UL 2006

Underwriters Laboratories Inc.

Standard for Safety

Halon 1211 Recovery/ Recharge Equipment

UL Standard for Safety for Halon 1211 Recovery/Recharge Equipment, UL 2006

Fifth Edition, Dated September 8, 2011

Summary of Topics

This New Edition of UL 2006 is being issued to include the following changes in requirements:

Revisions to general component requirements

Deletion of Appendix A and addition of related component requirements to the body of the standard

Revisions to clarify requirements for the construction of barriers

Revisions to specify the materials and permit an additional option for gaskets

Revisions to add references to component standards used on halon 1211 recovery/ recharge equipment

Revisions to add component standard references for switches and controllers

Revisions to clarify requirements for capacitors

Revisions to clarify requirements for protective electronic circuits.

Addition of requirements to permit the use of spacings complying with the requirements of UL 840

Revisions to clarify requirements for the strain relief test

Revisions to define enclosures and cabinets

Revisions to polymeric parts requirements

Addition of exception to 45.1 and revision to 45.2 to include reference for testing with a dc potential

Revisions for editorial clarification

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated June 10, 2011.

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The requirements in this Standard are now in effect, except for those paragraphs, sections, tables, figures, and/or other elements of the Standard having future effective dates as indicated in the note following the affected item. The prior text for requirements that have been revised and that have a future effective date are located after the Standard, and are preceded by a ″SUPERSEDED REQUIREMENTS″ notice.

UL 2006

Standard for Halon 1211 Recovery/Recharge Equipment

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Fifth Edition

September 8, 2011

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

No Text on This Page

CONTENTS

INTRODUCTION

CONSTRUCTION

ELECTRICAL COMPONENTS

SPACINGS

PROTECTION AGAINST INJURY TO PERSONS

PERFORMANCE

MANUFACTURING AND PRODUCTION TESTS

MARKING

INSTRUCTIONS

INTRODUCTION

1 Scope

1.1 These requirements cover Halon 1211 recovery/recharge equipment rated 600 volts or less, and intended to be used in ordinary locations in accordance with the National Electrical Code, NFPA 70.

1.2 Halon 1211 recovery/recharge equipment covered by these requirements is intended for commercial use to recover/recharge Halon 1211 in fire equipment, including but not limited to portable, wheeled and automatic units and extinguishing systems.

1.3 These requirements apply to equipment intended for indoor or outdoor use, or both and to battery operated equipment.

1.4 These requirements include an evaluation to determine that the equipment recovers/recharges Halon 1211 to an adequate fire extinguishing performance level for reuse.

1.5 A product that contains features, characteristics, components, materials, or systems new or different from those covered by the requirements in this standard, and that involves a risk of fire, electric shock, or injury to persons shall be evaluated using the appropriate additional component and end-product requirements as determined necessary to maintain the acceptable level of safety as originally anticipated by the intent of this standard. A product whose features, characteristics, components, materials, or systems conflict with specific requirements or provisions of this standard cannot be judged to comply with this standard. Where considered appropriate, revision of requirements shall be proposed and adopted in conformance with the methods employed for development, revision, and implementation of this standard.

2 Units of Measurement

2.1 If a value for measurement is followed by a value in other units in parentheses, the second value may be only approximate. The first stated value is the requirement.

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

3 References

3.1 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 Terminology

4.1 The term ″product″ refers to any equipment covered by the Scope of this standard.

5 Glossary

5.1 For the purpose of these requirements, the following definitions apply.

5.2 BARRIER – A partition for isolating high-voltage electrical components, separating ignition sources from flammable materials, isolating moving parts and protection of wiring.

5.3 CABINET – The part of the equipment that provides physical protection to insulated wiring, enclosures, moving parts, motors, enclosed electrical parts, tubing or other parts that may cause injury to persons.

5.4 CIRCUITS, ELECTRICAL:

a) High-Voltage – A circuit involving a potential of not more than 600 volts and having circuit characteristics in excess of those of a low-voltage circuit.

b) Low-Voltage – A circuit involving a potential of not more than 30 volts alternating current, 42.4 volts peak or direct current, and supplied by a primary battery, standard Class 2 transformer, or a combination of a transformer and fixed impedance which, as a unit, complies with all performance requirements for a Class 2 transformer.

5.5 COMPONENT – A device or fabricated part of the equipment covered by the scope of a safety standard dedicated to that purpose. If incorporated in the equipment, a product that is otherwise typically field installed (e.g. luminaire) is considered to be a component. Unless otherwise specified, materials that compose a device or fabricated part, such as aluminum or copper, are not considered components. Generally, components are incomplete in construction features or restricted in performance capabilities. Such components are intended for use only under specific, limited conditions, such as certain temperatures not exceeding specified limits.

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

5.7 CONTROL, PROTECTIVE – A device or assembly of devices, the operation of which is intended to reduce the risk of electric shock, fire or injury to persons during normal and reasonably anticipated abnormal operation of the equipment. 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” or “safety controls” and are investigated under normal and single-fault conditions.

5.8 DESIGN PRESSURE – The maximum acceptable working pressure for which the equipment or a specific part is designed.

5.9 ENCLOSURE – The part of the equipment that does one or more of the following:

a) Isolates ignition sources,

b) Renders inaccessible all or any part(s) of the equipment that may otherwise present a risk of electric shock,

c) Retards propagation of flame initiated by electrical disturbances occurring within.

5.10 FUNCTIONAL PART – A part other than an enclosure or cabinet used to maintain the intended relative physical position of fixed or moving parts, or maintain the integrity of the structure.

5.11 IGNITION SOURCE – Any high-voltage electrical component not located within an enclosure.

5.12 MOTOR, DIRECTLY ACCESSIBLE – A motor that can be contacted without opening or removing any part, or that is located so as to be accessible to contact.

5.13 MOTOR, INDIRECTLY ACCESSIBLE – A motor that is accessible only by opening or removing a part of the cabinet, such as a guard or panel that can be opened or removed without using a tool, or that is located at such a height or is otherwise guarded or enclosed so that it is unlikely to be contacted.

5.14 NONFUNCTIONAL PART – A part of the equipment that does not perform a specific function.

5.15 NONFUNCTIONAL PART, SMALL – A nonfunctional part having an area of less than 1 ft2 (0.093 m^2) located so it cannot propagate flame from one area to another, and does not connect a possible source of ignition to the other ignitable parts.

5.16 PIPING – Includes pipe, flanges, bolting, gaskets, valves, fittings, the pressure-containing parts of other components, such as strainers and devices that serve such purposes as mixing, separating, muffling, snubbing, distributing, metering, or controlling flow.

5.17 RECHARGE – The act of removing contaminants in recovered Halon 1211 by single or multiple passes through devices, such as replaceable core filter-driers, that reduce moisture and particulate matter. Recharge usually occurs at the field job site or at a local service shop.

5.18 RECOVERED HALON 1211 – Halon 1211 that has been removed from fire equipment for the purpose of storage, recharging, or transportation.

5.19 RECOVERY – The act of removing Halon 1211 in any condition from fire equipment and storing it in an external container without necessarily testing or processing it in any way.

CONSTRUCTION

6 General

6.1 A product shall employ materials found by investigation to be acceptable for the intended application.

6.2 A component shall:

a) Comply with the safety standard covering 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;

d) Comply with the applicable requirements of this end product standard; and

e) Not contain mercury.

Exception: 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, or;

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.

6.3 A component that is also required to perform other necessary functions, such as overcurrent 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) covering products that provide those functions.

7 Barriers

7.1 A barrier shall be formed from one or more of the following:

a) Metal, minimum 0.005 inch (0.13 mm) thick;

b) Fiberglass, minimum 0.5 inch (12.7 mm) thick;

c) A nonmetallic material rated 5VA;

d) A nonmetallic material evaluated to the 127 mm (5 inch) End Product Flame Test as described in UL 746C;

e) Vulcanized fiber, varnished cloth, mica or phenolic composition, minimum 0.028 in. (0.71 mm) thick; or

f) Any other material or construction determined to be equivalent to items (a) to (e).

7.2 barrier shall be secured to the mounting surface such that tools are required for its removal.

7.3 Except as specified in 7.5 and 12.5.2(b), a nonmetallic barrier that isolates ignition source(s) shall comply with the enclosure requirements of Table 67.1.

7.4 A nonmetallic barrier providing mechanical protection shall comply with the cabinet requirements of Table 67.1.

7.5 A barrier made of the materials specified in 7.1(e) but less than 0.028 in. (0.71 mm) thick shall:

a) Be used in a location such that the air spacing between the parts being insulated by the barrier is not less than one-half of the required through-air spacing; and,

b) Not be less than 0.013 inch (0.3 mm) thick.

8 Assembly

8.1 Recovery/recharge system

8.1.1 The equipment shall be provided with a means to observe the presence of liquid Halon 1211 in the system, such as a liquid indicator having a sight port, to determine if the halon is discolored or contaminated with particulate matter.

8.1.2 The equipment shall incorporate a moisture indicator that indicates the moisture content of Halon 1211 and with a color chart, mounted adjacent to the indicator, that relates the moisture content to the color of the indicator.

8.1.3 The equipment shall be provided with a filter-drier that incorporates a desiccant package having a minimum volume of 48 cubic inches (787 cm^3) that is intended to be replaced when saturated with moisture and a filter with a 15 micron or smaller porosity to remove solid matter.

8.1.4 The equipment shall be provided with a minimum of two transfer hoses, each having a minimum length of 3 feet (0.9 m), to permit connection to the fire equipment being repaired or serviced and to the storage container charging adapter. One end of each hose shall incorporate a Compressed Gas Association (CGA) 660 female type fitting and the other end of each hose a self-sealing quick-connect type coupling.

8.1.5 The equipment pressure system shall incorporate a self-restoring type pressure relief valve(s). The start-to-discharge pressure setting of the pressure relief valve(s) shall relieve excessive pressures automatically on all components and the reclose pressure setting shall reduce unnecessary emissions of Halon 1211.

8.1.6 Equipment having provision for the storage of halon containers or the like shall be provided with:

a) A means for retaining the containers in position.

b) A means, such as the use of scales and a shutoff device, to terminate the recovery/recharge operation when or before the container liquid level reaches 90 percent of container capacity at 70°F (21.1°C).

8.1.7 Pressure-containing parts shall be factory connected with piping or tubing complying with the requirements specified in Table 40.1.

8.2 Mechanical protection

8.2.1 A product shall be assembled so that it will not be adversely affected by the vibration of operation. Brush caps shall be tightly threaded or otherwise constructed to prevent loosening.

8.2.2 A switch other than a through-cord switch, a lampholder, an attachment-plug receptacle, a motor-attachment plug, or similar component shall be mounted securely and shall be prevented from turning. See 8.2.4.

Exception No. 1: A switch need not be prevented from turning if all four of the following conditions are met:

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

b) The means for mounting the switch make it unlikely that operation of the switch will loosen it.

c) The spacings are not reduced below the minimum required values if the switch rotates.

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

Exception No. 2: A lampholder of the type in which the lamp cannot be replaced, such as a neon pilot or indicator light in which the lamp is sealed in a nonremovable jewel, need not be prevented from turning or shifting in position, if such motion does not result in a reduction of spacings below the minimum acceptable values.

8.2.3 Uninsulated live parts shall be secured to the base or mounting surface so that they will be prevented from turning or shifting in position, if such motion may result in a reduction of spacings below the minimum required values.

8.2.4 The means for preventing the turning or shifting mentioned in 8.2.2 and 8.2.3 shall consist of more than friction between surfaces – for example, a properly applied lock washer is acceptable as the means for preventing a small stem-mounted switch or other device, having a single-hole mounting means, from turning.

9 Enclosure

9.1 General

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

9.1.2 Outlet boxes shall comply with the Standard for Metallic Outlet Boxes, UL 514A or the Standard for Nonmetallic Outlet Boxes, Flush Device Boxes, and Covers, UL 514C. Fittings shall comply with the Standard for Conduit, Tubing and Cable Fittings, UL 514B. Cover plates shall comply with the Standard for Cover Plates for Flush-Mounted Wiring Devices, UL 514D.

9.1.3 Wireways, auxiliary gutters and associated fittings shall comply with the Standard for Wireways, Auxiliary Gutters and Associated Fittings, UL 870.

9.2 Metal enclosures

9.2.1 Cast and sheet-metal portions of an enclosure shall not be thinner than the applicable values specified in Table 9.1.

Exception: Thinner metal can be used provided the surface under consideration is curved, ribbed, or otherwise reinforced to provide mechanical strength equivalent to that required.

Table 9.1
Thickness of enclosure metal

Metal	Minimum thickness, inch (mm)			
	At small, flat, unreinforced surface and at a surface of a shape or size to provide mechanical strength		At a relatively large unreinforced flat surface	
Die-cast metal	3/64	(1.2)	5/64	(2.0)
Cast malleable iron	1/16	(1.6)	3/32	(2.4)
Other cast metal	3/32	(2.4)	1/8	(3.2)
Uncoated sheet steel	0.026	(0.66)	0.026	(0.66)
Galvanized sheet steel	0.029	(0.74)	0.029	(0.74)
Nonferrous sheet metal	0.036	(0.91)	0.036	(0.91)

9.3 Nonmetallic parts

9.3.1 All nonmetallic parts, except for small nonfunctional parts shall comply with 9.4 – 9.6 and Table 63.1.

9.3.2 In addition to the requirement in 9.3.1, nonmetallic materials that serve as electrical insulation or that directly support live parts shall comply with the requirements for electric insulation in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

9.4 Nonmetallic materials

9.4.1 Materials shall be classified with respect to flammability characteristics that are established by the tests specified in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

9.4.2 Materials shall be assigned flammability ratings based on greatest to least resistance to flame and are identified as: 5VA, 5VB, V-0, V-1, V-2, HF-1, HF-2, HB, and HBF.

9.4.3 In reference to 9.4.2, the assigned flammability rating shall be appropriate for the material-use application in accordance with 9.5 and Table 63.1.

9.5 Nonmetallic material ignition sources separation

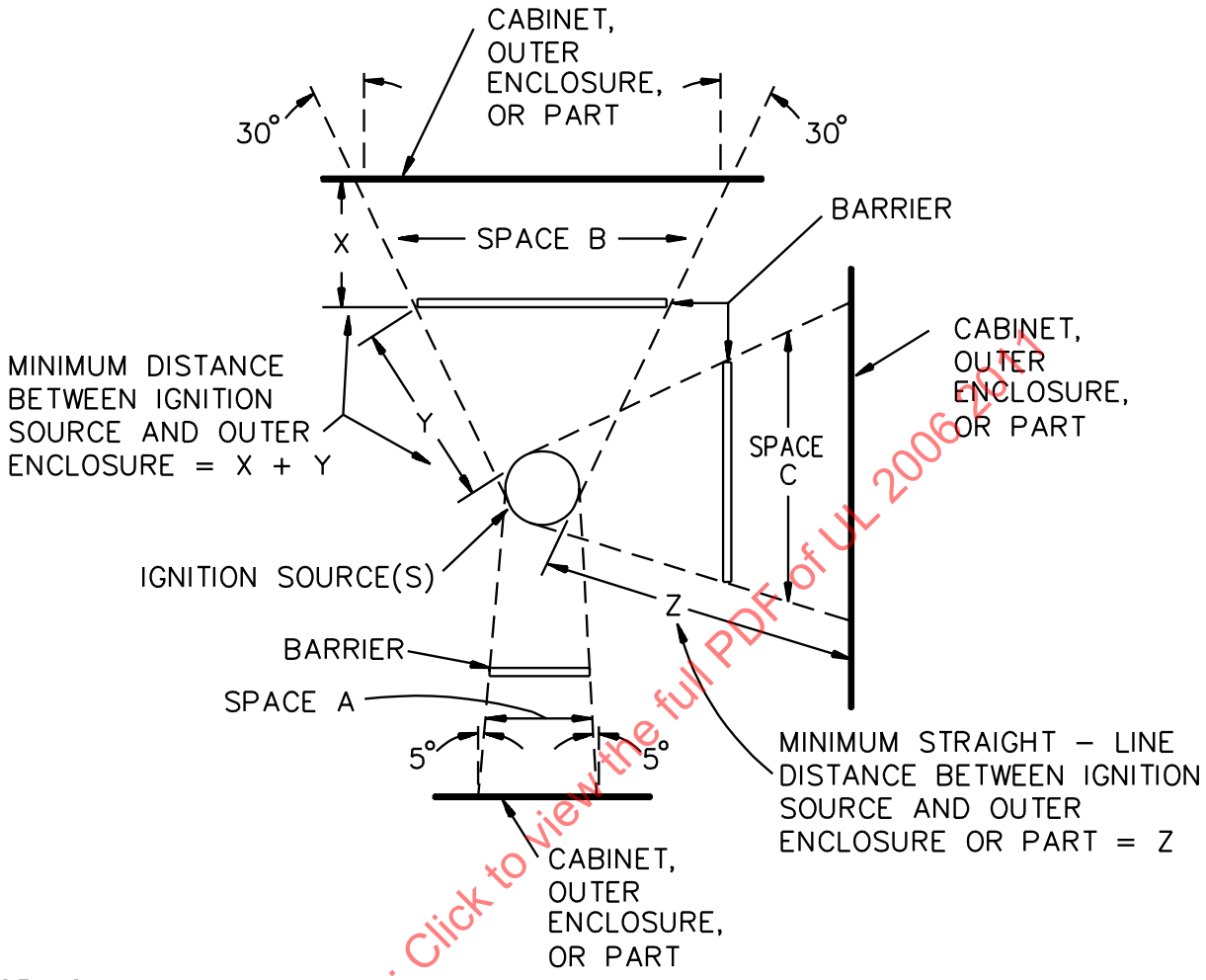
9.5.1 Parts formed from nonmetallic materials that are rated HB or HBF and positioned as shown in Figure 9.1 shall be separated from ignition sources by means of a barrier, extending at least to the boundary surface of the space whenever such parts are located:

a) Below an ignition source and within Space A; and

b) Above an ignition source and within Space B; and

c) In the vertical plane relative to an ignition source and within Space C.

Figure 9.1
Separation of ignition sources from nonmetallic materials



Notes:

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

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

9.5.2 The HB or HBF materials referenced by 9.5.1 shall be located such that the distance between:

a) High-voltage wiring not employing VW-1 insulation and the HB or HBF materials shall be a minimum of 2 inches (51 mm), and

b) Any other ignition source and the HB or HBF materials shall be a minimum of 4 inches (102 mm).

9.5.3 In reference to 9.5.2 and Figure 9.11, the minimum distance for HB or HBF materials located:

a) Above the ignition source shall be as shown in Distance X + Y; and

b) In the vertical plane relative to the ignition source shall be as shown in straight-line Distance Z.

9.6 Nonmetallic material application and location

9.6.1 Nonmetallic materials shall comply with the applicable tests as described in Table 63.1.

9.6.2 Nonmetallic fasteners used as a part of the enclosure shall comply with the Fastener Strength Test in 63.

9.7 Enclosure integrity

9.7.1 The enclosure shall prevent molten metal, burning insulation, flaming particles, or the like from falling on flammable materials, including the surface upon which the product is supported.

9.7.2 The requirement in 9.7.1 will necessitate that a switch, a relay, a solenoid, or the like be individually and completely enclosed, except for terminals, unless it can be shown that malfunction of the component would not result in a risk of fire, or there are no openings in the bottom of the product enclosure. It will also necessitate the use of a barrier of nonflammable material:

a) Under a motor unless:

1) The structural parts of the motor or of the product provide the equivalent of such a barrier;

2) The protection provided with the motor is such that no burning insulation or molten material falls to the surface that supports the product when the motor is energized under each of the following fault conditions:

i) Open main winding,

ii) Open starting winding,

iii) Starting switch short-circuited, and

iv) Capacitor of permanent-split capacitor motor short circuited – the short-circuit is to be applied before the motor is energized, and the rotor is to be locked;

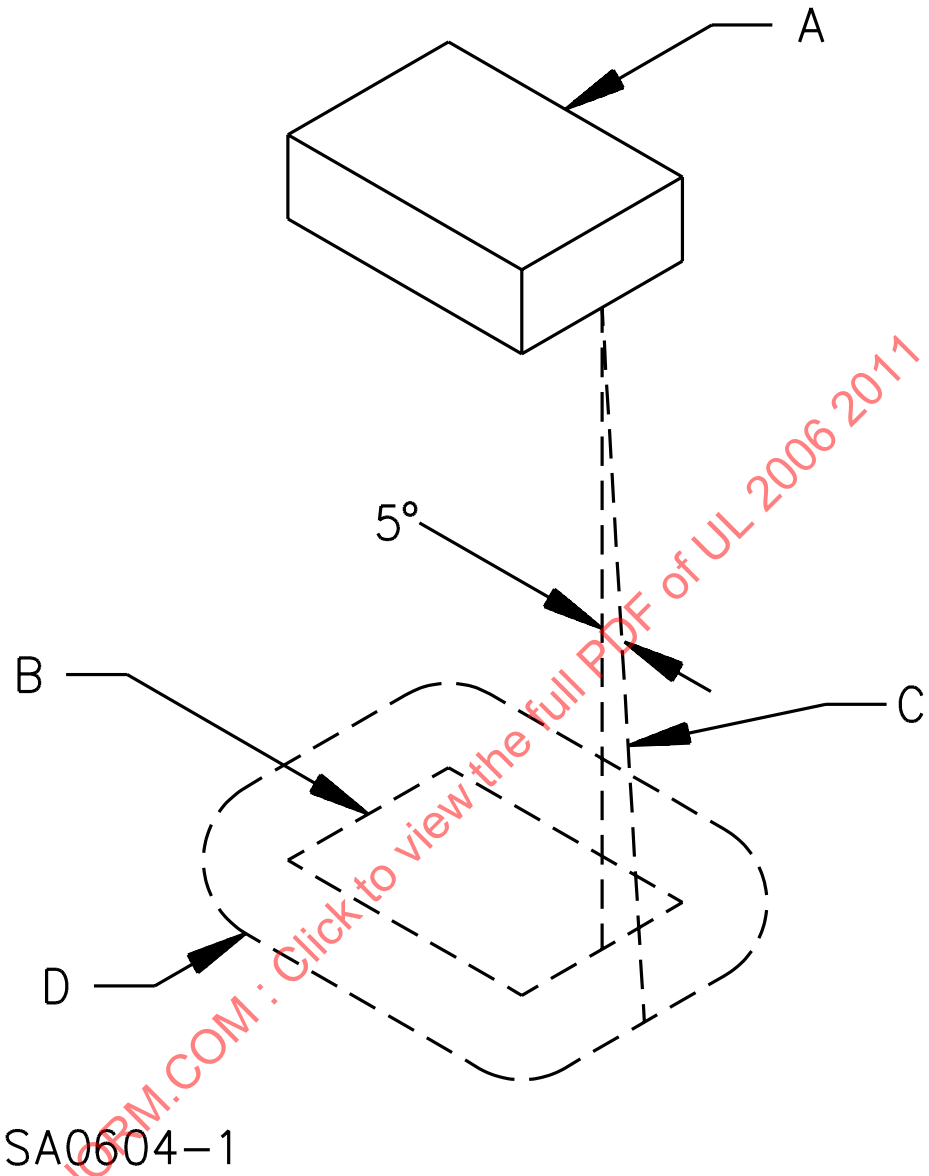
3) The motor is provided with a thermal motor protector – a protective device that is sensitive to temperature and current – that will prevent the temperature of the motor windings from exceeding 125°C (257°F) under the maximum load under which the motor will run without causing the protector to cycle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

4) The motor complies with the requirements for impedance-protected motors in the Standard for Overheating Protection for Motors, UL 2111, or the Standard for Impedance Protected Motors, UL 1004-2, and the temperature of the motor winding will not exceed 150°C (302°F) during the first 72 hours of operation with the rotor of the motor locked.

b) Under wiring, unless it is neoprene- or thermoplastic-insulated.

9.7.3 The barrier mentioned in 9.7.2 shall be horizontal, shall be located as indicated in Figure 9.2, and shall not have an area less than that described in that illustration. Openings for drainage, ventilation, and the like can be employed in the barrier, provided such openings would not permit molten metal, burning insulation, or the like to fall on flammable material.

Figure 9.2
Location and extent of barrier



A – Region to be shielded by barrier. This will consist of the entire component if it is not otherwise shielded and will consist of the unshielded portion of a component that is partially shielded by the component enclosure or equivalent.

B – Projection of outline of component on horizontal plane.

C – Inclined line that traces out minimum area of barrier. The line is always tangent to the component, 5 degrees from the vertical, and oriented so that the area traced out on a horizontal plane is maximum.

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

9.8 Doors and covers

9.8.1 A door or a cover of an enclosure that provides access to any overload-protective device that requires resetting or renewal shall be hinged or otherwise attached in an equivalent manner.

9.8.2 Means shall be provided for holding the door or cover over a fuseholder in a closed position, and the door or cover shall be tight-fitting.

9.9 Enclosures exposed to weather

9.9.1 Sheet steel cabinets and electrical enclosures exposed to the effects of weathering shall be protected against corrosion by the means specified in Table 9.2 or by other metallic or nonmetallic coatings that provide equivalent protection.

Exception: These requirements are not applicable to a metal part, such as a decorative grille, that is not required for conformance with this standard.

Table 9.2
Corrosion protection means

Type of cabinet and enclosure	Thickness 0.053 inch (1.35 mm) and heavier as specified by	Thickness less than 0.053 inch (1.35 mm) as specified by
Outer cabinets which protect motors, wiring or enclosed current-carrying parts	9.9.2	9.9.3
Inside enclosures which protect current-carrying parts other than motors	9.9.2	9.9.3
Outer cabinets which are the sole enclosure of current-carrying parts	9.9.3	9.9.3

9.9.2 To comply with the requirements of 9.9.1, one of the following coatings shall be used:

a) Hot-dipped mill-galvanized sheet steel conforming with the Coating Designation G60 or A60 in the Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process, ASTM A653/A653M, with not less than 40 percent of the zinc on any side, based on the minimum single spot test requirement in the ASTM Specification. The weight of zinc coating can be determined by any recognized method; however, in case of question, the weight of coating shall be established in accordance with the Test Method for Weight of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles, ASTM A90/90M. An A60 (alloyed) coating shall also comply with 9.9.4.

b) A zinc coating, other than that provided on hot-dipped mill-galvanized sheet steel, uniformly applied to an average thickness of not less than 0.00041 inch (0.0104 mm) on each surface with a minimum thickness of 0.00034 inch (0.0086 mm). The thickness of the coating is to be established by the Metallic Coating Thickness Test, Section 66. An annealed coating shall also comply with 9.9.4.

c) Two coats of an organic finish of the epoxy or alkyd-resin type or other outdoor paint on both surfaces. Unless acceptability of the paint can be determined by consideration of its composition, corrosion tests are required.

9.9.3 To comply with 9.9.1, one of the following coatings shall be used:

a) Hot-dipped mill-galvanized sheet steel conforming with the Coating Designation G90 in the Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process, ASTM A653/A653M, with not less than 40 percent of the zinc on any side, based on the minimum single spot test requirements in that ASTM Specification. The weight of zinc coating can be determined by any recognized method; however, in case of question, the weight of coating shall be established in accordance with the Test Method for Weight of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles, ASTM A90/90M.

b) A zinc coating, other than that provided on hot-dipped mill-galvanized sheet steel, uniformly applied to an average thickness of not less than 0.00061 inch (0.0155 mm) on each surface with a minimum thickness of 0.00054 inch (0.0137 mm). The thickness of the coating shall be established by the Metallic Coating Thickness Test, Section 66. An annealed coating shall also comply with 9.9.4.

c) A cadmium coating of not less than 0.001 inch (0.025 mm) thick on both surfaces. The thickness of coating is to be established in accordance with the Metallic Coating Thickness Test, Section 65.

d) A zinc coating conforming with 9.9.2 (a) and (b) with one coat of outdoor paint as specified in 9.9.2(c).

e) A cadmium coating of not less than 0.00075 inch (0.0191 mm) thick on both surfaces with one coat of outdoor paint on both surfaces or not less than 0.0005 inch (0.013 mm) thick on both surfaces with two coats of outdoor paint on both surfaces. The thickness of the cadmium coating is to be established in accordance with the Metallic Coating Thickness Test, Section 66, and the paint shall be as specified in 9.9.2(c).

9.9.4 An annealed zinc coating that is bent or similarly formed after annealing shall be painted in the bent or formed area if the bending or forming process has damaged the zinc coating, as evidenced by flaking or cracking of the zinc coating at the outside radius of the bent or formed section visible at 25 power magnification.

9.9.5 With reference to the requirements of 9.9.4, simple sheared or cut edges and punched holes are not considered to be formed, but extruded and rolled edges and holes shall comply with 9.9.4.

9.9.6 With reference to the requirements of 9.9.1, other finishes, including paints, special metallic finishes, and combinations of the two, are acceptable if comparative tests with galvanized sheet steel without annealing, wiping, or other surface treatment complying with 9.9.2(a) or 9.9.3(a), as applicable, indicate that they provide equivalent protection. Among the factors to be taken into consideration when judging the acceptability of such coating systems are exposure to salt spray, to moist carbon dioxide-sulfur dioxide-air mixtures, to moist hydrogen sulfide-air mixtures, and to ultraviolet light and water.

9.9.7 Nonferrous enclosures may be employed without special corrosion protection. See 9.1.1.

9.9.8 Gaskets required to seal electrical enclosures against the entrance of rain and condensate shall be held in place by mechanical fasteners or adhesives, and shall:

a) Be neoprene, rubber, thermoplastic or other materials with equivalent properties that comply with 65.1 – 65.4; or

b) Comply with the Standard for Gaskets and Seals, UL 157.

9.9.9 Sealing compounds required to seal electrical enclosures shall comply with 65.5.

9.9.10 Adhesives required to secure gaskets shall comply with 65.6.

9.9.11 Gaskets that are not held in place by mechanical fasteners or adhesives but are intended to be retained in the correct position by some other means shall be prevented from displacement either:

a) Due to their location within the equipment, or

b) By the placement of other components in the enclosure so that if the equipment cover is removed, the gasket will be reengaged in the intended manner when the cover is replaced.

10 Protection Against Corrosion

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

Exception No. 1: Surfaces of sheet-steel and cast-iron parts within an enclosure may not be required to be protected against corrosion if the oxidation of the metal due to the exposure to air and moisture is not likely to be appreciable. The thickness of metal and temperature are also to be considered.

Exception No. 2: Bearings, laminations, or minor parts of iron or steel, such as washers, screws, and the like.

10.2 Metal shall be used in combinations that are galvanically compatible.

11 Accessibility of Uninsulated Live Parts and Film-Coated Wire

11.1 To reduce the likelihood of unintentional contact that may involve a risk of electric shock from an uninsulated live part or film-coated wire, an opening in an enclosure shall comply with either (a) or (b).

a) For an opening that has a minor dimension (see 11.5) less than 1 inch (25.4 mm), such a part or wire shall not be contacted by the probe illustrated in Figure 11.1.

b) For an opening that has a minor dimension of 1 inch or more, such a part or wire shall be spaced from the opening as specified in Table 11.1.

Exception: A motor need not comply with these requirements if it complies with the requirements in 11.2.

Figure 11.1
Articulate probe with web stop

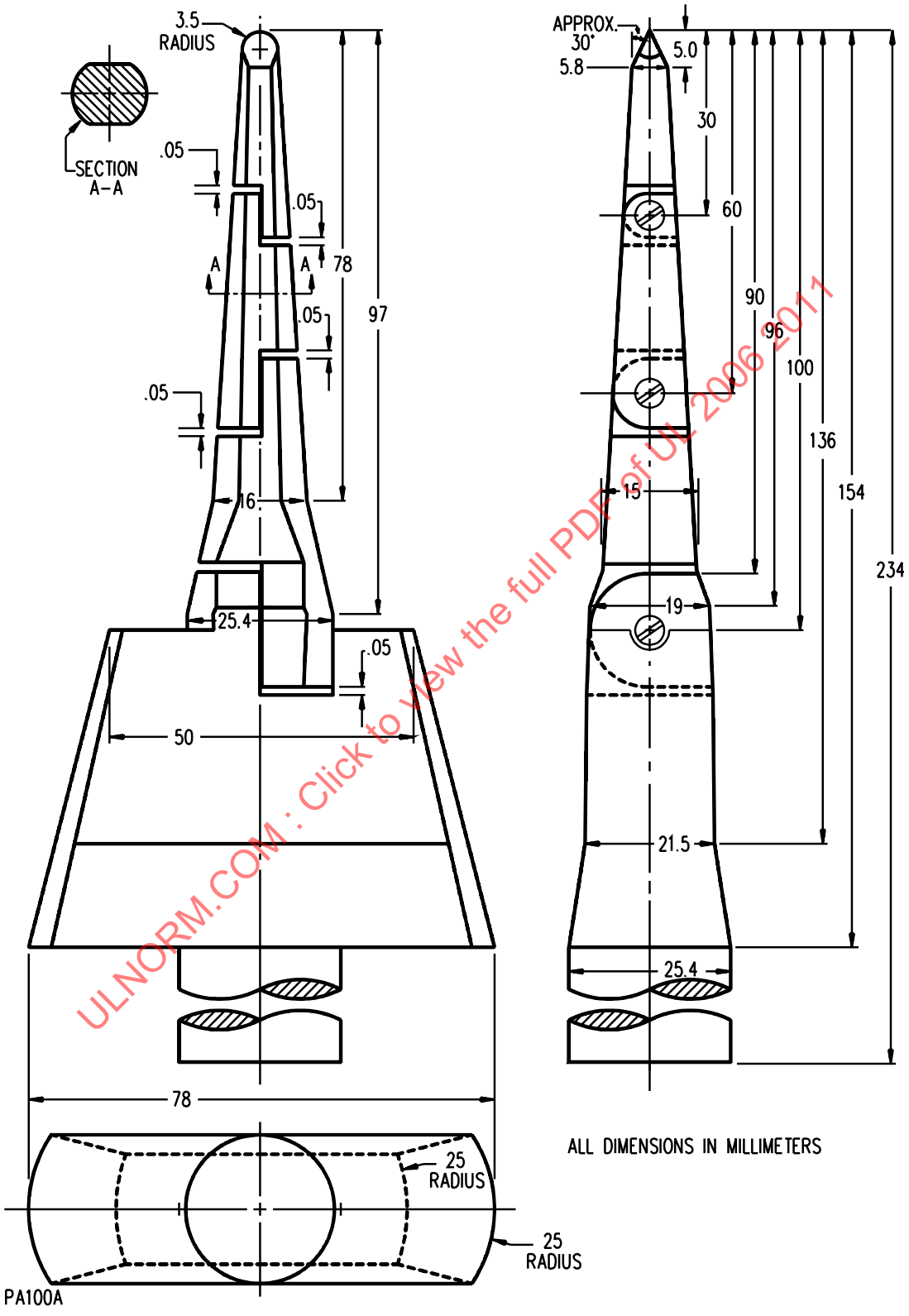


Table 11.1
Minimum acceptable distance from an opening to a part that may involve a risk of electric shock

Minimum 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	(190)
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	(444)
d		30	(762)

[a] See 11.5.
[b] Between 3/4 and 2-1/8 inches, interpolation is to be used to determine a value between values specified in the table.
[c] Any dimension less than 1 inch applies to a motor only.
[d] More than 2-1/8 inches, but not more than 6 inches (152 mm).

11.2 With respect to a part or wire as mentioned in 11.1, in an integral enclosure of a motor as mentioned in the Exception to 11.1:

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

1) A moving part cannot be contacted by the probe illustrated in Figure 11.2;

2) Film-coated wire cannot be contacted by the probe illustrated in Figure 11.3;

3) In a directly accessible motor, an uninsulated live part cannot be contacted by the probe illustrated in Figure 11.4; and

4) In an indirectly accessible motor, an uninsulated live part cannot be contacted by the probe illustrated in Figure 11.2.

b) An opening that has a minor dimension of 3/4 inch or more is acceptable if a part or wire is spaced from the opening as specified in Table 11.1.

Figure 11.2
Probe for moving parts and uninsulated live parts

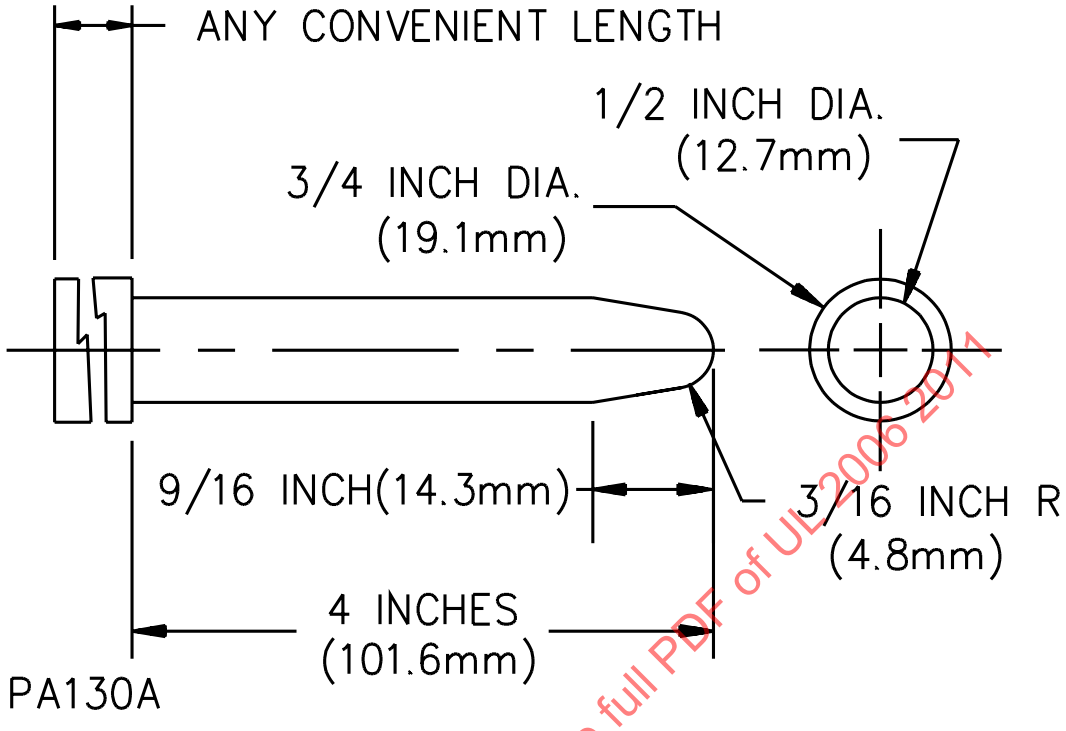


Figure 11.3
Probe for film-coated wire

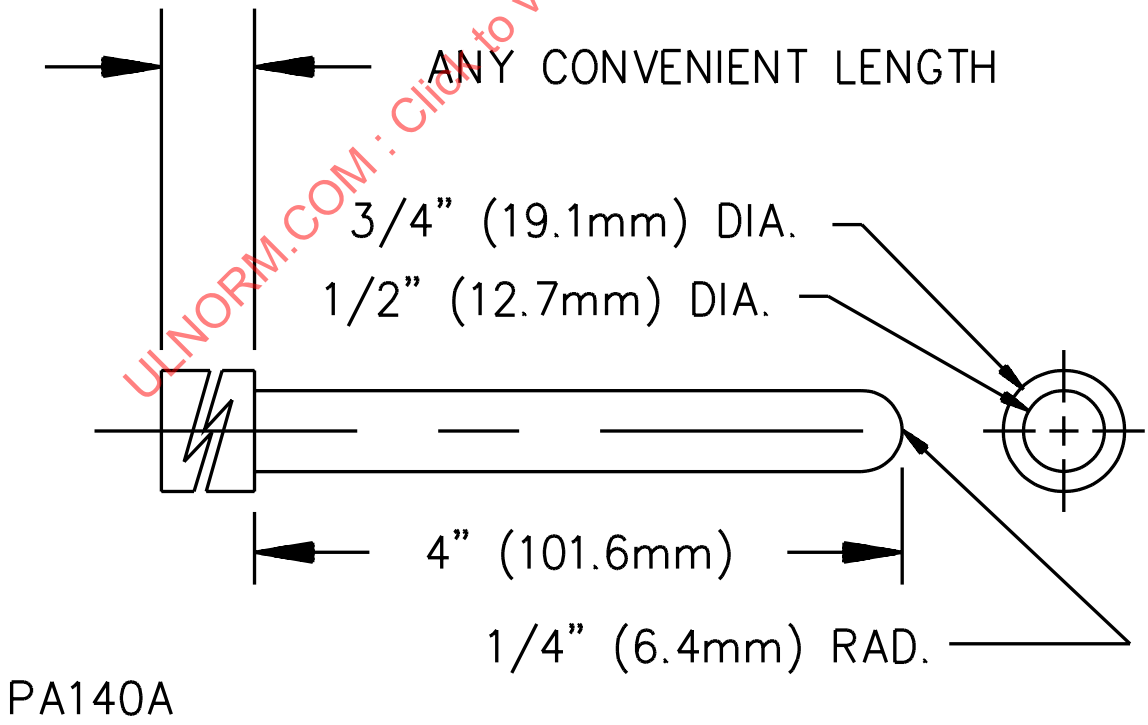
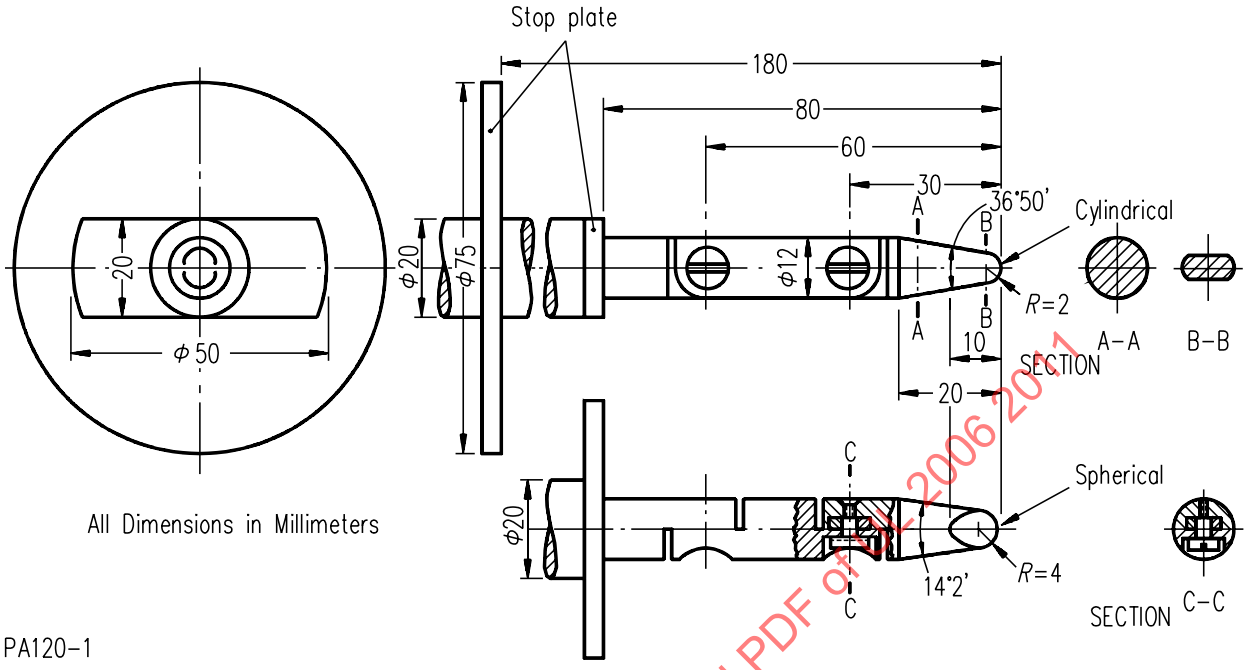


Figure 11.4
International electrotechnical commission (IEC) articulate accessibility probe with stop plate



All dimensions in millimeters

11.3 The probes mentioned in 11.1 and 11.2 and illustrated in Figures 11.1 – 11.4 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 Figures 11.1 and 11.4 are to be applied in any possible configuration; and, if necessary, the configuration is to be changed after insertion through the opening.

11.4 The probes mentioned in 11.3 and 11.5 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.

11.5 With reference to the requirements in 11.1 and 11.2, 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.

11.7 During the examination of an appliance to determine whether it complies with the requirements in 11.1 or 11.2, a part of the enclosure that may be opened or removed by the user without a tool (to make an operating adjustment or for other reasons) is to be opened or removed.

11.8 With reference to the requirements in 11.1 and 11.2, insulated brush caps are not required to be additionally enclosed.

12 Supply Connections

12.1 General

12.1.2 Equipment intended for cord-connection shall comply with 12.2. Equipment intended to be permanently connected to the electrical source of supply shall comply with 12.3.

12.2 Cord-connected equipment

12.2.1 Equipment intended for cord connection to the power supply shall be equipped with a flexible cord of a type, length, and ampacity, and an attachment plug of a type and rating complying with the requirements of 12.2.3 – 12.2.6.

12.2.2 In reference to 12.2.2, a power supply cord and plug shall comply with the Standard for Cord Sets and Power Supply Cords, UL 817.

12.2.3 The marked rating of cord-connected equipment, see 72.3, shall not exceed 80 percent of the rating of the attachment plug.

12.2.4 Cord-connected equipment shall employ a grounding-type attachment plug that complies with the ANSI/NEMA standard designated in Table 12.1.

Exception: Equipment rated 250 volts or less and intended for connection to circuits rated other than 60 hertz, other than the voltages specified in 36.1 (a) and (b), or both, can employ a grounding-type attachment plug acceptable for the circuit involved.

Table 12.1
Attachment plugs

Nameplate rating		Attachment plug		
Volts	Amperes[a]	Rating	Configuration[b]	NEMA designation[c]
110 – 120	12.0	15 amperes, 125 volts	See Figure 12.1	5-15P
110 – 120	16.0	20 amperes, 125 volts	See Figure 12.2	5-20P
200 – 240	12.0	15 amperes, 250 volts	See Figure 12.3	6-15P
200 – 240	16.0	20 amperes, 250 volts	See Figure 12.4	6-20P
200 – 240	24.0	30 amperes, 250 volts	See Figure 12.5	6-30P
110 – 120/200 – 240	12.0	15 amperes, 125/250 volts	See Figure 12.6	14-15P
110 – 120/200 – 240	16.0	20 amperes, 125/250 volts	See Figure 12.7	14-20P
110 – 120/200 – 240	24.0	30 amperes, 125/250 volts	See Figure 12.8	14-30P

[a] Ampere rating is maximum permitted to be marked on equipment nameplate for attachment plug shown. See 12.2.3.

[b] Illustrated not to scale. For detailed dimensions refer to requirements in the Standard for Electrical Attachment Plugs and Receptacles, UL 498.

[c] As part of the Standard for Wiring Devices – Dimensional Requirements, ANSI/NEMA WD6.

Figure 12.1
Attachment plug configuration: 5-15P

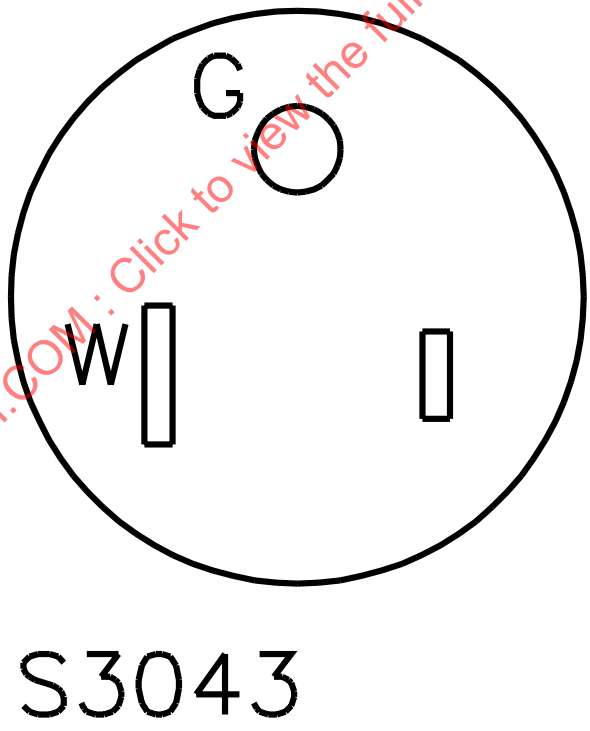


Figure 12.2
Attachment plug configuration: 5-20P

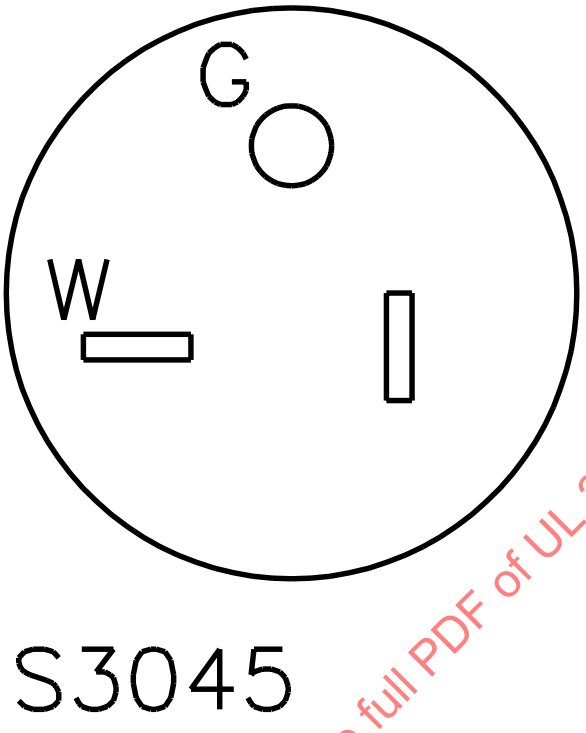


Figure 12.3
Attachment plug configuration: 6-15P

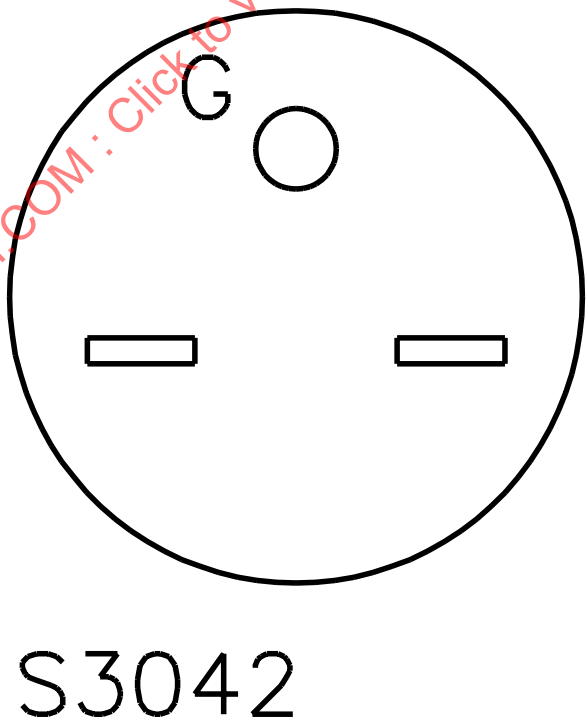
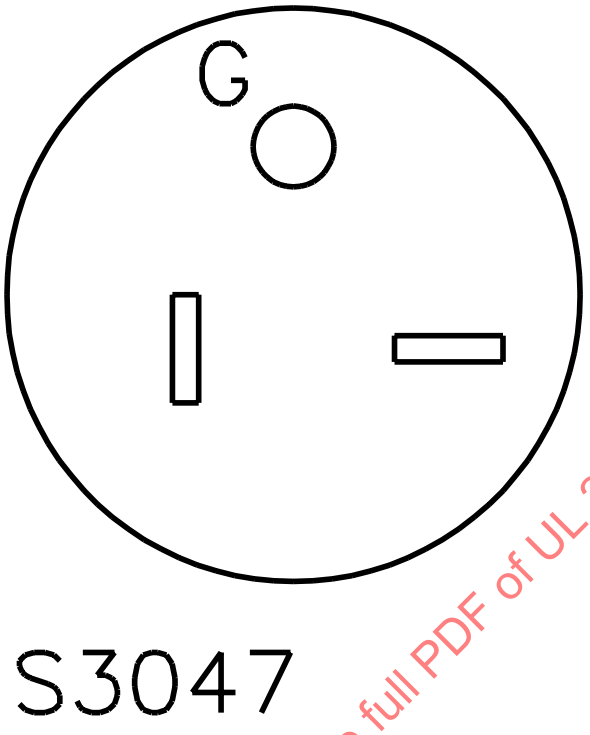
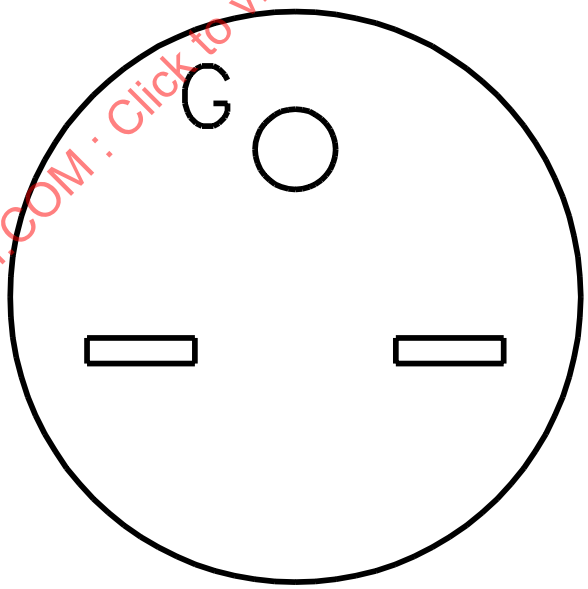


Figure 12.4
Attachment plug configuration: 6-20P



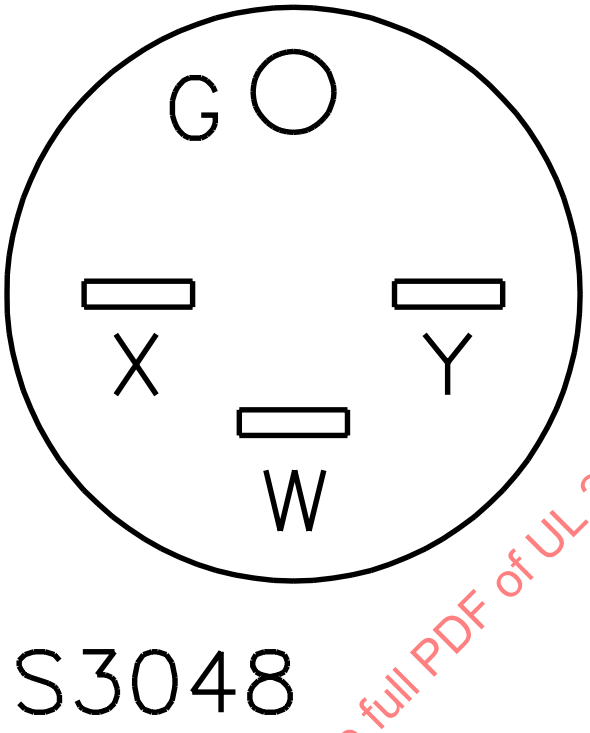
S3047

Figure 12.5
Attachment plug configuration: 6-30P



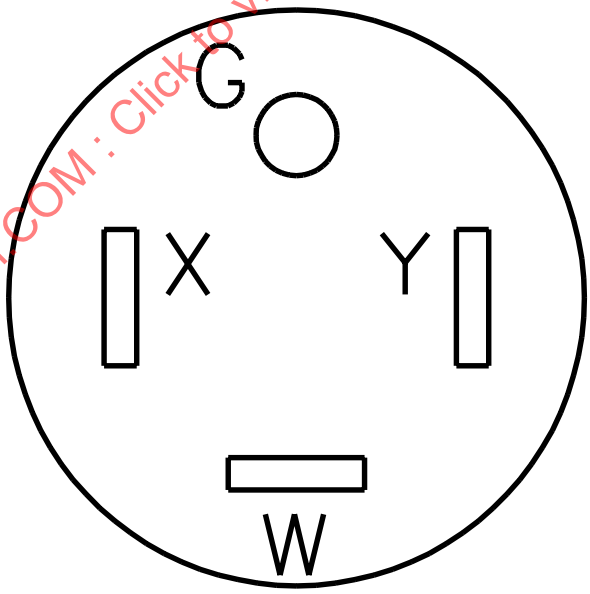
S3046

Figure 12.6
Attachment plug configuration: 14-15P



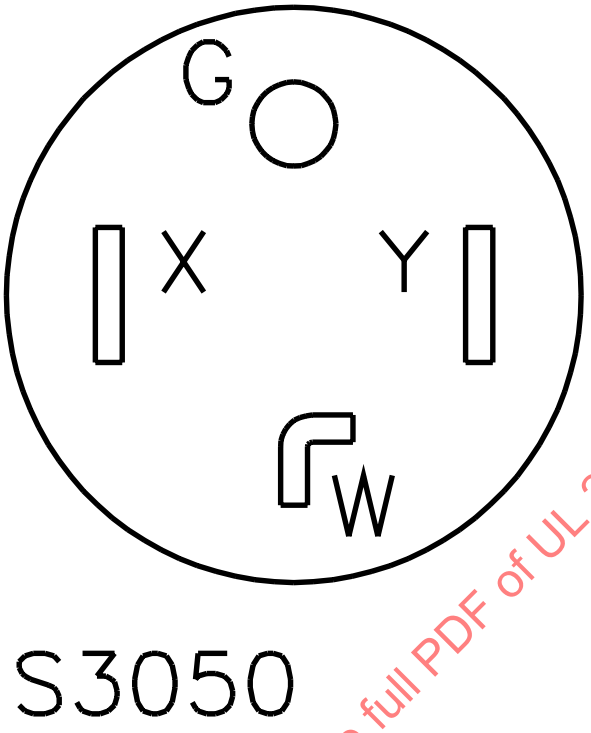
S3048

Figure 12.7
Attachment plug configuration: 14-20P



S3049

Figure 12.8
Attachment plug configuration: 14-30P



S3050

12.2.5 Cord connected equipment can employ Type SEO, SO, SOO, STO, STOO, SJEO, SJO, SJOO, SJTO, or SJTOO power-supply cord rated for use at a voltage not less than the rated voltage of the equipment. The ampacity of the cord as given in the National Electrical Code, ANSI/NFPA 70, shall be not less than that required by the ampere input measured in the Temperature Test, Section 40. The ampere input value shall include the loads for convenience outlets. See 72.5 and 72.6.

12.2.6 A power-supply cord for outdoor use equipment shall be one of the types specified in 12.2.5 and intended for outdoor use. Such cords are identified by the letters ″W-A″ or ″W″ following the cord type designation marked on the jacket. A cord that is marked ″Outdoor″ in addition to the letters ″W-A″ or ″W″ shall be used only on equipment that has been found acceptable for outdoor use.

12.2.7 The length of a power-supply cord shall be not less than 6 feet (1.8 m) nor more than 10 feet (3.0 m). The length is to be measured between the attachment plug and any point at which the cord exits the equipment cabinet or the last strain relief, whichever is shorter.

12.2.8 The power-supply cord shall be provided with strain relief means so that a stress on the cord will not be transmitted to terminals, splices, or internal wiring. The strain relief means shall comply with 58.1 when subjected to a direct pull of 35 pounds-force (156 N).

12.2.9 If a flexible cord is capable of being pushed into the equipment through the cord-entry hole, any such displacement shall not result in:

a) Mechanical damage to the cord;

b) Exposing the cord to a temperature higher than that for which it is rated;

c) Reducing spacings, such as to a metal strain-relief clamp, below the minimum required values; or

d) Damaging internal connections or components.

12.3 Permanently-connected equipment

12.3.1 Equipment intended for permanent connection to the power supply shall have provision for connection of one of the wiring systems that, in accordance with the National Electrical Code, ANSI/NFPA 70, would be applicable to the equipment.

12.3.2 A knockout or opening for connection of a field-wiring system to a field-wiring compartment shall be sized to accommodate the field supplied conduit of the applicable trade size.

12.3.3 Permanently-connected equipment shall be provided with wiring terminals or leads not less than 6 in (152 mm) long for connection of field-supplied wiring conductors. The terminals or leads shall not be less than the size required by the National Electrical Code, ANSI/NFPA 70, having an ampacity acceptable for the rating marked on the equipment.

12.3.4 A field wiring terminal or lead for the connection of a grounded conductor shall be finished a white or gray. No leads other than grounded conductors shall be so identified.

12.3.5 In reference to 12.3.3, size 14 AWG (2.1 mm^2) wire shall be considered as being the smallest wire that can be used for branch circuit wiring and at a terminal intended for the connection of the power supply leads.

12.3.6 Wiring terminals shall comply with the Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors, UL 486E.

12.4 Equipment grounding

12.4.1 For cord-connected equipment, there shall be an equipment grounding conductor in the power-supply cord terminating in an identified grounding terminal as specified in 12.4.2.

12.4.2 On cord-connected equipment, the grounding conductor shall be secured to the frame or enclosure of the equipment by means of a screw that is not likely to be removed during any servicing operation not involving the power-supply cord, or by other equivalent means. Solder alone shall not be used for securing the grounding conductor. Servicing as mentioned in this paragraph includes repair of the product by a qualified serviceperson. The grounding conductor shall be connected to the grounding blade of the attachment plug.

12.4.3 On permanently-connected equipment, a terminal or lead shall be provided for connection of the field-supplied equipment grounding conductor. The terminal or lead shall be located within the field wiring compartment. When a terminal is provided, the equipment shall comply with one of the following:

a) If the terminal is a wire binding screw, it shall have a green colored head that is hexagonal shaped, slotted, or both. Upturned lugs or the equivalent shall be provided at a wire binding screw to retain the conductor; or

b) If the terminal is a pressure wire connector, it shall be identified by being marked “G,” “GR,” or the equivalent, or by being represented on a wiring diagram provided on the unit.

12.4.4 With reference to the requirement in 12.4.3, the wire binding screw or pressure wire connector shall be located so that it does not need to be removed during servicing of the equipment and shall use a means other than friction to prevent it from turning.

12.4.5 The surface of a power supply cord grounding conductor or a lead intended for the connection of a field-supplied equipment grounding conductor shall be finished a continuous green color, or a green color with one or more yellow stripes. No conductor, other than grounding or bonding conductors, shall be so identified.

12.4.6 With reference to the requirement in 12.4.5, if a grounding conductor depends upon a single screw and threads for securement, two full threads shall engage the metal.

12.5 Bonding for grounding

12.5.1 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 are likely to become energized shall be electrically conductively connected to the grounding conductor of the power-supply cord. The grounding connection shall:

a) Be by a positive means, such as clamping, riveting, bolted or screwed connection, welding, or soldering and brazing materials having a softening or melting point greater than 455°C (850°F), and

b) Penetrate nonconductive coatings, such as paint or vitreous enamel.

12.5.2 With reference to the requirement in 12.4.3, the following dead metal parts are not considered likely to become energized:

a) A small metal part, such as an adhesive-attached foil marking, a screw, a handle, and the like, that is:

1) On the exterior of the enclosure and separated from all electrical components by grounded metal, or

2) Electrically isolated from all electrical components.

b) A panel, cover, or other metal part that is isolated from all electrical components by a barrier of vulcanized fiber, varnished cloth, phenolic composition, or other moisture-resistant insulating material not less than 1/32 inch (0.80 mm) thick and securely mounted in place.

c) A panel, cover, or other metal part that does not enclose uninsulated live parts and is electrically isolated from other electrical components.

d) Cores and assembly screws of a relay, a solenoid, and the like.

13 Internal Wiring

13.1 General

13.1.1 The internal wiring of a product shall comply with one of the following:

a) Standard for Appliance Wiring Material, UL 758;

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

c) Standard for Flexible Cords and Cables, UL 62; or

d) Standard for Thermoplastic-Insulated Wires and Cables, UL 83.

13.1.2 The internal wiring of the equipment shall have insulation rated for the potential involved and the temperatures to which it may be subjected. Compliance shall be determined in accordance with any of the following:

a) Wiring temperatures shall be evaluated on the basis of the temperatures measured during the applicable temperature test specified in Section 40.

b) Other than motor wiring, all wiring shall:

1) Have an ampacity of the conductors in accordance with Table 13.1; and,

2) Not be exposed to heat from radiating sources or heated components.

c) Motor wiring shall have an ampacity not less than 125 percent of the motor full load current rating in addition to complying with (b).

Table 13.1
Wiring material ampacities

AWG	(mm$^{2)}$	Ampacity A[a]
22	(0.41	4
20	(0.66)	7
18	(0.82)	10
16	(1.3)	13
14	(2.1)	18
12	(3.3)	25
10	(5.3)	30
8	(8.4)	40
6	(13.3)	55
4	(21.2)	70
2	(33.6)	95
1	(42.4)	110

[a] The ampacities shown apply to appliance wiring materials with insulation rated not less than 194°F (90°C).For types of wires other than appliance wiring materials, the ampacity shall be determined from Tables 310-16 and 310-21 in the National Electrical Code, ANSI/NFPA 70, for the type of wire employed. The correction factors of the referenced tables need not be applied.

13.1.3 With reference to 13.1.2, high voltage circuit conductors supplying more than one motor shall have an ampacity not less than 125 percent of the full load current rating of the largest motor plus the full load current rating of any other motors supplied. Conductors supplying a motor load and other loads shall have any ampacity not less than 125 percent of the motor full load current rating plus the marked current ratings or measured inputs of the additional loads supplied.

13.1.4 Internal wiring or flexible cord intended for interconnection in a product that is likely to be subjected to condensation or a moisture-laden atmosphere shall be resistant to moisture.

13.2 Protection of wiring

13.2.1 The wiring and connections between parts of a product shall be protected or enclosed. Insulated tubing shall comply with the Standard for Extruded Insulating Tubing, UL 224.

Exception: If flexibility is essential, a flexible cord may be used for external interconnection.

13.2.2 With respect to the requirement in 13.2.1, wiring is considered to be protected or enclosed if it is secured or located so that it is not likely to be grasped or hooked in such a manner that it or related electrical connections could be subjected to undue stress, even though it can be touched by the probe illustrated in Figure 11.3. Parts that are likely to be removed and replaced during user servicing are to be removed when the exposure of internal wiring is being judged.

13.2.3 Wiring space or other compartments intended to enclose wires shall be free of any sharp edge, burr, fin, moving part, or the like that can damage the conductor insulation. Wiring in a factory-wired enclosure, compartment, raceway, or the like shall be located or protected to reduce the likelihood of contact with any sharp edge, burr, fin, moving part, or the like that could damage the conductor insulation. Metal clamps and guides used for routing stationary internal wiring shall have smooth, rounded edges. Wire positioning devices shall comply with the Standard for Positioning Devices, UL 1565.

13.2.4 A hole through which insulated wires pass in a sheet-metal wall within the enclosure or cabinet of a product shall be provided with a smooth, rounded bushing or shall have a smooth, rounded surface upon which the wires may bear to reduce the likelihood of abrasion of the insulation. A flexible cord used for external interconnection as described in 13.2.1 shall be provided with a bushing and strain relief. Bushings shall comply with the Standard for Insulating Bushings, UL 635 or be fabricated from materials, such as ceramic, wood, phenolic, porcelain, cold-molded composition, or fiber and be reliably secured in place.

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

13.3 Connections

13.3.1 If breaking or loosening of an electrical connection could result in a risk of fire or electric shock, it shall be soldered, welded, or otherwise securely connected. A soldered joint shall be mechanically secured before soldering.

13.3.2 Except as indicated in 13.3.3, splices and connections shall comply with the Standard for Wire Connectors, UL 486A-486B or the Standard for Splicing Wire Connectors, UL 486C.

13.3.3 Insulation consisting of two layers of electrical insulating tape, or of one layer of friction tape on top of one layer of rubber insulating tape, can be used on a splice if the voltage involved is less than 250 volts. In determining acceptability of splice insulation consisting of coated-fabric, thermoplastic, or other tubing, consideration is to be given to its dielectric properties, resistance to heat and moisture, and other factors.

13.3.4 The means of connecting stranded internal wiring to a wire-binding screw shall be such that loose strands of wire cannot contact a dead metal part or another live part not always of the same polarity as the wire. This may be accomplished by use of pressure wire connectors, soldering lugs, crimped eyelets, soldering all strands of the wire together, or by other equivalent means.

13.3.5 Quick connecting assemblies shall comply with the Standard for Electrical Quick-Connect Terminals, UL 310, form a secure electrical connection, and be capable of carrying the current involved.

13.4 Terminations for aluminum conductors

13.4.1 An aluminum conductor, insulated or uninsulated, used as internal wiring, such as for interconnection between current-carrying parts or as motor windings, shall be terminated at each end by a method acceptable for the combination of metals involved at the connection point.

13.4.2 With reference to 13.4.1, a wire-binding screw construction, or a pressure wire connector used as a terminating device, shall be acceptable for use with aluminum under the conditions involved, such as temperature, heat cycling, vibration, and the like.

ELECTRICAL COMPONENTS

14 Current-Carrying Parts

14.1 All current-carrying parts shall be of silver, copper, a copper alloy, stainless steel, or other material inherently resistant to corrosion and acceptable for use as an electrical conductor.

Exception: Multimetallic thermal elements and heater elements of a thermal protector need not be inherently resistant to corrosion.

14.2 Aluminum can be used as a current-carrying part if treated to resist oxidation and corrosion.

14.3 In reference to 14.1, ordinary iron or steel shall not be used for current-carrying part.

Exception: Iron or steel, if provided with a corrosion resistant coating, or stainless steel can be used for a current-carrying part if used in inherent construction of a component, such as within a motor.

15 Insulating Material

15.1 Material for the mounting of uninsulated live parts shall be porcelain, phenolic composition, or other material having equivalent electrical and mechanical properties.

15.2 Vulcanized fiber can be used for insulating bushings, washers, separators, and barriers, but not as the sole support for uninsulated live parts where shrinkage, current leakage, or warpage can introduce a risk of fire or electric shock.

15.3 A polymeric material used for the sole support of uninsulated live parts shall comply with the applicable requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

15.4 Electrical insulation not complying with 15.1 to 15.3 shall comply with one of the following:

a) Film-coated wire or materials used in an insulation system that operates at or above Class 105 (Class A) shall comply with the Standard for Systems of Insulating Materials, UL 1446. The requirements for film-coated wire or materials used in insulation systems that operate below Class 105 (Class A) are unspecified.

b) Insulating tape shall comply with the Standard for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape, UL 510.

c) Insulating sleeving shall comply with the Standard for Coated Electrical Sleeving, UL 1441.

d) Insulating tubing shall comply with the Standard for Extruded Insulating Tubing, UL 224.

16 Switches and Controllers

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

16.2 The current 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 transformer, unless the switch has been investigated and found to be acceptable for the application.

16.3 Each switch shall be located or protected so that it will not be subjected to forces that could damage it in use.

16.4 A switch shall be of the indicating type.

16.5 The indicating means referred to in 16.4 can be incorporated on the switch or knob, on an attached plate, or on the panel on which the switch is mounted. A pilot light that complies with the requirements in 16.2 can also be used as an indicating means.

16.6 A single-pole switching device, including an automatic control having a marked “off” position, shall not be connected to the identified (grounded) conductor.

16.7 If a switching device or a pilot device that controls a switch operates to interrupt the main supply circuit, it shall, when open, disconnect all ungrounded power-supply conductors.

Exception: If there is no uninsulated live part exposed to unintentional contact when the switching device is open, the power-supply conductors are not required to be disconnected.

16.8 A switch that controls a medium-base lampholder of other than a pilot or indicating light shall:

a) have a T or L rating equal to the tungsten-filament lamp load; or,

b) be a general-use alternating-current snap switch, a circuit breaker, or a nonautomatic circuit interrupter suitable for controlling tungsten-filament lamps at their full ampacity; or,

c) have an alternating-current ampacity of six times or more of the tungsten-filament lamp load; or,

d) have an electrical rating equivalent to (a) – (c) and suitable for use with a tungsten-filament load.

16.9 A product provided with a power-supply cord and an attachment plug and employing a motor rated more than 1/3 horsepower (250 W output) shall be provided with a control for starting and stopping the motor.

16.10 If malfunction of a protective (limiting) control can result in a risk of fire due to overheating of the equipment, a backup protective control shall be provided to limit temperature.

16.11 A protective control required to reduce the risk of hazards in the equipment shall withstand not less than 100,000 cycles of operation under load if it is an automatic-reset control or 6,000 cycles of operation under load if it is a manual-reset control. In addition, the protective control shall:

a) be an integral part of the equipment;

b) comply with 16.12 (a), (b) or (c); and,

c) control the load(s) directly except as indicated in 16.13.

16.12 In reference to 16.11 (b) a protective control shall comply with one of the following standards:

a) the Standard for Temperature-Indicating and Regulating Equipment, UL 873: or,

b) the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1, as well as the specific applicable Part 2; or,

c) the Standard for Limit Controls, UL 353.

16.13 In reference to 16.11(c), if a protective control indirectly controls the load through a switching device, the switching device shall comply with the endurance test requirements for protective controls in 16.11 and be an integral part of the equipment.

16.14 The cutout calibration temperature of a heater protective (temperature-limiting) control shall be ±10°F (±6°C) of its maximum marked set-point temperature.

16.15 The cutout calibration pressure of a pressure protective (limiting) control shall not exceed 105 percent of its maximum marked setting.

16.16 If a thermal cutoff or similar device is employed to prevent a risk of fire due to overheating of the equipment during abnormal operation as specified in 16.10, it shall comply with the Standard for Thermal-Links – Requirements and Application Guide, UL 60691.

16.17 An operating control, including of the electronic type, shall comply with one of the standards specified in 16.12 or one of the following standards:

a) the Standard for Solid-State Controls for Appliances, UL 244A;

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

c) the Standard for Power Conversion Equipment, UL 508C;

d) the Standard for Clock-Operated Switches, UL 917;

e) the Standard for Special-Use Switches, UL 1054; or

f) the Standard for Switches for Appliances – Part 1 General Requirements, UL 61058-1.

16.18 A general-use snap switch shall comply with the Standard for General-Use Snap Switches, UL 20.

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

17 Lamps and Lampholders

17.1 Each lampholder with a screw shell base shall be wired so that the screw shell will be connected to the identified (grounded) conductor.

17.2 Lampholders and indicating lamps shall comply with the Standard for Lampholders, UL 496.

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

17.4 A filament or signal lamp used as a switch indicating means shall:

a) Have an estimated life at the operating voltage of not less than 20,000 hours; and

b) Be connected in a circuit in which the increased voltage incident to switching, or any operational characteristic of the product does not exceed 120 percent of the voltage recommended to provide the required estimated life.

18 Fuseholders

18.1 A fuseholder shall be 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. A separation of less than 4 inches (102 mm) from the insulating body of a fuse is considered to be adjacent.

18.2 Fuseholders shall comply with the Standard for Fuseholders – Part 1: General Requirements, UL 4248-1, in conjunction with any of the associated Standards tabulated below, as applicable for the class of fuseholder:

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

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

c) The Standard for Fuseholders – Part 8: Class J, UL 4248-8, or

d) The Standard for Fuseholders – Part 9: Class K, UL 4248-9, or

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

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

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

18.3 The screw shell of plug fuseholder used in a high-voltage circuit shall be connected toward the load.

18.4 Plug fuseholder of the Edison-base type shall be provided with an adapter designed for Type S fuses.

19 Receptacles

19.1 Receptacles shall comply with the Standard for Attachment Plugs and Receptacles, UL 498 and be rated at 15 or 20 amperes, 125 or 250 volts.

19.2 Receptacles shall be of the grounding type.

19.3 Receptacles shall be located so that liquid due to overflow, splashing, leakage, and cleaning will not enter the receptacle. This will require the face of the receptacle to be mounted not less than 60 degrees from the horizontal.

20 Overcurrent Protection

20.1 General

20.1.1 Fuses shall comply with the Standard for Low-Voltage Fuses – Part 1: General Requirements, UL 248-1, in conjunction with any of the associated standards tabulated below, as applicable for the class of fuse:

a) The Standard for Low-Voltage Fuses – Part 4: Class CC Fuses, UL 248-4, or

b) The Standard for Low-Voltage Fuses – Part 5: Class G Fuses, UL 248-5, or

c) The Standard for Low-Voltage Fuses – Part 8: Class J Fuses, UL 248-8, or

d) The Standard for Low-Voltage Fuses – Part 9: Class K Fuses, UL 248-9, or

e) The Standard for Low-Voltage Fuses – Part 10: Class L Fuses, UL 248-10, or

f) The Standard for Low-Voltage Fuses – Part 11: Plug Fuses, UL 248-11, or

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

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

20.1.2 Circuit breakers shall comply with the Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures, UL 489. In addition, circuit breakers used in telecommunications circuitry shall comply with the Standard for Circuit Breakers For Use in Communications Equipment, UL 489A.

20.1.3 Circuit breakers used to protect circuits 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 external handle ties does not in itself constitute a common trip mechanism.

20.1.4 An overcurrent protective device shall be electrically connected in the ungrounded side of the circuit.

20.1.5 A fusing resistor or supplementary protector shall not be used in place of a circuit breaker or protective control.

20.1.6 Fusing resistors shall comply with the Standard for Fusing Resistors and Temperature-Limited Resistors for Radio- and Television-Type Appliances, UL 1412.

20.1.7 Supplementary Protectors shall comply with the Standard for Supplementary Protectors for Use in Electrical Equipment, UL 1077.

20.1.8 A supplementary fuse shall comply with the Standard for Low-Voltage Fuses – Part 1: General Requirements, UL 248-1, in conjunction with the Standard for Low-Voltage Fuses – Part 14: Supplemental Fuses, UL 248-14.

20.2 Receptacle overcurrent protection

20.2.1 Except as specified in 20.2.2, a fuse or circuit breaker complying with 20.1.1 – 20.1.4 shall be provided as part of the equipment for each receptacle included in the equipment.

20.2.2 Equipment not complying with 20.2.1 shall:

a) Be intended for connection to a branch circuit rated at not more than 20 amperes in accordance with the National Electrical Code, ANSI/NFPA 70; and,

b) Not be marked as specified in 72.6.

20.2.3 Except as specified in 20.2.4, a 15 ampere protective device shall be provided if a single 15 ampere receptacle outlet is furnished. Two or more 15 ampere receptacles (two separate receptacles or a duplex receptacle) shall be protected by either a 15 or 20 ampere protective device. A 20 ampere receptacle or a combination 15 and 20 ampere receptacle shall be protected by a 20 ampere protective device.

20.2.4 If a receptacle circuit is protected by an overcurrent protective device rated less than required by 20.2.3, then the overcurrent protective device rating shall not be less than the receptacle load which is marked on the equipment in accordance with 72.7.

21 Capacitors

21.1 A capacitor shall comply with 21.2 or with one of the following:

a) the Standard for Capacitors, UL 810 if the capacitor is a motor starting or running capacitor; or,

b) the Standard for Capacitors and Suppressors for Radio- and Television-Type Appliances, UL 1414 if the capacitor is connected across the line, such as a capacitor for radio-interference elimination or power-factor correction

21.2 If a capacitor does not comply with 21.1, it shall comply with all of the following:

a) A capacitor shall be housed within an enclosure or container that protects the plates against mechanical damage and that prevents the emission of flame or molten material resulting from deterioration or breakdown of the capacitor. The container shall be of metal providing the strength and protection not less than that of uncoated sheet steel having a minimum thickness of 0.020 inch (0.51 mm); and,

b) The materials and construction of a capacitor or its enclosure within the equipment, including a means for venting, shall be such that no excessive pressure can develop in the capacitor because of a short circuit in the capacitor or the circuit in which it is connected; and,

c) If a dielectric medium more combustible than askarel is employed, the capacitor shall not cause or increase a risk of fire or electric shock and shall not vent or rupture and expel dielectric medium under normal or abnormal use conditions.

21.3 In reference to 21.2(a), if a capacitor sheet-steel container is less than 0.020 inch thick or is a material other than metal:

a) The material shall be equivalent to that specified and shall be provided with additional supporting material that is otherwise acceptable for live parts; or,

b) The capacitor shall be mounted within an enclosure.

21.4 If the container of an electrolytic capacitor is metal, the container shall be considered as a live part and shall be provided with moisture-resistant electrical insulation to isolate it from dead metal parts and to prevent contact during servicing operations. The insulating material shall be not less than 1/32 inch (0.8 mm) thick except as indicated in 7.5.

22 Motors

22.1 General

22.1.1 A motor shall comply with the requirements in the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1, and shall be capable of driving the maximum normal load of the product without a risk of fire or electric shock.

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

22.1.3 Each brush cap shall be secured or located so as to be protected from mechanical damage that may otherwise occur during intended use.

22.2 Motor protection

22.2.1 Except as indicated in 22.2.2, each motor shall be provided with overload protection consisting of one of the following:

a) Thermal protection complying with the applicable requirements in the Standard for Overheating Protection for Motors, UL 2111 or the Standard for Thermally Protected Motors, UL 1004-3; or

b) Impedance protection complying with the applicable requirements in the Standard for Overheating Protection for Motors, UL 2111 or the Standard for Impedance Protected Motors, UL 1004-2.

Exception No. 1: For a product that includes a control as mentioned in 22.2.3, the duration of the temperature test and the endurance test, both under locked-rotor conditions, can be less than that specified but shall not be less than the period of operation permitted by the product.

Exception No. 2: If the time required to operate a manually reset protective device through 10 cycles of operation is longer than the time that the product is likely to be operated during each use, the number of operations of the device for the temperature test under locked-rotor conditions can be less than 10 cycles but shall not be less than 4 cycles.

Exception No. 3: A motor intended to move air only, by means of an air-moving fan that is integrally attached, keyed, or otherwise fixed to the motor shaft, is not required to have running overload protection.

22.2.2 A motor not complying with 22.2.1 shall be provided with some other protection that is demonstrated by test to be equivalent to the protection specified by 22.2.1.

22.2.3 The control mentioned in Exception No. 1 to 22.2.1(a) is to positively and reliably limit the length of time the product can be operated – for example, a timer.

22.2.4 The motor of a product with load characteristics likely to result in an overload or stalled condition that will not be evident to the user shall incorporate thermal or overload protection as specified in 22.2.1 to protect the motor against those conditions likely to occur.

22.2.5 The functioning of a motor-protective device provided as part of a product, whether such device is required or not, shall not result in a risk of fire or injury to persons.

22.2.6 Overload devices employed for running overload protection, other than those that are inherent in a motor, shall be located in at least one ungrounded conductor of a single-phase supply system and in each ungrounded conductor of a 3-phase supply system.

22.2.7 Fuses employed for motor-running overload protection shall comply with 20.1.1; be located in each ungrounded conductor; and in the case of a 3-phase, 3-wire, alternating-current motor, they shall be located in each of the three phases.

22.2.8 In reference to 22.2.1(b), a protective electronic circuit providing motor protection shall comply with one of the following:

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

b) the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1, and the applicable Part 2 standard.

Exception: A motor protected by protective electronic circuits is not required to comply with UL 991 or UL 60730-1 if it does not create any hazard under abnormal conditions with the protective electronic circuit rendered ineffective (open or short-circuited).

22.2.9 Software in a protective electronic circuit required as part of a motor protective device or system shall comply with one of the following:

a) the Standard for Software in Programmable Components, UL 1998 and be software Class 1, or

b) the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1, as well as the specific applicable Part 2 standard and be software Class B.

Exception: The need for software to comply with UL 1998 or UL 60730-1 can be based on the actual construction and operation of the motor within the equipment. This could include a consideration of the protective electronic circuit being provided with independent redundant protective devices.

23 Overload- or Thermal-Protective Devices

23.1 An overload- or thermal-protective device shall have a current and voltage rating not less than the load that it controls.

23.2 A protective device such as a fuse, the functioning of which requires renewal or replacement, shall be in a readily accessible location. A protective device shall be wholly inaccessible from outside the product without opening a door or cover.

Exception: The operating handle of a circuit breaker, the operating button of a manually operable motor protector, and similar parts may project outside the enclosure.

23.3 In reference to 23.2, fuses or circuit breakers used as overload- or thermal-protective devices shall comply with 20.1.1 – 20.1.4.

24 Batteries and Battery Chargers

24.1 A lithium ion (Li-On) single cell battery shall comply with the requirements for secondary lithium cells in the Standard for Lithium Batteries, UL 1642. A lithium ion muiltiple cell battery, and a lithium ion battery pack, shall comply with the applicable requirements for secondary lithium cells or battery packs in the Standard for Household and Commercial Batteries, UL 2054.

24.2 Rechargeable nickel cadmium (Ni-Cad) and nickel metal-hydride (Ni-MH) battery cells and packs shall comply with the requirements in this Standard and with the applicable requirements for secondary cells or battery packs in the Standard for Household and Commercial Batteries, UL 2054.

24.3 A battery charger that is other than Class 2 shall comply with 30.2. A Class 2 battery charger shall comply with 30.1.

25 Connectors

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

26 Electrical Cable, Conduit and Tubing

26.1 Aluminum or steel armored cable shall comply with the Standard for Armored Cable, UL 4. Nonmetallic sheathed cables shall comply with the Standard for Nonmetallic Sheathed Cables, UL 719.

26.2 Flexible metal conduit shall comply with the Standard for Flexible Metal Conduit, UL 1. Rigid steel conduit shall comply with the Standard for Rigid Metal Conduit, UL 6.

26.3 Electrical steel tubing shall comply with the Standard for Electrical Metallic Tubing, UL 797.

27 Electromagnetic Interference Filters

27.1 Electromagnetic interference filters shall comply with the Standard for Electromagnetic Interference Filters, UL 1283.

28 Heating Elements

28.1 A heating element shall:

a) Comply with the construction requirements of either the Standard for Electric Heating Appliances, UL 499; or the Standard for Sheathed Heating Elements, UL 1030; and

b) Be protected against mechanical damage and contact with outside objects.

28.2 A heating element shall be supported to prevent sagging, loosening or any other adverse conditions of the element that results from continuous heating.

29 Optical Isolators and Semiconductor Devices

29.1 An optical isolator shall comply with the Standard for Optical Isolators, UL 1577if it is relied upon to provide isolation between:

a) Primary and secondary circuits;

b) Extra-low-voltage safety circuits; or

c) Other high-voltage circuits

29.2 A power switching semiconductor device that is relied upon to provide isolation to ground shall comply with the Standard for Electrically Isolated Semiconductor Devices, UL 1557.

30 Power Supplies and Transformers

30.1 A Class 2 power supply shall comply with one of the following:

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

b) The Standard for Information Technology Equipment, Part 1: General Requirements, UL 60950-1 and with the Class 2 or limited power source requirements.

30.2 A power supply that is other than Class 2 shall comply with one of the following:

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

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

30.3 A transformer (including an autotransformer), shall comply with the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1 in conjunction with one of the associated standards tabulated below, as applicable:

a) The Standard for Low Voltage Transformers – Part 2: General Purpose Transformers, UL 5085-2, or

b) The Standard for Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3.

31 Terminal Blocks

31.1 Terminal blocks shall comply with the Standard for Terminal Blocks, UL 1059, and, if applicable, be suitably rated for field wiring.

31.2 A terminal block complying with the alternate spacings requirements in Alternate Spacings – Clearances and Creepage Distances, Section 34, but not with the spacings requirements in High-Voltage Circuits, Section 32 shall not be used for field wiring.

SPACINGS

32 High-Voltage Circuits

32.1 The following electrical spacing requirements apply to high-voltage circuits, as defined in 5.2(a).

32.2 Unless specifically noted otherwise, the spacings between uninsulated live parts of opposite polarity and between an uninsulated live part and a dead metal part shall be not less than the values indicated in Table 32.1.

Table 32.1
Electrical spacings in refrigerated and/or air-handling compartments

Ratings		Minimum spacing in inches (mm)					
Volt-amperes	Volts	Through air[a]		Over surface[a]		To enclosure[c]	
2000 or less	300 or less	1/8[b]	(3.2)	1/4	(6.4)	1/4	(6.4)
	301 – 600	3/8	(9.5)	1/2	(12.7)	1/2	(12.7)
More than 2000	150 or less	1/8[b]	(3.2)	1/4	(6.4)	1/2	(12.7)
	151 – 300	1/4	(6.4)	3/8	(9.5)	1/2	(12.7)
	301 – 600	3/8	(9.5)	1/2	(12.7)	1/2	(12.7)

[a] At points other than field-wiring terminals, the spacings for heater elements only may be as indicated below provided the elements are not subject to moisture, such as may result from condensation on cooled surfaces:

1/16 inch (1.6 mm) Through Air and Over Surface for heaters rated 0 – 300 volts.

1/4 inch (6.4 mm) Through Air and Over Surface for heaters rated 301 – 600 volts.

[b] The spacings between wiring terminals of opposite polarity or between a wiring terminal and ground shall be not less than 1/4 inch (6.4 mm), except that if short-circuiting or grounding of such terminals will not result from projecting strands of wire, spacing need not be greater than that given in the above table. Wiring terminals are those connected in the field and not factory wired.

[c] Includes fittings for conduit or metal-clad cable.

32.3 The ″Through Air″ and ″Over Surface″ spacings given in Tables 32.1 and 32.2 at an individual component part are to be based on the total volt-ampere consumption of the load or loads which the component controls. For example, the spacings at a component which controls only the compressor motor are based on the volt-amperes of the compressor motor. The spacings at a component which controls loads in addition to the compressor motor are based on the sum of the volt-amperes of the loads so controlled, except that spacings at a component which independently controls separate loads are based on the volt-amperes of the larger load. The volt-ampere values for the loads referred to above are to be determined by the marked rating of the loads, except that for loads which are not required to have a marked rating, the measured input is to be used in determining the volt-ampere values.

Table 32.2
Spacings in non-refrigerated and/or non-air handling compartments

Ratings		Minimum spacing in inches (mm)					
Volt-amperes	Volts	Through air		Over surface		To enclosure[a]	
0 – 2000	0 – 125	1/16	(1.6 mm)	1/16	(1.6 mm)	1/4	(6.4 mm)
	125 – 250	3/32	(2.4 mm)	3/32	(2.4 mm)	1/4	(6.4 mm)

NOTE – See 32.5.

[a] Includes fittings for conduit or metal-clad cable.

32.4 With reference to 7.5 and 32.3, the spacings To Enclosure are not to be applied to an individual enclosure of a component part within an enclosure or cabinet.

32.5 The spacings indicated in Table 32.2 are applicable only to electrical components mounted in totally enclosed nonrefrigerated and/or nonair handling compartments which are free of moisture, including that caused by condensation. At wiring terminals and for circuits over 250 volts or over 2000 volt-amperes, spacings in Table 32.1 apply.

32.6 All uninsulated live parts connected to different circuits shall be spaced from one another as though they were parts of opposite polarity in accordance with the requirements indicated above and shall be judged on the basis of the highest voltage involved.

32.7 The above spacing requirements do not apply to the inherent spacings of a component part of the equipment, such as a hermetic motor-compressor, motor, snap switch, controller, attachment-plug cap, and the like, for which spacing requirements are given in a standard for the component. However, the electrical clearance resulting from the assembly of a component into the complete machine, including clearance to dead metal or the cabinet, shall be as indicated herein.

32.8 An insulating liner or barrier of fiber or similar material, employed where spacings would otherwise be less than the required values, shall be no less than 0.028 inch (0.7 mm) thick and shall be so located or of such material that it will not be adversely affected by arcing.

Exception No. 1: Fiber no less than 0.013 inch (0.3 mm) thick may be used in conjunction with an air spacing of no less than 50 percent of the spacing required for air alone.

Exception No. 2: Material having a lesser thickness may be used if it has equivalent insulating, mechanical, and flammability properties when compared with materials in thicknesses specified above.

32.9 If higher than rated potential is developed in a motor circuit through the use of capacitors, the rated voltage of the system shall be employed in applying the spacings indicated in this section.

Exception: If the developed steady-state potential as determined in the Temperature and Pressure Test, Section 49, exceeds 500 volts, the developed potential is to be used in determining spacings for the parts affected.

32.10 The spacing between uninsulated live terminals of the components in an electric-discharge lamp circuit and a dead metal part or enclosure shall be not less than 1/2 inch (12.7 mm) if the potential is 600 volts or less and not less than 3/4 inch (19.1 mm) if the potential is 601 – 1000 volts.

33 Low-Voltage Circuits

33.1 The following electrical spacing requirements apply to low-voltage circuits, as defined in 5.2(b).

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

33.3 The spacing for low-voltage electrical components that are installed in a circuit that includes a pressure-limiting device, motor overload protective device, or other protective device, where a short or grounded circuit may result in a risk of fire, electric shock, or injury to persons shall comply with the following:

a) The spacing between an uninsulated live part and the wall of a metal enclosure shall be not less than 1/8 inch (3.2 mm).

b) The spacing between uninsulated live parts regardless of polarity and between the uninsulated live part and a dead metal part, other than the enclosure, that may be grounded when the device is installed, shall be not less than 1/32 inch (0.8 mm) provided that the construction of the parts maintains required spacings.

c) The spacing between wiring terminals, regardless of polarity, and between the wiring terminal and a dead metal part, including the enclosure and fittings for the connection of conduit, which may be grounded when the device is installed, shall not be less than 1/4 inch (6.4 mm).

33.4 The spacings in low-voltage circuits that do not contain devices such as indicated in 33.3 are not specified.

34 Alternate Spacings – Clearances and Creepage Distances

34.1 Except as indicated in 34.2, the spacings requirements in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, are applicable as an alternative to the specified spacings requirements in the following:

a) High-voltage circuits - Section 32

b) Low-voltage circuits - Section 33

34.2 The spacings requirements in UL 840 shall not be used for spacings between field wiring terminals or between uninsulated live parts and a metal enclosure or cabinet.

34.3 The items outlined in 34.4 – 34.9 shall be considered when evaluating equipment to the requirements in UL 840.

34.4 Hermetically sealed or encapsulated enclosures are identified as pollution degree 1.

34.5 Coated printed wiring boards are identified as pollution degree 1 if they comply with one of the following:

a) Printed wiring board coating performance test of UL 840; or,

b) Conformal coating requirements as outlined in the Standard for Polymeric Materials – Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials Used in Printed Wiring Boards, UL 746E.

34.6 Indoor use equipment is identified as pollution degree 2.

34.7 Outdoor use equipment is identified as pollution degree 3.

34.8 Category II is the overvoltage category.

34.9 Printed wiring boards are considered as having a minimum comparative tracking index (CTI) of 100 unless further investigated for a higher CTI index.

34.10 Clearance B (Controlled Overvoltage) clearances as specified in UL 840 shall be achieved by providing an overvoltage device or system as an integral part of the recovery/recharge equipment.

PROTECTION AGAINST INJURY TO PERSONS

35 General

35.1 If the operation and maintenance of a product by the user involves a risk of injury to persons, means shall be provided to reduce the risk.

35.2 When judging a product with respect to the requirement in 35.1, consideration shall be given to reasonably foreseeable misuse of the product.

35.3 Whether a guard, a release, an interlock, or the like is required and whether such a device is adequate shall be determined from an investigation of the complete product, its operating characteristics, and the likelihood of a risk of injury to persons resulting from a cause other than gross negligence. The investigation shall include consideration of the results of breakdown or malfunction of any component; but not more than one component at a time, unless one event contributes to another. If the investigation shows that breakdown or malfunction of a particular component can result in a risk of injury to persons, that component shall be investigated for reliability.

35.4 Specific constructions, tests, markings, guards, and the like are detailed for some common constructions. Specific features and products not covered herein are to be examined and tested to determine whether they are acceptable for the purpose.

36 Sharp Edges

36.1 An enclosure, a frame, a guard, a handle, or the like shall not be sufficiently sharp to constitute a risk of injury to persons in normal maintenance and use.

Exception: This requirement does not apply to a part or portion of a part needed to perform a working function.

37 Enclosures and Guards

37.1 The rotor of a motor, a pulley, a belt, a gear, or other moving part that could cause injury to persons shall be enclosed or provided with other means to reduce the likelihood of unintentional contact therewith.

Exception: A part or portion of a part that is necessarily exposed to perform the working function need not be enclosed but, when necessary, guarding shall be provided. See 37.4.

37.2 The degree of protection required by 37.1 depends upon the general construction and intended use of a product.

37.3 A moving part that may involve a risk of injury to persons shall comply with the requirements specified in Accessibility of Uninsulated Live Parts and Film-Coated Parts, Section 11, and shall be considered with respect to:

a) The degree of exposure necessary to perform its intended function;

b) The sharpness of the moving part;

c) The likelihood of unintentional contact with the moving part;

d) The speed of the moving part; and

e) The likelihood that a part of the body could be endangered or that clothing could be entangled, resulting in a risk of injury to persons.

The above factors are to be considered with respect to both intended operation of the product and reasonably foreseeable misuse.

37.4 Some guards are required to be self-restoring. Other features of guards that are to be considered include:

a) Removability without the use of a tool;

b) Removability for servicing;

c) Strength and rigidity;

d) Completeness;

e) Creation of a risk of injury to persons, such as a pinch point, and the necessity for additional handling because of the increased need for servicing, such as for cleaning, unjamming, and the like; and

f) Usage.

37.5 An enclosure or guard over a rotating part shall:

a) Retain a part that, because of breakage or other reasons, may become loose or may separate from the rotating part; and

b) Retain a foreign object that may be struck and propelled by the rotating part.

37.6 If complete guarding of a moving part that could obviously cause injury to persons would defeat the utility of a product:

a) A control, such as a momentary contact switch, shall be provided, and

b) A marking shall be provided in the instruction manual warning the user of the potential risk.

37.7 The drive mechanism of a product shall be guarded so that no moving part, such as a pulley, a belt, a gear, or the like, is exposed to unintentional contact. An opening in a guard or enclosure around a moving part shall not be more than 3/8 inch (9.5 mm) wide.

38 Materials

38.1 The material of a part, such as an enclosure, a frame, a guard, or the like, the breakage of which may result in a risk of injury to persons, shall have such properties as to meet the demand of expected loading conditions.

38.2 The requirement in 38.1 applies to those portions of a part adjacent to moving parts considered to involve a risk of injury to persons.

38.3 A part as mentioned in 38.1 shall withstand the applicable impact test described in 38.5 without being affected to the extent that:

a) The performance of the product is adversely affected so as to result in a risk of injury, or

b) Parts capable of causing injury to persons are exposed to unintentional contact.

38.4 With reference to 38.3, a component such as a pilot lamp, lens, or control knob need not be subjected to the impact test.

38.5 A product is to be subjected to an impact of 5 foot-pounds (6.8 J) on any surface that is exposed to a blow during normal use. This impact is to be produced by dropping a steel sphere, 2 inches (50.8 mm) in diameter and weighing approximately 1.18 pounds (535 g), from a height of 51 inches (1.29 m) to produce the 5 foot-pound impact. For surfaces other than the top, the steel sphere is to be suspended by a cord and allowed to swing as a pendulum, dropping through a vertical distance of 51 inches to strike the surface.

38.6 If a part as mentioned in 38.1 is made of a polymeric material, the appropriate impact test shall first be conducted on a sample or samples in the as-received condition. The test shall then be repeated on a different sample or samples that have been cooled to room temperature after being conditioned for 7 hours in an air oven operating at 10°C (18°F) higher than the maximum operating temperature of the material, but not less than 70°C (158°F). While being conditioned, a part is to be supported in the same manner in which it is supported on the product.

38.7 Upon being removed from the oven mentioned in 38.6 and before being subjected to the appropriate impact test, no sample shall show signs of checking, cracking, or other deleterious effects from the oven conditioning, and no sample shall be distorted so as to result in a risk of injury to persons.

38.8 After the applicable impact test required by 38.5, the probe shown in Figure 11.1 is to be used to determine whether a moving part or a current-carrying part is exposed. The probe is to be inserted with a 1-pound force (4.4 N) through an opening to its maximum depth in a straight or articulated position.

39 Rotating or Moving Members

39.1 A rotating or moving part that, if it should become disengaged, may create a risk of injury to persons shall be provided with a means to retain the part in place under conditions of use.

39.2 A rotating member, breakage of which may create a risk of injury to persons, shall be constructed so as to reduce the likelihood of breakage, or the release or loosening of a part that could become a risk of injury to persons.

39.3 A product employing a series motor shall be tested as described in 39.4 to determine whether it complies with the requirement in 39.2. A part that can become a risk of injury shall not work loose.

39.4 For the test required by 39.3, a product employing a series motor is to be operated for 1 minute at the no-load speed resulting from application of 1.3 times rated voltage. A product in which the rotating load may be varied is to be tested for each condition of loading that can occur.

40 Parts Subject to Pressure

40.1 A pressure vessel having an inside diameter more than 6 inches (152 mm), subjected to a gauge pressure more than 15 psi (102 kPa), and within the scope of the applicable American Society of Mechanical Engineers (ASME) pressure vessel codes, shall be marked in accordance with these codes to include the code symbol and a working pressure not less than the pressure determined in accordance with 40.3.

40.2 A pressure vessel, because of its application, not covered by the scope of the inspection procedure of the ASME code shall be constructed so that it will comply with the requirements in 40.3.

Exception: Storage containers intended to receive the halon charge during the recovery/recharge operation that comply with Storage Containers, Section 46, are considered to comply with this requirement.

40.3 A part or an assembly that is subject to air or vapor pressure (including the vapor pressure in a vessel containing only a superheated fluid) during normal or abnormal operation shall withstand a pressure equal to the highest of the following that is applicable.

a) Five times the pressure corresponding to the maximum setting of a pressure-reducing valve provided as part of the assembly, but not more than five times the marked maximum supply pressure from an external source and not more than five times the pressure setting of a pressure-relief device provided as a part of the assembly.

b) Five times the marked maximum pressure to which the system may be exposed by an external source, unless the pressure is limited by a pressure-relief device in accordance with (a).

c) Five times the pressure setting of a required pressure-relief device.

d) Five times the maximum pressure that can be developed in the system during the Temperature Test, Section 50, unless the pressure is limited by a pressure-relief device in accordance with (a).

e) Five times the design pressure marked on the part.

Exception No. 1: This requirement does not apply to a section of a pressure system constructed of continuous tubing or of lengths of tubing connected by hard-soldered, brazed, or welded joints provided the wall thickness of the tubing is not less than the value specified in Table 40.1.

Exception No. 2: This requirement does not apply to a pressure vessel bearing an ASME code inspection symbol – other than the UM symbol – provided the vessel is marked with a value of working pressure not less than that to which it is subjected during normal or abnormal operation.

Table 40.1
Minimum thickness for copper and steel tubing

Outside diameter, inch (mm)		Wall thickness, inch (mm)		Maximum gauge pressure to which tubing is subjected, PSI (MPa)					
				Seamless copper		Butt-welded steel		Seamless steel	
3/8 or smaller	(9.5)	0.016	(0.41)	500	(3.45)	600	(4.14)	1000	(6.90)
1/2	(12.7)	0.016	(0.41)	400	(2.76)	480	(3.31)	800	(5.52)
5/8	(15.9)	0.016	(0.41)	320	(2.21)	384	(2.65)	640	(4.42)
5/8	(15.9)	0.021	(0.53)	420	(2.90)	504	(3.48)	840	(5.80)
3/4	(19.0)	0.021	(0.53)	360	(2.48)	432	(2.98)	720	(4.97)
3/4	(19.0)	0.025	(0.64)	420	(2.90)	504	(3.48)	840	(5.80)
1	(25.4)	0.021	(0.53)	260	(1.79)	312	(2.15)	520	(3.59)
1	(25.4)	0.025	(0.64)	320	(2.21)	384	(2.65)	640	(4.42)

40.4 If a test is necessary to determine whether a part complies with the requirements in 40.3, two samples of the part are to be subjected to a hydrostatic pressure test. Each sample is to be filled with water so as to exclude air, and is to be connected to a hydraulic pump. The pressure is to be raised gradually to the specified test value, and is to be held at that value for 1 minute. The results are not acceptable if either sample bursts or leaks.

Exception: Leakage or rupture of a nonmetallic fluid transfer line and its connections or leakage at a gasket is acceptable if tests conducted with the media they are intended to contain show no evidence of presenting a risk of injury to persons or a risk of electric shock.

40.5 Hoses provided for connection of the product to the fire equipment being repaired or serviced shall comply with Tests for Halon 1211 Hoses, Section 59. Such hoses provided with equipment for outdoor use and marked in accordance with 72.8 shall be investigated with respect to the effects of outdoor exposure. See 59.11.

40.6 The dial of a pressure gauge connected in a section of a pressure system shall be graduated up to no less than:

a) Two times the maximum operating pressure, and

b) 1.2 times the marked design pressure of the pressure-containing components.

41 Pressure-Relief Devices

41.1 A means for relieving pressure shall be provided for a part in which pressure may be generated by an external source of heat.

Exception: Storage containers intended to receive the halon charge during the recovery/recharge operation that comply with Storage Containers, Section 46, are considered to comply with this section.

41.2 A pressure-relief device, a fusible plug, a soldered joint, nonmetallic tubing, or other equivalent pressure-relief means can be employed to comply with the requirement in 41.1.

41.3 A pressure-relief device is considered to be a pressure actuated valve or rupture member intended to relieve excessive pressures automatically.

41.4 There shall be no shutoff valve between the pressure-relief means and the parts that it is intended to protect.

41.5 A vessel having an inside diameter of more than 3 inches (76 mm) and subject to air or vapor pressure generated or stored within the product shall be provided with a pressure-relief device.

41.6 The start-to-discharge pressure setting of a pressure-relief device shall not be higher than the working pressure marked on the vessel. The discharge rate of the device shall be adequate to relieve the pressure.

41.7 A pressure-relief device shall:

a) Be connected as close as possible to the pressure vessel or part of the system that it is intended to protect;

b) Be installed so that it is readily accessible for inspection and repair, and cannot be readily rendered inoperative so that it will not perform its intended function; and

c) Have its discharge opening located and directed so that:

1) Operation of the device does not deposit moisture on bare live parts or on insulation or components detrimentally affected by moisture, and

2) The likelihood of injury to persons is reduced.

41.8 A pressure-relief device having an adjustable setting is judged on the basis of the maximum setting unless the adjusting means is sealed at a lower setting.

41.9 A control that limits the pressure in a vessel required to have a pressure-relief device shall perform under rated load for 100,000 cycles of operation, and shall operate so that the pressure does not exceed 90 percent of the relief-device setting under any condition of normal operation.

42 Switches, Controls, and Interlocks

42.1 A product shall be constructed so as to reduce the likelihood of unexpected operation of a part capable of causing injury to persons.

42.2 Each function of a multiple-function product is to be taken into consideration in determining whether the product complies with the requirement in 42.1.

42.3 If, when energized, a product has a moving part that may cause injury to persons, a motor control switch, other than a momentary-contact switch, on the product shall have a plainly marked off position.

42.4 If unintentional operation of a switch can result in a risk of injury to persons, the actuator of the switch shall be located or guarded so that such operation is unlikely.

42.5 The actuator of a switch may be guarded by recessing, ribs, barriers, or the like.

42.6 The actuator of an interlock switch shall be located so that unintentional operation is unlikely.

42.7 Operation of an interlock in normal use shall not inconvenience the operator so as to encourage deliberate defeat of the interlock.

42.8 An interlock shall be such that it cannot be defeated readily:

a) Without damaging the product,

b) Without making wiring connections or alterations, or

c) By using materials that are readily available.

42.9 If an interlock is actuated by movement of a guard, the arrangement shall be such that the guard is in place when the interlock is in the position that permits operation of the part being guarded. With the guard removed, the interlock shall comply with the requirement in 42.6.

42.10 A device that automatically starts a product, such as a timer, an automatically reset overload-protective device, or the like, shall not be employed unless it can be demonstrated that automatic starting will not result in a risk of injury to persons.

42.11 The requirement in 42.10 will necessitate the use of an interlock if moving parts or the like could result in a risk of injury to persons upon automatic starting or restarting of a motor.

42.12 An interlock switch or control shall comply with the Standard for Industrial Control Equipment, UL 508; the Standard for Special-Use Switches, UL 1054; or the Standard for Switches for Appliances – Part 1: General Requirements, UL 61058-1. The interlock switch or control shall be able to withstand not less than 100,000 cycles of operation when endurance tested.

43 Stability

43.1 A portable product shall be tested as described in 43.2 – 43.4. If the product overturns, a risk of injury to persons shall not result.

43.2 A product is not to be energized during the stability test. The test is to be conducted under conditions most likely to cause the product to overturn. The following conditions are to be such as to result in the least stability:

a) Position of all doors, drawers, casters, and other movable or adjustable parts, including that of the supply cord resting on the surface supporting the product;

b) Connection of or omission of any attachment made available by or recommended by the manufacturer;

c) Provision of or omission of any normal load if the product is intended to contain a liquid or other mechanical load such as a storage container provided with the product; and

d) Direction in which the product is tipped or the supporting surface is inclined.

43.3 In conducting the stability test, the product is to be:

a) Placed on a plane inclined at an angle of 10 degrees from the horizontal, or

b) Tipped through an angle of 10 degrees from an at rest position on a horizontal plane.

43.4 With reference to the requirement in 43.3(b), for a product that is constructed so that while being tipped through an angle of 10 degrees a part or surface of the product not normally in contact with the horizontal supporting surface touches the supporting surface before the product has been tipped through an angle of 10 degrees, the tipping is to be continued until the surface or plane of the surface of the product originally in contact with the horizontal supporting surface is at an angle of 10 degrees from the horizontal supporting surface.

43.5 A product not intended to move from its de-energized position to perform its intended function but that may move from its de-energized position when operated shall be provided with an anchoring means.

44 Strength of Handles

44.1 A handle used to support or carry a product shall withstand a load of four times the weight of the product without damage to the handle, its securing means, or that portion of the enclosure to which the handle is attached.

44.2 The load is to be uniformly applied over a 3-inch (76-mm) width at the center of the handle, without clamping. The load is to be started at zero and gradually increased so that the test value is attained in 5 to 10 seconds; the test value is to be maintained for 1 minute. If a product has more than one handle and cannot be carried by one handle, the load is to be distributed between the handles. The distribution of the load is to be determined by measuring the percentage of the product weight sustained by each handle with the product in the normal carrying position. If a product is furnished with more than one handle and can be carried by only one handle, each handle is to withstand the total load.

45 Surface Temperature

45.1 During the Temperature Test, Section 50, the temperature of a surface that may be contacted by the user shall not be more than the value specified in Table 45.1. If the test is conducted at a room temperature of other than 25°C (77°F), the results are to be corrected to that temperature.

Table 45.1
Maximum surface temperatures

Location	Composition of surface[a]	
	Metal	Nonmetallic
Handles or knobs that are grasped for lifting, carrying, or holding	50°C (122°F)	60°C (140°F)
Handles or knobs that are contacted but do not involve lifting, carrying, or holding; and other surfaces subject to contact and user maintenance	60°C (140°F)	85°C (185°F)
Surfaces other than a heating function surface and known to be hot due to proximity to the heating function surface	70°C (158°F)	95°C (203°F)

[a] A handle, knob, or the like, made of a material other than metal, that is plated or clad with metal having a thickness of 0.005 inch (0.127 mm) or less is considered to be, and is judged as, a nonmetallic part.

46 Storage Containers

46.1 A storage container provided with the equipment, that is not an ASME marked pressure vessel and that receives the Halon 1211/nitrogen charge during the recovery/recharge operation, shall comply with all the following:

a) The storage container shall comply with DOT specifications, 49 CFR, and have a service pressure rating not less than 200 psig or 400 psig (1.37 or 2.75 MPa) as determined by the fire equipment being serviced and the design pressure marked on the product nameplate.

b) The cylinder valve shall comply with the Standard for Cylinder Valves, UL 1769. The valve connection shall be a Compressed Gas Association (CGA) 660 male type.

c) The pressure relief device, when required by the applicable DOT regulations, shall comply with the Pressure Relief Device Standard Part I – Cylinders for Compressed Gases, Compressed Gas Association Pamphlet S-1.1.

PERFORMANCE

47 General

47.1 All tests are to be conducted with the product connected to a supply circuit of rated frequency. The voltage of the supply circuit is to be:

a) For a product rated from 110 volts up to and including 120 volts, 120 volts;

b) For a product rated from 220 volts up to and including 240 volts, 240 volts; or

c) For a product rated other than as mentioned in (a) and (b), the maximum rated voltage.

47.2 A product rated 50 – 60 hertz is to be tested at 60 hertz.

48 Leakage Current Test

48.1 The leakage current of a cord-connected product rated 250 volts or less, when tested in accordance with 48.3 – 48.9, shall not be more than 0.75 milliamperes.

48.2 Leakage current refers to all currents, including capacitively coupled currents, that may be conveyed between exposed conductive surfaces of a product and ground or other exposed conductive surfaces of a product.

48.3 All exposed conductive surfaces are to be tested for leakage currents. If simultaneously accessible, the leakage currents from exposed conductive surfaces are to be measured to the grounded supply conductor individually as well as collectively, and from one surface to another. A part is considered to be an exposed surface unless guarded by an enclosure that complies with the requirements in 11.1 – 11.8. Surfaces are considered to be simultaneously accessible when 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 do not present a risk of electric shock.

48.4 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 a metal foil having an area of 10 by 20 centimeters in contact with the surface. If the surface is less than 10 by 20 centimeters, the metal foil is to be the same size as the surface. The metal foil is not to remain in place long enough to affect the temperature of the product.

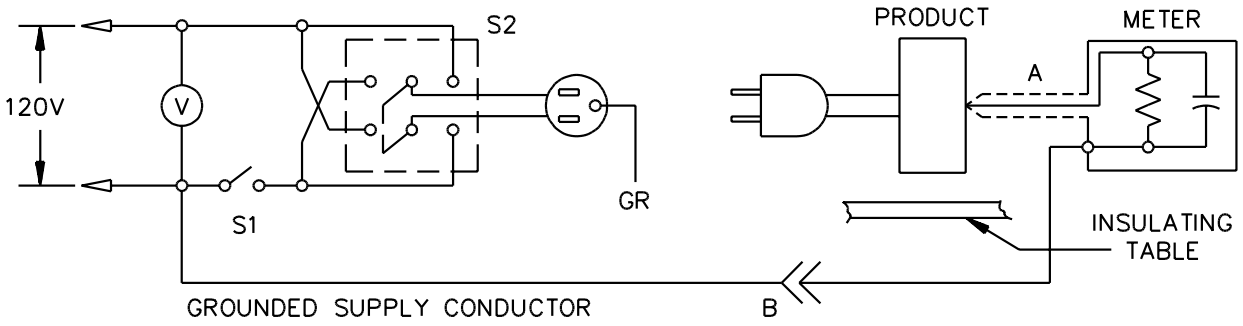
48.5 The measurement circuit for leakage current is to be as illustrated in Figure 48.1. The measurement instrument is defined in (a) – (c). The meter that is actually used for a measurement need only indicate the same numerical value for a particular measurement as would the defined instrument. The meter used need not have all the attributes of the defined instrument.

a) The meter is to have an input impedance of 1500 ohms resistive shunted by a capacitance of 0.15 microfarad.

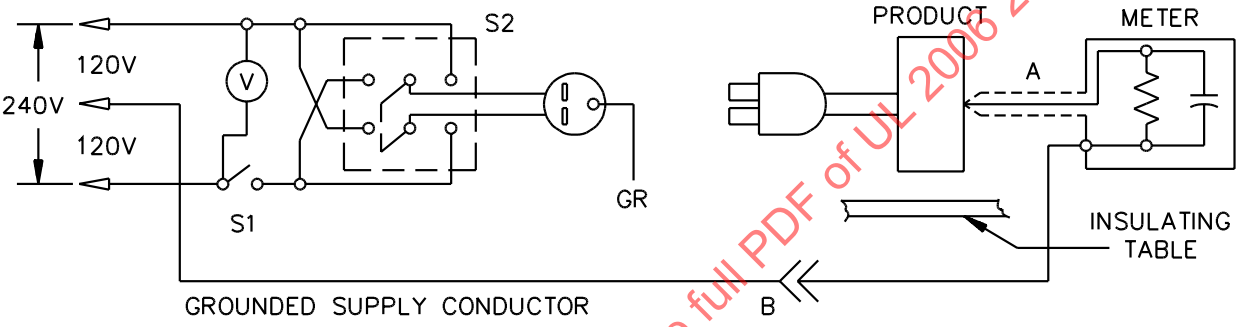
b) The meter is to indicate 1.11 times the average of the full-wave rectified composite waveform of voltage across the resistor or current through the resistor.

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 – that is 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 or 0.75 milliampere, the measurement is to have an error of not more than 5 percent at 60 hertz.

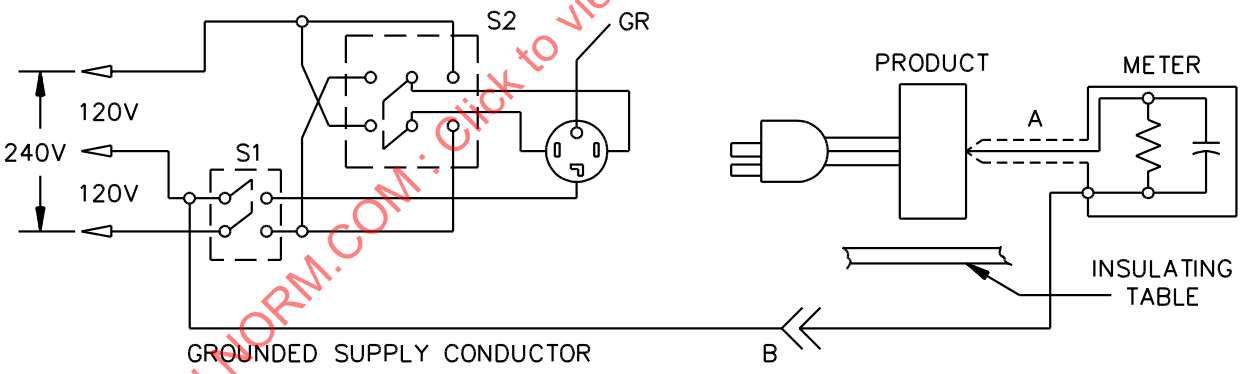
Figure 48.1
Leakage-current measurement circuits



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.

48.6 The meter is to be connected to the accessible part and the grounded supply conductor unless the meter is being used to measure leakage between two parts of a product.

48.7 A sample product is to be prepared for leakage current measurement as follows:

a) The sample is to be representative of the wiring methods, routing, components, component location and installation, and the like, of a production unit.

b) The grounding conductor is to be open at the attachment plug and the sample is to be isolated from ground.

c) The sample is to be tested in the as-received condition.

d) The test is to be conducted at ambient temperature and humidity.

e) The supply voltage is to be adjusted to rated voltage.

48.8 The test sample is to be arranged so that all parallel ground paths – such as through fill and drain lines– will be eliminated.

48.9 The leakage current test sequence, with reference to the measuring circuit, Figure 48.1, is to be as follows:

a) With switch S1 open, the product is to be connected to the measuring circuit. Leakage current is to be measured using both positions of switch S2, and with the product switching devices in all their normal operating positions.

b) Switch S1 is then to be closed energizing the product, and within 5 seconds, the leakage current is to be measured using both positions of switch S2, and with the product switching devices in all their normal operating positions.

c) The leakage current is to be monitored until thermal stabilization. Both positions of switch S2 are to be used in determining this measurement. Thermal stabilization is to be obtained by operation as in the temperature test.

49 Starting Current Test

49.1 A product shall start and operate normally on a circuit protected by an ordinary – not time-delay – fuse having a current rating corresponding to that of the branch circuit to which the product should be connected. The performance is unacceptable if the fuse opens or an overload protector provided as part of the product trips.

Exception: A time-delay fuse may be employed if the product is marked in accordance with 73.8.

49.2 In a test to determine whether a product complies with the requirement in 49.1, the product is to be started three times, with the product at room temperature at the beginning of the test. Each start of the motor is to be made under conditions representing the beginning of normal operation and the motor is to be allowed to come to rest between successive starts.

50 Input Test

50.1 The current input to a product shall not be more than 110 percent of the rated value when the product is tested as described in the Efficiency Test, Section 54, and when connected to a supply as specified in 47.1.

Exception: For battery-operated equipment, the input is to be measured with the equipment in the charging mode during the Efficiency Test after operating for five minutes. The battery is to be fully discharged in accordance with the battery manufacturer's instructions at the start of the test.

51 Temperature Test

51.1 A product, when tested as described in the Efficiency Test, Section 54, shall not reach a temperature high enough to cause a risk of a fire, to damage any materials used, or exceed the temperature rises specified in Table 51.1. See Surface Temperature, Section 45.

51.2 A thermal- or overload-protective device shall not open the circuit during the temperature test.

51.3 All values of temperature rise in Table 51.1 are based on an assumed ambient temperature of 25°C (77°F).

Table 51.1
Temperature rises

Materials and components	°C	°F
A. MOTORS		
1. Class A insulation systems on coil windings having a frame diameter of 7 inches (178 mm) or less, not including a universal motor and a vibrator coil[a,b]		
(a) In an open motor and on a vibrator coil:		
Thermocouple or resistance method	75	135
(b) In a totally enclosed motor:		
Thermocouple or resistance method	80	144
2. Class A insulation systems on coil windings of an a-c motor having a frame diameter of more than 7 inches (178 mm), of a d-c motor and of a universal motor[a,b]		
(a) In an open motor:		
Thermocouple method	65	117
Resistance method	75	135
(b) In a totally enclosed motor:		
Thermocouple method	70	126
Resistance method	80	144
3. Class B insulation systems on coil windings of an a-c motor having a frame diameter of 7 inches (178 mm) or less, not including a universal motor[a,b]		
(a) In an open motor:		
Thermocouple or resistance method	95	171
(b) In a totally enclosed motor:		
Thermocouple or resistance method	100	180
4. Class B insulation systems on coil windings of an a-c motor having a frame diameter of more than 7 inches (178 mm), of a d-c motor, and of a universal motor[a,b]		
(a) In an open motor:		
Thermocouple method	85	153
Resistance method	95	171
(b) In a totally enclosed motor:		
Thermocouple method	90	162
Resistance method	100	180
B. COMPONENTS		
1. Capacitors:		
(a) Electrolytic[c]	40	72
(b) Other types[d]	65	117
2. Fuses[e]	65	117
3. Relay, solenoid, and coils (except motor coil windings and transformers) with		
(a) Class 105 insulation systems		
Thermocouple method	65	117
Resistance method	85	153
(b) Class 130 insulation systems		
Thermocouple method	85	153
4. Sealing compound	40	104
	less than melting point	
5. Transformers		
(a) Class 155 insulation systems:		
Thermocouple method	110	198
Resistance method	115	207

Table 51.1 Continued on Next Page

Table 51.1 Continued

Materials and components	°C	°F
(b) Class 180 insulation systems:		
Thermocouple method	125	225
Resistance method	135	243
C. CONDUCTORS		
1. Rubber- or thermoplastic-insulated wires and cords[e,f]	35	63
D. ELECTRICAL INSULATION – GENERAL		
1. Fiber employed as electrical insulation	65	117
2. Phenolic composition employed as electrical insulation or as a part the deterioration of which could result in a risk of fire or electric shock[e]		
(a) Laminated	100	180
(b) Molded	125	225
3. Varnished-cloth insulation	60	108
E. SURFACES		
1. A surface upon which a product may be placed or mounted in service, and a surface that may be adjacent to the product when it is so placed or mounted	65	117
2. Any point within a terminal box	35	63
3. Wood or other combustible material, including the inside surface of the test enclosure and the surface supporting the product	65	117

[a] At a point on the surface of a coil where the temperature is affected by an external source of heat, the temperature measured by means of a thermocouple can be more than the maximum acceptable temperature specified in this table provided the temperature, as measured by the resistance method, is not more than that specified. The temperature measured by means of a thermocouple can be more than the specified value by:

1. 5°C (9°F) for Class A insulation systems on coil windings of alternating-current motors having a diameter of 7 inches (178mm) or less, open type,
2. 10°C (18°F) for Class B insulation systems on coil windings of alternating-current motors having a diameter of 7 inches or less, open type,
3. 15°C (27°F) for Class A insulation systems on coil windings of alternating-current motors having a diameter of more than 7 inches, open type,
4. 20°C (36°F) for Class B insulation systems on coil windings of alternating-current motors having a diameter of more than 7 inches, open type.

[b] See note a to Table 32.1.

[c] For an electrolytic capacitor that is physically integral with or attached to a motor, the maximum acceptable temperature rise on insulating material integral with the capacitor enclosure shall be not more than 65°C (117°F).

[d] A capacitor that operates at a temperature rise of more than 65°C (117°F) is to be judged on the basis of its marked temperature limit.

[e] A fuse that has been investigated, and found acceptable for use at a higher temperature can be used at that temperature.

[f] A rubber-insulated conductor within a motor, a rubber-insulated motor lead, and a rubber-insulated conductor of a flexible cord entering a motor can be subjected to a higher temperature if the conductor is provided with sleeving or a braid that has been investigated and found acceptable for use at the higher temperature. This does not apply to thermoplastic-insulated wires or cords.

51.4 A product having a single frequency rating is to be tested at that frequency. A product rated 50 – 60 hertz is to be tested on 60-hertz alternating current.

51.5 A short length of rubber- or thermoplastic-insulated flexible cord exposed to a temperature of more than 60°C (140°F), such as at terminals, is acceptable if supplementary heat-resistant insulation of adequate dielectric strength is employed on the individual conductors of the cord to prevent deterioration of the conductor insulation.

51.6 With reference to those tests that are to be continued until constant temperatures are attained, thermal equilibrium is considered to exist when three successive readings taken at intervals of 10 percent of the previously elapsed duration of the test, but not less than 5-minute intervals, indicate no change.

51.7 Coil winding temperatures are to be measured by thermocouples or by using the change-of-resistance method, whichever is appropriate. For a thermocouple measured temperature of a coil of an alternating-current motor having a diameter of 7 inches (178 mm) or less and a universal motor–see subitems 1 and 3 in Table 40.1 – the thermocouple is to be mounted on the integrally applied insulation on the conductor. For any other motor, the thermocouple may be applied on the outer surface of a wrap that is not more than 1/32 inch (0.8 mm) thick and consists of cotton, paper, rayon, or the like.

51.8 Thermocouples are to consist of wires not larger than 24 AWG (0.21 mm^2) and not smaller than 30 AWG (0.05 mm^2). Whenever referee temperature measurements by thermocouples are necessary, thermocouples consisting of 30 AWG iron and constantan wire and a potentiometer-type instrument are to be used. The thermocouple wire is to conform with the requirements for Special Tolerances thermocouples as listed in the Tolerances on Initial Values of EMF versus Temperature tables in theStandard Specification and Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples, ANSI/ASTM E230/E230M.

51.9 When using the resistance method, the windings are to be at room temperature at the start of the test, and the temperature rise of a winding is to be calculated using the formula:

$$t = \frac{R}{r}(k + t_1) - (k + t_2)$$

in which:

t is the temperature rise in °C,

R is the resistance of the coil in ohms at the end of the test,

r is the resistance of the coil in ohms at the beginning of the test,

t_1 is the temperature in °C of the coil at the time resistance "r" is being measured,

t_2 is the room temperature in °C at the end of the test, and

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

52 System Contamination Test

52.1 The equipment shall not contaminate Halon 1211 that has a maximum moisture content of 20 parts per million when operated as specified in 52.2 at 77°F (25°C) in accordance with the manufacturer's instructions.

52.2 The equipment inlet and outlet service hoses are to be connected to:

a) A fire extinguisher weighing 13 – 14 pounds-mass (5.9 – 6.3 kg) that has been charged and pressurized with Halon 1211 having a maximum moisture content of 20 parts per million, and

b) A clean and dry storage container.

The equipment is then to be operated to recover the halon from the fire extinguisher to the storage container. The procedure is to be repeated so that the same halon is cycled between the containers until passed through the equipment transfer system five times. A sample of the recovered halon taken from the liquid phase is to be subjected to a quantitative determination of water content in accordance with 52.3. The water content of the recovered halon shall be 20 parts per million maximum.

52.3 The apparatus employed for determination of water content is to be an automated coulometer[a] for the precise determination of small amounts of water. In conducting the test, a sample of liquid halon weighing 30 to 130 grams, which is allowed to vaporize, is to be introduced directly into the anolyte of the coulometer. A coulometric titration is conducted and the results are calculated and displayed as parts per million moisture by the instrument.

[a]Karl-Fischer Coulometer or equivalent is acceptable for this determination.

52.4 Special precautions are to be taken to ensure that representative samples are obtained for analysis. Sampling is to be done by trained laboratory personnel following accepted sampling and safety procedures.

a) The test cylinder is to be prepared as follows for obtaining gas and liquid phase samples.

1) Clean test cylinder (with valves) with 5 – 20 milliliter portions of reagent grade 1,1,1 – trichloroethane or other suitable solvent.

2) Blow out test cylinder with dry (<3 ppm water) nitrogen.

3) With valves open, place test cylinder in oven at approximately 110°C (230°F) for 1 hour.

4) When heated, connect clean copper tubing between storage container and test cylinder. Connect immediately to an evacuation system and evacuate to less than 1 millimeter mercury (1000 microns).

b) A liquid phase sample, that may be obtained as follows, is required for tests outlined in Sections 52 and 53. Do not load the cylinder over 80 percent full at room temperature. This can be accomplished by weighing the empty cylinder and then the cylinder with halon. When the desired amount of halon has been collected, close the valve(s) and disconnect the sample cylinder immediately.

53 Filter-Drier Test

53.1 The equipment shall clean contaminated Halon 1211 having an analyzed water content of 80 parts per million to less than 20 parts per million when operated as specified in 42.3 at 77°F (25°C) in accordance with the manufacturer's instructions.

53.2 Five 20 pounds-mass (9.1 kg) rechargeable Halon 1211 fire extinguishers that have been charged and pressurized with contaminated Halon 1211 and five clean and dry storage containers are to be used for this test.

53.3 The equipment inlet hose is to be connected to one of the extinguishers and the outlet hose to one of the storage containers. The equipment is then to be operated to recover/recharge in single or multiple passes the halon from the extinguisher into the storage container. The same test procedure is to be used to recover/recharge the halon from the other extinguishers into the separate storage containers. The five recovery/recharge cycles are to be completed within 90 minutes.

53.4 During the recovery/recharge operations the moisture and liquid indicator(s) is to be observed. If the system monitoring indicates particulate contamination or excessive moisture content during any cycle of the testing sequence, the test is to be terminated and the manufacturer's recommendations for service, such as filter-drier replacement, followed. The recovery/recharge operation is to then be started where terminated and the five recovery/recharge cycles completed.

53.5 A sample of the recovered halon taken from the liquid phase from the last recovery/recharge cycle is to be subjected to a quantitative determination of water content in accordance with 41.3. The water content shall be 20 parts per million maximum.

54 Efficiency Test

54.1 The equipment shall be capable of transferring Halon 1211 between fire equipment and storage containers with an efficiency of 99 percent or more when tested in accordance with 54.2 – 54.8.

54.2 The equipment is to be fitted with a pressure gauge on the high-side of the halon transfer system. Thermocouples are to be secured to electrical components, such as the motor windings, relay coils, capacitors, and wiring insulation, and to surfaces as indicated in item E of Table 51.1. The electrical input, the temperature of electrical components and surfaces, and the high-side pressure are to be recorded at intervals during the test.

54.3 The equipment is to be tested in an ambient temperature of 77 ±5°F (25 ±3°C).

54.4 The equipment shall comply with the Dielectric Voltage-Withstand Test, Section 56, following this test.

54.5 The manufacturer's maintenance and recovery/recharge instructions, and recommended equipment for field servicing are to be used for this test.

54.6 For the purpose of this section, the following definitions apply:

a) Efficiency – The total amount of halon transferred during the test less the halon lost to the atmosphere during the transfer operation, the resulting figure divided by the total amount of halon transferred.

b) Recovery/Recharge Cycle – A servicing sequence in which:

1) Halon 1211 in a fully charged and pressurized fire extinguisher is removed and placed in a storage container,

2) The extinguisher is depressurized and the valve removed,

3) The valve is then assembled onto the extinguisher,

4) The weight of the empty extinguisher is then recorded. See (d),

5) The same extinguisher is then charged and pressurized to the specifications and tolerances designated for the extinguisher. The extinguisher charged and pressurized weight is then recorded. See (e).

c) Complete System Weight Before Test – The total weight of the storage container, hoses, charged and pressurized fire extinguishers, manifolds, pump systems, and the like before the test. This is determined by measuring the individual weight of these assemblies before the test.

d) Extinguisher Empty Weight – The fire extinguisher's empty, unpressurized weight.

e) Charged Gross Weight – The weight of a Halon 1211 fire extinguisher that has been charged and pressurized to the specifications and tolerances designated for the extinguisher.

f) Complete System Weight After Test – The total weight of all the individual assemblies at the end of the test. See (c).

54.7 Five 5 pounds-mass (2.3 kg) rechargeable Halon 1211 fire extinguishers are to be used for this test. Each extinguisher is to be assigned a test item number, and the five extinguishers are to be considered as a lot. The extinguishers are to be emptied, have their valves removed, and then be reassembled and charged and pressurized to constitute a complete lot servicing sequence. A minimum of 20 complete lot servicing sequences are to be completed. The minimum amount of Halon 1211 transferred between containers during the test program is to be 1000 pounds-mass (454 kg). The test is to be completed within 8 hours.

54.8 The equipment is to be operated to complete a recovery/recharge cycle on each extinguisher in the lot in accordance with (a) – (e).

a) The total amount of halon recovered from an extinguisher is to be equal to the extinguisher charged gross weight less the extinguisher empty weight. The halon recovered from each extinguisher is to be recorded. Five extinguishers are to be serviced for each lot.

b) The lot of extinguishers is to then be assembled and charged. The charged gross weight and calculated weight of halon charged is to be recorded for each extinguisher. The weight charge is to be the actual charged gross weight less the extinguisher empty weight for each extinguisher.

c) The servicing sequence is to be repeated on the lot of five extinguishers at least 20 times and until a minimum of 1000 pounds-mass (454 kg) of Halon 1211 has been transferred.

d) Upon completion of the final recharge and pressurization cycle, the weight of all assemblies is to be recorded. The total weight of all assemblies at the end of this test is to be recorded as complete system weight after test. The complete system weight before test less the complete system weight after test is to be recorded as halon lost to atmosphere.

e) The total amount of halon recovered from the extinguishers and the total amount of halon charged into the extinguishers is to be calculated and recorded as total amount of halon transferred.

54.9 The transfer efficiency shall be 99 percent or more as calculated in accordance with 54.6(a).

55 Grounding Continuity Test

55.1 The resistance between the point of connection of the equipment-grounding means at or within the product and any other point in the grounding circuit of the product shall not be more than 0.1 ohm.

55.2 Determination of whether the product complies with the requirement in 44.1 can be made by an ohmmeter or the like, except that if unacceptable results are observed, an alternating current of 20 amperes or more from a power supply of 12 volts or less is to be passed from the point of connection of the equipment-grounding means to the metal part in the grounding circuit, and the resulting drop in potential is to be measured between the two points. The resistance in ohms is to be determined by dividing the drop in potential in volts by the current in amperes passing between the two points.

56 Dielectric Voltage-Withstand Test

56.1 A product shall withstand, without breakdown, a test potential applied for 1 minute between line-voltage live parts and dead metal parts and between live parts of high and low voltage circuits. The test potential shall be 1000 V plus twice rated voltage at any frequency between 40 and 70 hertz.

Exception No. 1: The test potential for units rated at not more than 1/2 horsepower (373 watts output) shall be 1000 V.

Exception No. 2: If the steady-state voltage developed in a motor circuit through the use of capacitor exceeds 500 V, as measured during the temperature and pressure test, the test potential for the parts affected shall be 1000 V plus twice the developed capacitor voltage.

Exception No. 3: If agreeable to all parties concerned, the test potential may be a direct-current (dc) potential as specified in Table 67.1, Condition A and applied for 1 minute.

56.2 Equipment employing a low-voltage circuit shall withstand, without breakdown, a test potential of 500 volts applied for 1 minute between low-voltage live parts and dead metal parts. The test potential shall be a dc potential or at any frequency between 40 and 70 hertz. If components specified in 33.3 are employed in the low-voltage circuit, the dielectric voltage withstand test shall also be conducted between live parts of opposite polarity.

56.3 With reference to the previous paragraph, the test between low-voltage parts of opposite polarity is to be conducted on magnet coil windings of the transformer after breaking the inner coil lead where it enters the layer. This opposite polarity test may be waived on the complete assembly provided that the components have been separately subjected to this test.

56.4 A 500 volt-ampere or larger transformer, the output voltage of which is essentially sinusoidal and can be varied, is to be used to determine compliance with the previous paragraphs. The applied potential is to be increased gradually from zero until the required test value is reached and is to be held at that value for 1 minute.

Exception: The requirement of a 500 volt-ampere or larger transformer can be waived if the high potential testing equipment maintains the specified high potential voltage at the equipment during the duration of the test.

56.5 If the charging current through a capacitor or capacitor-type filter connected across the line, or from line to earth ground, is large enough to make it impossible to maintain the required alternating-current test potential, the capacitors and capacitor-type filters may be tested as described in the next paragraph.

56.6 The capacitors and capacitor-type filters mentioned in the previous paragraph are to be subjected to a direct-current test potential of 1414 volts for equipment rated 250 volts or less or 1414 volts plus 2.828 times the rated circuit voltage for equipment rated at more than 250 volts. The direct-current test potential is to be maintained for 1 minute without breakdown.

56.7 Components providing a d.c. path in parallel with the insulation to be tested, such as discharge resistors for filter capacitors and voltage limiting devices (transient voltage suppressors), may be disconnected during the test.

57 Rain Test

57.1 Equipment exposed to weather shall be subjected to a rain exposure without creating a risk of electric shock due to current leakage or insulation breakdown.

57.2 The equipment is to be installed in accordance with the manufacturer's instructions and subjected to the rain exposure under conditions most likely to cause entrance of water into or onto the electrical components. The duration of exposure is to be 1 hour.

57.3 The rain test apparatus is to consist of three spray heads mounted in a water supply pipe rack as shown in Figure 57.1. Spray heads are to be constructed in accordance with the details shown in Figure 57.2. The water pressure for all tests is to be maintained at 5 psig (34 kPa) at each spray head. The distance between the center nozzle and the equipment is to be approximately 5 feet (1.5 m). The equipment is to be brought into the focal area of the three spray heads in such a position and under such conditions that the greatest quantity of water will enter it. The spray is to be directed at an angle of 45 degrees to the vertical toward the louvers or other openings closest to current-carrying parts. The equipment is to be operated so that electrical components are energized.