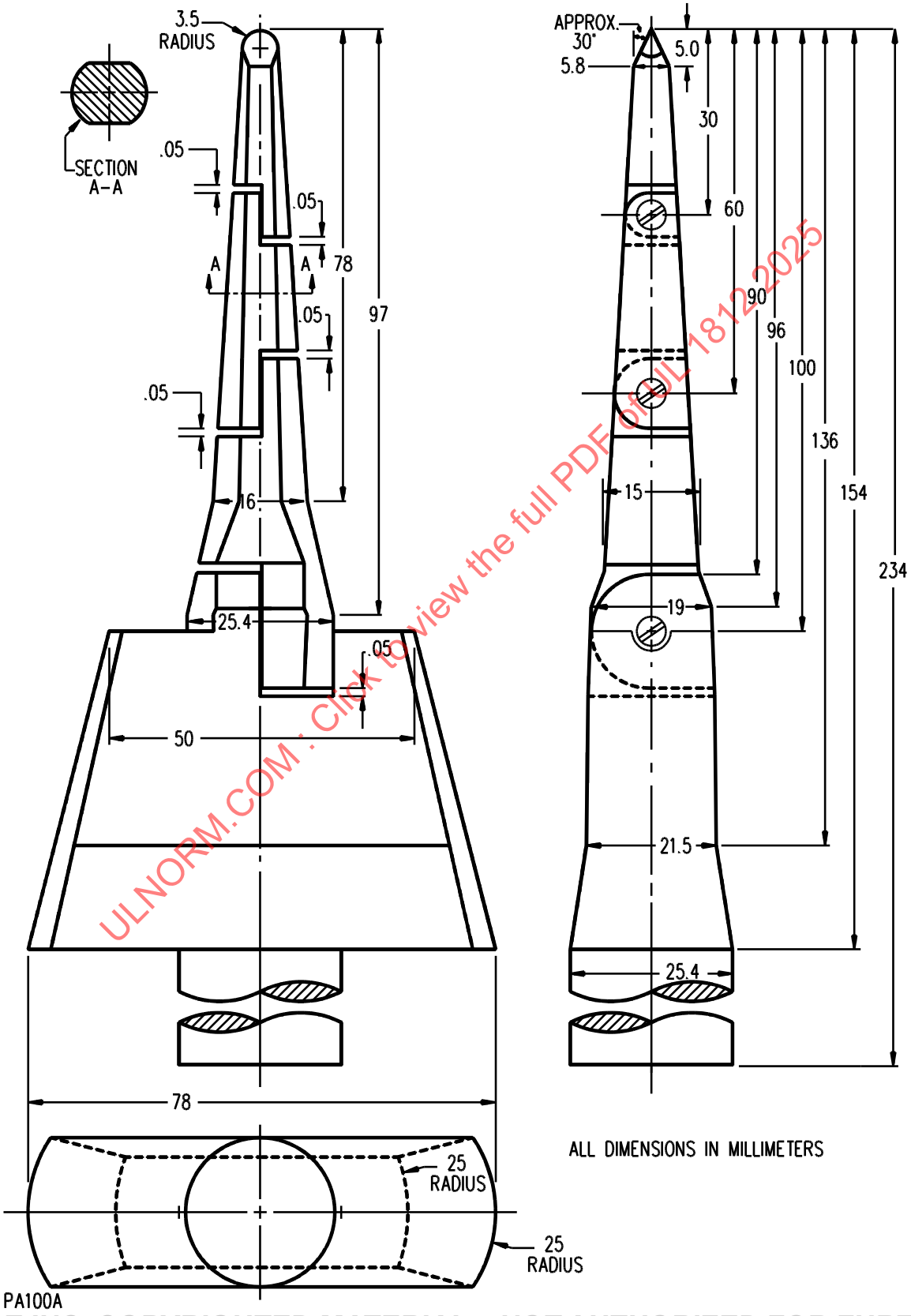


Table 9.5
Minimum Acceptable Distance from an Opening to a Part That May Involve a Risk of Electric Shock or Injury to Persons

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)
1[c]	(25.4)	6-1/2	(165)
1-1/4	(31.8)	7-1/2	(191)
1-1/2	(38.1)	12-1/2	(318)
1-7/8	(47.6)	15-1/2	(394)
2-1/8	(54.0)	17-1/2	(445)
> 2-1/8 and ≤ 6	(> 54.0 and ≤ 152)	30	(762)

[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.

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 (19.1 mm) 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

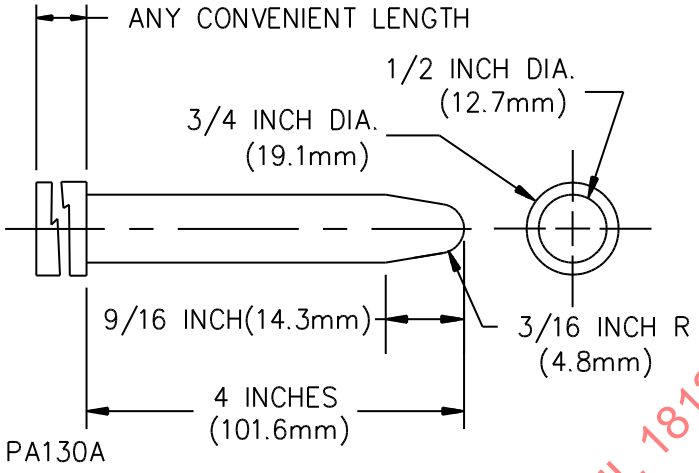


Figure 9.3

Probe for Film-Coated Wire

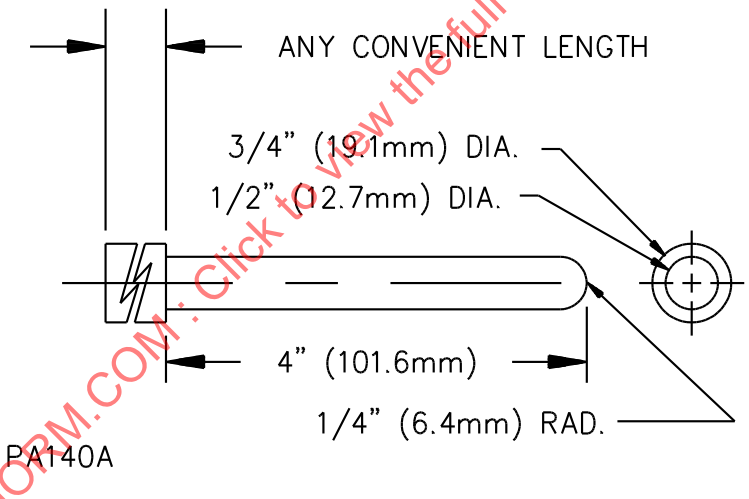
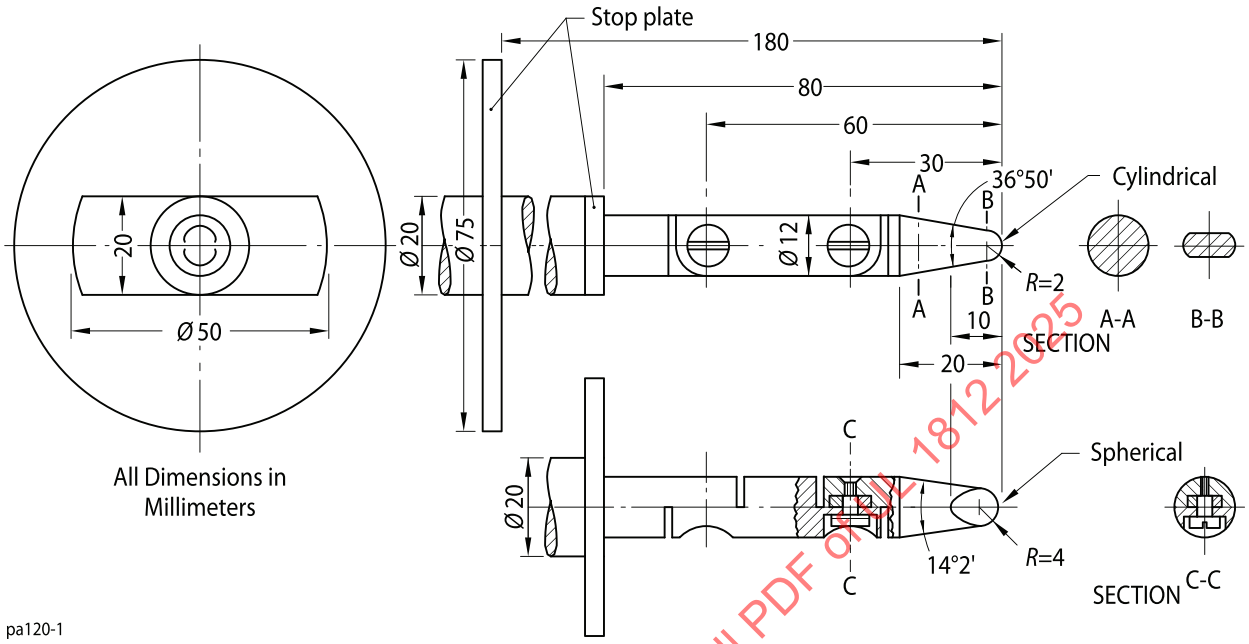


Figure 9.4

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; 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, 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. An indirectly accessible motor is a motor that is:

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

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 the unit:

a) Includes space-heating means (electric, hot water, or steam); or

b) Is intended only for nonresidential applications and provided with a marking as specified in 75.13.

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 requirements 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) The wiring would be acceptable in accordance with 9.7.1 and 9.7.2 if judged as film-coated wire.

9.8.7 The requirements in 9.8.1 will necessitate the use of a barrier of metal or a material classed 5V in accordance with 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; and

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 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;

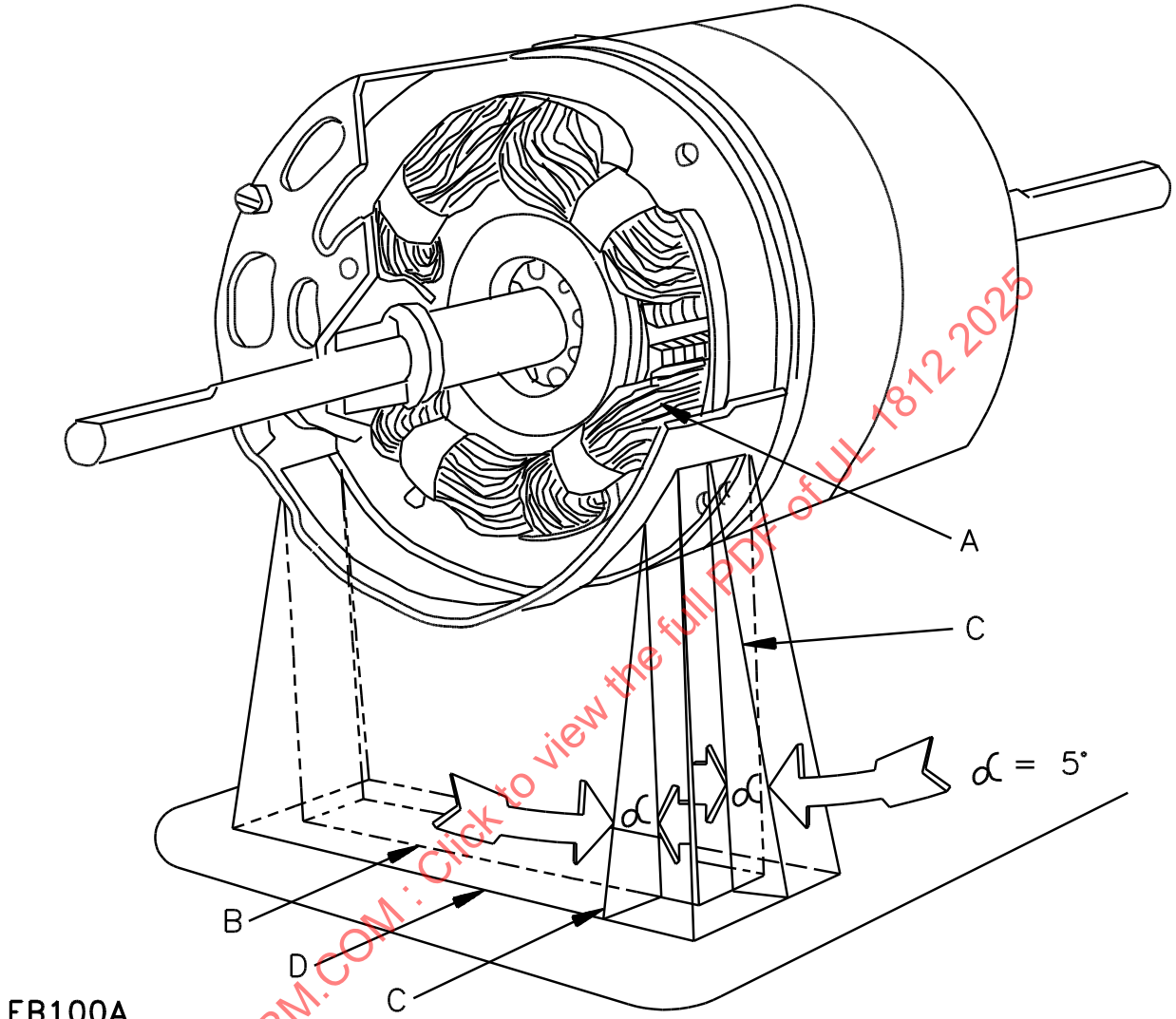
b) Be located as indicated in Figure 9.5; and

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° 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 and so that the spacers necessary to provide required clearances shall be integral, attached to the unit mounting base, and shall extend not less than 3 inches (76.2 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 is not required to 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 requirements 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 requirements in 10.1 do 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 Section 16, Bonding for Grounding.

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 the requirements in 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 requirements 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 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.

Exception: This requirement does not apply to the following:

a) An air filter that meets the test requirements in UL 900, 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 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 UL 900. When the Flame-Exposure Test is conducted, only two samples of the media are required to be tested; or

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 as specified in (g) of the Exception to 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 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 48, Tests for Polymeric Materials.

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 Section 41, Normal Temperature Test.

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]				
External source of ignition	Yes	Yes	Yes[e]	
Internal source of ignition	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 UL 723 is acceptable from a flammability standpoint.

[b] When applicable. See 23.2.8.

[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 48.11, Volume resistivity tests.

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 UL 746C.

12.2.2 Metallized or painted polymeric parts or enclosures shall comply with the applicable requirements in UL 746C.

Exception: This 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 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:

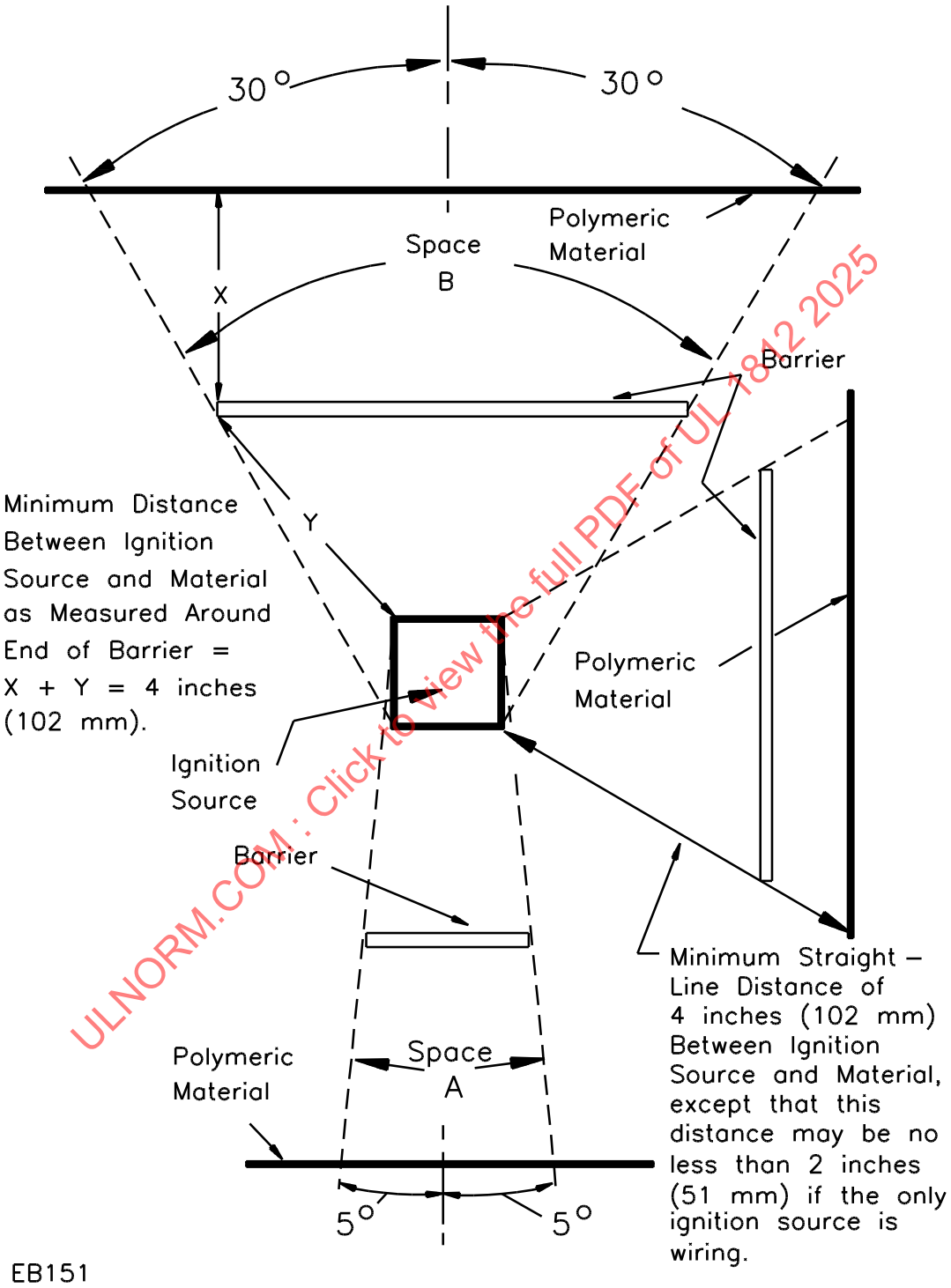
a) Metal not less than 0.010 inch (0.25 mm) thick; or

b) 5V polymeric material.

Exception: Wiring is not required to be isolated as indicated in 12.5, Material applications, if it complies with the VW-1 flame test or the vertical flame test described in UL 1581.

Figure 12.1

Exposure to Ignition Source



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

Space B – The volume above the ignition source, determined in the same manner as Space A, except that the angle is 30° 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 1.00 square inch (6.45 cm^2).

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, NFPA 70.

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

a) UL 1;

b) UL 360;

c) UL 6; or

d) 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:

a) UL 514B;

b) UL 514A; or

c) 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 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)	MCM	(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
–	–	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 that 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 NEMA 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 50.8 mm) and 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, 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 (1.83 m);

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

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

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

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

Exception: An appliance is not required to 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 (45 cm) 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, Strain relief.

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 requirements 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 76.7.

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 and with a grounding conductor shall comply with the requirements in 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 76.14.

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, NFPA 70, not less than 125 % 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 requirements 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 (e.g. 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 a 14 AWG (2.1 mm^2) copper conductor, except that such a terminal in a low-voltage circuit as defined in 5.13 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 Section 35, General.

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 76.17; and

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, 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 no switches or overcurrent protective devices of the single-pole type are connected, 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 16.12 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, 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:

a) UL 817; or

b) 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 (91 cm) to less than or equal to 72 inches (1.83 m) shall be marked in accordance with 75.20.

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 58.1.

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 of the clamp complies with the requirements specified in 58.3.

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; and

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 one of the following:

a) UL 1310;

b) UL 60950-1 with an output marked "Class 2" or that complies with the limited power source (LPS) requirements and is marked "LPS"; or

c) UL 62368-1, evaluated to either:

1) ES1 and PS1; or

2) ES1 and LPS.

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

a) UL 1012;

b) UL 60950-1; or

c) UL 62368-1.

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, including wiring which may not be completely enclosed and wiring which may be in the form of flexible cord or equivalent appliance wiring material, is considered to be all the interconnecting wiring beyond the wiring terminals or leads for field-wiring connections.

14.1.3 No temperature limit is applicable to a conductor (except as noted in the requirements for copper conductor, bare or insulated, without tinning, nickel coating, or silver plating in Table 41.1) 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, 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; and 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:

a) UL 44;

b) UL 83; or

c) 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 will abut a building structure after installation of the unit 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 requirements 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 is not required to 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 requirements in 14.1.18 do 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 % 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 Splices and connections shall be mechanically secure and bonded electrically. A soldered connection shall be made mechanically secure before being soldered.

14.2.6 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.

14.2.7 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.

14.2.8 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 its heat resistant and moisture resistant characteristics. Thermoplastic tape wrapped over a sharp edge is not acceptable.

14.2.9 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.

14.2.10 Other than as indicated in 14.2.11, 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 Section 49, Short-Circuit Tests.

14.2.11 With reference to 14.2.10, 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, 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 (76.2 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 (e.g. low-voltage and high-voltage 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 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.

15.3 Other than as noted in 15.5 and 15.6, 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 15.3 (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 15.3 (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.

15.4 With respect to 15.3 (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.

15.5 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. The following shall be considered in determining compliance with this requirement:

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 15.3, 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; and

c) To determine if a unit complies with the requirements in 15.3, 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.

15.6 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.

15.7 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 with a minimum thickness of 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.

15.8 The output of a transformer device supplying an 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.

15.9 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 15.8. If more than one such circuit is to be field wired, the several circuits shall be separated by barriers in accordance with 15.3, 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 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 16.11 and 16.12;

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 requirements for Minimum Size Equipment Grounding Conductors for Grounding Raceway and Equipment in the National Electrical Code, NFPA 70, based on the size of the overcurrent device protecting the circuit;

NOTE: The Minimum Size Equipment Grounding Conductors for Grounding Raceway and Equipment requirements of NFPA 70 can be found in Table 250.122.

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; and

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 the requirements in (b), except that it need be no larger than one of the power-supply conductors.

Exception: A permanently connected appliance provided with double insulation in accordance with UL 1097 is not required to comply with this requirement.

16.4 The equipment-grounding terminal or lead specified in 16.3 is not required for a low-voltage (NEC 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 (e.g. 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 76.22.

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 more than 75.5 amperes for aluminum or copper-clad aluminum conductors;

b) A minimum circuit ampacity is not required to be marked (see 75.8) and 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 76.15.

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 for use on a circuit operating at a potential of more than 150 volts to ground shall include an equipment-grounding conductor.

Exception: Appliances with no parts requiring electrical continuity in accordance with 16.1 and having no dead metal parts likely to become energized which are in contact with water are not required to be provided with an equipment grounding conductor.

16.8 A cord-connected appliance provided with double insulation in accordance with UL 1097 is not required to be provided with an equipment-grounding conductor. See also 7.2.

16.9 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.

16.10 The screw mentioned in 16.9(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.

16.11 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.

16.12 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.

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

16.14 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.

16.15 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.

16.16 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 16.15.

16.17 If the bonding means depends upon screw threads, two or more screws, or two full threads of a single screw engaging metal, it shall comply with the requirements in 16.15.

16.18 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.

16.19 A motor frame shall be bonded for grounding. A motor frame bonding connection shall be secured by riveting; bolting; 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 16.20, a connection that depends upon the clamping action of rubber or similar material is not acceptable.

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

a) Section 53, Grounding Means Overload Test; and

b) Section 49, Short-Circuit Tests, 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.

16.21 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 in:

1) Section 53, Grounding Means Overload Test; and

2) Section 49, Short-Circuit Tests.

Exception: The short-circuit tests may be waived if the conductor is an 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.

17 Refrigerant, Hot Water, and Steam Coils

17.1 Refrigerant-containing components shall comply with the following requirements:

a) They shall be constructed of corrosion-resistant material, or shall be plated, dipped, coated, or otherwise treated to resist external corrosion;

b) Except as stated in (c), tubing used to connect refrigerant-containing components shall comply with the minimum wall thickness requirements of Table 17.1 and with the strength requirements of 17.4; and

c) Tubing used in the construction of refrigerant-containing components, such as an evaporator or condenser coil, that is adequately protected by the inherent construction shall comply with the strength requirements specified in 17.4.

Table 17.1
Tubing Wall Thickness

Minimum wall thickness[a]							
Outside diameter		Copper				Steel	
		Protected		Unprotected			
inches	(mm)	inches	(mm)	inches	(mm)	inches	(mm)
3/16	(4.8)	0.0245	(0.622)	0.0265	(0.673)	0.025	(0.64)
1/4	(6.4)	0.0245	(0.622)	0.0265	(0.673)	0.025	(0.64)
5/16	(7.9)	0.0245	(0.622)	0.0285	(0.724)	0.025	(0.64)
3/8	(9.5)	0.0245	(0.622)	0.0285	(0.724)	0.025	(0.64)
1/2	(12.7)	0.0245	(0.622)	0.0285	(0.724)	0.025	(0.64)
5/8	(15.9)	0.0315	(0.800)	0.0315	(0.800)	0.032	(0.81)
3/4	(19.1)	0.0315	(0.800)	0.0385	(0.980)	0.032	(0.81)
7/8	(22.2)	0.0410	(1.041)	0.0410	(1.041)	0.046	(1.17)
1	(25.4)	0.0460	(1.168)	0.0460	(1.168)	0.046	(1.17)
1-1/8	(28.6)	0.0460	(1.168)	0.0460	(1.168)	0.046	(1.17)
1-1/4	(31.8)	0.0505	(1.283)	0.0505	(1.283)	0.046	(1.17)
1-3/8	(34.9)	0.0505	(1.283)	0.0505	(1.283)	0.046	(1.17)
1-1/2	(38.1)	0.0555	(1.410)	0.0555	(1.410)	0.062	(1.58)
1-5/8	(41.3)	0.0555	(1.410)	0.0555	(1.410)	0.062	(1.58)
2-1/8	(54.0)	0.0640	(1.626)	0.0640	(1.626)	–	–
2-5/8	(66.7)	0.0740	(1.880)	0.0740	(1.880)	–	–

NOTE – "Protected" implies that the tubing is shielded by the cabinet or assembly to the extent that unintended damage caused by objects, such as tools, falling on or otherwise striking the tubing during handling and after installation of the unit is prevented. This protection may be provided in the form of baffles, channels, flanges, perforated metal, or equivalent means. If a cabinet is employed for the intended installation of a unit, the tubing is considered shielded. Tubing not so shielded is considered to be unprotected with respect to this table.

[a] Nominal wall thickness of tubing shall be greater than the thickness indicated to maintain the minimum wall thickness.

17.2 Refrigerant-containing components that comply with the requirements in UL 207 meet the requirements of 17.1.

17.3 Refrigerant coils shall only utilize refrigerants classified as A1 in accordance with ASHRAE 34. Coils utilizing refrigerants with other classifications shall comply with the applicable requirements of UL 60335-2-40.

17.4 All parts of equipment subject to a refrigerant pressure shall have sufficient strength to withstand the pressure test requirements specified in Section 61, Strength Tests. The test pressure shall be three times the minimum design pressure specified in Table 17.2.

Exception No. 1: Pressure vessels that comply with the requirements in 17.7 are not required to meet the requirements of Section 61.

Exception No. 2: Pressure gauges and control mechanisms are not required to meet the requirements of Section 61.

Exception No. 3: A part or a complete system that complies with Section 62, Fatigue Test Analysis, is not required to meet the requirements of Section 61.

Exception No. 4: ASME pressure vessels bearing the code U or UM symbol with a working pressure not less than that required by 17.4 are acceptable without test.

Table 17.2
Refrigerant Minimum Design Pressures

Refrigerant	Name	Minimum design pressures[a]					
		Low side		High side			
				Water or evaporatively cooled		Air-cooled	
		PSIG	(kPa)	PSIG	(kPa)	PSIG	(kPa)
R-13	Chlorotrifluoromethane	521	(3592)	547	(3772)	547	(3772)
R-13B1	Bromotrifluoromethane	230	(1586)	321	(2213)	410	(2827)
R-14	Tetrafluoromethane	544	(3751)	544	(3751)	544	(3751)
R-22	Chlorodifluoromethane	144	(993)	211	(1455)	278	(1917)
R-134a	Tetrafluoroethane	88	(606)	135	(930)	186	(1282)
R-C318	Octafluorocyclobutane	34	(234)	59	(407)	85	(586)
R-404A	44 % pentafluoroethane, 52 % 1, 1, 1, trifluoroethane, 4 % 1, 1, 1, 2 tetrafluoroethane	174	(1200)	253	(1745)	331	(2281)
R-407A	20 % difluoromethane, 40 % pentafluoroethane, 40 % 1, 1, 1, 2 tetrafluoroethane	175	(1205)	255	(1757)	335	(2308)
R-407C	23 % difluoromethane, 25 % pentafluoroethane, 52 % 1, 1, 1, 2 tetrafluoroethane	162	(1116)	238	(1640)	315	(2170)
R-410A	50 % difluoromethane, 50 % pentafluoroethane	236	(1626)	341	(2349)	448	(3086)
R-500	Dichlorodifluoromethane 73.8 % and Ethylidene Fluoride 26.2 %	102	(703)	153	(1055)	203	(1399)
R-744	Carbon Dioxide	955	(6685)	1058	(7295)	1058	(7295)

[a] For other refrigerants, the minimum design pressure shall be no less than the saturation pressure of the refrigerant at the following temperatures:

a) 26.5 °C (80 °F) for low sides;

b) 40.5 °C (105 °F) for water-cooled high sides; and

c) 51.7 °C (125 °F) for air-cooled high sides.

17.5 A water coil operating at more than 93 °C (200 °F) and a steam coil shall withstand a hydrostatic pressure equal to three times the marked operating pressure without leakage or rupture when tested as described in Section 61, Strength Tests.

17.6 A water coil operating equal to or less than 93 °C (200 °F) shall withstand a hydrostatic pressure equal to 1035 kPa (150 psig) or two times the marked operating pressure, whichever is higher, without leakage or rupture when tested as described in Section 61, Strength Tests.

17.7 If the equipment includes pressure vessels having an inside diameter over 152 mm (6 inches) and having an internal or external design pressure greater than 15 psig (103.4 kPA gauge), they shall comply with the requirements in CSA B51 and shall be designed, tested, and stamped in accordance with the

ASME Unfired Pressure Vessel Code for a design pressure in compliance with the requirements specified in Section 61, Strength Tests.

Exception: Pressure vessels with a design pressure not exceeding 15 psig (103.4 kPa) are not required to be designed, tested, and stamped in accordance with CSA B51 and the ASME Unfired Pressure Vessel Code.

17.8 The tubing connections of dissimilar metals, such as aluminum and copper, shall be protected against moisture to minimize galvanic action.

CONSTRUCTION – ELECTRICAL COMPONENTS

18 Mounting of Components

18.1 A switch, a lampholder, an attachment-plug receptacle, a motor attachment plug, or a similar component shall be mounted securely and, other than as noted in 18.2 and 18.3, shall be prevented from turning. See 18.4.

18.2 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.

18.3 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, is not required to be prevented from turning if rotation cannot reduce spacings below the minimum acceptable values.

18.4 The means for preventing the turning indicated in 18.1 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.

18.5 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 35.1 and Table 35.2.

18.6 Friction between surfaces is not acceptable as a means to prevent shifting or turning of a live part as indicated in 18.5, but a lock washer as described in 18.4 is acceptable.

19 Printed Wiring Boards

19.1 Printed wiring boards, including the coatings, shall comply with the requirements in UL 796.

Exception: A printed-wiring board in a Class 2 nonsafety circuit is not required to comply with the bonding requirements in 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.

20 Live Parts

20.1 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.

20.2 With reference to 20.1, 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 2.1; or

b) Within a motor.

21 Electrical Insulating Material

21.1 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 21.2.

21.2 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, 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.

22 Supplemental Insulation, Insulating Bushings, and Assembly Aids

22.1 The requirements for supplemental insulation (e.g. tape, sleeving or tubing) are not specified unless the insulation or device is required to fulfill 14.2.8 or a performance requirement of this Standard.

22.2 In accordance with 22.1, supplemental insulation shall comply with the following requirements:

a) Insulating tape shall comply with the requirements in UL 510;

b) Sleeving shall comply with the requirements in UL 1441;

c) Tubing shall comply with the requirements in UL 224; and

d) Electrical insulation systems shall comply with requirements in UL 1446.

22.3 Wire positioning devices shall comply with the requirements in Section 16, Bonding for Grounding, and Section 20, Live Parts.

Exception: A device that complies with the requirements in UL 1565 is considered to fulfill this requirement.

22.4 Insulating bushings that comply with the requirements in Section 2, Components, of this end product Standard and with the requirements in 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.

23 Motors and Motor Protection

23.1 General

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

23.1.2 A motor winding shall resist the absorption of moisture.

23.1.3 With reference to the requirements in 23.1.2, 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.

23.2 Overload protection

23.2.1 Other than as specified in 23.2.2, 23.2.7, and 23.2.9, each motor shall be protected by:

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

1) UL 1004-1 and UL 1004-3; or

2) Electronic protection that meets the test requirements of UL 1004-7 and the requirements of Section 60, Controls – End Product Test Parameters; or

b) An overcurrent protective device rated or set in accordance with the National Electrical Code, 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 requirements in 43.1.

23.2.2 The overload protection of a single speed, continuous-duty blower motor having a marked rating over 1 horsepower (746 W output) is not required to 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;

Exception: A Class 2 power supply provided as part of the unit and protected in accordance with the Wiring and Protection – Overcurrent Protection requirements of the National Electrical Code, NFPA 70, is not required to be supplied by a separate circuit.

NOTE: The Wiring and Protection – Overcurrent Protection requirements of NFPA 70 can be found in Article 240, Parts I through VII per Article 430.53(C)(6).

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 23.2.3 and 75.5); and

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

23.2.3 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 23.2.4.

23.2.4 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 in Table 23.1, 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. If the percentage protection specified in Column A of Table 23.1 does not correspond to the percentage value of an overload relay of a standard size, the device of the next higher size may be used. However, the overload device of the next higher size shall protect against currents exceeding the percentage values specified in Column B of Table 23.1.

Table 23.1
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

23.2.5 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.

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

a) Three overcurrent units (see 23.2.1); 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 a permanently attached wiring diagram and shall be located where it is accessible after installation. See 76.3.

23.2.7 A direct drive fan motor is considered to comply with the requirements in 23.2.1 if it is provided with either:

a) An integral protector that meets the test requirements in UL 1004-1 and UL 1004-3, exclusive of temperature requirements applying to running overload conditions; or

b) Electronic protection that meets the test requirements of UL 1004-7 and the requirements of Section 60, Controls – End Product Test Parameters.

23.2.8 A direct drive fan motor, other than an impedance-protected motor as described in 23.2.9, employed with nonmetallic parts, such as fans, scrolls, or shaft supports, shall have running overload protection as described in 23.2.1, or the nonmetallic part shall comply with the requirements in 48.3, Heat deflection test, or alternatively the Mold Stress-Relief Distortion test in UL 746C.

23.2.9 An impedance-protected motor is considered to comply with the requirements in 23.2.1 if it:

a) Complies with the requirements in UL 1004-1 and the requirements in UL 1004-2 under conditions of use in the application, including such factors as evaluated ambient temperatures and any restricted ventilation; and

b) Does not generate smoke with the rotor of the motor locked under any required test condition for the unit.

23.2.10 An electronically protected motor shall comply with the requirements in UL 1004-1 and the requirements in UL 1004-7.

23.2.11 A fuse may be used to provide the necessary overload protection if the largest ampere-rated fuse that can be mounted in the fuseholder complies with the requirements or if a noninterchangeable fuse is used. The fuse used to provide this protection may be of the supplementary type (not required to 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 49.1. If a supplementary type fuse is used, the equipment shall be marked in accordance with the requirements in 76.20.

23.2.12 Electronically protected motor circuits shall comply with the requirements in UL 991. When the electronic circuit is relying on software as a protective component, it shall comply with the requirements in 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 requirements in UL 60730-1 and UL 60730-2-9. When the electronic circuit is relying on software as a protective component, it shall comply with the requirements for controls using software in 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 requirements in UL 508C or UL 61800-5-1 and is rated or set to trip at not more than 115 % of the motor nameplate full-load current rating.

23.2.13 The requirements in Table 23.2 are among the factors to be used in evaluating the protective circuit.

Table 23.2
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 23.2.12.	Conduct a failure-mode and effect analysis (FMEA) for the protective circuit identified in 23.2.12.
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:	Assumed temperature ranges are as follows:

Table 23.2 Continued on Next Page

Table 23.2 Continued

	Application of UL 991 and UL 1998	Application of UL 60730-1 and UL 60730-2-9
	a) Indoor Use: 0.0 ±2 °C (32.0 ±3.6 °F) and 40.0 ±2 °C (104 ±3.6 °F); and b) Outdoor Use: minus 35.0 ±2 °C (minus 31.0 ±3.6 °F).	a) Indoor Use: 0.0 ±2 °C (32.0 ±3.6 °F) and 40.0 ±2 °C (104 ±3.6 °F); and b) Outdoor Use: minus 35.0 ±2 °C (minus 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; and 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; and 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 – 26.7 °C (70 – 80 °F) and minimum 50 % relative humidity; and b) Outdoor Use: minimum 98 % relative humidity.	For exposure to humidity, the following conditions shall apply: a) Indoor Use: 21.1 – 26.7 °C (70 – 80 °F) and minimum 50 % relative humidity; and b) Outdoor Use: minimum 98 % 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.

23.3 Short-circuit protection

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

23.3.2 Other than as indicated in 23.3.3, 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 requirements in Section 49, Short-Circuit Tests. These tests are not required to be conducted if the device is rated for the conditions specified in Section 49.

23.3.3 The short-circuit test for risk of fire specified in 23.3.2 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.

24 Motors for Use in Unattended Areas

24.1 General

24.1.1 In addition to any other motor requirements specified in this Standard, the requirements specified in this Section 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 HRVs, through-wall HRVs, ceiling-insert HRVs, attic HRVs, whole house HRVs, and ducted HRVs.

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 UL 1004-1 and 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.

24.1.2 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 % cotton.

24.1.3 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.

24.2 Performance

24.2.1 Test preparation – fan motor failure mode analysis

24.2.1.1 The test procedure specified in 24.2.1 – 24.2.2 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 (back-up) protection, only three samples are to be tested. See 5.15, 5.19, and 5.23.

24.2.1.2 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.

24.2.1.3 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.

24.2.1.4 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.

24.2.1.5 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.

24.2.2 Test procedure – fan motor failure mode analysis

24.2.2.1 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.

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

24.2.2.3 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 back-up protection, or ignition of the cotton).

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

25 Capacitors

25.1 A capacitor shall comply with the requirements in UL 810.

25.2 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 49.1.

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 49.1 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 UL 1283 are considered to fulfill the requirements.

26 Circuit Breakers and Fuseholders

26.1 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.

26.2 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.

26.3 In addition to the requirements specified in this Standard, fuseholders shall comply with the requirements in UL 4248-1 and:

a) UL 4248-4;

b) UL 4248-5;

c) UL 4248-6;

d) UL 4248-8;

e) UL 4248-9;

f) UL 4248-11;

g) UL 4248-12; or

h) UL 4248-15.

26.4 With reference to 26.2, a separation less than 4 inches (102 mm) from the insulating body of a fuse is considered to be adjacent.

27 Overcurrent Protection, General

27.1 The overcurrent protection specified in 27.2 and 27.3 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, NFPA 70.

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

a) General-use duplex receptacle circuit; and

b) Lampholder circuit, independent of a heating element, unless the unit would be connected in accordance with the National Electrical Code, 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 76.7 is exempted from this requirement.

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

Exception: A receptacle in a unit marked in accordance with 76.7 is exempted from this requirement.

27.4 If a fuseholder is incorporated in a unit, the fuses shall be shipped with the unit by the manufacturer but are not required to be mounted in the fuseholder.

28 Overcurrent Protection, High-Voltage Control Circuit Conductors

28.1 General

28.1.1 If a control circuit is supplied through a transformer provided as part of the equipment, see Section 29, Transformer Protection, for additional requirements.

28.2 Direct-connected high-voltage control circuits

28.2.1 A unit employing a direct-connected high-voltage control circuit shall be marked in accordance with 76.23.

28.3 Tapped high-voltage control circuits

28.3.1 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 28.1.

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 Section 49, Short-Circuit Tests.

Exception No. 3: A lead 12 inches (305 mm) or less in length is not required to 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 if the protection:

a) Complies with requirements specified in Section 29, Transformer Protection; and

b) Does not exceed the applicable value specified in Table 28.1 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 the requirements for Maximum Rating of Overcurrent Protective Device in Amperes – Separate Protection Provided in the National Electrical Code, NFPA 70.

NOTE: The Maximum Rating of Overcurrent Protective Device in Amperes – Separate Protection Provided requirements of NFPA 70 can be found in Column A of Table 430.72(B)(2).

Table 28.1
Overcurrent Protective Device Rating for Control Circuit Conductors

Tapped control-circuit conductor size		Maximum rating of overcurrent protective device, amperes			
		Conductors contained in control equipment enclosure		Conductors extending beyond control equipment enclosure	
AWG	(mm^2)	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
> 10	(> 5.3)	[b]	[b]	[c]	[c]

[a] Includes copper-clad aluminum.

[b] 400 % of value specified for 60 °C conductors in the requirements for Ampacities of Single-Insulated Conductors in Free Air in the National Electrical Code, NFPA 70.

[c] 300 % of value specified for 60 °C conductors in the requirements for Ampacities of Insulated Conductors with Not More Than Three Current-Carrying Conductors in Raceway, Cable, or Earth (Directly Buried) in the National Electrical Code, NFPA 70.

28.4 Overcurrent protective devices

28.4.1 Overcurrent protection for a tapped high-voltage control circuit conductor, as required by 28.3.1, shall be provided as part of the equipment.

Exception: The overcurrent device(s) is not required to 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 28.1.

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

a) Be provided for all ungrounded conductors;

b) Be sized in accordance with requirements in 29.1.2.1; 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 49.1. If the supplementary type device used is a fuse, the equipment shall be marked in accordance with 76.20.

29 Transformer Protection

29.1 High-voltage transformers

29.1.1 General

29.1.1.1 A transformer (including an autotransformer) other than one as described in 29.2, Low-voltage transformers, is considered a high-voltage transformer and shall:

a) Be provided with thermal overload protection in accordance with the requirements in 29.1.2, Thermal protection;

b) Be protected by an overcurrent device in accordance with the requirements in 29.1.3, Overcurrent protection;

c) Be provided with electronic protection that meets the test requirements of 29.1.2, Thermal protection, and the circuits requirements of UL 1004-1; or

d) Comply with the requirements in Section 52, Burnout Test – High-Voltage Transformer.

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 is not required to comply with this requirement.

29.1.2 Thermal protection

29.1.2.1 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 Section 51, Overload Test – High-Voltage Transformer.

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 Section 52, Burnout Test – High-Voltage Transformer.

29.1.2.2 Thermal cutoffs shall comply with the requirements in UL 60691. A manual or automatic resetting thermal protector shall have an endurance rating of not less than 6,000 cycles and shall comply with the requirements pertaining to the calibration of temperature limiting controls specified in UL 60730-1 and UL 60730-2-9.

29.1.3 Overcurrent protection

29.1.3.1 If a high-voltage transformer is protected by an overcurrent device, such protection shall comply with the requirements specified in 29.1.3.2, 29.1.3.3, and 29.3, Overcurrent protective devices.

29.1.3.2 Other than as noted in 29.1.3.3, 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 29.1. See 29.2.2.

Exception: If the rated primary current of the transformer is 9 amperes or more and 125 % 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 the requirements for Standard Ampere Ratings in the National Electrical Code, NFPA 70.

NOTE: The Standard Ampere Ratings requirements of NFPA 70 can be found in Section 240.6.

Table 29.1
Rating of Overcurrent Devices

Rated primary current, amperes	Maximum rating of overcurrent device, percent of transformer primary current rating
< 2	300[a]
≥ 2 and < 9	167
≥ 9	125

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

29.1.3.3 If the circuit supplying a transformer other than an autotransformer is provided with overcurrent protection rated or set at not more than 250 % 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 % of the rated secondary current of the transformer. See 29.3.2.

Exception No. 1: If the rated secondary current of the transformer is 9 amperes or more and 125 % 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 the requirements for Standard Ampere Ratings in the National Electrical Code, NFPA 70.

NOTE: The Standard Ampere Ratings requirements of NFPA 70 can be found in Section 240.6.

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 % of the rated secondary current.

29.2 Low-voltage transformers

29.2.1 Other than as indicated in 29.2.2, a transformer having a rated output of not more than 30 volts and 1000 volt-amperes (NEC 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 % of the primary current rating of the transformer. See 29.3.1.

29.2.2 A transformer that directly supplies an NEC Class 2 circuit shall, in accordance with UL 5085-1 and UL 5085-3, either limit the output current (inherently limited transformer) or be equipped with an overcurrent device (not inherently limited transformer) and is not required to comply with the requirements in 29.2.1.

29.3 Overcurrent protective devices

29.3.1 Overcurrent protection in the primary circuit of a transformer, as described in 29.1.3.2 and 29.2.1, is not required to 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 29.1.3.2 or 29.2.1.

29.3.2 Overcurrent protection in the secondary circuit of a transformer, as required by 29.1.3.3, shall be provided as part of the equipment.

29.3.3 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 29.1.3.2 – 29.2.1, 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 a supplementary type other than indicated in 29.3.3 provided the fuse has a short-circuit rating acceptable for the circuit in which it is used. See Table 49.1. The unit shall be marked in accordance with the requirements specified in 76.20.

29.3.4 In addition to the requirements specified in this Standard, fuses shall comply with the requirements in UL 248-1 and:

a) UL 248-2;

b) UL 248-4;

c) UL 248-5;

d) UL 248-6;

e) UL 248-7;

f) UL 248-8;

g) UL 248-9;

h) UL 248-10;

i) UL 248-11;

j) UL 248-12; or

k) UL 248-15.

30 Switches and Controllers

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

30.2 In addition to the requirements specified in this Standard, switches shall comply with the requirements in:

a) UL 917;

b) UL 98;

c) UL 20; or

d) UL 61058-1.

Exception: Switches used in extra-low-voltage non-safety circuits that will not cause a risk of injury are not required to comply with this requirement.

30.3 With reference to the requirements in 30.1, 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.

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

30.5 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 requirements in Section 44, Switch Overload Test.

30.6 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.

30.7 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.

30.8 A shield or barrier used to cover supply wiring terminals that may be live when a switch as specified in 30.6 is in the off position shall comply with the requirements in 15.6 and 15.7 and shall be marked in accordance with 76.18.

30.9 More than one switch may be used to comply with the requirements in 30.7 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.

30.10 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.

30.11 A motor controller is considered to fulfill the construction and rating for the application requirements of this Standard if it complies with the requirements in one of the following:

a) UL 508;

b) UL 61800-5-1;

c) UL 60730-1 and UL 60730-2-9; or

d) UL 508C.

31 Controls

31.1 General

31.1.1 Auxiliary controls shall be evaluated using the applicable requirements of this end product Standard and the parameters in Section 60, Controls – End Product Test Parameters.

Exception: This requirement does not apply to circuits that comply with the requirements in Section 60.

31.1.2 Operating (regulating) controls shall be evaluated using the applicable component standard requirements specified in 31.2 – 31.4 and, if applicable, the parameters in Section 60, Controls – End Product Test Parameters, unless otherwise specified in this end product Standard.

Exception: This requirement does not apply to circuits that comply with the requirements in Section 60.

31.1.3 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:

a) UL 991 and UL 1998;

b) UL 60730-1; or

c) Section 60, Controls – End Product Test Parameters.

31.1.4 Protective (limiting) controls shall be evaluated using the applicable component standard requirements specified in 31.2 – 31.4 and, if applicable, the parameters in Section 60, Controls – End Product Test Parameters, unless otherwise specified in this end product Standard.

Exception: This requirement does not apply to circuits that comply with the requirements in Section 60.

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

a) UL 991;

b) UL 60730-1, except the requirements for Controls using software; or

c) Section 60, Controls – End Product Test Parameters.

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

a) UL 991 and UL 1998;

b) UL 60730-1; or

c) Section 60, Controls – End Product Test Parameters.

31.2 Electromechanical and electronic controls

31.2.1 A control, other than as specified in 31.3 – 31.4, shall comply with the requirements in:

a) UL 60730-1;

b) UL 61131-2; or

c) Section 60, Controls – End Product Test Parameters.

31.3 Motor and speed controls

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

a) UL 508;

b) UL 61800-5-1;

c) UL 60730-1;

d) UL 1917;

e) UL 244A;

f) UL 508C; or

g) Section 60, Controls – End Product Test Parameters.

31.4 Temperature controls

31.4.1 A temperature control shall comply with the requirements in:

a) UL 508;

b) UL 60730-1 and UL 60730-2-9; or

c) Section 60, Controls – End Product Test Parameters.

31.4.2 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 UL 1434.

32 Valves (Electrically Operated) and Solenoids

32.1 Electrically operated valves shall comply with the requirements in:

a) UL 429; or

b) UL 60730-1 and UL 60730-2-8.

33 Light Sources and Associated Components

33.1 Lampholders and indicating lamps shall comply with the requirements in UL 496.

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

33.2 Lighting ballasts shall comply with the requirements in:

a) UL 935; or

b) UL 1029.

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

33.3 Light emitting diode (LED) light sources shall comply with the requirements in UL 8750.

34 Safety Devices

34.1 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.

34.2 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.

34.3 In connection with the requirements in 34.1, particular attention is to be paid to a unit that, when being installed, requires partial disassembly or permits rearrangement of internal parts.

34.4 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.

34.5 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.

34.6 A solid state safety control shall comply with the requirements in UL 991.

Exception No. 1: A control that complies with the temperature limiter, thermal cutout, or protective control requirements of UL 60730-1 and UL 60730-2-9, as appropriate, is considered to fulfill the requirements of UL 991.

Exception No. 2: This requirement does not apply to circuits that comply with the requirements in Section 60, Controls – End Product Test Parameters.

CONSTRUCTION – SPACINGS

35 General

35.1 The spacings at field-wiring terminals, fuseholders, and thermal cutoffs shall not be less than the value specified in Table 35.1. See 13.2.1.

Table 35.1
Spacings at Field Wiring Terminals, at Fuseholders, and at Thermal Cutoffs

Potential involved in volts	Between parts mentioned above over surface or through air		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 (0 – 2000 volt-amperes)	1/4	(6.4)	1/4	(6.4)	1/4	(6.4)	1/4	(6.4)
≤ 250 (> 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 35.2.

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.

35.2 Other than as noted in 35.1, 35.3, 35.4, and 35.6, 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 35.2.

Table 35.2
Spacings Other Than at Field Wiring Terminals, at Fuseholders, and at Thermal Cutoffs

Rating[a]		Minimum spacings					
		Through air		Over surface		To enclosure	
Volt-amperes	Volts	inches	(mm)	inches	(mm)	inches	(mm)
0 – 2000	≤ 250	1/8	(3.2)	1/4	(6.4)	1/4	(6.4)
0 – 2000	> 250	3/8	(9.5)	1/2	(12.7)	1/2	(12.7)
> 2000	0 – 125	1/8	(3.2)	1/4	(6.4)	1/2	(12.7)
> 2000	126 – 250	1/4	(6.4)	3/8	(9.5)	1/2	(12.7)
> 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.

35.3 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.

35.4 The spacing requirements indicated in Table 35.2 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 35.2.

35.5 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 35.1 and 35.2 and shall be judged on the basis of the highest voltage involved.

35.6 The spacings "To Enclosure" as specified in Table 35.2 are not to be applied to an individual enclosure of a component that is within an outer enclosure or cabinet.

35.7 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.

35.8 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.

36 Clearance and Creepage Distances

36.1 As an alternative approach to the spacing requirements specified in Section 35, General, and other than as noted in this Section, clearances and creepage distances may be evaluated in accordance with the requirements in UL 840, as described in 36.3.

36.2 The clearance and creepage distance at field wiring terminals shall be in accordance with the requirements in Section 35, General.

36.3 In conducting evaluations in accordance with the requirements in UL 840, the guidelines in Table 60.1 – Table 60.3 shall be used.

37 Electric Heaters

37.1 An electric heater intended to be used with a unit shall be tested with the unit in accordance with the requirements in this Section.

37.2 A heating element shall be supported in its intended position in a substantial and reliable manner and shall be protected against mechanical injury and contact with outside objects. In determining if a heating element complies with this requirement, consideration shall be given to sagging, loosening, and other similar conditions resulting from:

a) Continuous heating of the element; and

b) Flexing of the element supports or related wiring due to alternate heating and cooling of the element.

37.3 Heating elements shall be so supported that, even if heaters are subjected to extreme conditions of operation, including the requirements in Section 63, Electric Heater Tests, short circuits cannot occur between turns, between sections of the heating elements, or between uninsulated live parts and non-current-carrying metal parts, and the spacings of Table 35.2 and Table 37.1 are maintained.

Table 37.1
Minimum Spacings at Electric Heating Elements

Description of spacing	Potential involved, V	Spacing	
		inches	(mm)
Between uninsulated live parts of opposite polarity; and between an uninsulated live part and a dead metal part, other than the enclosure, that either is exposed to contact by persons or may be grounded	0 – 250	1/16	(1.6)
Between uninsulated live parts of opposite polarity; and between an uninsulated live part and a dead metal part, other than the enclosure, that either is exposed to contact by persons or may be grounded	251 – 600	1/4[a]	(6.4)[a]
Between a live part and the enclosure	0 – 600	1/4	(6.4)

NOTES

1 – These spacings are applicable only to parts of the heating element and its terminals located inside the conditioned (heated or cooled) air handling compartment. If an uninsulated live part is not rigidly supported, or if a movable dead metal part is in proximity to an uninsulated live part, the construction shall be such that at least the minimum spacing is maintained under all operating conditions and under all normal conditions of handling. Spacings at a thermal cutoff shall comply with the requirements in Table 35.1.

2 – Metal-sheathed heater elements that have spacings at terminations between live parts and noncurrent-carrying metal parts as defined below shall be sealed against moisture.

Potential involved, V	Spacing	
	inches	(mm)
0 – 300	1/16 – < 1/8	1.6 – < 3.2
> 300 – 600	1/8 – < 1/4	3.2 – < 6.4

[a] A spacing of not less than 1/16 inch (1.6 mm) is permissible at a heating element rated for 300 V or less.

37.4 Coiled wire heating elements may be supported on porcelain, hook type insulators depending upon the stiffness of the coil, the spacing between hooks, the shape of the hook, etc. Porcelain insulators of all types will normally be required to be retained in place by means other than the heating element.

37.5 Heating elements shall be securely fastened to terminals (under the heads of terminal binding screws) in such a manner that the wire is not likely to become loosened during the lifetime of the heater.

37.6 If an auxiliary control device, such as a thermostat or a combination thermostat and control switch, in a product with electric heat or remote control assembly has a marked ON or OFF position or is marked with another wording or symbol such as "NO HEAT, COLD, O" or similar wording that conveys the same meaning as "OFF", it shall disconnect the element or elements and controls from all ungrounded conductors of the supply circuit when placed in that position. This requirement applies to a thermostat in a remote control assembly that is referred to on the product nameplate but does not apply to a remote auxiliary control device in an NEC Class 2 circuit, such as a room thermostat.

37.7 An auxiliary control is considered to be one that is intended primarily for regulating time, temperature, etc. under conditions of intended operation but is not intended for protection against overload or excessive temperature conditions, etc.

37.8 Electric heaters employing resistance-type heating elements intended for comfort heating shall be protected at not more than 60 A, and the protected circuit shall not have a concurrent load exceeding 48 A. These heating elements shall be connected in protected subdivided circuits if any total concurrent load of the unit exceeds 48 A based on nameplate ratings. If the overcurrent protective devices are in a separate assembly for independent mounting, as described in 37.9, the rating of the overcurrent protective devices also shall not exceed 1.5 times the current rating of the connected load if such rating is more than 16.7 A.

Exception: If a heater assembly is provided with means for field connection to a power supply for only the resistance-type elements, with or without their control circuit, in a wiring enclosure having a separate cover and physically separated from the power supply for other loads, the rating of the other loads is not required to be considered in applying this requirement.

37.9 The overcurrent protective devices for subdivided circuits as required by 37.8 may be provided by the product manufacturer as a separate assembly for independent mounting.

37.10 The overcurrent protection specified in 37.8 and 37.9 shall be circuit breakers, cartridge fuses, or type S plug fuses of a type and rating appropriate for branch circuit protection, in accordance with the requirements of the National Electrical Code, NFPA 70.

37.11 An electric heater shall be equipped with one or more automatically resetting temperature-limiting controls that will disconnect the heating element or elements from the supply circuit to prevent temperatures from exceeding the limits specified in Table 41.1. These temperature-limiting controls shall be factory-installed as an integral part of the heater.

37.12 The temperature-limiting controls shall comply with the applicable requirements of either:

a) UL 353; or

b) UL 60730-2-9 as Type 2, Protective controls.

37.13 A safety control or a temperature-limiting control intended to prevent heater operation that can result in risk of fire, electric shock, or injury to persons shall be operative whenever the heater is connected to its power supply and shall interrupt operation of a sufficient number of heating elements to prevent temperatures from exceeding applicable temperature limits.

37.14 A unit employing an automatically resetting temperature-limiting control shall interrupt the power supply to the heater by direct means or by means of a single magnetically operated relay device or contactor that complies with the requirements for the endurance test for the limit control.

37.15 Contactors and sequence controls, such as thermal relays or mechanical step controls, used to control one or more sections of the heater element load shall be able to withstand 100,000 cycles of making and breaking the load controlled.

37.16 All contactors and sequence controls that are used on open electric heaters shall break all ungrounded conductors. Phase break on three phase heaters shall not be permitted. Where silicon controlled rectifiers (SCRs) are used, the safety contactor shall break all ungrounded conductors.

37.17 A unit employing electric heaters shall be provided with one or more manually resettable or replaceable backup protective devices of the type specified in 37.18 that will, with the contacts of the

automatically resetting temperature-limiting control permanently closed, limit the temperatures to comply with the requirements specified in Section 64, Backup Protection Tests.

37.18 The manually resettable or replaceable protective devices specified in 37.17 shall be functionally independent of the automatically resetting temperature-limiting control. The following types of controls comply with this requirement:

a) One or more thermal cutoffs, nonresettable temperature-limiting controls, or manually resettable limit controls connected to open a sufficient number of ungrounded conductors to permit the unit to comply with the specified temperature limits; and

b) A combination consisting of one or more normally open switching device(s) and thermal cutoffs, nonresettable limit controls, or manually resettable limit controls. The thermal cutoff or limit control shall be connected in the coil circuit of the switching device. The combination shall be integral with the product, be able to open a sufficient number of ungrounded supply conductors to permit the product to comply with the specified temperature limits, and be independent of control by an automatic cycling device with the unit.

37.19 The backup protection specified in 37.17 is required for a product employing an electric heater that incorporates a switching device whose coil circuit is controlled by both the automatically resetting temperature-limiting control and a temperature-regulating control for the heater.

37.20 A thermal cutoff or nonresettable limit control shall be secured in place and located so that it will be accessible for replacement without damage to other connections or internal wiring, in compliance with 37.22 and 37.24.

37.21 A thermal cutoff or nonresettable limit control shall comply with the requirements in Section 64, Backup Protection Tests.

37.22 Replacement of a thermal cutoff or nonresettable limit control shall not necessitate any of the following:

a) Removal of the unit or heater assembly from its installation, except as specified in 37.23;

b) Disconnection of the field wiring systems;

c) Stretching or similar displacement of the heater element wire that could cause permanent displacement or distortion to the extent that the performance of the heater could be affected; or

d) Release of the heater element wire from its attachment if this would result in displacement of the element.

Exception: A thermal cutoff or nonresettable limit control that is not required in order to comply with any of the requirements in this Standard is not required to comply with (a) and (b).

37.23 With reference to the requirements of 37.22(a), removable heating elements or an element assembly may be withdrawn, or a heater may be partially withdrawn, to replace a thermal cutoff or nonresettable limit control if withdrawal will not result in noncompliance with the requirements of 37.22 (b), (c), and (d).

37.24 Wiring connected to a thermal cutoff or nonresettable limit control shall be secured so that replacement of the thermal cutoff or nonresettable limit control will not result in displacement or disturbance of internal wiring other than leads to the cutoff or limit control or leads to a heating element assembly on which the cutoff or limit control is mounted.

37.25 A thermal cutoff or nonresettable limit control shall not function during any test performed on a product employing electric heaters when the automatically resettable limit control is connected in the circuit.

37.26 Sequence controls, such as thermal relays or mechanical step controls, used to control one or more sections of the heater element load shall be able to withstand 100,000 cycles of making and breaking the load controlled unless the unit is capable of withstanding required tests without sequence controls.

PERFORMANCE

38 Installation

38.1 General

38.1.1 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.

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

38.1.3 Other than as indicated in 38.1.4, 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.

38.1.4 The enclosure specified in 38.1.3 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.

38.1.5 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.

38.1.6 If necessary to comply with the requirements in 41.3, 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.

38.1.7 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.

38.1.8 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.

38.1.9 The lengths and widths of the panels specified in 38.1.8 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.

38.1.10 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 38.1.8 and 38.1.9 over surfaces intended for zero clearance to combustible materials.

38.1.11 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.

38.1.12 If a clearance is specified for a unit intended for installation as described in 38.1.3, 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.

38.2 Supply connections

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

38.3 Assembly, leveling, and adjustable features

38.3.1 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.

38.3.2 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.

38.3.3 If a unit employs a fan or blower whose speed can be varied and which 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 38.3.4.

38.3.4 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.

39 Test Voltage

39.1 Unless otherwise specified, a unit is to be tested at rated frequency at the potentials indicated in Table 39.1 as detailed in the paragraphs describing the test.

Table 39.1
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 % Rated	85 % Rated

40 Input Test

40.1 The current input to a unit shall not be more than 110 % of the rated value when the unit is operated under the conditions specified in Section 41, Normal Temperature Test, and is connected to a supply circuit of rated frequency at the applicable voltage specified in Table 39.1.

41 Normal Temperature Test

41.1 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 Column 1 of Table 41.1. A temperature, overload, or overcurrent protective device shall not open the circuit during the tests.

Table 41.1
Maximum Temperatures

Device or material	Column 1 °C	Column 1 (°F)	Column 2 °C	Column 2 (°F)
A. Motors[a]				
1. Class A insulation systems on coil windings of alternating-current motors having a frame diameter ≤ 7 inches (≤ 178 mm), not including universal motors				
a. In open motors –				
Thermocouple or resistance method	102	(215)	142	(287)
b. In totally enclosed motors –				
Thermocouple or resistance method	107	(224)	142	(287)
2. Class A insulation systems on coil windings of alternating-current motors having a frame diameter > 7 inches (> 178 mm) and of direct-current motors and universal motors				
a. In open motors –				
Thermocouple method	92	(197)	142	(287)
Resistance method	102	(215)	142	(287)
b. In totally enclosed motors –				
Thermocouple method	97	(206)	142	(287)
Resistance method	107	(224)	142	(287)
3. Class E insulation systems on coil windings of alternating-current motors having a frame diameter ≤ 7 inches (≤ 178 mm), not including universal motors				
a. In open motors –				
Thermocouple or resistance method	112	(233)	142	(287)
b. In totally enclosed motors –				
Thermocouple or resistance method	117	(242)	147	(296)
4. Class E insulation systems on coil windings of alternating-current motors having a frame diameter > 7 inches (> 178 mm) and of direct-current motors and universal motors				
a. In open motors –				
Thermocouple method	102	(215)	142	(287)
Resistance method	112	(233)	142	(287)
b. In totally enclosed motors –				

Table 41.1 Continued on Next Page

Table 41.1 Continued

Device or material	Column 1 °C	Column 1 (°F)	Column 2 °C	Column 2 (°F)
Thermocouple method	107	(224)	142	(287)
Resistance method	117	(242)	147	(296)
5. Class B insulation systems on coil windings of alternating-current motors having a frame diameter ≤ 7 inches (≤ 178 mm), not including universal motors				
a. In open motors –				
Thermocouple or resistance method	122	(251)	152	(305)
b. In totally enclosed motors –				
Thermocouple or resistance method	127	(260)	157	(314)
6. Class B insulation systems on coil windings of alternating-current motors having a frame diameter of > 7 inches (> 178 mm) and of direct-current motors and universal motors				
a. In open motors –				
Thermocouple method	112	(233)	142	(287)
Resistance method	122	(251)	152	(305)
b. In totally enclosed motors –				
Thermocouple method	117	(242)	147	(296)
Resistance method	127	(260)	157	(314)
7. Class F insulation systems on coil windings of alternating-current motors having a frame diameter ≤ 7 inches (≤ 178 mm), not including universal motors				
a. In open motors –				
Thermocouple or resistance method	147	(296)	177	(350)
b. In totally enclosed motors –				
Thermocouple or resistance method	152	(305)	182	(359)
8. Class F insulation systems on coil windings of alternating-current motors having a frame diameter > 7 inches (> 178 mm) and of direct-current motors and universal motors				
a. In open motors –				
Thermocouple method	137	(278)	167	(332)
Resistance method	147	(296)	177	(350)
b. In totally enclosed motors –				
Thermocouple method	142	(287)	172	(341)
Resistance method	152	(305)	182	(359)
9. Class H insulation systems on coil windings of alternating-current motors having a frame diameter ≤ 7 inches (≤ 178 mm), not including universal motors				
a. In open motors –				
Thermocouple or resistance method	162	(323)	192	(377)
b. In totally enclosed motors –				
Thermocouple or resistance method	167	(332)	197	(386)
10. Class H insulation systems on coil windings of alternating-current motors having a frame diameter > 7 inches (> 178 mm) and of direct-current motors and universal motors				

Table 41.1 Continued on Next Page

Table 41.1 Continued

Device or material	Column 1 °C	Column 1 (°F)	Column 2 °C	Column 2 (°F)
a. In open motors –				
Thermocouple method	152	(305)	182	(359)
Resistance method	162	(323)	192	(377)
b. In totally enclosed motors –				
Thermocouple method	157	(314)	187	(368)
Resistance method	167	(332)	197	(389)
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 76.14	77	(170)	92	(197)
2. Relay, solenoid, transformer, and other coils with:				
a. Class A (105) insulated windings –				
Thermocouple method	92	(197)	142	(287)
Resistance method	112	(233)	142	(287)
b. Class E (120) insulated windings –				
Thermocouple method	102	(215)	142	(287)
Resistance method	122	(251)	152	(305)
c. Class B (130) insulated windings –				
Thermocouple method	112	(233)	142	(287)
Resistance method	132	(269)	152	(305)
d. Class F (155) insulated windings –				
Thermocouple method, except Class 2 Transformers	137	(278)	167	(332)
Thermocouple method, Class 2 Transformers	122	(198)	152	(305)
Resistance method	147	(297)	172	(341)
e. Class H (180) insulated windings –				
Thermocouple method, except Class 2 Transformers	152	(305)	182	(359)
Thermocouple method, Class 2 Transformers	142	(234)	167	(332)
Resistance method	162	(323)	192	(377)
3. Sealing compounds	40 less than its melting point	(104 less than its melting point)	40 less than its melting point	(104 less than its melting point)
4. Fuses[d]	92	(197)	122	(251)
5. Copper conductor, bare or insulated, without tinning, nickel coating, or silver plating except as noted in B8	202	(342)	232	(449)
6. Termination of copper conductor in a pressure terminal connector unless both are tinned, nickel-coated, or silver-plated	152	(252)	177	(350)
C. Insulated Conductors[b,c]	25 less than its tempera-ture rating	(77 less than its tempera-ture rating)	25 less than its tempera-ture rating	(77 less than its tempera-ture rating)
D. Electrical Insulation – General				

Table 41.1 Continued on Next Page

Table 41.1 Continued

Device or material	Column 1 °C	Column 1 (°F)	Column 2 °C	Column 2 (°F)
1. Fiber used as electrical insulation or cord bushings	92	(144)	124	(255)
2. Phenolic composition used as electrical insulation or as parts where failure will result in a risk of fire or electric shock[b]	152	(252)	177	(350)
3. Thermoplastic material[b]	25 less than its tempera-ture rating	(77 less than its tempera-ture rating)	25 less than its tempera-ture rating	(77 less than its tempera-ture rating)
4. Varnished cloth insulation	87	(135)	117	(274)
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	92	(144)	124	(255)
2. Unit air filter	92	(144)	124	(255)
3. Wood or other combustible material which is a part of the unit	92	(144)	124	(255)

[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 this table.

[c] 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.

[d] 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.

41.2 A unit is to be installed in accordance with Section 38, Installation, and supplied by test voltages in accordance with Section 39, Test Voltage. The unit is to be operated continuously until temperatures stabilize.

41.3 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.

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

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

41.6 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 on one of the following:

a) The integrally applied insulation of a coil without a wrap; or

b) 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 the requirements for Class A insulation systems on coil windings of alternating-current motors having a frame diameter ≤ 7 inches (≤ 178 mm), not including universal motors, and the requirements for Class B insulation systems on coil windings of alternating-current motors having a frame

diameter ≤ 7 inches (≤ 178 mm), not including universal motors, in Table 41.1, the thermocouple is to be mounted on the integrally applied insulation on the conductor.

41.7 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 deviate from the indicated maximum in Table 41.1 – provided that the temperature rise of the coil, as measured by the resistance method, is no more than that specified – as follows:

a) For Class A insulation systems on coil windings of alternating-current motors having a frame diameter ≤ 7 inches (≤ 178 mm), not including universal motors, in open motors, 5 °C (9 °F) more;

b) For Class A insulation systems on coil windings of alternating-current motors having a frame diameter > 7 inches (> 178 mm) and of direct-current motors and universal motors in open motors; and for relay, solenoid, transformer, and other coils with Class A (105) insulated windings, 15 °C (27 °F) more;

c) For Class B insulation systems on coil windings of alternating-current motors having a frame diameter ≤ 7 inches (≤ 178 mm), not including universal motors, in open motors, 10 °C (18 °F) more; and

d) For Class B insulation systems on coil windings of alternating-current motors having a frame diameter of > 7 inches (> 178 mm) and of direct-current motors and universal motors in open motors, 20 °C (36 °F) more.

41.8 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 ASTM E230/E230M.

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

41.10 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.

41.11 The values in Table 41.1 are based on an assumed ambient-air temperature of 26.6 °C (80 °F), but a test may be conducted at any ambient-air temperature within the range of 10 – 40 °C (50 – 104 °F).

41.12 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.

42 Overflow Tests

42.1 If a test is considered necessary to determine if a unit complies with the requirements in 6.8, it is to be performed as follows:

a) The unit is to be leveled in any intended mounting position likely to cause wetting of electrical components;

b) 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; and

c) The test is to be conducted with the fan motor energized.

43 Motor Overload Tests

43.1 A motor overcurrent protective device as described in 23.2.1(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 this Section.

Exception: Tests in accordance with this Section 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; and

c) The overload relay is selected to trip at not more than 125 % 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 % for any other motor.

43.2 The motor and protective device combination is to be connected to a supply circuit of voltage as indicated in Table 39.1. Temperatures are to be measured by thermocouples on the surface of coils of the motor.

43.3 The motor and protective device shall be tested in the ambient encountered in normal operation as determined in Section 41, Normal Temperature Test.

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 43.4 and 43.5 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).

43.4 When a motor is operating under the maximum overload that it can carry without causing the protective device to function, the maximum acceptable temperature is 140 °C (284 °F) for a Class A insulated motor winding and 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.

43.5 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 175 °C (347 °F) thereafter. After the first hour of operation, the average temperature (the average of the arithmetic mean of the maximum temperatures and 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.

43.6 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.

44 Switch Overload Test

44.1 If it is necessary to conduct this test to comply with the requirements in 30.5, 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.

44.2 In a test to determine if the switch or other control device is capable of performing acceptably in the overload test mentioned in 44.1, the unit is to be connected to a grounded supply circuit of rated frequency and normal test voltage (see Table 39.1) 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.

45 Dielectric Voltage-Withstand Test

45.1 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 45.1.

Table 45.1
Dielectric Voltage Withstand Voltages

Unit under test	Test potential	
	V AC	V DC
Low-voltage circuit	500	700
Motor rated at ≤ 1/2 horsepower (373 W output) and ≤ 250 volts	1000	1400
Secondary circuit of a transformer or autotransformer that operates at ≤ 250 volts	1000	1400
Secondary circuit of a transformer or autotransformer that operates at 251 – 600 volts	1000 + 2V[a]	1400 + 2.8V[a]
Other than as noted in previous rows	1000 + 2V[a]	1400 + 2.8V[a]

[a] Maximum marked voltage.

45.2 To determine if a unit complies with the requirements in 45.1, 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 if it can be demonstrated that the test equipment will detect a breakdown.

46 Insulation Resistance Test

46.1 A unit 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 % at a temperature of 32 ±2 °C (90 ±4 °F) (see 21.2) if employing one of the following:

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.

46.2 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.

47 Overvoltage and Undervoltage Tests

47.1 Other than as indicated in 47.2 and 47.3, an electromagnet as employed on a relay or solenoid in a low-voltage circuit shall withstand 10 % above the normal test voltage without damage and shall operate successfully at 15 % below the normal test voltage (see Table 39.1) when tested as described in 47.4 or 47.5, whichever applies.

47.2 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 39.1, the test potential for the Overvoltage and/or Undervoltage Test is to be such marked operating voltage limit.

47.3 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 requirements in 47.1. See 2.1 – 2.2.

47.4 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.

47.5 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 %, 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.

48 Tests for Polymeric Materials

48.1 General

48.1.1 The tests for polymeric materials in this Section are to be conducted as indicated in Table 12.1.

48.1.2 Materials shall be classed 5V, V-0, V-1, V-2, HF-1, HF-2, HBF, or HB by the burning tests described in 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 48.2, Flammability – 5-inch flame.

48.1.3 The Mold Stress-Relief Distortion Test in UL 746C may be performed as an alternative to 48.3, Heat deflection test.

48.1.4 The Water Exposure and Immersion Test in UL 746C may be performed as an alternative to 48.4, Water absorption test.

48.2 Flammability – 5-inch flame

48.2.1 The test is to be conducted employing the apparatus and test method described for the Vertical Burning Test for Classifying Materials 5V in 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.

48.2.2 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 48.5, Air-oven aging, 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; and

b) The thermal-aging program used for such determination includes specimens having a thickness equal to or less than the wall thickness of the polymeric enclosure.

48.2.3 Two of the three samples from each set shall show acceptable performance as follows:

a) Samples shall not continue to flame or exhibit consuming combustion for more than 1 minute after the fifth application of the test flame; and

b) 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.

48.3 Heat deflection test

48.3.1 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.

48.3.2 The heat deflection temperature is to be measured in accordance with the requirements for Deflection Temperature of Polymeric Materials Under Load in UL 746A, at a loading of 66 psi (455 kPa) fiber stress.

48.4 Water absorption test

48.4.1 The percentage of water absorption by weight of a polymeric part shall not exceed 1-1/2 %.

Exception: If dimensional changes in any measurable direction on the sample tested do not exceed 1/10 of 1 %, the percentage of water absorption by weight may be not more than 2 %.

48.4.2 Three samples approximately 1 by 2 by 1/8 inch (25.4 by 50.8 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.

48.5 Air-oven aging

48.5.1 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 48.1.

Table 48.1
Aging Temperature and Time

Intended use[a]	Maximum normal operating temperature[b] °C	(°F)	Aging temperature °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.

48.5.2 Following the air-oven aging, the specimens are to be subjected to the Flammability Test required for the material application and to the requirements in 48.6, Tensile-strength test, 48.7, Flexural-strength test, 48.8, Izod impact test, or 48.9, Tensile-impact test, if required for the material application. See Table 12.1 and Table 12.2 and the applicable tests described in this Section.

48.6 Tensile-strength test

48.6.1 The tensile strength of a polymeric part after air-oven aging shall:

a) Not decrease more than 50 %; and

b) Be essentially stabilized.

48.6.2 The tensile strength is to be determined in accordance with the procedures of ASTM D638 on samples in the "as-received" condition and after the appropriate air-oven aging.

48.7 Flexural-strength test

48.7.1 The flexural strength of a polymeric part after air-oven aging shall:

a) Not decrease more than 50 %; and

b) Be essentially stabilized.

48.7.2 The test is to be conducted in accordance with the procedure of ASTM D790 on appropriate samples in the "as-received" condition and after air-oven aging.

48.8 Izod impact test

48.8.1 The Izod impact strength of a polymeric part after air-oven aging shall:

a) Not decrease more than 50 %; and

b) Be essentially stabilized.

48.8.2 The test is to be conducted on samples obtained from the finished part and in accordance with the procedure of ASTM D256.

48.8.3 If the Izod Impact Test is not considered appropriate based on the material and the thickness of the part involved, the test specified in 48.9, Tensile-impact test, is to be conducted in lieu of the Izod Impact Test.

48.9 Tensile-impact test

48.9.1 The tensile impact strength of a polymeric part after air-oven aging shall:

a) Not decrease more than 50 %; and

b) Be essentially stabilized.

48.9.2 The test is to be conducted on samples obtained from the finished part and in accordance with the procedure of ASTM D1822.

48.10 Impact test

48.10.1 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 defeats its intended use.

48.10.2 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.

48.10.3 A decorative part which is not necessary for the operation of the unit and does not serve as the enclosure of uninsulated live parts is not required to comply with the requirements of 48.10.1 or 48.10.2.

48.10.4 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 (50.8 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.

48.11 Volume resistivity tests

48.11.1 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 % at a temperature of 32 ±3 °C (90 ±5 °F) for 96 hours.

48.11.2 The test is to be conducted in accordance with the procedure of Tests for D-C Resistance or Conductance of Insulating Materials in UL 746A on samples measuring 2 inches (50.8 mm) in diameter and in the minimum thickness of the finished part.

49 Short-Circuit Tests

49.1 Devices and conductors as referenced in 14.2.10, 16.20, 16.21, and 23.3.1 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 49.3.

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.

49.2 For the purpose of these tests:

a) Fuses of the same rating are considered to be interchangeable;

b) Circuit breakers of the same rating are considered to be interchangeable;

c) Circuit breakers and fuses are not considered to be interchangeable; and

d) Different types of circuit breakers are not considered to be interchangeable with each other.

49.3 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, 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.

49.4 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 49.1. Each concurrent-load condition is to be considered separately, and the maximum resulting current is to be 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 49.1
Short-Circuit Test Currents

Product ratings, amperes								Circuit capacity, amperes
110 – 120 V	Single phase		254 – 277 V	200 – 208 V	Three phase		550 – 600 V	
	200 – 208 V	220 – 240 V			220 – 240 V	440 – 480 V		
≤ 9.8	≤ 5.4	≤ 4.9	–	≤ 2.12	≤ 2.0	–	–	200
9.9 – 16.0	5.5 – 8.8	5.0 – 8.0	≤ 6.65	2.13 – 3.7	2.1 – 3.5	≤ 1.8	≤ 1.4	1000
16.1 – 34.0	8.9 – 18.6	8.1 – 17.0	–	3.8 – 9.5	3.6 – 9.0	–		2000
34.1 – 80.0	18.7 – 44.0	17.1 – 40.0	–	9.6 – 23.3	9.1 – 22.0	–	–	3500
> 80.0	> 44.0	> 40.0	> 6.65	> 23.3	> 22.0	> 1.8	> 1.4	5000

49.5 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.

50 Starting Test

50.1 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 75.12.

50.2 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 30 minutes under the conditions specified in Section 40, Input Test, 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.

51 Overload Test – High-Voltage Transformer

51.1 This test applies to a high-voltage transformer provided with thermal protection of other than the nonrenewable thermal cutoff type. See 29.1.2.1.

51.2 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 51.3 and 51.4. 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.

51.3 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 39.1. 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.

51.4 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).

51.5 The transformer shall comply with the requirements in Section 45, Dielectric Voltage-Withstand Test, following the test specified in 51.3 and 51.4.

52 Burnout Test – High-Voltage Transformer

52.1 When a high-voltage transformer is tested as described in 52.2 and 52.3, 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 29.1.2.1) or that is protected by overcurrent devices in accordance with the requirements in 29.1.3.1.

52.2 Three samples of the transformer are to be tested at the normal test voltage specified in Table 39.1 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.

52.3 The load connected to the output terminals is to be the highest of the following:

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.

The load is to be readjusted to the specified value after 2 minutes of operation, if necessary, with no further readjustment during the test.

Exception: The test may be conducted with the output terminals short-circuited if this results in less than three times rated secondary current.

53 Grounding Means Overload Test

53.1 The test specified in 53.2 is to be conducted only if required by 16.20 or 16.21(c).

53.2 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 53.1.

Table 53.1
Duration of Current Flow, Bonding Conductor Test

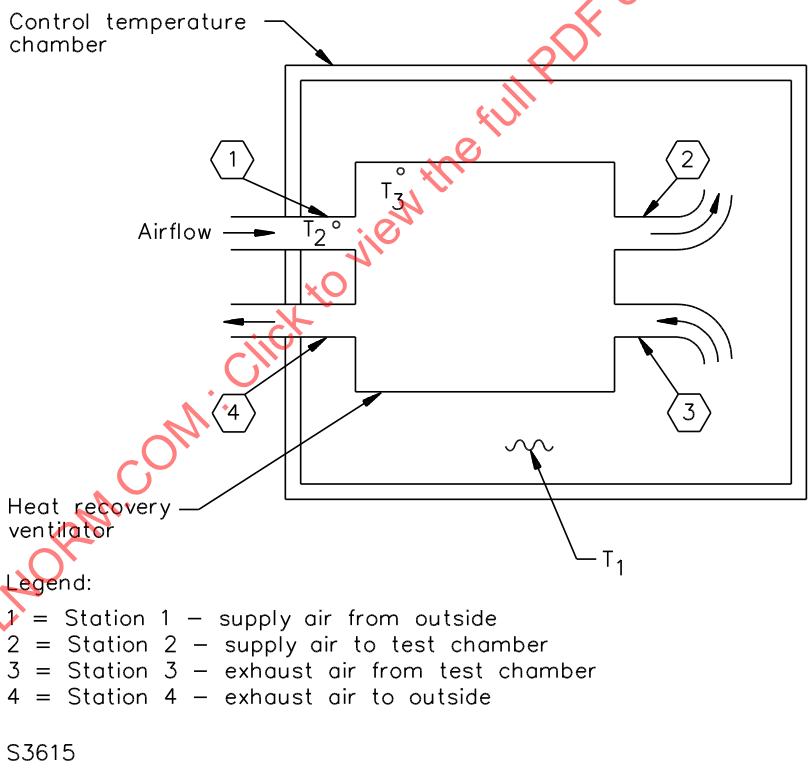
Rating of overcurrent protection device, amperes	Minimum duration of current flow, minutes
≤ 30	2
31 – 60	4
61 – 100	6
101 – 200	8

54 Condensation Test

54.1 An appliance operating under the conditions described in 54.2 and 54.3 shall have a surface temperature on all live electrical components exposed to ambient air or the warm exhaust air (Figure 54.1, Station 3) greater than the minimum permissible temperature as determined in 54.4.

Figure 54.1

Condensation Test



54.2 The appliance shall be installed in a test facility as shown in Figure 54.1. Test chamber air temperature shall be maintained at 20 ±1 °C (36 ±2 °F) above the air temperature entering the appliance (Figure 54.1, Station 1). The airflow rate entering the equipment shall be adjusted to the manufacturer's maximum recommended value.

54.3 The temperature shall be considered constant when three successive readings taken at 10-minute intervals indicate no change with not less than 1-hour elapsed duration of the test.

54.4 The minimum permissible temperature shall be computed by means of the following formula:

$$T_3 = 0.8T_1 + 0.2T_2$$

where:

T_3 = the minimum permissible temperature in °C

T_1 = the air temperature of test chamber in °C

T_2 = the air temperature entering the heat recovery ventilator in °C

55 Leakage Current Test

55.1 A cord-connected appliance rated for a nominal 240 volt or less supply shall be tested in accordance with 55.3 – 55.6. 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.

55.2 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.

55.3 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 – 9.7. 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.

55.4 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 cm in contact with the surface. If the surface has an area of less than 10 by 20 cm, 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.

55.5 The measurement circuit for leakage current is to be as illustrated in Figure 55.1. The measurement instrument is defined as follows:

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;

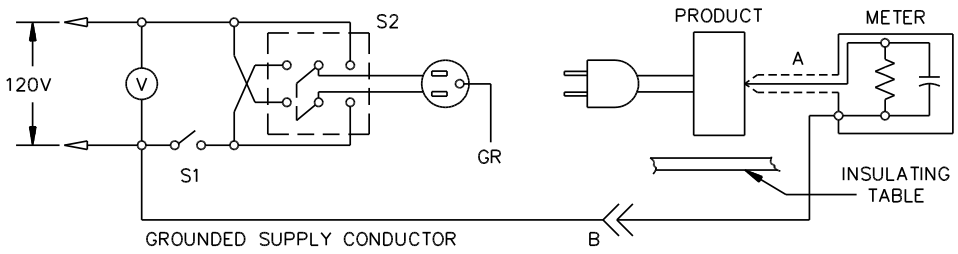
c) Over a frequency range of 0 – 100 kilohertz, the measurement circuitry is to have a frequency response—ratio of indicated to actual value of current—equal to the ratio of the impedance of a 1500-ohm resistor shunted by a 0.15-microfarad capacitor to 1500 ohms. At an indication of 0.5 milliampere, the measurement is not to have an error of more than 5 % at 60 hertz; and

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.

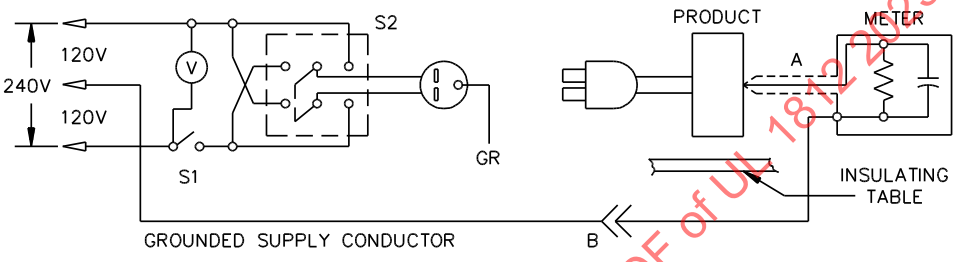
The meter that is actually used for a measurement need only indicate the same numerical value for a particular measurement as would the defined instrument. The meter used is not required to have all the attributes of the defined instrument.

Figure 55.1

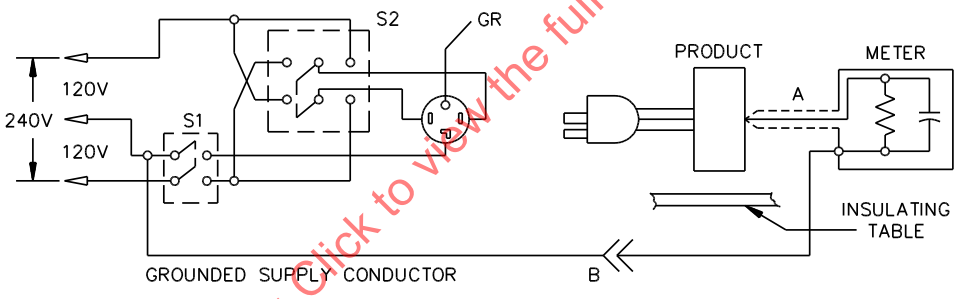
Leakage Current Measurement Circuits



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.

LC300J

A – Probe with shielded lead.

B – Separated and used as clip when measuring currents from one part of product to another.

55.6 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 Section 39, Test Voltage. The test sequence, with reference to the measuring circuit (Figure 55.1), 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; and

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.

55.7 Normally, the complete leakage current test as described in 55.6 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.

56 Continuity of Grounding Circuit Test

56.1 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; and

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.

57 Humidity Conditioning Test

57.1 After conditioning as specified in 57.2, a cord-connected appliance shall comply with the requirements in Section 45, Dielectric Voltage-Withstand Test. For an appliance rated 240 volts or less, the leakage current shall not be more than the applicable value in 55.1.

57.2 For the conditioning mentioned in 57.1, 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 % and a temperature of 32 ±2 °C (90 ±4 °F). Following the conditioning:

a) The appliance is to be tested unenergized as specified in 55.6(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 55.6(b) and (c). The test is to be discontinued when the leakage current stabilizes or decreases; and

b) The appliance shall comply with the dielectric voltage-withstand requirements in Section 45, Dielectric Voltage-Withstand Test.

57.3 Insulation resistance is to be measured by means of a high-resistance voltmeter using a 250-volt, direct current circuit.

58 Strain Relief Test

58.1 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: The strain relief means provided on 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 if an uninsulated conductor of the cord is exposed.

58.2 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.

58.3 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 test specified in Section 45, Dielectric Voltage-Withstand Test, and shall then comply with the strain-relief tests specified in 58.1 in the as-received condition. Three samples shall comply with the requirements specified in 58.1 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 41, whichever is greater;

b) The samples are then to be subjected to the Dielectric Voltage-Withstand Test, Section 45, 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; and

c) The conditioned samples then are to be cooled at room temperature.

59 Push-Back Test

59.1 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.

59.2 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-mm) increments until the cord buckles or the force to push the cord into the product exceeds 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 59.1.

60 Controls – End Product Test Parameters

60.1 General

60.1.1 Spacings of controls shall comply with either the electrical spacing requirements or the clearances and clearance distance requirements of the applicable control standard as determined in Section 31, Controls.

60.1.2 References made to declared deviation and drift indicate the manufacturer's declaration of the control's tolerance before and after certain conditioning tests.

60.2 Auxiliary controls

60.2.1 Auxiliary controls shall not introduce a risk of electric shock, fire, or personal injury.

60.2.2 Auxiliary controls shall comply with the requirements of this end product Standard.

60.3 Operating controls (regulating controls)

60.3.1 The following test parameters shall be among the items considered when judging the acceptability of an operating control investigated using UL 60730-1:

a) Control Types 1 or 2;

b) Unless otherwise specified in this Standard, manual controls 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 IEC 61000-4-5;

d) For the applicable Overvoltage Category, see Table 60.1;

e) For the applicable Material Group, see Table 60.2; and

f) For the applicable Pollution Degree, see Table 60.3.

Annex B provides more examples of controls intended to be used as operating controls.

Table 60.1
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.	

Table 60.2
Material Groups

CTI PLC value of insulating materials	Material group
CTI ≥ 600 (PLC = 0)	I
CTI ≥ 400 < 600 (PLC = 1)	II
CTI ≥ 175 < 400 (PLC = 2 or 3)	IIIa
CTI ≥ 100 < 175 (PLC = 4)	IIIb
NOTE – PLC stands for Performance Level Category and CTI stands for Comparative Tracking Index, as specified in UL 746A.	

Table 60.3
Pollution Degrees

Appliance control microenvironment	Pollution degree
No pollution or only dry, nonconductive pollution. The pollution has no influence. Typically hermetically sealed or encapsulated controls without contaminating influences, or printed wiring boards with a protective coating can achieve this degree.	1
Normally, only nonconductive pollution. However, a temporary conductivity caused by condensation may be expected. Typically indoor appliances for use in household or commercial clean environments achieve this degree.	2
Conductive pollution, or dry, nonconductive pollution that becomes conductive due to condensation that is expected. Typically controls located near and may be adversely affected by motors with graphite or graphite composite brushes, or outdoor use appliances achieve this degree.	3

60.4 Protective controls (limiting controls)

60.4.1 An electronic control that performs a protective function shall comply with the requirements in Section 31, Controls, while tested using the parameters in this Section. Examples of protective controls include those used to sense abnormal temperatures of components within the appliance; to provide temperature protection of the motor due to locked rotor, running overload, loss of phase; or to perform some other function intended to reduce the risk of electric shock, fire, or injury to persons. During the evaluation of the protective control/circuit, the protective functions are verified under normal and single-fault conditions of the control/circuit. Annex B provides more examples of controls intended to be used as protective controls.

60.4.2 The following test parameters shall be among the items considered when judging the acceptability of an electronic protective control investigated using UL 60730-1:

a) Failure-Mode and Effect Analysis (FMEA) or equivalent Risk Analysis method;

b) Power supply voltage dips, variation, and interruptions within a temperature range of 10 °C (50 °F) and the maximum ambient temperature determined by conducting the Normal Temperature Test, Section 41;

c) Surge immunity test – installation Class 3 shall be used;

d) Electrical fast transient/burst test, a test level 3 shall be used;

e) Electrostatic discharge test;

f) Radio-frequency electromagnetic field immunity:

1) Immunity to conducted disturbances – When applicable, test level 3 shall be used; and

2) Immunity to radiated electromagnetic fields; field strength of 3 V/m shall be used;

g) Thermal cycling test shall be conducted at ambient temperatures of 10.0 +2 °C (50 +4 °F) and the maximum ambient temperature determined by conducting the Normal Temperature Test, Section 41. The test shall be conducted for 14 days;

h) Overload shall be conducted based on the maximum declared ambient temperature (T_{max}) or as determined by conducting the Normal Temperature Test, Section 41; and

i) If software is relied upon as part of the protective electronic control, it shall be evaluated as software Class B.

60.4.3 The test parameters and conditions used in the investigation of the circuit covered by 60.4.1 shall be as specified in UL 991, using the following test parameters:

a) With regard to electrical supervision of critical components, for attended appliances, a motor operated system becoming permanently inoperative with respect to movement of an exposed portion of the appliance meets the criteria for trouble indication. For unattended appliances, electrical supervision of critical components may not rely on trouble indication;

b) A field strength of 3 V per meter is to be used for the Radiated EMI test;

c) The Composite operational and cycling test is to be conducted for 14 days at temperature extremes of 0 °C (32 °F) and 70 °C (158 °F);

d) The Humidity Class is to be based on the appliance's intended end use and is to be used for the Humidity test;

e) A vibration level of 5 g is to be used for the Vibration test;

f) When a computational investigation is conducted, I_p shall not be greater than 6 failures/10^6 hours for the entire system. The Operational test is to be conducted for 14 days;

g) When the Demonstrated method test is conducted, the multiplier for the test acceleration factor is to be 576.30 for intermittent use appliances, or 5763.00 for continuous use appliances. The test acceleration factor equation is to be based on a 25 °C (77 °F) use ambient;

h) The Endurance test is to be conducted concurrently with the Operational test. The control shall perform its intended function while being conditioned for 14 days in an ambient air temperature of 60 °C (140 °F) or 10 °C (50 °F) greater than the operating temperature of the control, whichever is higher. During the test, the control is to be operated in a manner representing normal use;

i) For the Electrical fast transient burst test, test level 1 is to be used;

j) Conduct a failure-mode and effect analysis (FMEA); and

k) If software is relied upon as part of the protective electronic control, it shall be evaluated as software Class 1 in accordance with UL 1998.

60.4.4 Unless otherwise specified in this Standard, protective controls shall be evaluated using the rated current for 100,000 cycles for Type 2 controls and 6,000 cycles for Type 1 controls.

60.5 Controls using a temperature sensing device

60.5.1 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 be tested using the following number of cycles when testing a sensing device in accordance with the endurance test of UL 60730-1:

a) For a device employed as an operating device – 6,000 cycles;

b) For a device employed as a protective device – 100,000 cycles; and

c) For a device employed as a combination operating and protective device – 100,000 cycles.

61 Strength Tests

61.1 These tests shall be applicable to those refrigerant-containing parts and hot water and steam coils that are required to comply with the strength requirements specified in Section 17, Refrigerant, Hot Water, and Steam Coils.

Exception: Pressure-actuated refrigeration controllers are not required to meet the requirements of this Section.

61.2 Two samples of each refrigerant-containing part shall be tested, except that only one sample of the following need be tested on liquid chillers employing centrifugal motor-compressors:

a) Motor-compressor enclosure;

b) Volutes;

c) Cross-over pipe;

d) Condenser and evaporator; and

e) Items equivalent to those specified in (a) – (d).

61.3 The test samples shall be filled with any inert liquid, such as water, to exclude air and shall be connected in a hydraulic pump system. The pressure shall be raised gradually until the required pressure is reached and shall be maintained for 1 minute.

61.4 The test pressure required shall be computed in accordance with 17.4 – 17.6.

61.5 Parts shall be considered to comply with the requirement if they do not burst or leak, except that leakage at gaskets shall not be considered a failure if the leakage occurs at a pressure greater than 40 % of the required test pressure.

61.6 With reference to 61.1 – 61.5, sections of the refrigerant system constructed of continuous tubing or of lengths of tubing connected by hard soldered brazed or welded joints shall be considered as meeting the requirements, provided the tubing employed in the assembly meets the minimum thickness requirements of Table 17.1.

62 Fatigue Test Analysis

62.1 General

62.1.1 These tests shall be applicable to those parts or the complete system that contains refrigerant and that are required to comply with the strength requirements specified in Exception No. 3 to 17.4.

62.2 Test specifications

62.2.1 When tested in accordance with this Section, a part or a complete system shall have sufficient strength to withstand the pressure strength test requirements specified in Section 61, Strength Tests. The

test pressure utilized for Section 61 shall be three times the minimum design pressure specified in Table 17.2.

62.3 Material specifications

62.3.1 Materials used in the pressure containment system and subjected to this test shall be identified by reference to an industry standard material specification, such as ASTM, SAE, AISI, and the like, as specified by the manufacturer. Joining methods shall be specified by materials, the manufacturer's process specifications, or the equivalent.

62.4 General test specifications

62.4.1 Three samples of each refrigerant-containing part shall be tested at the cyclic pressure values specified in 62.6.2 and 62.7.1 for the number of cycles specified in 62.6.1, as described in the test method, 62.5.1 and 62.5.2. At the manufacturer's option, three samples of the complete system shall be used for the test.

62.4.2 The samples shall be considered to comply if they comply with the requirements in 62.5.3 at the completion of the test and if they do not rupture, burst, or leak.

62.5 Test method

62.5.1 The test samples shall be filled with inert fluid and shall be connected to a pressure driving source. The pressure shall be raised and lowered between the upper and lower cyclic values at a rate specified by the manufacturer. The full specified pressure excursion shall occur during each cycle. The shape of the pressure cycle shall be such that the upper and lower pressure values shall be maintained for at least 0.1 second.

NOTE: For safety purposes, it is suggested that the inert fluid described in 62.5.1 should be a hydraulic fluid. The fluid should completely fill the part, displacing all air.

62.5.2 Materials such as steel, copper, and aluminum have fatigue properties that are practically independent of temperature at the continuous operating temperatures normally encountered under the operating temperature conditions and internal system temperatures of the unit. If the continuous operating temperature is less than or equal to 121 °C (250 °F) for copper or aluminum or 204 °C (400 °F) for steel, the test temperature of the component part or assembly shall be at least 20 °C (68 °F). If the continuous operating temperature of the component exceeds 121 °C (250 °F) for copper or aluminum or 204 °C (400 °F) for steel, the test temperature of the parts or assemblies that are at these temperatures and subjected to the pressure shall be at least 149 °C (300 °F) for copper or aluminum and 260 °C (500 °F) for steel. For other materials or higher temperatures, the effects of temperature on the material fatigue characteristics shall be evaluated.

62.5.3 Following the specified number of test cycles, the test pressure shall be increased to the highest amount, either:

a) Two times the minimum upper pressure values specified in 62.7.1; or

b) One and one-half times the marked or accepted pressure rating required in 75.23.

After the pressure is raised, the test value shall be maintained for 1 minute without rupture, burst, or leak.

62.6 Test parameters

62.6.1 The number of cycles shall be 500,000. The test pressure of the first cycle of the test shall be determined by 62.6.2. The test pressure for the remainder of the test shall be determined by 62.7.1.

62.6.2 Except as specified in 62.6.3, the test pressure for the first cycle shall be the pressure identified in 62.2.1 prior to multiplying by three.

62.6.3 If the high-side maximum design pressure for the equipment equals or exceeds the critical pressure of the refrigerant, then the upper pressure of the high-side parts during the first cycle shall be the higher of either the equipment maximum abnormal pressure or maximum design pressure.

62.6.4 With reference to 62.6.3, the critical pressure of R-744 is 1,058 psig (7,295 kPa).

62.7 Cycle test pressure specification

62.7.1 Except as specified in 62.7.2, the pressure for the remainder of the test cycles shall be as follows:

a) Except as indicated in (c) and (d), for components subject to high-side pressures, the upper pressure value shall not be less than the saturated vapor pressure of the refrigerant at 49 °C (120 °F) and the lower pressure value shall not be greater than the saturated vapor pressure of the refrigerant at 4.4 °C (40 °F);

b) Except as indicated in (c) and (d), for components subjected to only low side pressures, the upper pressure value shall be not less than the saturated vapor pressure of the refrigerant at 26.7 °C (80 °F) and the lower pressure value shall be between 0 psig (0 kPa) and the greater of 5 psig (34.5 kPa) or the saturated vapor pressure of the refrigerant at minus 12.2 °C (10 °F);

c) For components used in equipment intended to utilize carbon dioxide (R744) in a secondary loop or cascade system or in the low-side of a transcritical system, the upper pressure value shall not be less than the start-to-discharge value of the pressure-regulating relief valve. The lower pressure shall be not more than 100 psig (690 kPa); and

d) For components used in equipment intended to utilize carbon dioxide (R-744) in portions of a transcritical system designed for operation at pressures between the low-side and high-side of the system, the upper pressure value shall not be less than start-to-discharge value of the pressure relief valve. The lower pressure shall be not more than saturated vapor pressure of the refrigerant at 10 °F (minus 12 °C). For R-744, this value is 345 psig (2.4 MPa).

NOTE 1: The objective is to avoid a test value that is a negative pressure but to require a lower pressure value of the saturated vapor pressure at minus 12.2 °C (10 °F) or 5 psig (34.5 kPa), whichever is greater.

NOTE 2: For zeotropic mixtures, the average of the dew point pressure value and the bubble point pressure value at the specified temperature is used as the saturated vapor pressure value.

62.7.2 If the high-side design pressure of the equipment equals or exceeds the critical pressure of the refrigerant, then the upper pressure for the remaining cycles shall be not less than 95 % of the higher of either the maximum abnormal pressure or the maximum design pressure of the equipment.

62.7.3 With reference to 62.6.3 and 62.7.2, the lower pressure for all cycles shall not be greater than the saturated vapor pressure of the refrigerant at 40 °F (4.4 °C). For R-744, this value is 580 psig (4.0 MPa).

63 Electric Heater Tests

63.1 General

63.1.1 The tests in this Section shall be conducted on any unit that employs electric resistance heaters.

63.1.2 The maximum temperatures measured during the tests described in this Section shall not exceed:

a) The value specified in Column 2 of Table 41.1 during 1 hour after the first operation of a limit control or motor overload protective device; and

b) The value specified in Column 1 of Table 41.1 thereafter.

Exception: A motor may attain the temperature specified in Column 2 during any part of the test.

63.2 Continuity of operation

63.2.1 The test voltage shall be as specified in Table 39.1.

63.2.2 The product shall be placed in heating operation with all electric heaters energized. There shall be no inlet air restriction except as inherent in the device with air filters in place.

63.2.3 The test shall continue until the outlet air and surface temperatures have stabilized.

63.2.4 Inlet air shall be 80 °F (26.7 °C) except for equipment, such as makeup air units with electric heat, designed and intended to be utilized at entering air temperatures less than 80 °F and employing one of the following control schemes:

a) A functional limit control (that meets the requirements in 37.11 – 37.14) to operate to de-energize the appropriate number of heaters. This functional limit control shall have the same construction as the primary limit controls but shall be set at a temperature 3 °C (5.4 °F) lower so the functional limit control would always function first, before the primary limit controls (that meet the requirements in 37.11 – 37.14 and 63.2.4); or

b) A regulating control to control the heaters if the heaters also have primary limit controls and back-up protection limit controls as described in Section 64, Backup Protection Tests.

63.3 Limit control cutout test

63.3.1 A limit control, when adjusted to the maximum setting allowed by a fixed stop, shall prevent a unit from delivering air at a temperature exceeding 121 °C (250 °F).

63.3.2 The test arrangement and conditions shall be as described in 63.2, Continuity of operation. The unit shall be operated as described in 63.2 until the outlet air temperature is constant.

63.3.3 The inlet opening shall be slowly and uniformly restricted at the rate indicated in 63.3.5, with no other readjustment of the system until a limit control opens, at which point the outlet air temperature shall be measured.

63.3.4 If the heater circuits are not fully deenergized by the first limit control operation, the test shall be continued by further restricting the inlet air until either all limit controls trip or the outlet air temperature stabilizes.