UL 961

STANDARD FOR SAFETY

Electric Hobby and Sports Equipment

UL Standard for Safety for Electric Hobby and Sports Equipment, UL 961

Fifth Edition, Dated December 5, 2014

Summary of Topics

This reaffirmation of ANSI/UL 961 dated April 16, 2025 is being issued to update the title page to reflect the most recent designation as a Reaffirmed American National Standard (ANS). No technical changes have been made.

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

The requirements are substantially in accordance with Proposal(s) on this subject dated February 28, 2025.

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UL 961

Standard for Electric Hobby and Sports Equipment

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Second Edition – May, 1990
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Fifth Edition

December 5, 2014

This ANSI/UL Standard for Safety consists of the Fifth Edition including revisions through April 16, 2025.

The most recent designation of ANSI/UL 961 as a Reaffirmed American National Standard (ANS) occurred on April 16, 2025. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

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

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INTRODUCTION

1 Scope

1.1 These requirements cover electrically-powered hobby and sports equipment rated 250 volts or less for use in ordinary locations in accordance with the National Electrical Code, NFPA 70.

1.2 These requirements cover equipment intended for the home entertainment and amusement of adults.

1.3 These requirements do not cover toys and games intended to be used by children, amusement machines, photographic equipment, or other products that are covered by separate requirements.

1.4 In the following text, a requirement that does not apply to all of the types of products covered by this standard is identified by a specific reference in that requirement to the type or types of product involved. Absence of such specific reference or use of the term product indicates that the requirement applies to all types of products unless the context indicates otherwise.

2 Components

2.1 Except as indicated in 2.2, a component of a product covered by this standard shall comply with the requirements for that component. See Appendix A for a list of standards covering components used in the products covered by this standard.

2.2 A component is not required to comply with a specific requirement that:

a) Involves a feature or characteristic not required in the application of the component in the product covered by this standard, or

b) Is superseded by a requirement in this standard.

2.3 A component shall be used in accordance with its rating established for the intended conditions of use.

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

3 Units of Measurement

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

3.2 Unless otherwise indicated, all voltage and current values mentioned in this standard are root-mean-square (rms).

4 Undated References

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

5 Glossary

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

5.2 LINE-VOLTAGE CIRCUIT – A circuit involving a potential of not more than 250 volts and having circuit characteristics in excess of those of a low-voltage circuit.

5.3 LOW-VOLTAGE CIRCUIT – A circuit involving a peak open-circuit potential of not more than 42.4 volts supplied by:

a) A primary battery;

b) A Class 2 transformer; or

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

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

CONSTRUCTION

6 Enclosure

6.1 A product shall have the strength and rigidity necessary to resist the abuses to which it may be subjected, without increasing the risk of fire, electric shock, or injury to persons due to total or partial collapse of the enclosure and resulting reduction of spacing, loosening or displacement of a part, or other malfunction.

6.2 Among the factors taken into consideration when an enclosure is evaluated are its:

a) Mechanical strength;

b) Resistance to impact;

c) Resistance to corrosion;

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

e) Dielectric properties, insulation resistance, and resistance to arc tracking.

6.3 Cast- and sheet-metal portions of the enclosure shall not be thinner than the applicable value specified in Table 6.1 unless the enclosure is determined to be acceptable when evaluated under the considerations specified in 6.2.

Table 6.1
Thickness of metal enclosure

Metal	Minimum thickness			
	At small, flat unreinforced surfaces and at surfaces that are reinforced by curving, ribbing, and the like		At relatively large unreinforced flat surfaces	
	inch	(mm)	inch	(mm)
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)

6.4 A nonmetallic enclosure shall comply with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

7 Accessibility of Parts

7.1 To reduce the likelihood of unintentional contact that may involve a risk of electric shock from uninsulated live parts and film-coated wire and contact that may involve a risk of injury to persons from a moving part, an opening in an enclosure of a product or in a motor shall be investigated as described in (a) or (b).

a) For an opening that has a minor dimension (see 7.4) less than 1 inch (25.4 mm), such a part or wire shall not be contacted by the probe illustrated in Figure 7.1.

b) For an opening that has a minor dimension of 1 inch or more:

1) A moving part shall be spaced from the opening as specified in Table 7.1, and

2) Neither an uninsulated live part nor film-coated wire shall be within:

i) X inches of the perimeter of the opening; or

ii) The volume generated by projecting the perimeter X inches normal to its plane. X equals five times the minor dimension of the opening, but not less than 6-1/16 inches (154 mm) – see Figure 7.2.

Exception No. 1: A motor other than one used in either a hand-held product or a hand-supported portion of a product need not comply with these requirements if it complies with the requirements in 7.2.

Exception No. 2: An opening necessary for intended operation of a product need not comply with this requirement.

7.2 With reference to the requirements in 7.1, in the enclosure of a motor:

a) An opening that has a minor dimension (see 7.4) less than 3/4 inch (19.1 mm) is acceptable if:

1) A moving part cannot be contacted by the probe illustrated in Figure 7.3;

2) Film-coated wire cannot be contacted by the probe illustrated in Figure 7.4;

3) In a directly accessible motor, an uninsulated live part cannot be contacted by the probe illustrated in Figure 7.5; and

4) In an indirectly accessible motor (see 7.5), an uninsulated live part cannot be contacted by the probe illustrated in Figure 7.3.

b) An opening that has a minor dimension of 3/4 inch or more is acceptable if:

1) A moving part is spaced from the opening as specified in Table 7.1; and

2) An uninsulated live part or film-coated wire is not within:

i) X inches of the perimeter of the opening; or

ii) The volume generated by projecting the perimeter X inches normal to its plane (see Figure 7.2). X equals five times the minor dimension of the opening, but not less than 3-5/32 inches (80 mm) for contact with an uninsulated live part through an opening in the enclosure of a directly accessible motor, and 4 inches (102 mm) for all other openings.

Figure 7.1

Articulate probe with web stop

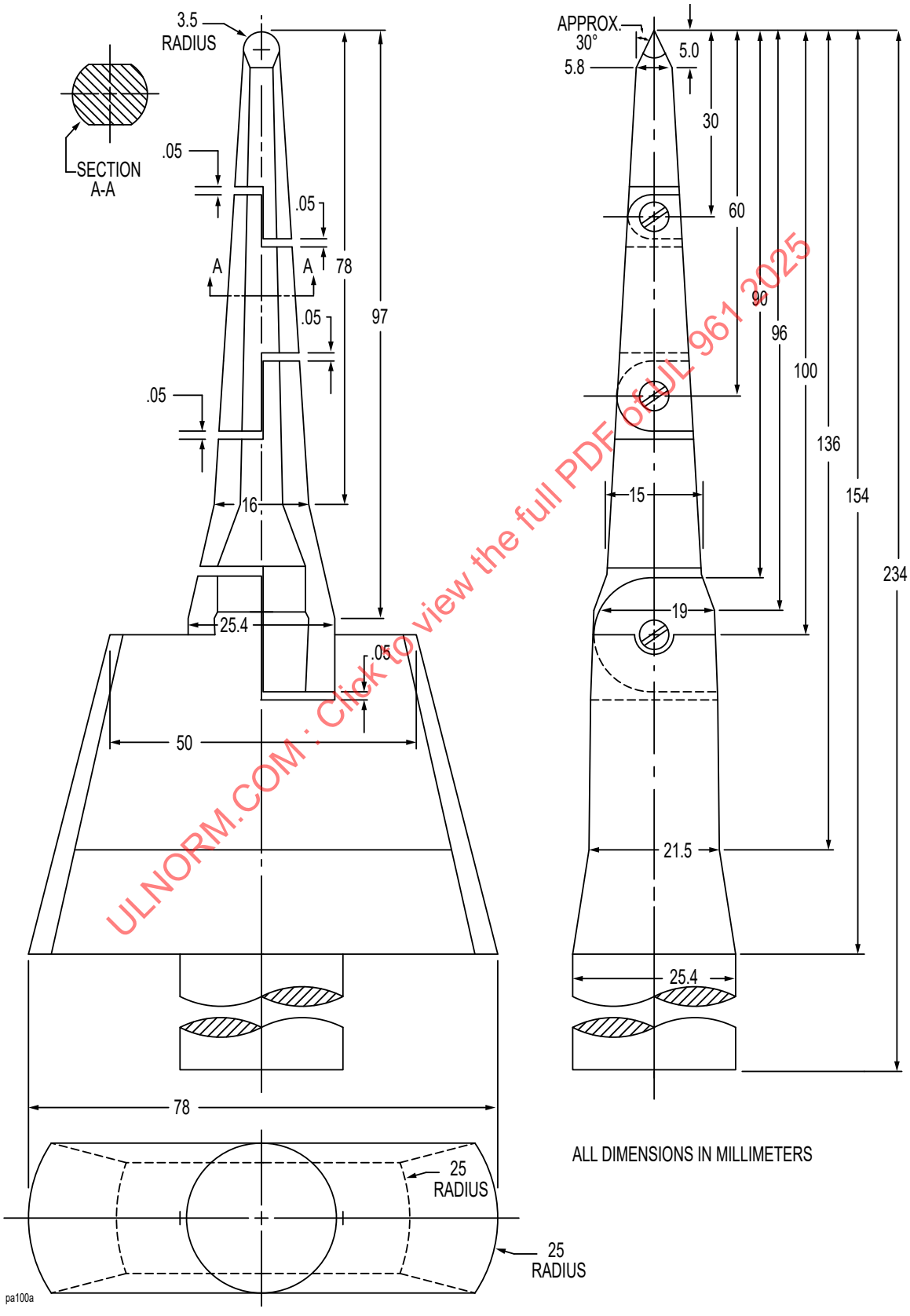


Table 7.1
Minimum distance from an opening to a moving part that may involve a risk of injury to persons

Minor dimension of opening		Minimum distance from opening to part	
inches	(mm)	inches	(mm)
3/4	(19.1)	4-1/2	(114)
1	(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)
c	(c)	30	(762)

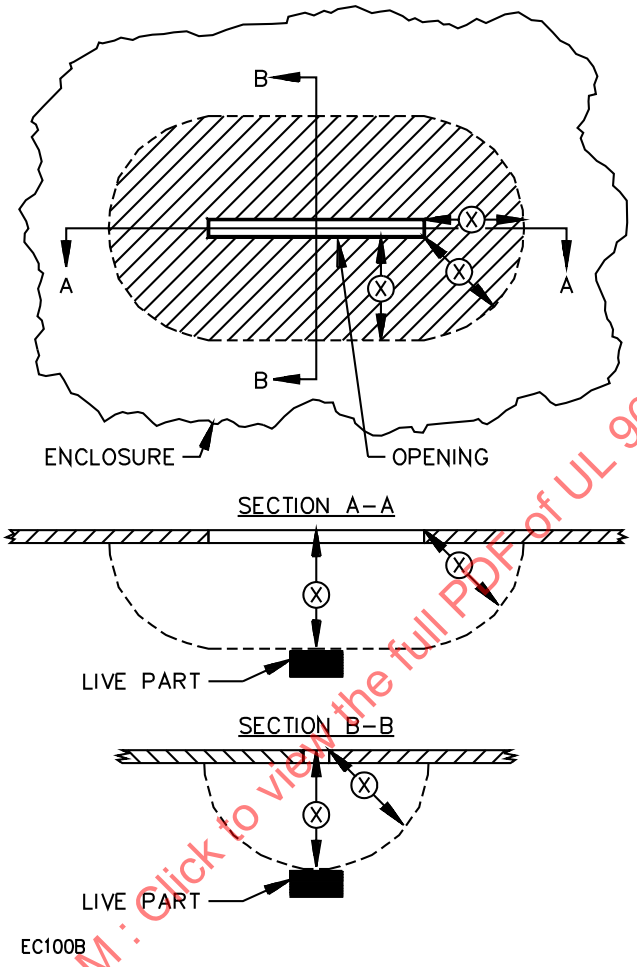
[a] See 5.2.

[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] More than 2-1/8 inches, but not more than 6 inches (152 mm).

Figure 7.2

Opening in enclosure



(Proportions exaggerated for clarity)

Figure 7.3

Probe for moving parts and uninsulated live parts

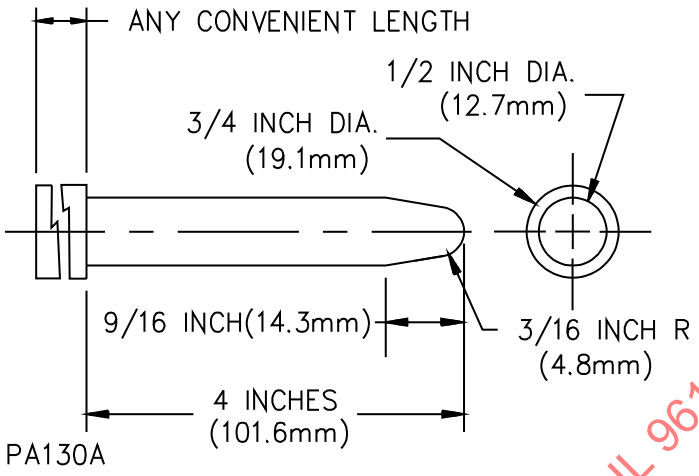


Figure 7.4

Probe for film-coated wire

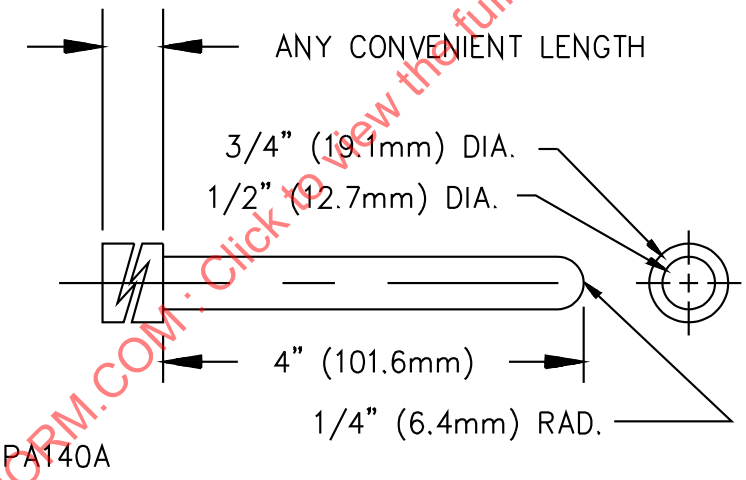
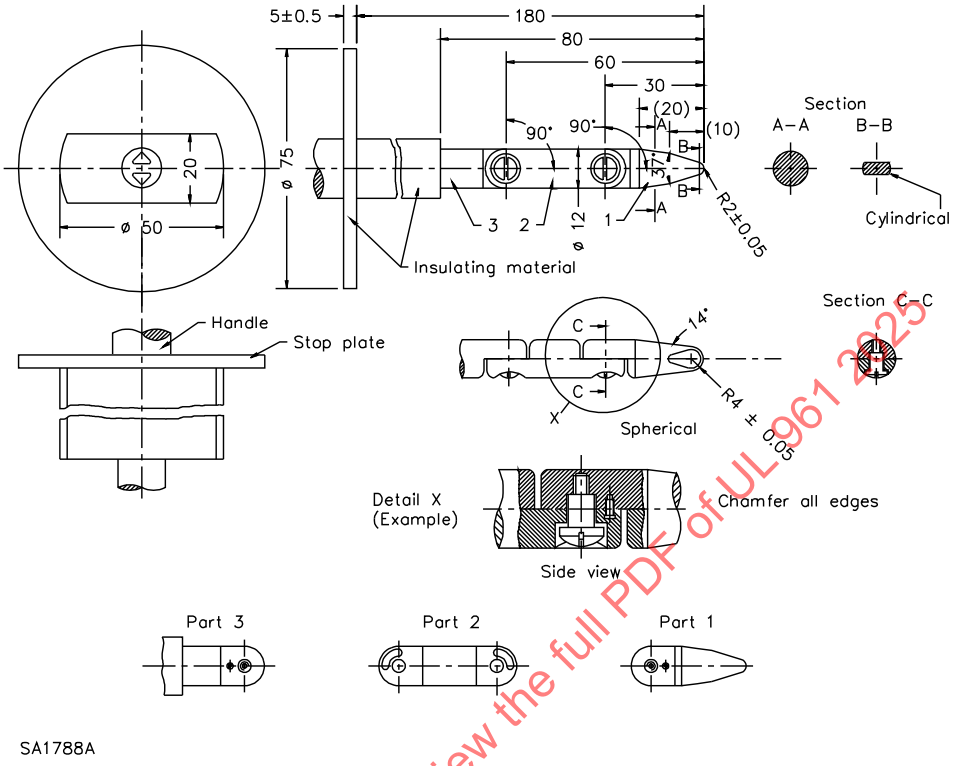


Figure 7.5

IEC articulate probe



7.3 The probes specified in 7.1 and 7.2 and illustrated in Figure 7.1 and Figure 7.3 – Figure 7.5 are to be applied to any depth that the opening will permit and with a force not greater than 1 pound (4.4 N); and are to be rotated or angled before, during, and after insertion through the opening to any position that is necessary to examine the product or motor. The probes illustrated in Figure 7.1 and Figure 7.5 are to be applied in any possible configuration; and, if necessary, the configuration is to be changed after insertion through the opening.

7.4 With reference to the requirements in 7.1 and 7.2, the minor dimension of an opening is the diameter of the largest cylindrical probe having a hemispherical tip that can be inserted through the opening perpendicular to the plane of the opening with a force not greater than 5 pounds (22.2 N).

7.5 With reference to the requirements in 7.2, an indirectly accessible motor is a motor that is:

a) Accessible only by removing a part of the outer enclosure of a product, such as a guard or panel, that can be removed without using a tool; or

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

7.6 During the examination of a product to determine whether it complies with the requirements in 7.1 and 7.2, a part of the enclosure that may be removed by the user without using a tool – to attach an accessory, make an operating adjustment, or for other reasons – is to be disregarded.

7.7 With reference to the requirements in 7.1 and 7.2, insulated brush caps are not required to be additionally enclosed.

8 Mechanical Assembly

8.1 A product shall be assembled so that it will not be adversely affected by the vibration of intended operation. A brush cap shall be threaded or shall be provided with other means to reduce the likelihood of loosening.

8.2 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 8.3 for specifications.

Exception No. 1: A means need not be provided to prevent a switch 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 method of mounting is such that operation of the switch will not loosen the switch.

c) The spacings are not reduced below the minimum acceptable 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, may turn if rotation cannot reduce spacings below the acceptable values.

8.3 The means for preventing the turning specified in 8.2 shall consist of more than friction between surfaces. For example, a lock washer may be used as the means for preventing a small, stem-mounted switch, or other device having a single-hold mounting means, from turning.

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

8.5 Friction between surfaces is not to be used to prevent shifting or turning of live parts, but a lock washer applied as intended may be used.

9 Protection Against Corrosion

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

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

10 Power-Supply Connections – Cord-Connected Products

10.1 Cords and plugs

10.1.1 Other than as noted in 10.1.2, a cord-connected product shall be provided with 6 – 10 feet (1.8 – 3.0 m) of flexible cord and an attachment plug for connection to the power-supply circuit.

10.1.2 A cord-connected product may be provided with not more than 18 inches (457 mm) of permanently attached flexible cord or with a connector base motor-attachment plug if:

a) Use of the product is such that it is necessary to connect it by means of an extension cord during intended operation; the manufacturer makes extension cords available; and a statement indicating the availability of such extension cords is marked on the product or is included in an instruction book or the like that is furnished with the product; or

b) The manufacturer furnishes a detachable cord set, 6 feet (1.8 m) long or more, with the product.

10.1.3 If a product employs a detachable cord set, the arrangement shall be such that live parts will not be exposed under any conditions encountered in intended use of the product.

10.1.4 The flexible cord shall have a voltage rating not less than the rated voltage of the product, and shall have an ampacity not less than the current rating of the product.

10.1.5 Other than as noted in 10.1.6, the flexible cord provided with a product shall be Type SP-2, SPE-2, or SPT-2, or a type determined to be equivalent.

Exception: Type SPT-1 cord may be used for a household golf practice putter.

10.1.6 A flexible power-supply cord provided with a product intended for outdoor use shall be Type SEW, STW, STOW, SJW, SJEW, SJOW, SJTW, SJTOW, or SW.

10.1.7 The attachment plug shall have an ampacity not less than the rated current at the rated voltage of the product.

10.1.8 The circuit conductors in the flexible cord shall be connected to the attachment plug and to the wiring in the product so that any of the following devices used in the line-voltage circuit are connected to the ungrounded side of the line:

a) The center contact of an Edison-base lampholder;

b) A fuseholder; and

c) Any other overcurrent-protective device or single-pole switch other than an automatic control without a marked-off position.

10.1.9 The attachment plug for a double-insulated appliance as specified in the Exception of 12.1 shall be of a two-blade type. If a double-insulated appliance incorporates a single-pole switch that disconnects the appliance from the branch circuit, and the appliance includes an Edison-base lampholder or a 15- or 20-ampere rated convenience receptacle, the attachment plug shall also be of the polarized type and comply with the Standard for Attachment Plugs and Receptacles, UL 498.

10.2 Strain relief

10.2.1 Strain relief shall be provided so that mechanical stress placed on a flexible cord is not transmitted to a terminal, splice, or interior wiring. See Strain Relief Test, Section 39.

10.2.2 Means shall be provided so that the flexible cord cannot be pushed into the product through the cord-entry hole if such displacement may subject the cord to mechanical damage or to exposure to a temperature higher than that for which the cord is intended, or may reduce spacings, such as to a metal strain-relief clamp, below the minimum required values. See Figure 40.1 for the specific test method. To determine compliance, the supply cord or lead shall be tested in accordance with Section 40, Push-Back Relief Test.

10.2.3 If a metal strain-relief clamp or band is used with Type SP-2 cord, auxiliary insulation shall be provided over the cord for mechanical protection.

10.2.4 Unless investigated and determined to be acceptable for the purpose, a clamp of any material – metal or otherwise – is not to be used with Type SPT-1, SPT-2, SVT, or SVTO cord, except that, if the cord is protected by varnished-cloth tubing or the equivalent under the clamp, the construction may be acceptable. For heavier types of thermoplastic-insulated cord, a clamp may be used and the auxiliary insulation is not required unless the clamp may damage the cord insulation.

10.2.5 If a knot in a flexible cord serves as strain relief, the surfaces that the knot may touch shall be free from burrs, fins, sharp edges, and projections that can damage the cord.

10.3 Bushings

10.3.1 At a point where a flexible cord passes through an opening in a wall, barrier, or enclosing case, there shall be a bushing or the equivalent which shall be secured in place, and shall have a smooth, rounded surface against which the cord may bear. An insulating bushing shall be provided if:

a) Type SPT-1, SP-2, or SPT-2 cord is employed;

b) The wall or barrier is of metal; or

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

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

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

10.3.4 Ceramic materials and some molded compositions may be used for insulating bushing; but separate bushings of wood or of hot-molded, shellac-and-tar compositions shall not be used.

10.3.5 A bushing of vulcanized fiber at least 3/64 inch (1.2 mm) thick may be used if formed and secured in place so that it will not be adversely affected by conditions of moisture encountered in the intended use of the product.

10.3.6 A bushing made of the same material as – and molded integrally with – the supply cord may be used on a Type SP-1 or heavier cord if the built-up section is at least 1/16 inch (1.6 mm) thick at the point where the cord passes through the enclosure.

10.3.7 A separate soft-rubber, neoprene, or polyvinyl chloride bushing may be employed in the frame of a motor or in the enclosure of a capacitor attached to a motor – but not elsewhere in the product – if the bushing is:

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

b) Located so that it will not be exposed to oil, grease, oily vapor, or other substances having a deleterious effect on its material.

Exception: A bushing made of any of the materials specified above may be employed at any point in a product if used with a type of cord for which an insulating bushing is not required and the edges of the hole in which the bushing is mounted are smooth and free from burrs, fins, and the like.

11 Power-Supply Connections – Permanently-Connected Products

11.1 General

11.1.1 A product intended for permanent connection to the power-supply circuit shall have provision for connection of one of the wiring systems that is intended for the product.

11.2 Field-wiring compartments

11.2.1 A field-wiring compartment in which power-supply connections are to be made shall be located so that these connections may be readily inspected after the product has been installed as intended.

11.2.2 A field-wiring compartment intended for connection of a supply raceway shall be attached to the product so that it cannot turn.

11.2.3 An outlet box, terminal box, wiring compartment, or the like, in which connections to the supply circuit will be made in the field, shall be free from any sharp edge, including screw threads, a burr, a fin, a moving part, or the like, that could damage the insulation on a conductor.

11.3 Field-wiring terminals and leads

11.3.1 A field-wiring terminal is considered to be a terminal to which a wire may be connected in the field, unless the wire and a means of making the connection, such as a pressure wire connector, soldering lugs, soldered loop, crimped eyelet, and the like, factory-assembled to the wire, are provided as a part of the product.

11.3.2 A permanently-connected product shall be provided with wiring terminals for the connection of conductors having an ampacity acceptable for the product, or the product shall be provided with leads for such connection.

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

Exception: A wire-binding screw may be employed at a wiring terminal intended to accommodate a 10 AWG (5.3 mm^2) or smaller conductor if upturned lugs or the equivalent are provided to hold the wire in position.

11.3.4 A wiring terminal shall be prevented from turning by means other than friction between surfaces.

11.3.5 The free length of a lead inside an outlet box or wiring compartment shall be 6 inches (152 mm) or more if the lead is intended for field connection to an external circuit.

Exception: Leads of field-wiring supply connections enclosed in a motor terminal box or motor wiring compartment may be less than 6 inches long.

11.3.6 A wire-binding screw at a wiring terminal shall not be smaller than No. 10.

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

11.3.7 A wire-binding screw shall thread into metal.

11.3.8 A terminal plate tapped for a wire-binding screw shall be of metal not less than 0.050 inch (1.27 mm) thick. There shall be at least two full threads in the metal of the plate.

Exception: A plate not less than 0.030 inch (0.76 mm) thick may be used if the tapped threads have the required mechanical strength.

11.3.9 A terminal plate formed from stock having an acceptable thickness as specified in 11.3.8, may have the metal extruded at the tapped hole to provide two full threads for the binding screw.

11.3.10 Upturned lugs or a cupped washer shall be capable of retaining a supply conductor of the size indicated in 11.3.2 under the head of the screw or washer.

11.4 Grounded connections

11.4.1 A permanently-connected product rated 125 or 125/250 volts (3-wire) or less and employing a lampholder of the Edison-screw-shell type, or a single-pole switch or overcurrent-protective device other than an automatic control without a marked-off position, shall have one terminal or lead identified for the connection of the grounded conductor of the supply circuit. The identified terminal or lead shall be the one that is electrically connected to screw shells of lampholders and to which no switches or overcurrent-protective devices of the single-pole type, other than automatic controls without a marked-off position, are connected.

11.4.2 A terminal intended for the connection of a grounded power-supply conductor shall be plated with or be of metal that is substantially white in color and shall be readily distinguishable from the other terminals, or proper identification of that terminal shall be clearly shown in some other manner, such as on an attached wiring diagram.

11.4.3 A lead intended for the connection of a grounded power-supply conductor shall be finished to show a white or gray color and shall be readily distinguishable from the other leads.

11.5 Equipment-grounding

11.5.1 An equipment-grounding terminal or lead shall be provided on the product.

11.5.2 A field-wiring terminal intended solely for connection of an equipment-grounding conductor shall be capable of securing a conductor of the size intended for the application. See 11.5.5.

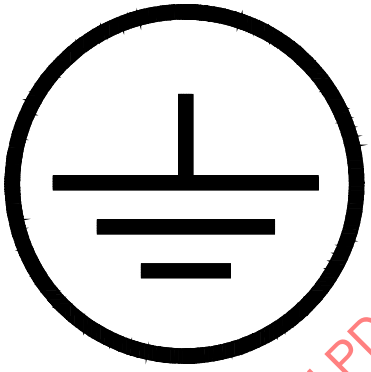
11.5.3 The surface of the insulation on a lead intended solely for connection of an equipment-grounding conductor shall be green with or without one or more yellow stripes, and no other lead shall be so identified.

11.5.4 The requirements in 11.4.2 – 11.5.3 relating to color coding for identification do not apply to internal wiring that is not visible in a wiring compartment in which field connections are to be made.

11.5.5 A wire-binding screw intended for the connection of an equipment-grounding conductor shall have a green-colored head that is hexagonal, slotted, or both. A pressure wire connector intended for connection of such a conductor shall be plainly identified, such as by being marked, "G", "GR", "GND", "Ground", "Grounding", the grounding symbol illustrated in Figure 11.1, or by a marking on a wiring diagram provided on the product. The wire-binding screw or pressure wire connector shall be located so that it is unlikely to be removed during servicing of the product and shall have upturned lugs or the equivalent to retain the conductor.

Figure 11.1

Grounding Symbol



IEC417, Symbol 5019

12 Grounding

12.1 A power-supply cord of a product intended for use:

a) Outdoors;

b) In the presence of water; or

c) On a circuit operating at a potential of more than 150 volts to ground.

shall include an equipment-grounding conductor.

Exception: A product intended for use outdoors and operating at potentials of not more than 150 volts to ground may be provided with double insulation complying with the Standard for Double Insulation Systems for Use in Electrical Equipment, UL 1097, in lieu of grounding.

12.2 If a means for grounding is provided in a product even though it is not required, it shall comply with the requirements in 12.3 – 12.6.

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

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

b) Connected to the grounding member of an attachment plug having a fixed grounding contact; and

c) Connected to the frame or enclosure of the product by a screw or other equivalent means not likely to be removed during any servicing operation not involving the power-supply cord. Solder alone shall not be used for securing the grounding conductor.

12.4 The screw mentioned in 12.3(c) shall be of corrosion-resistant material, or shall be protected against corrosion in a manner that will not inhibit electrical conductivity between the screw and any other conductor. A lock washer shall be used to reduce the likelihood of the screw becoming loosened by vibration.

12.5 All exposed dead-metal parts and all dead-metal parts within the enclosure that are exposed to contact during any servicing operation and that are likely to become energized shall be conductively connected to the grounding means.

12.6 With reference to the requirement in 12.5, 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, or 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 or cover that is secured in place and 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 (0.8 mm) thick.

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

d) A core and assembly screw of a relay, solenoid, and the like.

13 Current-Carrying Parts

13.1 A current-carrying part shall be silver, copper, a copper alloy, or other metal intended for the application.

13.2 Ordinary iron or steel, if provided with a corrosion-resistant coating, may be used for a current-carrying part if evaluated in accordance with 2.1, or within a motor or associated governor; but ordinary iron or steel for current-carrying parts elsewhere in the product is not to be used. The foregoing restriction does not apply to stainless steel.

13.3 The frame or enclosure of a product shall not be used to carry current.

14 Internal Wiring

14.1 General

14.1.1 The wiring and electrical connections between parts of a product shall be protected or enclosed.

Exception: A length of flexible cord may be employed for external connections if flexibility is essential. See 14.1.2.

14.1.2 Insulated wiring exposed through an opening in the enclosure of a product is considered to be protected if, when judged as though it were film coated wire, the wiring complies with the requirements in Accessibility of Parts, Section 7. Internal wiring not so protected may be used if it is secured within the enclosure so that it is unlikely to be subjected to stress or mechanical damage.

14.1.3 Wiring that may be located in proximity to flammable material, or that may be subjected to mechanical damage shall be enclosed in armored cable, rigid metal conduit, electrical metallic tubing, metal raceway, or other protection determined to be equivalent.

14.1.4 Internal wiring shall be routed and secured so that neither it nor related electrical connections are likely to be subjected to stress or mechanical damage.

14.1.5 Metal clamps and guides used for routing stationary internal wiring shall be provided with smooth, rounded edges. Auxiliary nonconducting mechanical protection shall be provided under a clamp if pressure is exerted on a conductor having thermoplastic insulation less than 1/32 inch (0.8 mm) thick and no overall braid.

14.1.6 Each splice and connection shall be mechanically secured and shall provide electrical contact. A soldered connection shall be made mechanically secure before being soldered if breaking or loosening of the connection may result in a risk of fire, electric shock, or injury to persons. Consideration shall be given to vibration, or the like, when evaluating electrical connections. Mechanical splicing devices may be used.

14.1.7 Insulated wires may be bunched and passed through a single opening in a metal wall within the enclosure of a product if inductive heating from wires carrying large currents will not present a risk of fire or electric shock.

14.1.8 A hole in a sheet-metal wall within the overall enclosure of a product through which insulated wires shall be provided with a smooth, rounded bushing or shall have smooth, rounded surfaces upon which the wire can bear, to reduce the likelihood of damage to the conductor insulation.

14.1.9 A flexible cord used for external interconnection as specified in 14.1.1 shall be provided with strain relief and bushings in accordance with the requirements in 10.2.1 – 10.3.7 and the Strain Relief Test, Section 39.

14.2 Wires

14.2.1 Each type of internal wiring shall be intended for the application when considered with regard to:

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

b) Exposure to oil or grease; and

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

14.2.2 Wiring and any supplementary insulation provided on wire that is subject to motion may be subjected to a flexing test to determine acceptability for the application.

14.2.3 A splice shall be provided with insulation determined to be equivalent to that of the wires involved if permanence of spacing between the splice and other metal parts may not be maintained.

14.2.4 Insulation consisting of two layers of friction tape, two layers of thermoplastic tape, or one layer of friction tape on top of one layer of rubber tape, may be used on a splice. To determine if splice insulation consisting of coated-fabric, thermoplastic, or other type of tubing may be used, consideration is to be given

to such factors as its dielectric properties, heat- and moisture-resistant characteristics, and the like. Thermoplastic tape wrapped over a sharp edge shall not be used.

14.2.5 Aluminum conductors, insulated or uninsulated, used as internal wiring, such as for internal connection between current-carrying parts or as motor windings, shall be terminated by a method determined to be acceptable for the combination of metals involved at the point of connection.

14.2.6 With reference to the requirements in 14.2.5, a wire-binding screw or a pressure wire connector used as a terminating device shall be intended for use with aluminum under the conditions involved – for example, temperature, heat cycling, and vibration.

14.2.7 Where stranded internal wiring is connected to a wire-binding screw, loose strands of wire shall not contact other uninsulated live parts that are not always of the same polarity as the wire and shall not contact dead-metal parts. This may be accomplished by use of pressure terminal connectors, soldering lugs, crimped eyelets, soldering all strands of the wire together, or other means determined to be equivalent.

14.2.8 A nominal 0.110, 0.125, 0.187, 0.205, or 0.250 inch (2.79, 3.18, 4.75, 5.21, or 6.35 mm) wide quick-connect terminal shall comply with the Standard for Electrical Quick-Connect Terminals, UL 310. Other sizes of quick-connect terminals shall be investigated with regard to crimp pull-out, engagement-disengagement forces of the connector and tab, and temperature rises, all tests to be conducted in UL 310.

15 Insulating Materials

15.1 Electrical insulation

15.1.1 Uninsulated live parts shall be mounted on porcelain, phenolic composition, or other material that complies with the requirements for the application.

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

15.1.3 Small molded parts, such as brush caps, shall have the necessary mechanical strength and rigidity to withstand the stresses of actual service.

15.1.4 A printed wiring-board used in a primary circuit, or in a secondary circuit where loosening of the conductor from the base material might result in a risk of electric shock, shall comply with the requirements for the application.

15.2 Thermal insulation

15.2.1 Flammable or electrically conductive heat-insulating material shall not contact an uninsulated live part.

15.2.2 With reference to 15.2.1, some types of mineral-wool thermal insulation contain conductive impurities in the form of slag that may result in a risk of fire or electric shock if used in contact with uninsulated live parts.

16 Motors

16.1 General

16.1.1 A motor shall be intended for the application, and shall be capable of handling the maximum intended load of the product without introducing a risk of fire, electric shock, or injury to persons.

16.2 Overload protection

16.2.1 A product employing a motor rated at 1 horsepower (746 W output) or less and intended to be remotely or automatically controlled, or intended for continuous operation, shall incorporate motor-overload protection in accordance with 16.2.6.

16.2.2 A motor intended for continuous operation is one that operates at a substantially constant load for not less than 3 hours.

16.2.3 For a multispeed motor, of any of the types specified in 16.2.1, that employs a separate overload-protective device to provide overload protection, the requirements in 16.2.1 apply at all speeds at which the motor is intended to operate.

16.2.4 A product is considered to be remotely controlled if it is not within sight of the operator at the location of the starting device.

16.2.5 A product is considered to be automatically controlled under any one or more of the following conditions:

a) If the repeated starting of the product beyond one complete predetermined cycle of operation, to the point where some form of limit switch opens the circuit, is independent of any manual control.

b) If, during any single predetermined cycle of operation, the motor is caused to stop and restart one or more times.

c) If, upon energizing the product, the initial starting of the motor may be intentionally delayed beyond intended, conventional starting.

d) If, during any single predetermined cycle of operation, automatic changing of the mechanical load may reduce the motor speed sufficiently to reestablish starting-winding connections to the supply circuit.

16.2.6 Motor-overload protection required for a product shall consist of one of the following:

a) Thermal protection or the equivalent, complying with the applicable requirements in the Standard for Rotating Electrical Machines, UL 1004-1, the Standard for Impedance Protected Motors, UL 1004-2, or the Standard for Thermally Protected Motors, UL 1004-3.

Exception: 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, shall be provided with locked rotor protection.

b) Impedance protection complying with the applicable requirements in the Standard for Rotating Electrical Machines, UL 1004-1, the Standard for Impedance Protected Motors, UL 1004-2, or the Standard for Thermally Protected Motors, UL 1004-3, when the motor is tested as used in the product.

16.2.7 Motor overload protection provided for a product not required to have such protection shall:

a) Comply with the requirements in 16.2.6; or

b) Be investigated to determine that it will not introduce or increase the risk of fire, electric shock, or injury to persons.

16.3 Brush-holder assembly

16.3.1 A brush cap shall be secured or located to reduce the likelihood of mechanical damage that might result during intended use.

16.3.2 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:

a) An accessible dead-metal part becoming energized; and

b) A live part becoming accessible.

17 Overcurrent Protection

17.1 If a circuit breaker provides branch circuit overcurrent protection and the circuit breaker handle is operated vertically rather than rotationally or horizontally, the up position of the handle shall be the on position.

18 Switches and Controls

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

18.2 With reference to the requirement in 18.1, the current rating of a switch that controls an inductive load other than a motor, such as a transformer or an electric-discharge-lamp ballast, shall not be less than twice the rated full-load current of the component unless the switch has been investigated and determined to be intended for the application.

18.3 A manually-operated motor-control switch shall be provided in a cord-connected product that employs a motor rated more than 1/3 horsepower (250 W output).

18.4 A switch that controls a lampholder for an incandescent lamp other than a 15-watt or smaller pilot or indicating lamp shall be intended for use with tungsten-filament lamps or shall have a current rating not less than six times the steady state tungsten load for alternating current or ten times the steady state load for direct current.

19 Lampholders

19.1 The screw shell of an Edison-base lampholder in a product equipped with a polarized attachment plug shall be connected to the lead that is intended to be connected to the grounded conductor of the power-supply circuit.

20 Capacitors

20.1 A capacitor that employs a liquid dielectric medium more combustible than askarel shall not expel the dielectric medium when tested in accordance with the applicable performance requirements in this standard.

20.2 A capacitor provided as a part of a capacitor motor and a capacitor connected across the line, such as a capacitor for radio-interference elimination or power-factor correction, shall be housed within an

enclosure or container so that the plates will not be subject to mechanical damage and so that there will be no emission of flame or molten material should malfunction or breakdown of the capacitor occur. The container shall be of metal providing strength equivalent to uncoated steel having a thickness of 0.020 inch (0.51 mm).

Exception: The individual container of a capacitor may be of sheet metal less than 0.020 inch thick or may be of material other than metal if the capacitor is mounted in an enclosure that houses other parts of the product, and provided that such a box, case, or the like, complies with the requirements for the enclosure of live parts.

21 Secondary Circuits

21.1 Each secondary circuit shall comply with the applicable requirements in this standard.

Exception No. 1: A circuit supplied by the secondary winding of a transformer that complies with the requirements for a Class 2 transformer need not be investigated.

Exception No. 2: A circuit supplied by a single source consisting of an isolating transformer with an open circuit potential of 30 volts rms (42.4 volts peak) or less need not be investigated from the point at which the current and voltage are limited if the combination of the transformer and a fixed impedance or regulating network complies with the performance requirements for a Class 2 transformer or a secondary circuit fuse having a maximum current rating as specified in Table 21.1 is provided.

Table 21.1
Rating of fuse or circuit protector

Open-circuit volts (peak)	Rating, amperes
0 – 21.2	5.0
21.3 – 42.4	3.2

21.2 With reference to 21.1, if an interchangeable fuse – a fuse is interchangeable if any fuse of a higher ampere rating will fit the fuseholder – is used, a legible and permanent marking shall be provided next to the fuseholder indicating the ampere rating of the fuse to be used for replacement. See 58.5.

22 Spacings

22.1 The spacings at wiring terminals through air or over surface shall not be less than 1/4 inch (6.4 mm) between wiring terminals and terminals and other parts not always of the same polarity (this applies to the sum of the spacings involved where an isolated dead-metal part is interposed). See 22.13.

22.2 Other than at wiring terminals, or inside a motor, the spacings between uninsulated live parts of opposite polarity, and between an uninsulated live part and a dead-metal part shall not be less than the value specified in Table 22.1. If an uninsulated live part is not rigidly fixed in position, by means other than friction between surfaces, or if a movable dead-metal part is in proximity to an uninsulated live part, the construction shall be such that the minimum spacing shall be maintained. See 22.13.

Exception: Spacings may be less than indicated in Table 22.1 if they comply with the applicable requirements in 22.8 – 22.10.

Table 22.1
Spacings at other than wiring terminals

Potential involved volts	Minimum spacings					
	Product employing a motor having a diameter[a] of:					
	7 inches (178 mm) or less		More than 7 inches (178 mm)			
	Through air or over surface		Over surface		Through air	
	inch	(mm)	inch	(mm)	inch	(mm)
0 – 125	3/32	(2.4[b])	1/4	(6.4[c])	1/8	(3.2[c])
126 – 250	3/32	(2.4)	1/4	(6.4[c])	1/4	(6.4[c])

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

[b] For a motor rated 1/3 horsepower (250 W output) or less, these spacings may be not less than 1/16 inch (1.6 mm).

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

22.3 The spacings in a motor shall comply with the spacing requirements in the Standard for Rotating Electrical Machines, UL 1004-1, the Standard for Impedance Protected Motors, UL 1004-2, or the Standard for Thermally Protected Motors, UL 1004-3. In a product incorporating two or more motors of different sizes, the spacings inside each motor are to be judged on the basis of the size of that motor, and the spacings elsewhere in the product are to be judged on the basis of the size of the largest motor in the product.

22.4 If an isolated dead-metal part is interposed between or is in close proximity to:

a) Live parts of opposite polarity;

b) A live part and an exposed dead-metal part; or

c) A live part and a dead-metal part that may be grounded,

the spacing may not be less than 3/64 inch (1.2 mm) between the isolated dead-metal part and any one of the other parts previously mentioned if the total spacing between the isolated dead-metal part and the two other parts is not less than the value specified in Table 22.1.

22.5 An insulating liner or barrier of vulcanized fiber or similar materials employed where spacings would otherwise be insufficient shall not be less than 1/32 inch (0.8 mm) thick, and shall not be adversely affected by arcing, except that vulcanized fiber not less than 1/64 inch (0.4 mm) thick may be used in conjunction with an air spacing of not less than 50 percent of the spacing required for air alone.

Exception: Thinner insulating material may be used if, upon investigation, it is determined to be intended for the application.

22.6 Barriers shall be held in place by a means more secure than friction between surfaces. The elasticity of tubing shall not be depended upon to hold the tubing in place, but dilated or heat-shrunk tubing may be used.

22.7 The spacing between parts of different circuits shall not be less than the largest spacings required for the circuits involved.

22.8 The spacings specified in 22.2 do not necessarily apply to the inherent spacings of a component of the product, such as a snap switch. Such spacings shall comply with the requirements for the component in question if they are less than the applicable values specified in Table 22.1.

22.9 At closed-in points, such as the screw-and-washer construction of an insulated terminal mounted in metal, a spacing less than 3/64 inch (1.2 mm) shall not be used. Within a thermostat, other than at the contacts, the spacing between uninsulated live parts on opposite sides of the contacts may not be less than 1/32 inch (0.8 mm) through air and 3/64 inch over the surface of insulating material if the spacings will be maintained permanently.

22.10 The acceptability of spacings in an isolated secondary circuit supplied by a transformer with a potential of 30 volts rms (42.4 volts peak) or less shall be determined by the applicable Dielectric Voltage-Withstand Test, Section 34.

22.11 Film-coated wire is regarded as an uninsulated live part when spacings are being considered.

22.12 In applying Table 22.1 to a motor not rated in horsepower, use is to be made of the appropriate table in the National Electrical Code, NFPA 70, that gives the relationships between horsepower and full-load currents for motors.

22.13 At terminal screws and studs to which connection may be made in the field by means of wire connectors, eyelets, and the like, as described in 11.3.1, the spacings shall not be less than those specified in Table 22.1 when the connectors, eyelets, and the like are in such position that minimum spacings – opposite polarity and to dead metal – exist.

23 Batteries and Battery Chargers

23.1 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 multiple 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.

23.2 Primary batteries (non-rechargeable) that comply with the relevant UL standard and 23.1 are considered to fulfill the requirements of this standard.

23.3 A Class 2 battery charger 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 – Safety – Part 1: General Requirements, UL 60950-1 with an output marked "Class 2", or that complies with the limited power source (LPS) requirements and is marked "LPS".

23.4 A non-Class 2 battery charger shall comply with one of the following:

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

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

24 Attachments

24.1 A functional attachment that is made available or recommended by the manufacturer for use with the basic product shall be included in the investigation of the product. Unless the manufacturer recommends the use of two or more attachments at the same time, only one attachment at a time shall be investigated with the product.

24.2 The literature accompanying a package containing a basic product and attachment intended to be marketed as a complete unit shall indicate what attachments are intended for use with the basic product if use of such attachments may expose the user to a risk of injury.

24.3 An attachment that is packaged and marketed separately from the basic product and recommended by the manufacturer for use with the basic product shall be marked in a manner that will identify the product with which it is intended to be used. The identification shall appear in at least one of the following locations:

a) On the attachment;

b) On the package housing the attachment;

c) In the instruction book for the basic product; or

d) In information furnished with the attachment.

25 Sharp Edges and Corners

25.1 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.

25.2 Whenever referee measurements are necessary to determine that a part as described in 25.1 is not sufficiently sharp to constitute a risk of injury to persons, the method described in the Standard for Tests for Sharpness of Edges on Equipment, UL 1439, is to be employed.

26 Enclosures and Guards

26.1 A rotor of a motor, pulley, belt, gear, or other moving part that can present a risk of injury shall be enclosed or guarded to reduce the likelihood of unintentional contact by persons.

Exception: A part or portion of a part that is necessarily exposed to perform its intended function need not be enclosed or guarded. See 26.4.

26.2 An enclosure or guard over a rotating part shall be capable of retaining:

a) A part that, because of malfunction or other reasons, may become loose or separate from a rotating part; and

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

26.3 A guard or portion of an enclosure acting as a guard for a part capable of causing injury to persons shall be:

a) Mounted to the assembly so that the part cannot be operated with the guard removed;

b) Secured to the assembly using fasteners requiring a tool for removal; or

c) Provided with interlocks to reduce access to the part.

26.4 Some guards are required to be of the self-restoring type. 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 additional risks of injury to persons, such as pinch points, and the necessity for additional handling because of the increased need for servicing, such as for cleaning, unjamming, and the like; and

f) Usage.

26.5 A moving part that may involve a risk of injury to persons shall comply with the requirements specified in Accessibility of Parts, Section 7, and shall be considered with regard to:

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

b) The sharpness of the moving part;

c) The likelihood of unintentional contact therewith;

d) The speed of the moving part; and

e) The likelihood that a part of the body or clothing would be endangered by the moving part.

These factors are to be considered with regard to both intended operation of the appliance and reasonably foreseeable misuse.

26.6 A manual or automatic feeding mechanism shall reduce the likelihood or need for an operator's finger to be in an area that is capable of causing injury.

26.7 If complete guarding of a moving part capable of causing injury to persons would defeat the utility of a product, a control, such as a momentary contact switch, shall be provided and an appropriate marking shall be provided in the instruction manual warning the user against the risk of injury to persons.

27 Switches, Controls, and Interlocks

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

27.2 The requirement in 27.1 will necessitate the use of an interlock if moving parts or the like would result in a risk of injury to persons upon automatic starting or restarting of the motor.

27.3 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.

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

27.5 A product that is provided with a switch that can be locked in the on position shall not introduce a risk of injury to persons when connected to a supply source with the switch in the on position and the product in an at-rest position.

27.6 The off position of a switch, other than a momentary-contact type, shall be such that the operator can determine visually that the product is off.

27.7 The actuator of an interlock switch shall be located so that unintentional operation is unlikely. See 27.4.

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

27.9 An interlock shall not be capable of being defeated by materials, such as wood or metal chips that could accumulate in intended use.

27.10 An interlock shall not be defeated readily:

a) Without damaging the product;

b) Without making wiring connections or alterations; or

c) By using household tools and materials that are readily available, such as a screwdriver, pliers, coin, paperclip, and the like.

27.11 If an interlock is actuated by movement of a guard, the part being guarded shall be capable of operation when the guard is in place and the interlock is in position. With the guard removed, the interlock shall comply with the requirements in 27.7.

PERFORMANCE

28 General

28.1 A product having both alternating- and direct-current ratings is to be tested while connected to an alternating-current supply and again to a direct-current supply, unless it can be established that one test will result in the most severe operating conditions.

28.2 A product rated 50 – 60 hertz is to be tested both at 50 and 60 hertz if performance is dependent upon frequency, unless it can be established that one test will result in the most severe operating conditions. A universal motor is generally considered not dependent upon frequency.

28.3 Unless otherwise noted in the individual requirements, all tests are to be conducted with the product connected to a supply circuit of rated frequency, and having a potential of:

a) For a product rated from 110 to 120 volts, inclusive, 120 volts;

b) For a product rated from 220 to 240 volts, inclusive, 240 volts; and

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

29 Leakage Current Test

29.1 The leakage current of a product, rated for a nominal 240 volt or less supply, when tested in accordance with 29.3 – 29.8, shall not be more than 0.5 milliampere.

29.2 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.

29.3 All exposed conductive surfaces are to be tested for leakage currents. For exposed conductive surfaces that are simultaneously accessible, the leakage currents from each are to be measured:

a) Individually to the grounded supply conductor;

b) Collectively to the grounded supply conductor; and

c) From one surface to another.

Parts are considered to be exposed surfaces unless guarded by an enclosure considered acceptable for reducing a risk of electric shock – see Accessibility of Parts, Section 7. 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 involve a risk of electric shock.

29.4 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 with an area of 10 by 20 centimeters (3.9 by 7.9 inches) in contact with the surface. Where 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.

29.5 The measurement circuit for leakage current is to be as shown in Figure 29.1. 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.

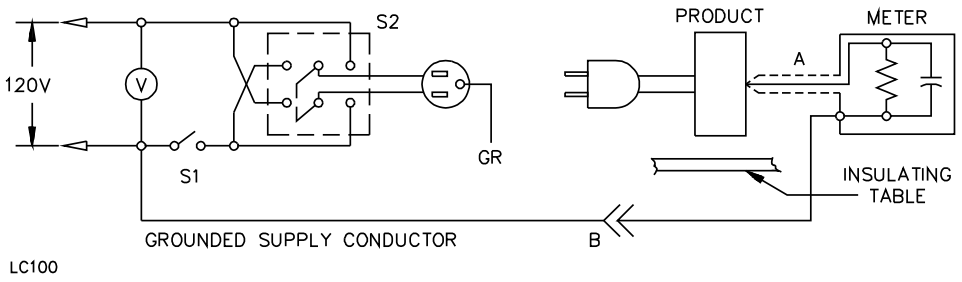
a) The meter is to have an input impedance of 1500 ohms resistive shunted by a capacitance of 0.15 microfarad.

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.

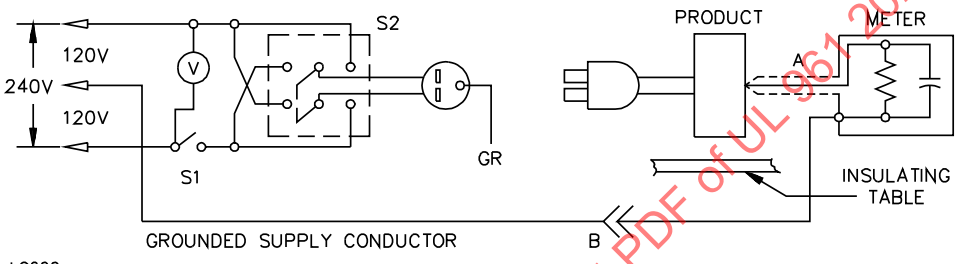
Figure 29.1

Leakage current measurement circuits



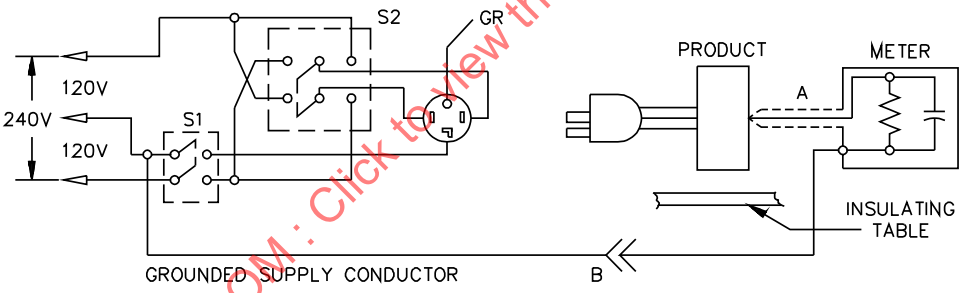
LC100

Product intended for connection to a 120-volt power supply.



LC200

Product intended for connection to a 3-wire, grounded neutral power supply, as illustrated above.



LC300

Product intended for connection to a 3-wire, grounded neutral power supply, as illustrated above.

A – Probe with shielded lead.

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

29.6 Unless the meter is being used to measure leakage from one part of a product to another, the meter is to be connected between the accessible parts and the grounded supply conductor.

29.7 A sample of the product is to be tested for leakage current starting with the as-received condition – as-received being without prior energization except as may occur as part of the production-line testing. The grounding conductor, if any, is to be open at the attachment plug. The supply voltage is to be adjusted to 120 or 240 volts, whichever is applicable based on the rating of the product. The test sequence, with reference to the measuring circuit, Figure 29.1, 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's switching devices in all their intended 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, with the product switching devices in all their intended 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 considered to be obtained by operation as in the temperature test.

29.8 Normally, the complete leakage current test program as described in 29.7, is to be conducted without interruption for other tests. However, with the concurrence of those concerned, the leakage current tests may be interrupted for the purpose of conducting other nondestructive tests.

30 Humidity Conditioning

30.1 A cord-connected product shall comply with the Leakage Current Test, Section 29, after being subjected to the humidity conditioning described in 30.2.

30.2 With reference to 30.1, a product is to be conditioned for 48 hours in moist air having a relative humidity of 88 ±2 percent at an ambient temperature of 32.0 ±2.0°C (89.6 ±3.6°F). The product is to be at a temperature just above that of the test chamber when placed inside the chamber. Following this exposure, while still in the test chamber, the product is to be tested unenergized as described in 29.7(a). The product is then to be tested energized as described in 29.7 (b) and (c), except that the test may be discontinued when the leakage current has stabilized or decreased. This test, 29.7 (b) and (c), may be conducted in the humidity chamber or immediately after the product has been removed from the humidity chamber.

31 Starting Current Test

31.1 A product shall start and operate as intended on a branch circuit employing a fuse that is other than a time-delay type and has a current rating corresponding to that of the branch circuit to which the product should be connected. To determine whether a product complies with this requirement it is to be started three times from standstill without opening the fuse. Tripping of an overload protector provided as part of the product or opening of the fuse is not acceptable.

Exception: The requirement does not apply if:

a) The product or the nature of its usage is such that it is likely to be used continually on the same branch circuit after installation;

b) The product will start and operate as intended on a circuit protected by a time-delay fuse; and

c) The product is marked in accordance with 55.1.

31.2 The product is to be at room temperature at the beginning of the test. The test is to be conducted at the voltage specified in 28.3, and rated frequency. Each start is to be made under conditions representing the beginning of operation – the beginning of the intended operating cycle in the case of an automatic product – and any motor is to be allowed to come to rest between successive starts.

32 Input Test

32.1 The current or wattage input to a product shall not be more than 110 percent of the rated value when the product is operated under the condition of maximum normal load as described in 32.2, and when connected to a supply circuit of maximum rated voltage and rated frequency. See 28.3.

32.2 In testing a product, maximum normal load is considered to be the load that approximates as closely as possible the most severe conditions of intended use. It is not a deliberate overload except as the conditions of actual use are likely to be somewhat more severe than the maximum load conditions that are recommended by the manufacturer of the product.

33 Temperature Test

33.1 When subjected to the temperature test described in 33.3 – 33.11, a product shall not:

a) Attain a temperature at any point sufficiently high to constitute a risk of fire or to damage any materials used in the product; or

b) Exceed the temperature rises specified in Table 33.1.

Also, a thermal- or overcurrent-protective device shall not open the circuit during the temperature test.

Table 33.1
Maximum temperature rises

Materials and components	°C	(°F)
A. MOTORS		
1. Class A insulation systems on coil windings of an AC 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	75	(135)
b) In a totally enclosed motor:		
Thermocouple or resistance method	80	(144)
2. Class A insulation systems on coil windings of an AC motor having a frame diameter of more than 7 inches (178 mm) of a DC 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 AC motor having a frame diameter of 7 inches (178 mm) or less, not including a universal motor:[a,b]		
a) In an open motor:		

Table 33.1 Continued on Next Page

Table 33.1 Continued

Materials and components	°C	(°F)
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 AC motor having a frame diameter of more than 7 inches (178 mm), of a DC 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)
5. Class F insulation systems on coil windings of an AC motor having a frame diameter of 7 inches (178 mm) or less, not including a universal motor:[b]		
a) In an open motor:		
Thermocouple or resistance method	120	(216)
B. COMPONENTS		
1. Capacitors:		
a) Electrolytic[c]	40	(72)
b) Other types[d]	65	(117)
2. Coil form:		
a) Nylon	40	(72)
b) Other thermoplastic	25	(45)
3. Contacts:		
a) Laminated	50	(90)
b) Solid	30	(54)
4. Fuses[e]	65	(117)
5. Lampholder screw shell and center contact	175	(315)
6. Rectifier:		
a) Selenium[f]	50	(90)
b) Silicon[f]	75	(135)
7. Relay, solenoid, and coils (except motor coil windings and transformers) with:		
a) Class 105 insulation systems:		
Thermocouple method	65	(117)
Resistance method	75	(135)
b) Class 130 insulation systems:		
Thermocouple method	85	(153)
Resistance method	105	(189)
c) Class 155 insulation systems:		
Thermocouple method	100	(180)
Resistance method	135	(243)
8. Sealing compound[g]	40	(104)

Table 33.1 Continued on Next Page

Table 33.1 Continued

Materials and components	°C	(°F)
	less than melting point	
9. Terminals	50	(90)
10. Transformers:		
a) Class 105 insulation systems:		
Thermocouple method	65	(117)
Resistance method	75	(135)
b) Class 130 insulation systems:		
Thermocouple method	85	(153)
Resistance method	95	(171)
c) Class 155 insulation systems:		
Thermocouple method	110	(198)
Resistance method	115	(207)
d) Class 180 insulation systems:		
Thermocouple method	125	(225)
Resistance method	135	(243)
11. Vibrator coils:		
Class 130 insulation systems:		
Thermocouple or resistance method	95	(171)
C. CONDUCTORS		
1. Copper conductors – general		
a) Copper conductor, bare or insulated, without tinning, nickel coating, or silver plating	175	(315)
b) Termination of copper conductor in a pressure terminal connector, unless both are tinned, nickel coated, or silver plate	125	(225)
2. Flexible cords (for example, SJO, SJT, SPT-3)	30	(54)
3. Rubber- or thermoplastic-insulated wires and cords[f,h]	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[f]:		
a) Laminated	100	(180)
b) Molded	125	(225)
3. Varnished-cloth insulation	60	(108)
E. SURFACES		
1. A surface upon which a unit may be placed or mounted in service, and surfaces that may be adjacent to the unit when it is so placed in or mounted	65	(117)
2. Wood or other combustible material, including the inside surface of the test enclosure and the surface supporting the appliance	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 may be more than the maximum 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 may be more than the specified value by:

1) 5°C (9°F) for Class A insulation on coil windings of alternating-current motors having a diameter of 7 inches (178 mm) or less, open type.

Table 33.1 Continued on Next Page

Table 33.1 Continued

Materials and components	°C	(°F)
2) 10°C (18°F) for Class B insulation on coil windings of alternating-current motors having a diameter of 7 inches (178 mm) or less, open type.		
3) 15°C (27°F) for Class A insulation on coil windings of alternating-current motors having a diameter of more than 7 inches (178 mm), open type.		
4) 20°C (36°F) for Class B insulation on coil windings of alternating-current motors having a diameter of more than 7 inches (178 mm) open type.		
[b] This is the diameter measured in the plane of the laminations of the circle circumscribing the stator frame, excluding lugs, fins, boxes, and the like, used solely for motor mounting, cooling, assembly, or connection.		
[c] For an electrolytic capacitor that is physically integral with or attached to a motor, the maximum temperature rise on insulating material integral with the capacitor enclosure may be no more than 65°C (117°F).		
[d] A capacitor that operates at a temperature rise of more than 65°C (117°F) may be evaluated on the basis of its marked temperature limit.		
[e] A fuse that has been investigated and determined to be intended for use at a higher temperature may be used at that temperature.		
[f] These limitations do not apply to compounds and components that have been investigated and determined to be acceptable for use at higher temperatures.		
[g] The maximum sealing compound temperature when corrected to a 25°C (77°F) ambient temperature is 15°C (27°F) less than the softening point of the compound as determined by the Standard Test Method for Softening Point by Ring-and-Ball Apparatus, ASTM E28.		
[h] A rubber-insulated conductor within a motor, a rubber-insulated motor lead, and a rubber-insulated conductor of a flexible cord entering a motor may be subjected to a higher temperature if the conductor is provided with sleeving or a braid that has been investigated and determined to be acceptable for use at the higher temperature. This does not apply to thermoplastic-insulated wires or cords.		

33.2 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, may be used if supplementary heat-resistant insulation of intended dielectric strength is used on the individual conductors of the cord to reduce the likelihood of conductor insulation deterioration.

33.3 Material that is subject to deterioration is to be removed from feet and other supports of the product prior to conducting the temperature test if absence of the material may result in the product attaining a higher temperature.

33.4 All values for temperature rise in Table 33.1 are based on an assumed ambient temperature of 25°C (77°F). Tests are to be conducted at any room ambient temperature within the range of 10 – 40°C (50 – 104°F).

33.5 For the test, the voltage is to be as specified in 28.3. If the product has a single frequency rating, the test is to be conducted at that frequency. A product rated AC-DC or DC-60 hertz is to be tested on direct current or 60-hertz alternating current, whichever results in higher temperatures. A product rated 25 – 60 or 50 – 60 hertz is to be tested on 60-hertz alternating current.

33.6 Temperatures are to be measured by thermocouples except when the resistance method may be used as indicated in 33.10. The 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 are necessary, thermocouples consisting of 30 AWG iron and constantan wires and a potentiometer-type indicating instrument are to be employed.

33.7 The thermocouples and related instruments are to be accurate and calibrated in accordance with accepted laboratory practice. The thermocouple wire is to conform with the requirements specified in the Tolerances on Initial Values of EMF versus Temperature tables in the Standard Specification and Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples, ASTM E230/E230M.

33.8 A thermocouple junction and adjacent thermocouple lead wire are to be held in thermal contact with the surface of the material the temperature of which is being measured. In most cases, acceptable thermal contact will result from taping or cementing the thermocouple in place; but if a metal surface is involved, brazing or soldering the thermocouple to the metal may be necessary.

33.9 Ordinarily, the temperature of a coil or winding is to be measured by means of thermocouples mounted on the outside of the coil wrap. If the coil is inaccessible for mounting thermocouples; for example, a coil immersed in sealing compound, or if the coil wrap includes thermal insulation or more than 1/32 inch (0.8 mm) of cotton, paper, rayon, or similar insulation, the resistance method is to be used. For the thermocouple-measured temperature of a coil of an alternating-current motor, other than a universal motor having a frame diameter of 7 inches (178 mm) or less, the thermocouple is to be mounted on the integrally applied insulation of the conductor.

33.10 In using the resistance method, the windings are to be at room temperature at the start of the test. The temperature rise of a winding is to be calculated from the formula:

$$\Delta t = \frac{R_2}{R_1}(k + t_1) - (k + t_2)$$

in which:

Δt is the temperature rise in degrees C;

R_2 is resistance of the coil at the end of the test in ohms;

R_1 is resistance of the coil at the beginning of the test in ohms;

k is 234.5 for copper, 225.0 for electrical conductor grade (EC) aluminum. Values of the constant k for other grades must be determined;

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

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

33.11 For a product that is not intended for continuous operation, the probable intermittent or short-time operation is to be taken into consideration when conducting the temperature test.

33.12 To determine whether a product complies with the requirement in 33.1, the product is to be operated until constant temperatures have been reached. A constant temperature 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. The product may be stationary during the test, and simulation of actual use conditions need not be attempted.

33.13 During the Temperature Test, Section 33, the temperature of a surface that may be contacted by the user shall not be more than the value specified in Table 33.2. If the test is conducted at an ambient temperature of other than 25°C (77°F), the results are to be corrected to that temperature.

Table 33.2
Maximum surface temperatures

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

[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 (0.13 mm) or less is to be evaluated as a nonmetallic part.

[b] See 31.2.

33.14 A surface that performs a needed heating function and is exposed to contact by the user of the product may exceed the temperature limits specified in Table 33.2 if:

a) It is obvious that the surface is hot;

b) A marking is provided as described in 58.7; and

c) The temperature of the surface drops below 70°C (158°F) within 3 minutes after the product is turned off.

34 Dielectric Voltage-Withstand Test

34.1 A product shall withstand for 1 minute without breakdown the application of a 60-hertz essentially sinusoidal potential between live parts and dead-metal parts with the product at the maximum operating temperature reached during intended use. Except as noted in 34.3 and 34.4, the test potential is to be:

a) One thousand volts for a product having no motor rated 1/2 horsepower (373 W output) or more.

b) One thousand volts plus twice the rated voltage for a product employing a motor rated more than 1/2 horsepower.

34.2 Secondary circuits of a product shall withstand for 1 minute the application of a test potential:

a) Between primary and secondary circuits;

b) Between secondary circuits and grounded metal with all chassis-connected components disconnected at the chassis; and

c) Between secondary circuits supplied from separate transformer windings with common connections disconnected.

The product is to be at its maximum normal operating temperature during the test. The test potential is to be as specified in 34.3.

34.3 The test potential for the secondary circuit is to be:

a) One thousand volts plus twice the operating voltage if the secondary operates at 251 – 600 volts.

b) One thousand volts if the secondary operates at 51 – 250 volts.

c) Five hundred volts if the secondary operates at 50 volts or less.

34.4 The test potential between the terminals of a capacitor employed for radio-interference elimination or arc suppression is to be 1000 volts, or 1000 volts plus twice rated voltage as indicated in 34.1 (a) and (b).

34.5 To determine compliance with 34.1 – 34.4, the product is to be tested by means of a 500 volt-ampere or larger transformer, the output voltage of which is essentially sinusoidal and can be varied. Starting at zero, the applied potential is to be increased until the required test value is reached, and is to be held at that value for 1 minute. The increase in the applied potential is to be at a substantially uniform rate, and as rapid as is consistent with its value being correctly indicated by a voltmeter.

35 Continuity of Ground Connection Test

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

35.2 The measurement required by 35.1 may be made using any instrument determined to be acceptable. If unacceptable results are measured, an alternating current of at least 20 amperes from a power supply of not more than 12 volts is to be passed from the point of connection of the equipment grounding means to a point in the grounding circuit, and the resulting drop in potential between the two points is to be measured. 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. The grounding conductor of a power-supply cord is not included in this measurement.

36 Resistance to Moisture Test

36.1 If a product incorporates a reservoir or liquid-storage chamber that is likely to be overfilled in service, liquid overflowing from the reservoir or chamber shall not wet uninsulated live parts or film-coated wires or electrical insulation that may be adversely affected by the liquid intended to be used in the reservoir.

36.2 To determine compliance with the requirements in 36.1, a product is to be tested as follows: a water solution consisting of 1/2 gram of calcium sulphate ($CaSO_4$) per liter of distilled water is to be used for the test, and is to be poured into the reservoir through an orifice 3/8 inch (9.5 mm) in diameter. The reservoir is to be filled to the level specified by the manufacturer, if such level is plainly marked; otherwise, the reservoir is to be filled to capacity. Additional solution, equal to 50 percent of the volume just mentioned, but not more than 200 milliliters, is then to be poured into the reservoir. To determine whether uninsulated live metal parts have become wet as a result of the overflow, the product is to be subjected to a leakage-current measurement or dielectric voltage-withstand test, or both if appropriate.

37 Rain Test

37.1 After conditioning as described in 37.2 and 37.3, a product intended for outdoor use shall comply with:

a) The requirement in 29.1 in a repeated leakage current test, except that the test is to be discontinued when the leakage current stabilizes; and

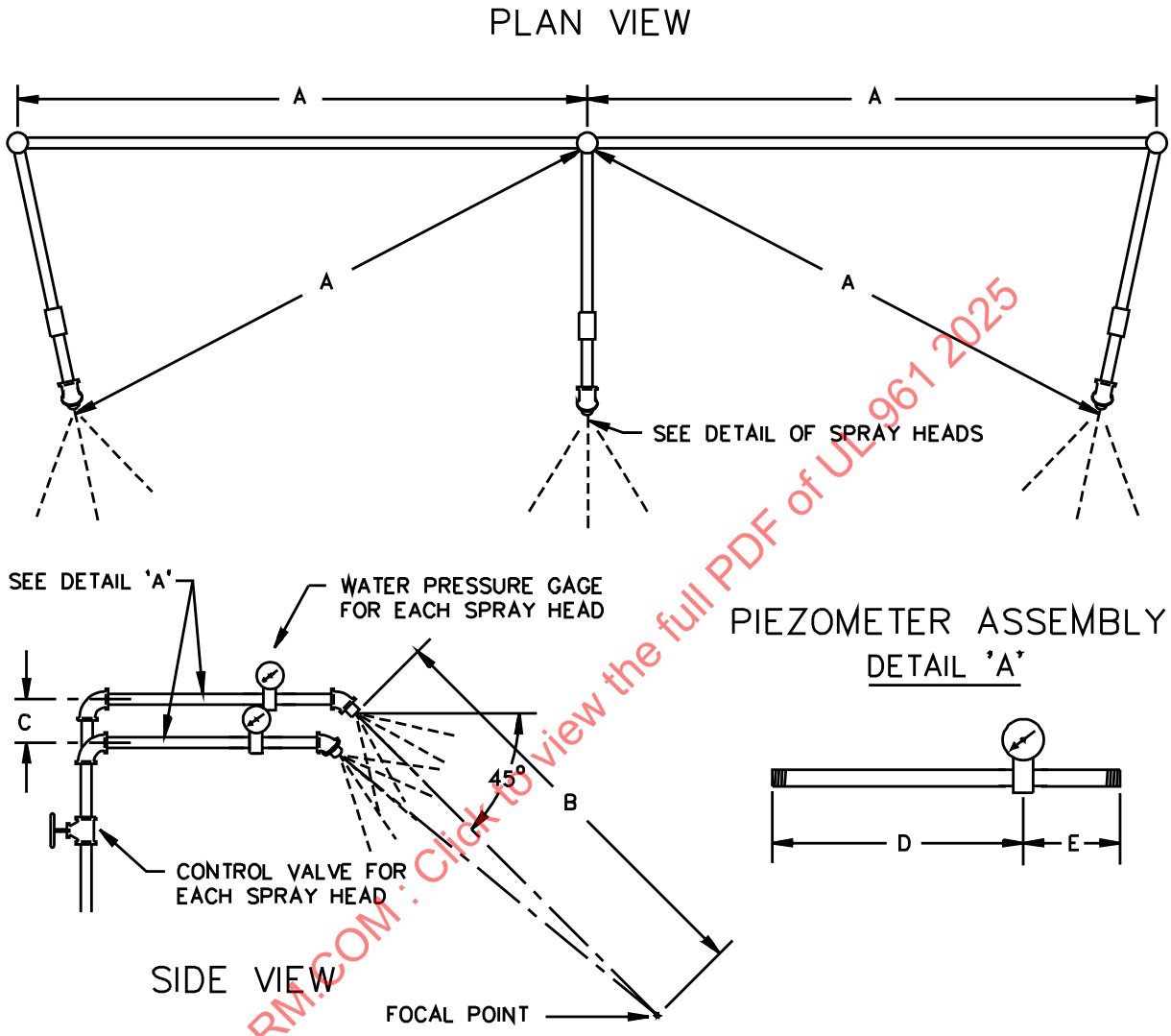
b) The requirement in 34.1 in a repeated dielectric voltage-withstand test.

37.2 A product supported in the intended operating position, is to be subjected for 1 hour to a downward spray of water onto the top and sides, applied to the product at an angle of 45 degrees from the vertical and in the direction most likely to cause water to enter. The product is not to be operated during exposure to the water spray.

37.3 The water spray test apparatus is to consist of three spray heads mounted in a water supply pipe rack as illustrated in Figure 37.1. The spray heads are to be constructed in accordance with the details illustrated in Figure 37.2. The water pressure for all tests is to be maintained at 5 pounds per square inch (34.5 kP) at each spray head. The distance between the center nozzle and the product is to be approximately 5 feet (1.5 m). The spray is to be directed at an angle of 45 degrees to the vertical toward louvers or other openings nearest current-carrying parts.

Figure 37.1

Spray head pipe rack



Item	inch	mm
A	28	710
B	55	1400
C	2–1/4	55
D	9	230
E	3	75

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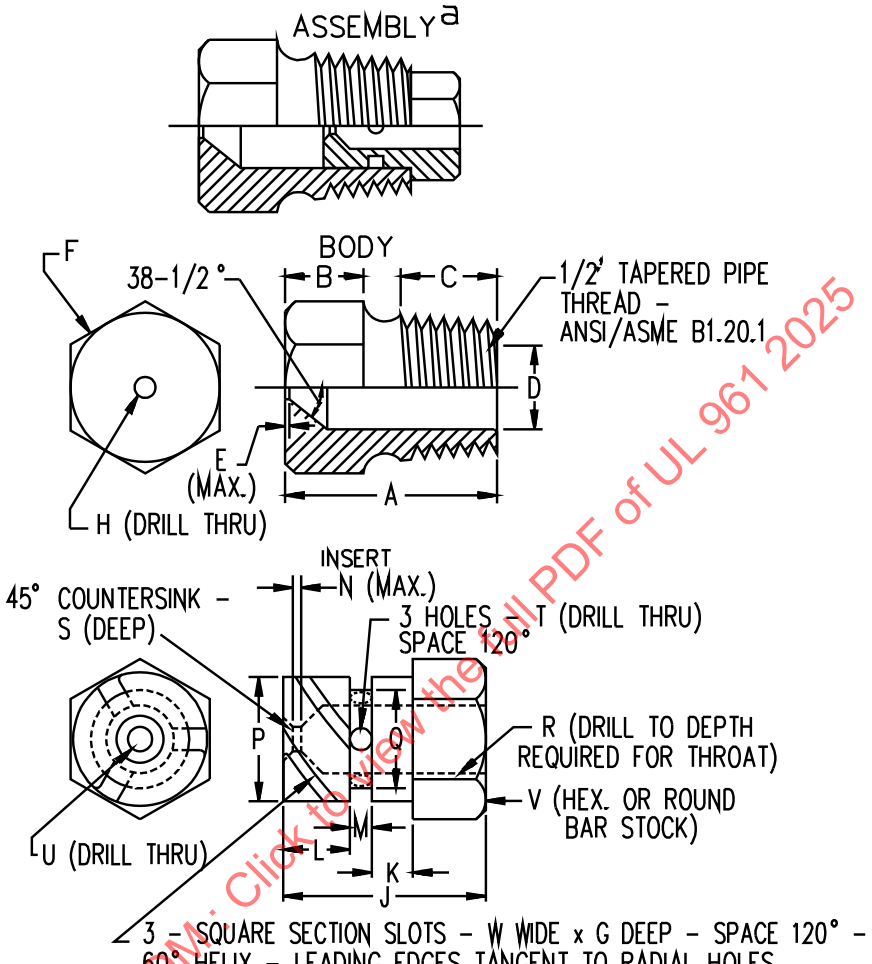
Figure 37.2

Spray head assembly



Item	inch	mm	Item	inch	mm
A	1-7/32	31.0	N	1/32	0.80
B	7/16	11.0	P	.575	14.61
C	9/16	14.0		.576	14.63
D	.578	14.68	Q	.453	11.51
	.580	14.73		.454	11.53
E	1/64	0.40	R	1/4	6.35
F	c	c	S	1/32	0.80
G	.06	1.52	T	(No. 35)[b]	2.80
H	(No.9)[b]	5.0	U	(No. 40)[b]	2.50
J	23/32	18.3	V	5/8	16.0
K	5/32	3.97	W	0.06	1.52
L	1/4	6.35			
M	3/32	2.38			

[a] Nylon Rain-Test Spray Heads are available from Underwriters Laboratories

[b] ANSI B94.11M Drill Size

[c] Optional - To serve as a wrench grip.

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38 Abnormal Operation Test

38.1 When a product is operated continuously under abnormal conditions that are likely to occur, there shall be no emission of flame or molten metal other than drops of melted solder, or glowing or flaming of flammable material upon which the product may be placed or, for a permanently installed product, flammable material that may be in proximity to the product as installed. The fuse in the grounding circuit shall not open. See 38.5.

38.2 After having been subjected to an abnormal test, a cord-connected product shall comply with the requirements of the Leakage Current Test, Section 29.

38.3 To determine whether a product complies with the requirements in 38.1 and 38.2, a separate burnout or abnormal test is to be conducted with the product operating continuously until the ultimate result has been determined. A cord-connected product is to be tested on white tissue paper on a softwood surface. The test is to be conducted with the applied voltage and method of mounting in accordance with 28.3 and 38.4, and with a 3-ampere fuse connected between the frame and ground. Continuous operation for 7 to 8 hours is usually necessary to determine that the ultimate result has been observed.

38.4 The test is to be conducted simulating the most severe installation for a product. Installation in an alcove, in a right-angle corner of a room, or against a wall is to be simulated if the product lends itself to such placement.

38.5 The abnormal conditions specified in 38.1 are determined from the individual product construction. Examples of abnormal conditions considered in the evaluation of a product include stalled rotor, overload, operation with current-carrying parts short-circuited, short or open circuiting of circuit components, and the like. For the test required in 38.1, only one malfunction is simulated at a time.

39 Strain Relief Test

39.1 The strain relief means provided on an attached flexible cord shall withstand without displacement the test described in 39.2. The strain relief does not comply with the requirements if, at the point of disconnection of the conductors, there is such movement of the cord as to indicate that stress would have resulted on the connections.

39.2 To determine whether the strain relief complies with the requirement in 39.1, the supply-cord conductors are to be severed immediately adjacent to the terminals or splices. A 35-pound (16-kg) weight is to be suspended on the cord for 1 minute. The strain relief means is to be stressed from any possible angle.

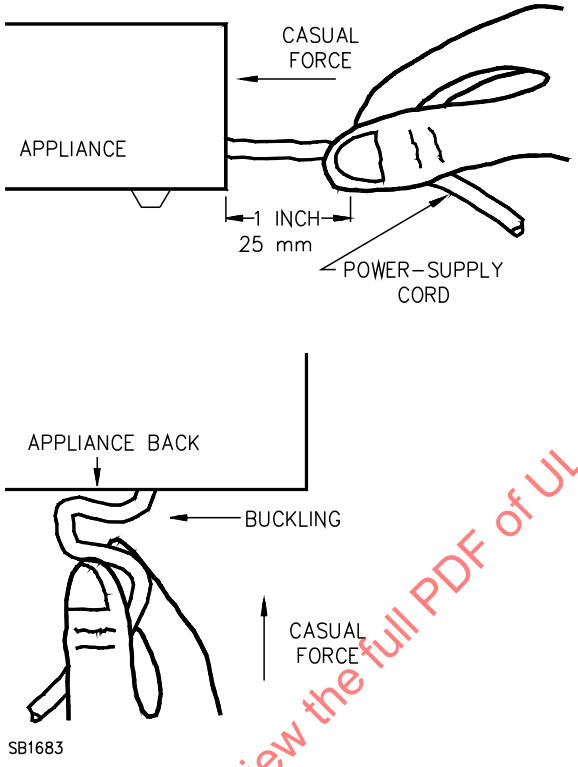
40 Push-Back Relief Test

40.1 To determine compliance with 10.2.2, a product shall be tested in accordance with 40.2 without occurrence of any of the conditions specified in 10.2.2.

40.2 The supply cord or lead is to be held 1 inch (25.4 mm) from the point where the cord or lead emerges from the product and is then to be pushed back into the product, as shown in Figure 40.1. When a removable bushing which extends further than 1 inch is present it is to be removed prior to the test. When the bushing is an integral part of the cord, then the test is to be carried out by holding the bushing. The cord or lead is to be pushed back into the product in 1 inch (25.4 mm) increments until the cord buckles or the force to push the cord into the product exceed 6 pounds-force (26.7 N). The supply cord or lead within the product is to be manipulated to determine compliance with 10.2.2.

Figure 40.1

Flexible cord or lead push-back/strain relief evaluation



41 Switches and Controls

41.1 Controls for solenoids, relay coils, or the like

41.1.1 A switch or other device that controls a solenoid, a relay coil, or the like shall perform as intended when subjected to an overload test consisting of 50 cycles of operation as described in 41.1.2. There shall be no electrical or mechanical malfunction or breakdown of the device or undue burning or pitting of the contacts, and the fuse in the grounding connection shall not open.

Exception: A device that has been investigated and determined to be intended for the application need not be subjected to an overload test.

41.1.2 To determine whether a switch or other control device complies with the requirement in 41.1.1, the product is to be connected to a power-supply circuit of rated frequency and 110 percent of maximum rated voltage. The load on the device being tested is to be the same as that which it is intended to control in service. During the test, exposed dead-metal parts of the product are to be connected to ground through a 3-ampere plug fuse. The device is to be operated at a rate of not more than 10 cycles per minute, except that a faster rate of operation may be used if agreeable to those concerned.

41.2 Controls for motors

41.2.1 A switch or other device that controls a motor of a product shall perform as intended when subjected to an overcurrent test consisting of 50 cycles of operation, making and breaking the locked-rotor current of the product. There shall be no electrical or mechanical malfunction or breakdown of the device, or undue pitting or burning of the contacts, and the fuse in the grounding connection shall not open.