SUBJECT 2682

OUTLINE OF INVESTIGATION

FOR

SWITCH-RATED PLUGS AND RECEPTACLES

Issue Number: 1

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Summary of Topics

This first issue of the Subject 2682 Outline of Investigation for Switch-Rated Plugs and Receptacles covers non-interlocking plugs, receptacles, power inlets and connectors for use in switching applications.

The UL Foreword is no longer located within the UL Standard. For information concerning the use and application of the requirements contained in this Standard, the current version of the UL Foreword is located on ULStandardsInfoNet at: http://ulstandardsinfonet.ul.com/ulforeword.html

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INTRODUCTION

1 Scope

1.1 This standard applies to non-interlocking plugs, receptacles, power inlets, and connectors for use in switching applications, rated up to 800 amperes and up to 600 volts ac or dc, and which may include pilot contacts. These devices are intended to provide power from branch circuits, or are for direct connection to the branch and motor circuit in accordance with the National Electrical Code ANSI/NFPA 70, using copper conductors, for use in either indoor or outdoor nonhazardous locations.

1.2 This standard does not apply to:

a) Single conductor pin and sleeve devices.

b) Devices molded integrally with flexible cord or cable that are covered by the Standard for Cord Sets and Power Supply Cords, UL 817.

c) General and special use devices, such as attachment plugs, receptacles, cord connectors, inlets, current taps, flatiron and appliance plugs, that are covered by the Standard for Attachment Plugs and Receptacles, UL 498.

d) Single and multi-pole connectors intended for connection to copper conductors, for use in data, signal, control and power applications within and between electrical equipment, where exposed, that are covered by the Standard for Component Connectors for Use in Data, Signal, Control and Power Applications, UL 1977.

e) Products such as branch circuit switches that are covered by the Standard for Enclosed and Dead-Front Switches, UL 98.

f) Products such as pin and sleeve devices that are not intended for switching applications and are otherwise covered by the Standard for Plugs, Receptacles, and Cable Connectors, of the Pin and Sleeve Type, UL 1682.

g) Devices intended for use in hazardous (Classified) locations that are covered by the Standard for Receptacle-Plug Combinations For Use in Hazardous (Classified) Locations, UL 1010.

2 Glossary

2.1 For the purposes of this standard, the following definitions apply:

2.2 CONNECTOR (CABLE CONNECTOR) – A portable receptacle that is intended to provide power, with means for attachment of flexible cord or cable and not intended for permanent mounting.

2.3 CONTACT – A conductive element in a component that mates with a corresponding element to provide an electrical path.

2.4 CONTACT, PILOT – A conductive element intended to carry an indicating or controlling signal.

2.5 DEAD FRONT – A mechanism or design that prevents unintentional exposure or accessibility to live contacts on the line side of the connector.

2.6 DELAYED ACTION – An arrangement that delays the separation of device housings, which is intended to reduce the likelihood of exposure of arcing contacts during the breaking of the circuit when the plug is withdrawn.

2.7 ENCLOSURE – The case or housing into which the insulator and contacts are assembled. The enclosure system may be composed of elements such as outlet boxes, mounting panels, receptacles, plugs, and connectors.

2.8 GROUNDING (BONDING) PATH – A path between the grounding contact and the grounding terminal or, if the device has no grounding terminal, the point at which the path makes contact with a part of the metal raceway system, such as a box, box cover, or the raceway itself.

2.9 GROUNDING TYPE DEVICE – A device having a grounding (bonding) path.

2.10 INSULATION, ELECTRICAL – The insulation necessary for the proper functioning of the product and for basic protection against electrical shock.

2.11 INSULATOR – That portion of a device that provides for separation and support of contacts.

2.12 LOCKING RETAINING MEANS – A mechanical arrangement that holds a plug or connector in position when it is in proper engagement and is intended to reduce the likelihood of its unintentional withdrawal. It may also facilitate environmental sealing.

2.13 MOTOR RATING – A rating expressed in horsepower (hp) and/or full load and locked rotor current, and voltage assigned to a device that is intended to control a motor load.

2.14 PLUG (ATTACHMENT PLUG) – A device intended to receive power when inserted in a receptacle or connector, which establishes connection between conductors of the attached flexible cord or cable and the conductors connected to the receptacle or cable connector.

2.15 POWER INLET – A permanently mounted plug intended to receive power from a cable connector.

2.16 RECEPTACLE (OUTLET) – A device that is intended to provide power to an inserted plug, and that is installed as a fixed outlet or on equipment.

2.17 SWITCH RATED PLUGS AND RECEPTACLES – Plugs and receptacles that may be used in either branch circuit or motor circuit switching applications.

2.18 TERMINAL – A conductive part provided on a contact for connecting a conductor.

2.19 TERMINAL, CRIMP TYPE – A terminal in which an electro-mechanical connection is made between the terminal lug and a conductor by compressing the lug onto the conductors.

2.20 TERMINAL, FIELD WIRING – A terminal to which power supply, load, control, or equipment grounding connections will be made in the field when the device is installed.

2.21 TERMINAL, PRESSURE-WIRE – A terminal in which the conductor is clamped under a pressure plate or saddle by one or more screws or nuts.

2.22 TERMINAL, SET SCREW – A terminal in which the clamping pressure is applied by the end of the screw bearing directly on the conductor.

2.23 TERMINAL, WIRE-BINDING SCREW – A terminal in which the conductor is bent around the screw and is clamped directly under the head of the screw when it is tightened.

3 General

3.1 Components

3.1.1 Except as indicated in Clause 3.1.2, a component of a product covered by this outline shall comply with the requirements for that component. See Appendix A for a list of standards covering components generally used in the products covered by this outline. A component shall comply with standards as appropriate for the country where the product is to be used.

3.1.2 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 outline, or

b) Is superseded by a requirement in this outline.

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

3.1.4 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.

3.2 Units of Measurement

3.2.1 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.

CONSTRUCTION

4 General

4.1 The ratings mentioned throughout this outline, including those mentioned in Clause 46.2, represent the maximum ampacity and voltage for a device. A device is considered to be for use with either alternating or direct current unless the rating includes a marking to restrict the use to alternating current. See Clause 47.5.1.

5 Configurations

5.1 Combinations of attachment plugs and receptacles are covered by this outline and standardized configurations of these attachment plugs and receptacle combinations are located in the Standard for Pin and Sleeve Configurations, UL 1686.

6 Insulating Material

6.1 A base or body in or on which live parts are mounted shall be of ceramic or other insulating material meeting the requirements of this outline.

6.2 Vulcanized fiber or rubber may be used for insulating washers, separators, and barriers, but not as the sole support for live parts. The material shall be moisture resistant in accordance with Section 24.

6.3 A polymeric material used for electrical insulation, an internal barrier necessary to maintain electrical clearances and creepage distances, or enclosure of live parts shall have a flame class rating of HB, V-2, V-1, V-0, VTM-2, VTM-1, VTM-0, 5VA or 5VB in accordance with the requirements of the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94. The flammability classification shall be judged at the actual minimum thickness employed within 0.8 mm (1/32 inch) of live parts within the device.

6.4 The internal insulating systems of components for which component requirements exist need not have a flame class rating.

6.5 A small part meeting all the following criteria need not have a flame class rating:

a) Its volume does not exceed 2 cm^3 (0.122 cubic inch);

b) Its maximum dimension does not exceed 3 cm (1.18 inches); and

c) Its location is such that it cannot propagate flame from one area to another or act as a bridge between a possible source of ignition and other ignitable parts.

6.6 Fiber and similar material that is equal to or less than 0.25 mm (0.010 inch) thick need not have a flame class rating.

6.7 A polymeric material used for electrical insulation, an internal barrier necessary to maintain electrical clearances and creepage distances, or enclosure of live parts shall comply with the requirements in Section 20 – 27.

6.8 A polymeric material having a maximum comparative tracking index (CTI) performance level class of 3 or a minimum CTI value of 175 need not comply with Comparative Tracking Index, Section 20.

6.9 A polymeric material having hot wire ignition (HWI) corresponding to the values shown in Table 6.1 for the applicable flammability classification need not comply with Glow Wire, Section 21.

6.10 A polymeric material having high-current arc resistance to ignition (HAI) corresponding to the values shown in Table 6.1 for the applicable flammability classification need not comply with High-Current Arc Resistance to Ignition, Section 22.

Table 6.1
Hot wire ignition (HWI) and high-current arc resistance to ignition (HAI) ratings of insulating materials
(See Clause 6.9)

Flammability classification[b]	HWI[c,e]		HAI[d]	
	Maximum PLC[a]	Minimum value	Maximum PLC[a]	Minimum value
V-0, VTM-0	4	7	3	15
V-1, VTM-1, 5VA, 5VB	3	15	3	15
V-2, VTM-2	3	15	3	15
HB	2	30	1	60

[a] For materials with other than VTM flammability classifications, the performance level class (PLC) for material shall be evaluated using the specimen thickness employed in the end product or nominal 3.2 mm (1/8 inch) thickness, whichever thickness is greater.

[b] Flammability classification- Described in Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94. The flammability classification shall be judged at the actual minimum thickness employed within 0.8 mm (1/32 inch) of live parts within the device.

[c] Hot Wire Resistance to Ignition – Described in Polymeric Materials – Short Term Property Evaluations, UL 746A.

[d] High-current arc resistance to ignition – Described in Polymeric Materials – Short Term Property Evaluations, UL 746A.

[e] The requirements for hot wire ignition (HWI) performance level class values do not apply to a polymeric material used as an enclosure of a portable device, that does not enclose live parts or insulated live parts where the insulation thickness is greater than 0.7 mm (0.028 inch).

6.11 The internal insulating systems of components for which component requirements exist need not comply with the requirements in Sections 20 – 22.

6.12 A small part meeting all the following criteria need not comply with the requirements in Sections 20 – 22:

a) Its volume does not exceed 2 cm^3 (0.122 cubic inch);

b) Its maximum dimension does not exceed 3 cm (1.18 inches); and

c) Its location is such that it cannot propagate flame from one area to another or act as a bridge between a possible source of ignition and other ignitable parts.

6.13 Fiber and similar material that is equal to or less than 0.25 mm (0.010 inch) thick need not comply with the requirements in Sections 20 – 22.

6.14 A polymeric material used for electrical insulation, an internal barrier necessary to maintain electrical clearances and creepage distances, or enclosure of live parts shall have the temperature index ratings shown in Table 6.2 for the specific application of the insulating material.

Table 6.2
Minimum relative thermal indices of insulating materials
(See Clause 6.14)

Application	Minimum relative thermal index[a], Degrees C		
	Electrical	Mechanical[b]	
		With impact	Without impact
ELECTRICAL INSULATION			
All devices	80	60	80
ENCLOSURE or parts of an ENCLOSURE			
A. All permanently wired devices and other devices containing fuses	80	60	80
B. All other devices	60	60	60

[a] Relative thermal index – Described in UL 746B. For materials with other than VTM flammability classifications, the material shall be evaluated using specimen thickness of no more than the thickness employed in the end product or nominal 3.2 mm (1/8 inch) thickness, whichever is greater.

[b] For filament wound tubing, industrial laminates, vulcanized fiber and similar polymeric materials, the minimum RTI for mechanical shall be the values specified for Electrical.

7 Resistance to Corrosion

7.1 Parts of iron or steel other than stainless steel parts shall be protected against corrosion, in accordance with Moisture Resistance, Section 44.

8 Enclosures

8.1 General

8.1.1 An enclosure shall be constructed to reduce the risk of unintentional contact with uninsulated live parts, as indicated in Clause 11.1, and to provide internal parts with protection from specified external conditions. Additional items used to form an enclosure, such as adapters, hoods, covers, and the like, shall be permitted to be permanently secured to the device.

8.2 Mechanical Strength

8.2.1 An enclosure shall have adequate strength and rigidity in accordance with Impact (Plugs and Connectors), Section 30 and Crush, Section 31.

8.3 Nonmetallic enclosures

8.3.1 A nonmetallic enclosure or a nonmetallic part of an enclosure shall comply with the applicable requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

8.3.2 If a nonmetallic enclosure is identified as being intended to be exposed to specific chemicals, oils, acids, solvents, cleaning agents, and the like, the performance of the enclosure material shall not be adversely affected by such substances as determined by applicable tests as described in the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A.

8.3.3 Pliable, molded natural or synthetic rubber, or a combination thereof, or a pliable composition, the basic constituent of which is vinyl chloride or a copolymer of vinyl chloride and vinyl acetate, in the finished device that complies with Accelerated Aging, Section 19, may be employed as an insulating material for the enclosure of an attachment plug or a cord connector.

8.4 Metallic enclosures

8.4.1 An enclosure may be constructed of iron, steel, copper, brass, zinc, aluminum, or their alloys. Aluminum alloys containing less than 80% aluminum shall not be used. Magnesium and its alloys shall not be used.

8.4.2 Zinc or a zinc-based alloy shall not be used for an enclosure or parts of an enclosure which are in the primary grounding path.

8.5 Attachment plugs

8.5.1 An attachment plug shall not be provided with more than one multiconductor cord-outlet hole.

8.6 Specific enclosures

8.6.1 An enclosure marked with one or more environmental enclosure type designations shall comply with the applicable requirements in Environmental Enclosure Type Designators, Section 45 and Environmental Enclosures, Section 47.13.

9 Current-Carrying Parts

9.1 A current-carrying part shall be of silver, copper, a copper alloy, or other material acceptable for the application. Plated iron or steel shall not be used for parts that are depended upon to carry current.

9.2 Stainless steel may be employed for a part not subject to arcing.

9.3 Pressure wire terminal screws and wire binding screws shall be permitted to be made of plated iron or steel

9.4 Iron or steel, if protected against corrosion by zinc, tin, or equivalent plating, may be used for screws, plates, yokes, or other parts that are employed as a means of clamping the conductor, providing such parts are not the primary current-carrying members.

9.5 Suitable means shall be provided for retaining live parts within such limits of alignment as to ensure that plugs will enter receptacles, connectors, and the like in the intended manner.

9.6 Uninsulated live parts shall be secured in place to ensure the clearances and creepage distances required in Clauses 10.1 and 10.3 are maintained.

9.7 A current-carrying part shall be prevented from turning relative to the surface on which it is mounted if such turning would result in a reduction of spacings below the minimum acceptable values.

10 Clearances and Creepage Distances

10.1 The clearances and creepage distances shall be not less than 6.4 mm (1/4 inch) between:

a) Field wiring terminals of opposite polarity; and

b) A field wiring terminal and any other uninsulated metal part of a different polarity.

10.2 For field wiring terminals intended for solder connections using solid or tin dipped stranded wire only, the minimum clearances and creepage distances between the terminals shall be as specified in UL 840.

10.3 In all circuits other than at field wiring terminals, the acceptability of the clearances and creepage distances between an uninsulated live part and any other uninsulated metal part, not of the same polarity shall be as specified in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840.

10.4 The dead metal mentioned in Clause 10.3 includes a metal surface on which the device is mounted in the intended manner. A dead-metal screw head, rivet, or the like is not considered to be exposed to contact by persons after the device is installed in the intended manner, if it cannot be contacted by the probe illustrated in Figure 10.1.

10.5 Clearances and creepage distances shall be measured in accordance with the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840. In determining the pollution degree and overvoltage category, the end-use application may be considered for a higher pollution degree and may modify those characteristics given in Clauses 10.8 and 10.9.

10.6 Clearances and creepage distances shall be measured in all conditions of use, both with and without mating devices of the intended configuration installed and any movable parts displaced to the position of a minimum spacing.

10.7 The clearances and creepage distances required in Clause 10.1 shall be measured through air and over insulating and conductive surfaces with the device wired as intended with the maximum anticipated conductor size. They shall be measured from any point on the terminal that may contact the clamped conductor as in the case of a wire-binding-screw terminal, or from any point on the perimeter of an opening to receive a conductor in the case of an enclosed terminal.

10.8 Indoor use equipment shall comply with the requirements for pollution degree 3. Outdoor use equipment shall comply with the requirements for pollution degree 4, unless protection is afforded by a suitable enclosure appropriate for the installation in which case a lower pollution degree can be achieved. The interior of equipment with enclosure Types 3, 3S, 4, 4X, 6 and 6P or Marine Type shall comply with the requirements for pollution degree 3. Hermetically sealed or encapsulated enclosures shall comply with the requirements for pollution degree 1.

10.9 Plugs, connectors, inlets, and other cord connected devices shall be rated overvoltage Category II and receptacles and other devices connected to fixed wiring shall be rated overvoltage Category III as defined in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840.

11 Accessibility of Live Parts

11.1 To reduce the likelihood of unintentional contact that may involve a risk of electric shock from uninsulated live parts, a live part shall not be contacted by the probe illustrated in Figure 10.1. See Clause 11.6.

11.2 The contacts of an outlet device must be protected from unintentional contact by means of a dead front with a means of indicating if the device is in the on or off position.

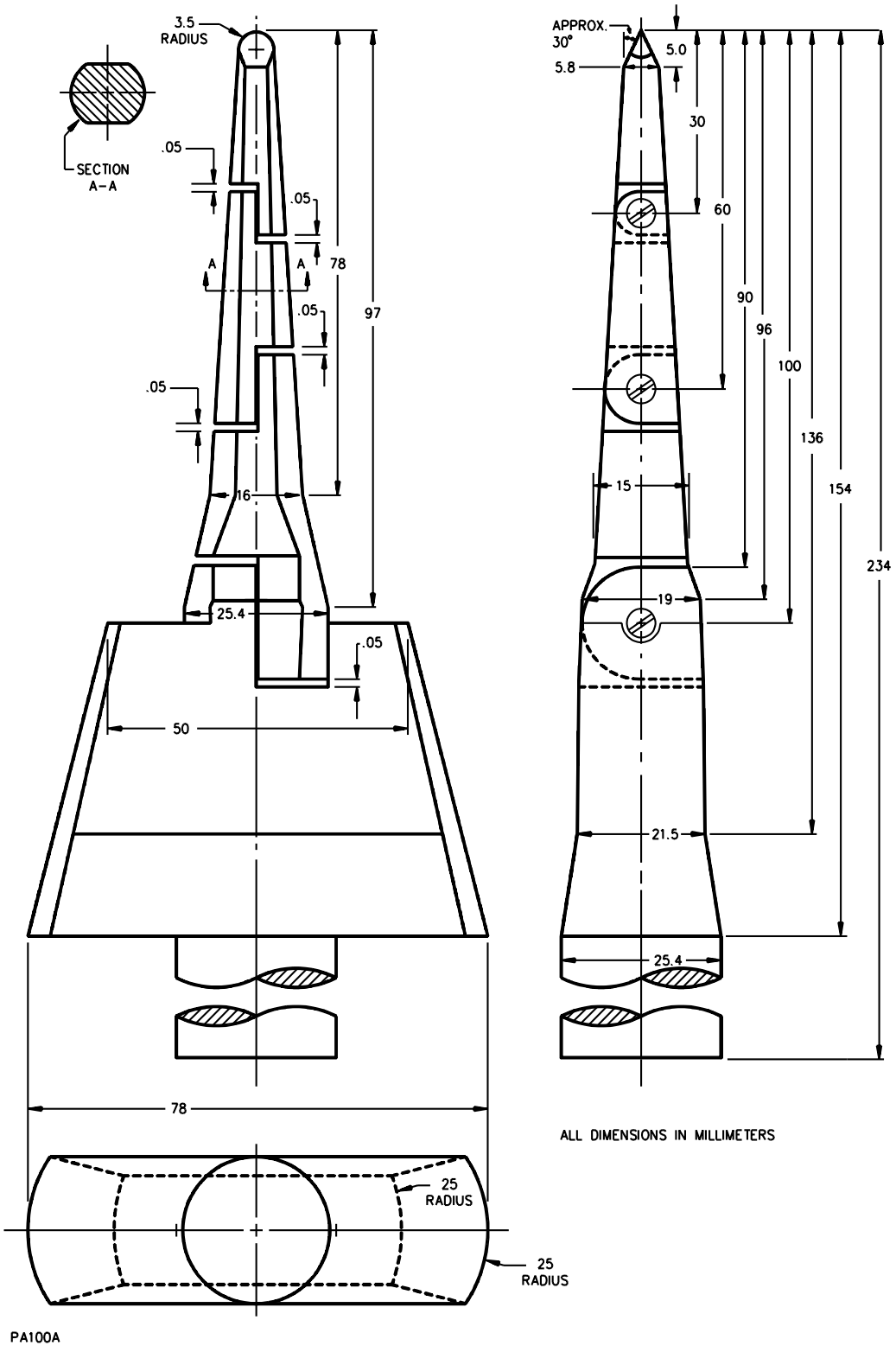
11.3 The probe illustrated in Figure 10.1 shall be applied to any depth that the recessing will permit, and shall be rotated, changed in configuration or angled before, during, and after application to any position that is necessary to examine the device.

11.4 The probe mentioned in Clause 11.1 shall be used as a measuring instrument to judge the accessibility provided by the recessing and not as an instrument to judge the strength of a material. The probe shall be applied with a force of 13 N (3 lbf) to determine accessibility.

11.5 During the examination of a product to determine whether it complies with the requirements in Clause 11.1, the device shall be wired and assembled in accordance with the manufacturer's instructions. Any other part that may be opened or removed by the user without using a tool shall be opened or removed.

11.6 Mating devices shall not have exposed live contacts when fully mated or during engagement or withdrawal.

Figure 10.1
Articulate probe with web stop
[See Clauses 10.4, 11.1, 11.3, 11.7, 23.1(a), 30.5(a), and 31.4(a)]



11.7 Compliance with Clause 11.6 shall be determined with the use of the probe shown in Figure 10.1 in every possible position. See Clause 11.3.

11.8 The probe shall not be applied to holes in the shroud provided for locking if they do not exceed 10.2 mm (0.400 inch) diameter.

12 Grounding (Bonding) and Dead Metal Parts

12.1 A grounding type device shall have a separate contact for interconnection of the equipment grounding conductor.

12.2 The equipment grounding terminal or lead and its corresponding contact of a male inlet or equipment outlet intended for permanent installation shall be conductively connected to the mounting means, housing, hood, shell or other dead-metal parts of a device that may come into contact with the equipment enclosure.

12.3 The conductive connection need not be provided if the mounting means, housing, hood, or shell is constructed of an insulating material and the lack of ground continuity to the equipment enclosure is readily apparent.

12.4 The conductive connection need not be provided if the device is marked in accordance with Clause 47.3.1.

12.5 A device that has a metal shell used as the grounding contact member shall be as follows:

a) The surface of the shell that is depended upon for grounding continuity shall not have a nonconductive coating or otherwise be subjected to conditions that may result in loss of grounding continuity;

b) One or more separate spring type components shall be incorporated to provide grounding path continuity;

c) The grounding components shall be protected against damage; and

12.6 The grounding contact shall be located and formed so the path of electrical continuity to the grounding contact of the mating plug is completed before continuity is established between any other contact and its respective contact on the plug.

12.7 The grounding contact path, except for the metal housing or mounting, shall be of copper or a copper alloy or equivalent material. If a metal housing is a part of the primary equipment grounding path, it shall not be of zinc or a zinc-based alloy.

12.8 A copper-base alloy rivet, which is used to hold parts together in the grounding-contact path or forms a part of the grounding path, shall not contain less than 80% copper.

12.9 A connection in the grounding-contact path shall be secured by riveting, bolting, clamping, or welding or by an equivalent mechanical means of securement, capable of complying with the requirements of Grounding (Bonding) Path Current, Section 33.

12.10 In mating devices provided with an equipment-grounding contact, the grounding contact shall not be capable of touching a line-side phase contact, independent of any polarization feature of the enclosure. The above requirement is applicable only to devices rated 100 A and less, with four or fewer power contacts, excluding grounding contacts. Such devices shall comply with the requirements of Resistance to Arcing, Section 38.

12.11 All exposed non-current-carrying metal parts of a device that are likely to become energized, shall be conductively connected to the equipment ground.

12.12 Grounding and other dead-metal parts shall be secured in place so the spacing required in Section 10 are maintained.

13 Grounding (Bonding) Connections

13.1 The grounding (or bonding) conductors of a device shall not be smaller in size than indicated in Table 13.1.

13.2 An integral grounding or bonding pigtail lead for field connection shall not be shorter than 150 mm (6 inches).

13.3 A terminal provided for the field connection of a grounding (or bonding) conductor shall:

a) Employ a mechanical clamping means that does not depend upon solder for the connection of the wire; and

b) Be capable of securing a conductor of the minimum size indicated in Table 13.1.

Table 13.1
Minimum acceptable sizes of grounding (bonding) conductors
(See Clauses 13.1 and 13.3)

Device rating, amperes	Copper grounding conductors[a]	
Not exceeding	AWG	mm^2
15	14	(2.1)
20	12	(3.3)
30	10	(5.3)
40	10	(5.3)
60	10	(5.3)
100	8	(8.4)
200	6	(13.3)
300	4	(21.2)
400	3	(26.7)
500	2	(33.6)
600	1	(42.4)
800	1/0	(53.5)

[a] Equivalent metric cross-sectional area provided for reference only.

14 Terminal Parts

14.1 Devices shall be provided with suitable terminals or leads for the connection of conductors having an ampacity not less than the current rating for which they are intended in accordance with the NFPA 70. See Clauses 47.1.2 – 47.1.4.

14.2 Pressure wire and set screw terminals used with single or multiple copper conductors for fixed wiring shall comply with the applicable requirements in the Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors, UL 486E.

14.3 The tightening torque for the field wiring terminals of the devices mentioned in Clause 14.2 shall be specified by the device manufacturer and shall be marked as described in Clause 47.11.1.

14.4 A terminal plate that has a tapped hole for a soldering lug or pressure-wire connector shall be at least 1.27 mm (0.050 inch) thick and shall have no fewer than two full threads in the metal for a terminal screw.

14.5 Wiring terminals of a receptacle or power inlet shall be located or protected so they cannot be forced against the wiring in the terminal box or compartment during installation.

14.6 Crimp type terminals may be provided with an inspection hole at the end of the crimp well to assure the full insertion of the conductor. Devices with crimp terminals shall be provided with manufacturer's installation instructions and be used with stranded conductors only and marked in accordance with Clause 47.11.3.

14.7 Wire binding screws used in making electrical connections shall not be smaller than indicated in Table 14.1. Wiring terminal screws shall have no fewer than two threads of engagement into metal.

14.8 A No. 8 or larger binding screw that has more than the number of threads per inch indicated in Table 14.1, with a terminal plate formed from stock 0.76 mm (0.030 inch) thick, is not prohibited from having the metal extruded at the tapped hole to provide the two full threads of minimum engagement for the binding screw. To determine compliance with note b of Table 14.1, six devices shall be used. Solid No. 14 AWG (2.1 mm^2) copper wire shall be placed under the screw head and wrapped 2/3 – 3/4 turn around the screw. The screw shall then be tightened with a clutch-type torque screwdriver that has been calibrated and preset to release at 1.8 N·m (16 lbf in).

Table 14.1
Minimum sizes of wire binding screws
(See Clauses 14.7 and 14.8)

Contact rating, Amperes	Minimum size of screw	Minimum head diameter	Maximum number of threads per inch
20 or less	#6[a]	0.275 in	36
up to 35	#8[b]	0.315 in	32

[a] An No. 6 terminal screw, minimum head diameter 6.3 mm (1/4 inch), may be used on devices not intended for permanent installation and rated at 15 A.

[b] A No. 8 or larger screw having more than the number of threads per inch indicated may be used for terminals if the assembly is capable of withstanding a tightening torque of 1.8 N·m (16 lbf in) applied to the wire-binding screw without stripping either the screw threads or the terminal plate threads, or damaging the slot in the head of the screw. See Clause 14.8.

14.9 A wiring terminal that involves a wire-binding screw shall have upturned lugs, or the equivalent, to hold a wire under the head of the screw.

14.10 Terminal parts that are depended upon to carry current and that come into contact with branch circuit conductors other than the grounding conductor, shall not have a coating of zinc or cadmium.

14.11 For a receptacle or an inlet, the integral supply leads shall not be shorter than 10 cm (4 inches).

15 Assembly

15.1 General

15.1.1 A device incorporating two or more pieces shall be of such design that any intended grounding contact polarization will not be defeated by improper assembly during installation.

15.1.2 Means shall be provided for securely attaching the body of an inlet to the supporting base. When assembled, the body shall be prevented from turning with respect to the base.

15.1.3 Screws upon which the permanent assembly of a device depends shall not loosen under normal use.

15.1.4 A device shall be capable of being readily wired as intended and shall be capable of accepting a flexible cord or cable having an ampacity at least equal to the rating of the device and of the type and size specified by the manufacturer.

15.1.5 Electrical contact shall be reliably maintained at any point at which a connection is made between current-carrying parts.

15.1.6 A sealing compound, if used, and in contact with live parts, shall be of an insulating, waterproof material that will not melt or flow at a temperature lower than the temperature rating of the conductors.

15.1.7 A determination of the softening point of a sealing compound shall be made in accordance with ASTM E28-1967 (1982).

15.1.8 Sulphur shall not be acceptable as a sealing compound.

15.2 Mating and Intermateability

15.2.1 A device, including any configuration illustrated in Figures C1 – C5 of the Standard for Pin and Sleeve Configurations, UL 1686, shall be constructed so that electrical continuity between respective and similarly marked terminals is established when the mating plug and outlet device are connected together.

15.2.2 An outlet device shall not permit an attachment plug other than one that is specifically intended for use with the outlet to be inserted to the extent that electrical contact is made.

15.2.3 Attachment plugs, cord connectors, power inlets, receptacles, and other devices that have different electrical ratings or are intended to be wired with conductors having different temperature ratings shall not be interchangeable with one another. See Clauses 37.2, 47.1.3, and 47.1.4.

16 Devices Intended to Accommodate a Fuse

16.1 Devices shall be constructed so they will accommodate an enclosed fuse or fuses having a voltage rating not less than the voltage rating of the device.

16.2 The arrangement for holding the fuse shall comply with the requirements in the Standard for Fuseholders, UL 512.

16.3 A device shall include provision for a fuse in each ungrounded conductor, but there shall not be any provision for a fuse in any other conductor.

16.4 The removal or replacement of a fuse shall not expose any live parts in a device to personal contact.

16.5 The construction of a plug shall ensure that a fuse or fuses will not be removable when the plug is engaged in an outlet.

16.6 An enclosure shall be provided for the fuse or fuses in a device intended to accommodate such components. An enclosure shall comply with all of the following:

a) a) Shall be of a moisture-resistant material in accordance with Moisture Absorption Resistance, Section 24.

1) Fiber and similar absorptive materials shall not be considered as having moisture absorptive properties acceptable for use as the enclosure of a fuse.

2) Molded phenolic and similar thermosetting polymeric materials shall be considered as having moisture-absorptive properties acceptable for use as the enclosure of a fuse.

b) Shall reduce the likelihood of persons unintentionally contacting uninsulated live parts of the fuse and fuse holder.

c) Shall confine the effects of a fuse rupture to the interior of the enclosure.

d) Shall comply with the requirements for insulating materials in Clauses 6.3 – 6.5.

16.7 Polymeric materials used as the enclosure of a fuse shall have a flame class rating of V-0, V-1, V-2, 5VA, or 5VB in accordance with the requirements of the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

17 Cord or Cable Grip

17.1 A cord or cable grip shall be provided on a plug or cord connector to:

a) Permit the flexible supply cord or cable to be readily replaced; and

b) Prevent a stress to be transmitted to the conductor connections within the terminal enclosure.

17.2 Devices provided with a suitable flexible conduit adapter or threaded inlet need not comply with the requirement of Clause 17.1.

17.3 If the cord or cable grip is threaded to the enclosure, it shall form a tight engagement. When assembled in the intended manner, the cord or cable entry shall not turn or loosen. The grip and cord or cable entry shall be smooth and free from sharp edges that may damage the jacket of the flexible cord or cable.

17.4 The strain relief means shall be capable of being easily tightened or assembled on the specified flexible cords to grip both the jacket and individually insulated conductors so that forces exerted on the cord (pushing or pulling) are not transmitted to the wiring terminal.

17.5 The cord or cable grip shall comply with the requirements of Cord or Cable Secureness, Section 29.

PERFORMANCE

18 Representative devices

18.1 Prior to initial electrical testing all device male and female pairs shall be assembled or installed in accordance with the manufacturer's instructions. Testing with the use of a 60 Hz supply voltage may represent testing with the use of a higher frequency supply voltage not exceeding 400 Hz. A 60 Hz test current at 110 % of the rated current is considered to represent a 50 Hz rating.

18.2 Unless stated otherwise, the test potential of a test circuit shall not be less than the test potential in volts corresponding to the voltage rating of devices as indicated in Table 18.1.

18.3 Unless indicated for use at a higher ambient temperature, the tests shall be conducted at any ambient temperature within the range of 10 – 40°C (50 – 104°F). The ambient temperature shall be determined using either thermometers or thermocouples placed in the vicinity of the equipment being tested. See Clause 47.1.1.

18.4 Temperature readings shall be obtained by means of thermocouples consisting of No. 28 – 32 AWG (0.08 – 0.032 mm^2) iron and constantan wires. It is a common practice to employ thermocouples consisting of No. 30 AWG (0.05 mm^2) iron and constantan wires with a potentiometer type of indicating instrument. This equipment shall be used if a referee measurement of temperature is necessary.

18.5 Unless stated otherwise, three representative devices shall be used for each test. A lesser number of complete devices may be used if:

a) The test can be repeated using different portions of a previously tested device; and

b) It is agreeable to all parties concerned.

18.6 Devices shall be subjected to the appropriate tests outlined in Table 18.2.

Table 18.1
Voltage for tests
(See Clause 18.2)

Device rating[a], volts	Test potential in volts
110 – 120, ac	120, ac
110 – 125, dc	125, dc
208, ac	208, ac
220 – 240, ac	240, ac
220 – 250, dc	250, dc
265 – 277, ac	277, ac
347, ac	347, ac
440 – 480, ac	480, ac
550 – 600, ac	600, ac
550 – 600, dc	600, dc

[a] If the rating of the device does not fall within any of the indicated voltage ranges, shall be tested at its rated voltage.

Table 18.2
Applicable tests
(See Clause 18.6)

Test	Product							
	Plugs		Connectors		Receptacles		Inlets	
	Motor Circuit-Rated	Branch Circuit-Rated	Motor Circuit-Rated	Branch Circuit-Rated	Motor Circuit-Rated	Branch Circuit-Rated	Motor Circuit-Rated	Branch Circuit-Rated
Accelerated Aging[a,j]	X	X	X	X	X	X	X	X
Comparative Tracking Index[b]	X	X	X	X	X	X	X	X
Glow Wire[b]	X	X	X	X	X	X	X	X
High-Current Arc Resistance to Ignition[b]	X	X	X	X	X	X	X	X
Mold Stress[a]	X	X	X	X	X	X	X	X
Moisture Absorption Resistance[a,b]	X	X	X	X	X	X	X	X
Humidity[c]	X	X	X	X	X	X	X	X
Insulation Resistance[c]	X	X	X	X	X	X	X	X
Dielectric Withstand[c]	X	X	X	X	X	X	X	X
Conductor Secureness[d]	X	X	X	X				

Table 18.2 Continued on Next Page

Table 18.2 Continued

Test	Product							
	Plugs		Connectors		Receptacles		Inlets	
	Motor Circuit-Rated	Branch Circuit-Rated	Motor Circuit-Rated	Branch Circuit-Rated	Motor Circuit-Rated	Branch Circuit-Rated	Motor Circuit-Rated	Branch Circuit-Rated
Cord or Cable Secureness[a]	X	X	X	X				
Impact[a]	X	X	X	X				
Crush[a]	X	X	X	X				
Withdrawal Force[a]			X	X				
Ground Path Current[a,e]	X	X	X	X			X	X
Short Circuit Withstand and Closing[a,k]	X	X	X	X	X	X	X	X
Strength of Insulating Base and Support[a]					X	X	X	X
Overload[g]			X	X	X	X		
Temperature Rise[g]	X	X	X	X	X	X	X	X
Resistance to Arcing[g]			X	X	X	X		
Horsepower Rated Locked Rotor			X		X			
Endurance with Load[f]			X	X	X	X	X	X
Electromagnetic[m]			X	X	X	X		
Polarization Integrity[e,h]	X	X	X	X	X	X	X	X
Resistance to Corrosion[a]	X	X	X	X	X	X	X	X
Moisture Resistance[a,n]	X	X	X	X	X	X	X	X
Environmental Enclosure Type Designators[i]	X	X	X	X	X	X	X	X

[a] Each of these tests shall be performed on a separate device.

[b] Based on properties of insulating materials. Refer to construction requirements.

[c] The humidity, insulation resistance, and dielectric strength tests shall be performed on the same device.

[d] Factory-wired devices only.

[e] Required for specific grounding constructions only. Refer to test description.

[f] These tests are performed alternately on the same device.

[g] The overload, temperature rise, and resistance to arcing tests shall be performed on the same device.

[h] Mated pairs shall be provided.

[i] For device enclosures identified by a Type no. or nos. for environmental protection.

[j] Pliable rubber or pliable vinyl chloride elastomeric devices only.

[k] Motor rated devices only.

[m] For devices employing pilot contacts.

[n] For marine and watertight devices.

19 Accelerated Aging

19.1 Rubber compounds

19.1.1 A molded-rubber attachment plug, or cord connector, or parts shall not show any apparent deterioration and no greater change in hardness than five numbers as the result of exposure for 70 hours in a full-draft circulating-air oven at a temperature of 100.0 ±1.0°C (212.0 ±1.8°F).

19.1.2 If possible, the molded rubber device shall be used complete. The hardness of the rubber shall be determined as the average of five readings with an appropriate gauge, such as the Rex hardness gauge or the Shore durometer. The device shall be allowed to rest at room temperature for four or more hours after removal from the oven. The hardness shall be determined again as the average of five readings. The difference between the average original hardness reading and the average reading taken after exposure to the heat conditioning is the change in hardness.

19.1.3 The accelerated-aging tests mentioned in Clauses 19.1.1 and 19.1.2 shall be made on each color of rubber and on each basic rubber compound employed for the device.

19.2 PVC compounds

19.2.1 A device having a body of molded plasticized polyvinyl chloride or a polyvinyl chloride copolymer thermoplastic elastomer having a hardness of Shore D65 or less shall not show any cracks, discoloration, or other visible signs of deterioration as the result of exposure for 96 hours in a full-draft circulating-air oven at a temperature of 100.0 ±1.0°C (212.0 ±1.8°F).

20 Comparative Tracking Index

20.1 A polymeric material used for electrical insulation, an internal barrier necessary to maintain electrical clearances and creepage distances or enclosure of live parts tested in accordance with the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A shall have a minimum Performance Level Class of 3 or a minimum CTI voltage of 175.

21 Glow Wire

21.1 A polymeric material used for electrical insulation, an internal barrier necessary to maintain electrical clearances and creepage distances, or enclosure of live parts shall be tested in accordance with the requirements of Clause 21.2 to determine its resistance to ignition from overheated conductors caused by circuit overloads.

21.2 Three finished devices, or fewer, if appropriate, shall be subjected to the glow wire ignition test described in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C or IEC 60695-2-1. There shall not be ignition of the insulating material during 30 seconds of application of the probe at 750°C ±10°C.

22 High-Current Arc Resistance to Ignition

22.1 A polymeric material used for electrical insulation, an internal barrier necessary to maintain electrical clearances and creepage distances, or enclosure of live parts when tested as described in Clauses 22.4 – 22.7 shall not ignite within the number of arcs specified in Table 22.1 for the flame class of the insulating material. In addition, there shall not be dielectric breakdown caused by formation of a permanent carbon conductor path.

Table 22.1
High-current arc resistance to ignition test
(See Clause 22.1)

Arcing criteria	
Flame class	**No. of arcs**
HB	60
V-2, VTM-2	15
V-1, VTM-1, 5VA, 5VB	15
V-0, VTM-0	15

22.2 An insulating material used in the face of an outlet device that has been subjected to the test in Temperature Rise, Section 37 need not be subjected to the test in Clause 22.1.

22.3 An insulating material that has previously been accepted for use in the face of an outlet device in accordance with Clause 22.2 shall be acceptable for use in other applications without being subjected to the test in Clause 22.1.

22.4 Three fully assembled devices shall be tested. When preparing devices for test, the condition that will cause the greatest arcing near the material being tested in the device shall be simulated. For example, if the material being tested is used in the face of an attachment plug, one line contact shall be connected to the test circuit described in Clause 22.5.

22.5 The test circuit shall provide test currents and test voltages equal to the current and voltage ratings of the device to be tested but not exceeding 30 A or 240 Vac in any case. The test arc shall be established between the live parts and any adjacent part where breakdown is likely to occur. The arc shall be used to attempt to ignite materials forming parts of the enclosure or to ignite materials located between the parts of different potential. The arc shall be established by means of a copper or stainless steel conductive probe. The conductive probe shall be used to break through insulation, create arc tracking or create a carbon build-up across the surface of the insulating material at the rate of 30 – 40 arc separations per minute. The arc length developed with the probe shall not to exceed the creepage distances specified in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840.

22.6 Immediately following the completion of the arcing portion of the test, the device shall be subjected to a 50 – 60 Hz essentially sinusoidal potential applied as described in Clause 22.7 between live parts of opposite polarity and between live parts and non-current carrying parts. The test potential shall be as indicated in Dielectric Withstand, Section 27. Humidity conditioning shall not be applied.

22.7 The device shall be tested by means of a 500 VA or larger capacity transformer whose output voltage is essentially sinusoidal and can be varied. The applied potential shall be increased from zero until the required test level is reached, and shall be held at that level for one minute. The increase in the applied potential shall be at a uniform rate and as rapid as is consistent with its value being correctly indicated by a voltmeter.

22.8 If the output of the test-equipment transformer is less than 500 volt-amperes, the equipment shall include a voltmeter in the output circuit to indicate the test potential directly.

23 Mold Stress Relief

23.1 As a result of temperature conditioning specified in Clause 23.3, there shall not be any warpage, shrinkage, or other distortion that results in any of the following:

a) Making uninsulated live parts, other than exposed wiring terminals, or internal wiring accessible to contact, by the probe illustrated in Figure 10.1. See Clause 11.3;

b) Defeating the integrity of the enclosure so that acceptable mechanical protection is not afforded to the internal parts of the device;

c) Interference with the operation, function or installation of the device;

d) A condition that results in the device not complying with the strain relief requirements, if applicable;

e) A reduction of clearances and creepage distances between uninsulated live parts of opposite polarity, uninsulated live parts, and accessible dead or grounded metal below the minimum acceptable values; and

f) Any other evidence of damage that could increase the risk of fire or electric shock.

23.2 Devices employing only thermosetting materials need not be subjected to the mold stress relief test.

23.3 The devices shall be placed in a circulating-air oven maintained at a temperature of at least 10°C (18°F) higher than the maximum temperature of the device measured during the temperature test described in Polarization Integrity, Section 42, but not less than 70°C (158°F). The devices shall remain in the oven for 7 hours, then be removed from the oven and allowed to cool to room temperature before determining compliance.

23.4 Immediately following the completion of this test, the devices shall be subjected to the test described in Dielectric Withstand, Section 27.

24 Moisture Absorption Resistance

24.1 Moisture-resistant insulating materials shall not absorb more than 6% of water by mass.

24.2 The material shall be:

a) Dried at 105 ±5°C for 1 hour;

b) Weighed (W1);

c) Immersed in distilled water at 23 ±1°C for 24 hours;

d) Removed from the distilled water and the excess surface moisture wiped off; and

e) Reweighed (W2).

24.3 The moisture absorbed by the material shall be calculated as:

24.4 A material tested in accordance with the Standard Test Method for Water Absorption of Plastics, ASTM D 570 and having a value of 6% or less need not be tested.

25 Humidity

25.1 Devices shall not be adversely affected by humid conditions that may occur in anticipated use.

25.2 Cable entries, if any, shall be left open. If knock-outs are provided, one of them is to be opened.

25.3 Previously untested devices wired as intended, shall be used for this test. A mating attachment plug is to be inserted into the contact openings of one of the mating devices. Covers that can be removed without the aid of a tool, shall be removed and subjected to the humidity conditioning with the main part; spring lids shall be open during this conditioning.

25.4 The devices shall be placed for 7 days (168 hours) into an environmental chamber maintained at a minimum relative humidity of 90 ±2%, and at a temperature (t) of 35 ±2°C (95 ±3.6°F).

25.5 After this conditioning, the devices shall be subjected to the tests described in Insulation Resistance, Section 26 and Dielectric Withstand, Section 27.

26 Insulation Resistance

26.1 The insulation resistance of a device, after conditioning as indicated in Humidity, Section 25, shall not be less than 5 megohms.

26.2 Compliance shall be checked by the tests made immediately after the humidity test in the humidity cabinet or in the room in which the devices were brought to the prescribed temperature, after reassembly of covers which may have been removed.

26.3 For the purpose of these tests, the neutral contact and pilot contact are each considered as a pole.

26.4 The insulation resistance shall be measured with a dc voltage of approximately 500 V applied, the measurement being made 1 minute after application of the voltage.

26.5 For receptacles and connectors, the insulation resistance shall be measured consecutively:

a) Between all poles connected together and the body. The measurement shall be made with and without a plug in engagement; and

b) Between each pole in turn and all others, these being connected to the body, with a plug in engagement;

c) Between any metal enclosure and metal foil in contact with the inner surface of its insulating lining, if any, a gap of approximately 4 mm (0.15 inches) being left between the metal foil and the edge of the lining.

26.6 For plugs, the insulation resistance shall be measured consecutively:

a) Between all poles connected together and the body;

b) Between each pole in turn and all others, these being connected to the body;

c) Between any metal enclosure and metal foil in contact with the inner surface of its insulating lining, if any, a gap of approximately 4 mm (0.15 inches) being left between the metal foil and the edge of the lining.

26.7 The term ″body″ includes all accessible metal parts, metal foil in contact with the outer surface of external parts of insulating material, other than the engagement face of connectors and plugs, fixing screws of bases, enclosures and covers, external assembly screws and grounding terminals, if any.

27 Dielectric Withstand

27.1 Devices intended for permanent or fixed installation shall withstand without breakdown a 50 – 60 Hz essentially sinusoidal potential applied as described in Table 27.1 for one minute between live parts of opposite polarity and between live parts and grounding or non-current carrying immediately following the humidity conditioning and insulation resistance measurements described in Humidity, Section 25 and Insulation Resistance, Section 26.

Table 27.1
Dielectric withstand test voltage
(See Clause 27.1)

Device rating, volts	Test voltage, volts
Up to and including 300	2000
Over 300 up to and including 600	3000

27.2 Each device shall be tested by means of a 500 VA or larger capacity transformer whose output voltage is essentially sinusoidal and can be varied. The applied potential shall be increased from zero until the required test level is reached, and shall be held at that level for one minute. The increase in the applied potential shall be at a uniform rate and as rapid as is consistent with its value being correctly indicated by a voltmeter.

27.3 If the output of the test-equipment transformer is less than 500 volt-amperes, the equipment shall include a voltmeter in the output circuit to indicate the test potential directly.

27.4 Devices intended for other than fixed or permanent installation and devices intended for installation on flexible cords, shall be capable of withstanding the application of an ac potential of 1000V plus 2 times the rated voltage applied for a period of one minute between live parts of opposite polarity and between live parts and grounding or non-current carrying immediately following the humidity conditioning and insulation resistance measurements described in Humidity, Section 25 and Insulation Resistance, Section 26.

27.5 Immediately after the test, it shall be possible to engage mating plugs, receptacles, and connectors, any of which are made of thermoplastic materials. It shall be impossible to mate the plug with its intended receptacle or connector in any but the correct polarization. There shall be no deformation that results in the exposure of live parts, or to the extent affecting the intended and proper functioning of the device.

28 Conductor Secureness

28.1 If a conductor of a flexible cord or cable is connected to an element (male or female contact) of a device before the element has been assembled into the device, the connection shall not break under a pull applied for 1 minute between the element and the conductor before the element has been assembled into the device.

28.2 While the test mentioned in Clause 28.1 is being performed, the angle between the element and the cord conductor shall be that used in the completely assembled device. The pullout force as specified in Table 28.1 shall be applied gradually.

Table 28.1
Test values for conductor secureness test
(See Clause 28.2)

Size of conductor		Pullout force	
AWG or kcmil	mm^2	N	pounds
30	0.05	2.2	0.5
28	0.08	4.5	1
26	0.13	8.9	2
24	0.20	13.4	3
22	0.32	20	4.5
20	0.52	30	6.75
18	0.82	30	6.75
16	1.3	40	9
14	2.1	50	11.5
12	3.3	60	13.5
10	5.3	80	18.0
8	8.4	90	20.5
6	13.3	94	21
4	21.2	133	30
3	26.7	156	35
2	33.6	186	42
1	42.4	236	53
1/0	53.5	285	64
2/0	67.4	285	64
3/0	85.0	351	79
4/0	107	427	96
250	127	427	96
300	152	441	99
350	177	503	113
400	203	503	113
500	253	578	130
600	304	578	130
700	355	645	145
750	380	690	155
800	405	690	155
900	456	702	158
1000	507	778	175
1250	633	965	217
1500	760	1174	264
1750	887	1347	303

Table 28.1 Continued on Next Page

Table 28.1 Continued

Size of conductor		Pullout force	
AWG or kcmil	mm^2	N	pounds
2000	1010	1521	342

29 Cord or Cable Secureness

29.1 A cord or cable connected device shall not show any evidence of damage to the flexible cord or cable, the enclosure of live parts, the strain relief means, or grounding means after the force specified in Table 29.1 is applied and removed. It shall be tested using both the maximum and minimum diameter flexible cord or cable that the cable grip is designed to accommodate. After being subjected to each test described and with the force removed, there shall be no axial displacement of the supply conductors, conductor insulation, or outer jacket of the flexible cord or cable from the assembled condition exceeding the maximum allowed displacement as specified in Table 29.1.

29.2 The device shall be assembled as intended onto a 30 cm (12 inch) or longer length of flexible cord or cable placed in the device with its conductors positioned as if the conductors were to be connected to the terminals. Screws, nuts, or other hardware shall be tightened according to the manufacturer's instructions. The flexible cord or cable shall be cut at a right angle to its major axis (but not stripped).

29.3 The cord or cable clamp shall be held firmly in place. The force shall be applied gradually and sustained for a period of 1 minute to the flexible cord or cable, at a point not less than 15 cm (6 inches) from the cord or cable grip, in a direction perpendicular to the plane of the opening and in line with the flexible cord or cable.

29.4 After the force in Table 29.1 is applied and removed, a torque shall be applied to the flexible cord or cable at a point 15 cm (6 inches) from the cord or cable grip (as specified in Table 29.1) for 1 minute in the direction least favorable to the clamp construction.

Table 29.1
Cord or cable secureness test values
(See Clauses 29.1 and 29.4)

Device rating, amperes	Force		Torque		Maximum displacement
	lbf	N	ft-lb	N•m	mm
15	30	133	0.3	0.41	2.4
16 – 20	30	133	0.4	0.54	2.4
21 – 35	75	333	0.5	0.68	2.4
36 – 70	150	667	1.0	1.4	2.4
71 – 125	150	667	2.0	2.7	2.4
126 – 200	150	667	4.0	5.4	2.4
201 – 400	300	1334	8.0	10.8	4.8
401 – 800	600	2668	12.0	16.3	4.8

30 Impact (Plugs and Connectors)

30.1 A rewireable plug or a connector shall be fitted with a length of the maximum size flexible cord or cable, as specified in the manufacturer's instructions, that corresponds to the rating of the device.

30.2 The free end of the cord or cable, which shall be approximately 2250 mm (90 inches) long, shall be fixed to a wall at a height of 750 mm (30 inches) above the floor, as shown in Figure 30.1.

30.3 The device shall be held so that the cord or cable is horizontal and then allowed to fall to a concrete floor eight times. The cord or cable shall be rotated through approximately 45° at its point of fixing each time.

30.4 A device employing a nonmetallic enclosure or an enclosure of a zinc-based alloy shall be conditioned for 6 hours in air maintained at -25 ±1°C (-13 ±1.8°F) prior to the test. Immediately following removal from the conditioning chamber the devices shall be subjected to the impacts as described in Clauses 30.1 – 30.3.

30.5 As a result of the applied impacts specified in Clause 30.3, there shall be no cracking or breakage, deformation, loosening or detachment of parts, or other adverse effect that results in any of the following:

a) Making uninsulated live parts or internal wiring accessible to contact, by the probe illustrated in Figure 10.1. See Clause 11.3;

b) Defeating the integrity of the enclosure so that acceptable mechanical protection is not afforded to the internal parts of the device or polarization of the device is defeated. Cracks, chips, and dents that do not adversely affect the protection against electric shock or moisture shall be disregarded;

c) Interference with the operation, function, or installation of the device. The locking retaining means used to hold mating devices together is not prohibited from sustaining damage if it does not interfere with the operation or function of the devices or if it is obvious that they are damaged and must be replaced;

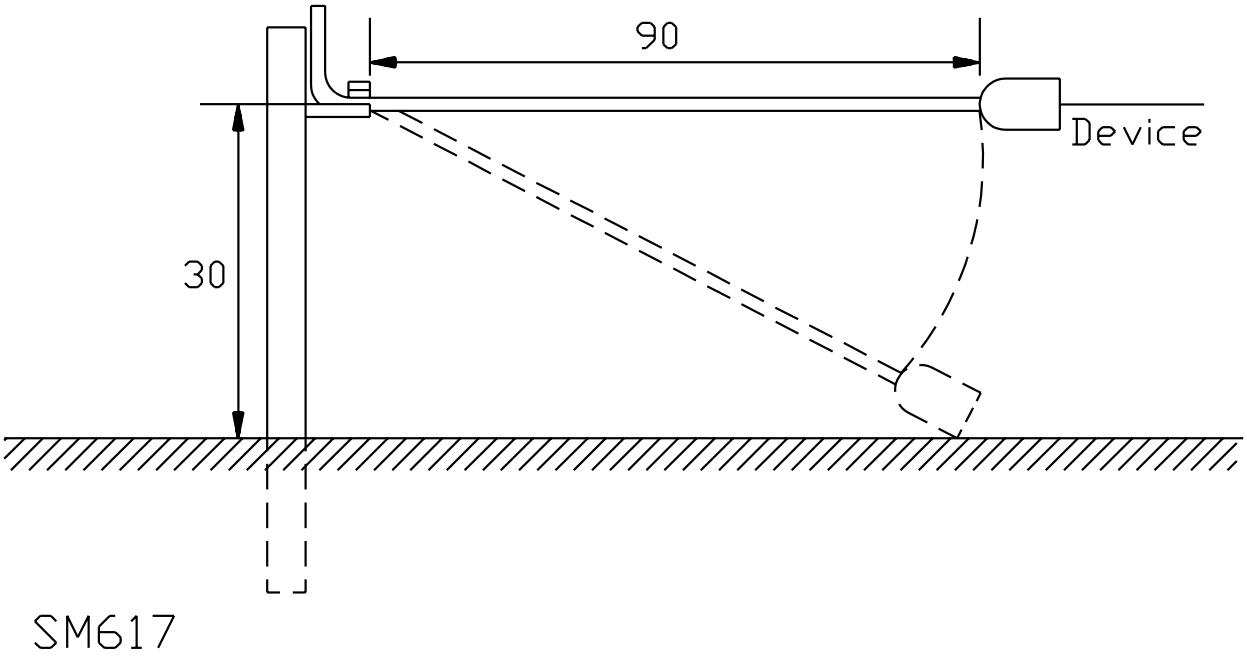
d) A condition that results in the device not complying with the strain relief requirements, if applicable;

e) A reduction of clearances and creepage distances between uninsulated live parts of opposite polarity, uninsulated live parts and accessible dead or grounded metal below the minimum acceptable values; and

f) Any other evidence of damage that could increase the risk of fire or electric shock.

30.6 Immediately following the completion of this test, the devices shall be subjected to a repeated Dielectric Voltage-Withstand Test as described in Section 27.

Figure 30.1
Impact test equipment
(See Clause 30.2)



31 Crush

31.1 Devices intended to be wired onto flexible cord shall be placed between flat rigid horizontal steel plates that are large enough to cover the device with the cable installed. A crushing force shall be applied, increased gradually to a value of 1113 N (250 lbf) and held for one minute. The force shall then be gradually removed. Each device shall be oriented in a natural resting position before applying the force.

31.2 The flexible cord used to wire the device shall be the minimum size specified for use with the product by the manufacturer. See Clause 47.1.4.

31.3 A device employing a nonmetallic enclosure or an enclosure of a zinc-based alloy shall be conditioned for 6 hours in air maintained at -25 ±1°C (-13 ±1.8°F) prior to the test. Immediately following removal from the conditioning chamber the devices shall be subject to the crushing force as described in Clauses 31.1 and 31.2.

31.4 As a result of the applied force specified in Clause 31.1, there shall not be any cracking or breakage, deformation, or other adverse effect that results in any of the following:

a) Making uninsulated live parts or internal wiring accessible to contact by the probe illustrated in Figure 10.1. See Clause 11.3.

b) Defeating the integrity of the enclosure so acceptable mechanical protection is not afforded to the internal parts of the device or polarization of the device is defeated.

c) Interference with the operation, function or installation of the device. The locking retaining means used to hold mating devices together might sustain damage if it does not interfere with the operation or function of the devices or it is obvious they are damaged and must be replaced.

d) A condition that results in the device not complying with the strain relief requirements, if applicable.

e) A reduction of clearances and creepage distances between uninsulated live parts of opposite polarity, uninsulated live parts and accessible dead or grounded metal below the minimum acceptable values.

f) Any other evidence of damage that could increase the risk of fire or electric shock.

31.5 Immediately following the completion of this test, the devices shall be subjected to a repeated Dielectric Voltage-Withstand test as described in Section 27.

32 Withdrawal Force

32.1 The plug and receptacle shall connect in a manner such that the plug will be prevented from working out of the receptacle or connector in normal use. The circuit shall not be disconnected by the application of a force less than the value shown in Table 32.1. The force shall be applied for one minute.

32.2 Compliance shall be checked with the device fully engaged as intended, mounted so the axis of the contacts are vertical with the device openings facing downward. During the test, any manually operated locking retaining devices shall not be engaged.

Table 32.1
Minimum withdrawal force
(See Clause 32.1)

Device rating, amperes	Minimum withdrawal force[a]	
	N	lb
15	18	4
16 – 20	22	5
21 – 35	27	6
36 – 70	67	15
71 – 125	89	20
126 – 800	111	25

[a] The minimum withdrawal force includes the weight of the test plug. If the weight of the mating plug exceeds the specified withdrawal force, the device shall retain the test plug.

33 Grounding (Bonding) Path Current

33.1 Clauses 33.1 – 33.4 apply. The assembly of mating grounding devices shall carry the current specified in Table 33.1 for the time specified in that table. The current shall be based on the minimum size equipment grounding conductor required for the ampere rating of the device. See Table 33.1. The components in the grounding path shall not crack, break, or melt.

Table 33.1
Short-time test currents
(See Clause 33.1)

Device rating, amperes	Minimum size equipment grounding (bonding) conductor (copper)		Time, seconds	Test current, amperes
	AWG	mm^2		
0 – 15	14	2.1	4	300
16 – 20	12	3.3	4	470
21 – 60	10	5.3	4	750
61 – 100	8	8.4	4	1180
101 – 200	6	13.3	6	1530
201 – 300	4	21.2	6	2450
301 – 400	3	26.7	6	3100
401 – 500	2	33.6	6	3900
501 – 600	1	42.4	6	4900
601 – 800	1/0	53.5	9	5050

33.2 The mating devices shall be mounted and assembled as intended. A grounding conductor of the appropriate size, not less than 0.6 m (2 feet) long, shall be connected to the grounding terminal of each device, with the terminals employed to hold the conductor tightened using a torque as specified by the manufacturer's instructions. Receptacles and power inlets shall be wired with the minimum allowable size copper building wire conductor. Plugs and connectors shall be wired with flexible, stranded conductor from flexible cord or cable sized on the basis of the ampere rating of the device. The test current shall be passed through the mating devices and grounding wires in series.

33.3 After having carried the current specified in Clause 33.1, continuity shall exist on the test assembly when measured between the grounding (bonding) conductors.

33.4 Any indicating device such as an ohmmeter, battery-and-buzzer combination, or the like, may be used to determine whether continuity exists.

34 Short Circuit Withstand and Closing

34.1 General

34.1.1 Two devices shall be subjected the tests in Clauses 34.1.1 – 34.3.4.11. One device for the short circuit withstand test and one for the short circuit closing test.

34.1.2 A device having a switch rating shall be subjected to the tests in accordance with Clauses 34.2.6 – 34.2.16 when protected by a fuse or circuit breaker as specified in Clauses 34.2.1 and 34.2.2. The overcurrent protective device used shall have an interrupting rating at least equal to the test current specified in Table 34.1. See Clauses 47.12.2 and 47.12.4.

Table 34.1
Short circuit test values
(See Clauses 34.1.2, 34.2.13, and 34.2.15)

Device rating, horsepower (kw)		Test current amperes, minimum[a]	Power factor[b]
1.5 – 50	(1.1 – 37.3)	10,000	0.40 – 0.50
51 – 200	(38 – 149)	10,000	0.40 – 0.50
201 – 400	(150 – 298)	18,000	0.25 – 0.30
401 – 600	(299 – 447)	30,000	0.15 or less
601 – 643	(448 – 480)	42,000	0.15 or less

[a] Symmetrical rms amperes.

[b] Lower power factors may be used.

34.1.3 If such equipment is marked to limit protection to fuses only, it shall not be considered as intended for use in a circuit protected by an inverse-time circuit breaker.

34.1.4 Testing with inverse-time circuit breakers shall not be required if it is shown that the clearing time of the inverse-time circuit breakers will be less than that of the fuse with which the product has been tested.

34.2 Protective devices

34.2.1 The fuses used for the tests shall be specified as follows:

a) For a device intended for use on general-purpose branch circuits, the rating of the fuse used shall be the ampere rating of the device.

b) For a device intended for use on motor branch circuits, the manufacturer shall specify the fuses used for the tests in accordance with Table 34.2.

34.2.2 An inverse-time circuit breaker used for the test described in Clauses 34.2.6 – 34.2.16 shall be specified by the manufacturer in accordance with (a), (b), or (c):

a) For a device intended for use on general-purpose branch circuits, the rating of the inverse time circuit breaker shall be the ampere rating of the device.

b) For a device intended for use on motor branch circuits, the inverse-time circuit breaker may be rated four times the maximum full-load motor-current rating for full-load currents of 100 amperes or less or three times the maximum full-load motor-current rating for full-load currents greater than 100 amperes. If the calculated value of the circuit breaker is between two standard ratings as specified in Clause 34.2.4, a circuit breaker of the nearest standard rating less than the calculated value shall be used. If the calculated value of the circuit breaker is less than 15 amperes, a circuit breaker rated 15 amperes shall be used. No marking of the circuit breaker rating is required on the product.

c) The inverse-time circuit breaker mentioned above may have a rating less than that specified in (b) if the product is marked to indicate the limit of protection.

34.2.3 Standard ampere ratings for fuses are 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90, 100, 110, 125, 150, 175, 200, 225, 250, 300, 350, 400, 450, 500, 600, 601, 700, 800, 1000, 1200, 1600, 2000, 2500, 3000, and 4000.

34.2.4 Standard ampere ratings for inverse-time circuit breakers are 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90, 100, 110, 125, 150, 175, 200, 225, 250, 300, 350, 400, 450, 500, 600, 700, 800, 1000, 1200, 1600, 2000, 2500, 3000, and 4000.

34.2.5 The marking referred to in Clauses 34.1.1, 34.2.2 and Table 34.2 may alternatively be located in the installation instructions.

34.2.6 A device shall be tested in an enclosure representative of that likely to be encountered in service.

34.2.7 A receptacle shall be wired to each of the testing terminals by 1.2 m (4 feet) of wire per pole. For a device intended for use on motor branch circuits, the wire shall be the smallest size having an ampacity of at least 125 % of the maximum full-load motor-current ratings of the device. For a device intended for use on general-purpose branch circuits, the wire shall be the smallest size having an ampacity matching the ampere rating of the device. The wire size shall be determined in accordance with the National Electrical Code, NFPA 70 as applicable based on the wire temperature rating marked in accordance with Clauses 47.1.2 and 47.1.3. If the terminal will not receive that size of wire the maximum allowable wire size shall be used. An attachment plug wired as specified in Clause 34.2.8(a), and using the same size wire shall be plugged into the receptacle.

34.2.8 For an attachment plug, cord connector, or inlet, each assembly shall be tested as assembled. The wire, cord, or cable used to connect each device shall be determined in accordance with the National Electrical Code, NFPA 70 as applicable based on the wire temperature rating and minimum conductor size, if applicable, marked on the device. The grounding (bonding) conductor shall be installed as intended. For this test:

a) An attachment plug shall be assembled to a 0.6 m (2 ft) length of flexible cord or cable. The load conductors shall be shorted together at the end. The plug shall then be inserted in a receptacle wired as described in Clause 34.2.7.

b) A cord connector shall be assembled to a 1.2 m (4 feet) length of flexible cord or cable wired at one end to the testing terminals. An attachment plug, shorted as described in Clause 34.2.7, shall be plugged into the cord connector.

c) An inlet shall be assembled and installed as intended. The load terminals shall be wired with a 0.6 m (2 ft) length of flexible cord or cable that is shorted together at the end. The mating cord connector shall be wired to the testing terminals by 1.2 m (4 feet) of wire.

34.2.9 The test wires and cord may exceed the specified length if they are in the circuit during calibration.

34.2.10 The grounding (bonding) conductor or the metal enclosure shall be connected through a non-time-delay, 30-ampere cartridge fuse to the electrical supply live pole judged least likely to arc to ground. The fuse referred to in Clause 34.1.1 shall be connected in series with the pole judged most likely to strike ground. The connection shall be made to the load side of the limiting impedance by a No. 10 AWG (5.3 mm^2) copper wire that is 1.2 – 1.8 m (4 – 6 ft) long.

34.2.11 The ground connection may be made with No. 12 or 14 AWG (3.3 or 2.1 mm^2) copper wire if the branch-circuit conductors the equipment is intended to be connected to are No. 12 or 14 AWG, respectively.

34.2.12 During the test, surgical cotton shall be placed at all openings, covers, flanges, joints, and the like, on the outside of the enclosure.

34.2.13 Equipment rated for direct current shall be tested using a direct current electrical source; alternating-current equipment shall be tested on a 60 Hz essentially sinusoidal current electrical source. The open-circuit voltage of the test circuit shall be 100 to 105 % of the voltage rating of the device, except that the voltage may exceed 105 % of the rated voltage with the concurrence of those concerned. The test circuit shall be capable of delivering the current specified in Table 34.1 for a given motor rating when the system is short-circuited at the testing terminals to which the device under test is connected, and this shall be verified by means of an oscillograph.

34.2.14 For short circuit withstand test operations, the devices shall be mated before the test circuit is closed. For short circuit closing test operations, the devices shall be mated after the circuit is closed.

34.2.15 Air core type reactors shall be employed in the line to obtain the power factor in accordance with Table 34.1. The reactors may be connected in parallel, but no reactor shall be connected in parallel with a resistor, except that a resistor may shunt a reactor in any phase if the power consumed by the resistor

is approximately 0.6% of the reactive volt-amperes in the reactor in that phase. The minimum value of the shunting resistance used with a reactor having negligible resistance shall be calculated by the equation:

$$R = 167 (E/I)$$

in which:

E is the voltage across the reactor with current I flowing as determined by oscillographic measurement during the short circuit calibration or by proportion from meter measurements at some lower current.

Table 34.2
Ratings of fuses used for test
(See Clauses 34.2.1(b), 34.2.5, and 47.12.3)

Type of fuse[a]	Current, amperes	Motor circuit rated only: Maximum percentage of rated motor full-load current[b]	Branch circuit rated only: Maximum percentage of rated device full-load current	Fuse size marking required (for motor circuit rated devices
Non time-delay	0 – 600	400[c,d]	100	No
Non time-delay	0 – 600	< 400 but ≥ 300[e]	100	Yes
Non time-delay	0 – 600	< 300 but > 225[f]	100	Yes
Time-delay	0 – 600	≤ 225[g]	100	Yes
Non time-delay	601 – 6000	300[h]	100	No
Non time-delay	601 – 6000	< 300[i]	100	Yes

[a] For motor circuit switch-rated devices, tests with 225% full load ampere time delay fuses are not considered representatives of tests with 400% full load ampere non time-delay fuses.

[b] These values are approximate and shall be used when the manufacturer does not specify fuse sizes but refers to a maximum percentage level, such as ″Fuse not to exceed 300% of motor full load amps″.

[c] If the calculated value of the fuse is between two standard ratings as specified in Clause 34.2.4, a fuse of the nearest standard rating but not more than four times the full-load motor-current rating shall be used. If the calculated value of the fuse is less than 1 ampere, a fuse rated 1 ampere shall be used, and no marking of fuse size shall be required on the product.

[d] For motor circuit switch-rated devices, tests with 400 % non time-delay fuses cover use with 225% time delay fuses.

[e] Tests with non-time delay fuses rated less than 400%, but equal to or greater than 300% cover use with 175% time-delay fuses.

[f] For motor switch rated devices, tests with less than 300% non time-delay fuses require additional testing with 225% (or as marked) time-delay fuses.

[g] The product is marked to indicate the level of protection and that the branch-circuit protective device may need to be of the time-delay type.

[h] If the calculated value of the fuse is between two standard ratings as specified in Clause 34.2.4, a fuse of the nearest standard rating but not more than three times the full-load motor-current rating shall be used.

[i] The protective device may be a non time-delay fuse smaller than the size specified in note h if the product is marked to indicate this limit of protection.

34.2.16 If a group of devices having different ratings are of the same construction and material and are intended for use with one size of fuse, tests on the lowest and highest ratings may be considered to be representative of that group.

34.2.17 After the protective device has cleared the fault, the device shall comply with the following:

a) There shall not be any discharge of parts. The contacts shall not disintegrate, evaporate, or weld. There shall not be any damage to the device, the wiring terminals or other parts that would impair the function of the device.

b) There shall not be any breakage of insulating bases or supports to the extent that the integrity of the mounting or insulation of live parts is impaired.

c) There shall not be any ignition of the cotton or cord insulation, or any other risk of a fire, and the circuit breaker shall operate when the test circuit is closed.

d) The fuse connected between the live pole and the grounding (bonding) conductor or the enclosure shall not open.

34.3 Calibration of test circuits

34.3.1 General

34.3.1.1 The available current capacity of the circuit shall be at least the value required for the short-circuit rating of the device. The frequency of the test circuit shall be 60 ±12 Hz.

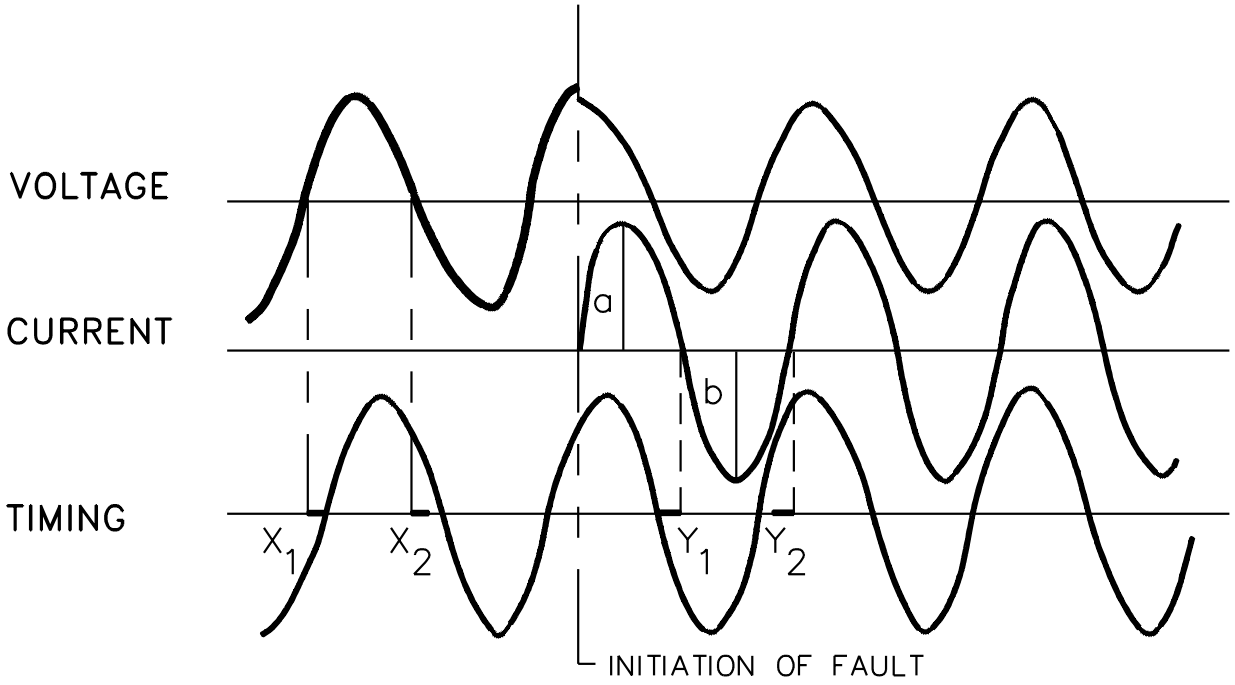
34.3.2 Available current of 10,000 amperes (See Table 34.1)

34.3.2.1 For an alternating-current circuit intended to deliver 10,000 amperes the current and power factor shall be determined as follows:

a) For a 3-phase test circuit, the current shall be determined by averaging the rms values of the first complete cycle of current in each of the three phases; the voltage to neutral shall be used to determine the power factor.

b) For a single-phase test circuit, the current shall be the rms value of the first complete cycle (See Figure 34.1) when the circuit is closed to produce an essentially symmetrical current waveform. The direct-current component shall not be added to the value obtained when measured as illustrated. To obtain the desired symmetrical waveform of a single-phase test circuit, controlled closing is recommended although random closing methods may be used. The power factor shall be determined by referring the open-circuit voltage wave to the two adjacent zero points at the end half of the first complete current cycle by transposition through a suitable timing wave. The power factor shall be computed as an average of the values obtained by using these two current zero points.

Figure 34.1
Determination of current and powerfactor for circuits of 10,000 amperes and less
(See Clause 34.3.2.1)



$$Current = \frac{a+b}{2} \text{ rms calibration of instrument element}$$

$$Power\ Factor = \frac{Cos\left[(Y_1 + X_1) \times 180°\right]}{2} + \frac{Cos\left[(Y_2 + X_2) \times 180°\right]}{2}$$

Where X and Y values are fractions of the 1/2–cycle distance in which they occur.

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34.3.3 Available current greater than 10,000 amperes (See Table 34.1)

34.3.3.1 For circuits intended to deliver equal to or greater than 10,000 amperes, the current and power factor shall be determined in accordance with the requirements in Clauses 34.3.3.2 – 34.3.3.8. Instrumentation used to measure test circuits of over 10,000 amperes shall comply with the requirements in Clauses 34.3.4.1 – 34.3.4.11.

34.3.3.2 The rms symmetrical current shall be determined, with the supply terminals short-circuited by measuring the alternating-current component of the wave at an instant 1/2 cycle – on the basis of the test frequency timing wave – after the initiation of the short circuit. The current shall be calculated in accordance with Figure 7 in ANSI/IEEE C37.09.

34.3.3.3 For a 3-phase test circuit, the rms symmetrical current shall be the average of the currents in the three phases. The rms symmetrical current in any one phase is not to be less than 90% of the required test current.

34.3.3.4 The test circuit and its transients shall be such that:

a) 3 cycles after initiation of the short circuit, the symmetrical alternating component of current will not be less than 90% of the symmetrical alternating component of current at the end of the first 1/2 cycle; or

b) The symmetrical alternating component of current at the time at which the overcurrent protective device will interrupt the test circuit is at least 100% of the rating for which the device is being tested. In 3-phase circuits, the symmetrical alternating component of current of all three phases shall be averaged.

34.3.3.5 The power factor shall be determined at an instant 1/2 cycle – on the basis of the test frequency-timing wave – after the short circuit occurs. The total asymmetrical rms amperes shall be measured in accordance with Clause 34.3.3.2 and the ratio M_A or M_M shall be calculated as follows:

M_A (3 phase) = (Average 3 phases-Asymmetrical rms Amperes)/(Average 3 phases-Symmetrical rms Amperes)

M_M (1 phase) = (Asymmetrical rms Amperes)/(Symmetrical rms Amperes)

Using ratio M_A or M_M, the power factor shall be determined from Table 34.3.

Table 34.3
Short-circuit power factor
(See Clause 34.3.3.5)

Short-circuit power factor, percentage	Ratio M_M	Ratio M_A	Short-circuit power factor, percentage	Ratio M_M	Ratio M_A
0	1.732	1.394	30	1.130	1.066
1	1.696	1.374	31	1.121	1.062
2	1.665	1.355	32	1.113	1.057
3	1.630	1.336	33	1.105	1.053
4	1.598	1.318	34	1.098	1.049
5	1.568	1.301	35	1.091	1.046
6	1.540	1.285	36	1.084	1.043
7	1.511	1.270	37	1.078	1.039
8	1.485	1.256	38	1.073	1.036
9	1.460	1.241	39	1.068	1.033
10	1.436	1.229	40	1.062	1.031
11	1.413	1.216	41	1.057	1.028
12	1.391	1.204	42	1.053	1.026
13	1.372	1.193	43	1.049	1.024
14	1.350	1.182	44	1.045	1.022
15	1.330	1.171	45	1.041	1.020
16	1.312	1.161	46	1.038	1.019
17	1.294	1.152	47	1.034	1.017
18	1.277	1.143	48	1.031	1.016
19	1.262	1.135	49	1.029	1.014
20	1.247	1.127	50	1.026	1.013
21	1.232	1.119	55	1.015	1.008
22	1.218	1.112	60	1.009	1.004
23	1.205	1.105	65	1.004	1.002
24	1.192	1.099	70	1. 002	1.001
25	1.181	1.093	75	1.0008	1.0004
26	1.170	1.087	80	1.0002	1.00005
27	1.159	1.081	85	1.00004	1.00002
28	1.149	1.075	100	1.00000	1.00000
29	1.139	1.070			

34.3.3.6 The power factor of a 3-phase circuit may be calculated by using controlled closing so that upon subsequent closings a different phase will be caused to have maximum asymmetrical conditions. The power factor of each phase could then be determined using the method described for single-phase circuits in Clause 34.3.3.5. The power factor of the 3-phase circuit shall be considered to be the average of the power factors of each of the phases.

34.3.3.7 The recovery voltage shall be at least equal to the rated voltage of the device. The peak value of the recovery voltage within the first complete half cycle after clearing and for the next five successive peaks shall be at least equal to 1.414 times the rms value of the rated voltage of the device. Each of the peaks shall not be displaced by more than ±10 electrical degrees from the peak values of the open-circuit recovery voltage – that is, the displacement of the peak from its normal position on a sinusoidal wave. The average of the instantaneous values of recovery voltage each of the first six, half cycles measured at the 45° and 135° points on the wave shall be not less than 85% of the rms value of the rated voltage of the device. The instantaneous value of recovery voltage measured at the 45° and 135° points of each of the first six, half cycles shall not be less than 75% of the rms value of the rated voltage of the device.

34.3.3.8 If there is no attenuation or phase displacement of the first full cycle of the recovery voltage wave when compared with the open-circuit secondary voltage wave before current flow in a circuit that employs secondary closing, the detailed measurement of recovery voltage characteristics as indicated in Clause 34.3.3.7 shall not be required.

34.3.4 Instrumentations for test currents above 10,000 amperes

34.3.4.1 The galvanometers in a magnetic oscillograph employed for recording voltage and current during circuit calibration and while testing shall be of a type having a flat (±5%) frequency response from 50 – 1200 Hz. For fast acting fuses, current limiters, or motor-short-circuit protectors, a galvanometer may need to have a flat frequency response from 50 – 9000 Hz, or an oscilloscope may be needed to obtain accurate values of peak current, (Ip), and energy let-through, (I2t).

34.3.4.2 Galvanometers shall be calibrated as described in Clauses 34.3.4.3 – 34.3.4.6.

34.3.4.3 When a shunt is used to determine the circuit characteristics, a direct-current calibrating voltage is normally used. The voltage applied to the oscillograph galvanometer circuit is to result in a deflection of the galvanometer approximately equivalent to that which is expected when the same galvanometer circuit is connected to the shunt and the nominal short-circuit current is flowing. The voltage shall be applied to cause the galvanometer to deflect in both directions. Additional calibrations shall be made using approximately 50% and approximately 150% of the voltage used to obtain the deflection indicated above, except that if the anticipated maximum deflection is less than 150%, such as a symmetrically closed single-phase circuit, any other suitable calibration point shall be chosen. The sensitivity of the galvanometer circuit in volts per millimeter (or volts per inch) shall be determined from the deflection measured in each case, and the results of the six trials averaged. The peak amperes per millimeter (or amps per inch) shall be obtained by dividing the sensitivity by the resistance of the shunt. This multiplying factor shall be used for the determination of the rms current as described in Clause 34.3.3.2.

34.3.4.4 A 60 Hz sine-wave potential may be used for calibrating the galvanometer circuit, using the same general method described in Clause 34.3.4.3. The resulting factor shall be multiplied by 1.414.

34.3.4.5 When a current transformer is used to determine the circuit characteristics, an alternating current shall be used to calibrate the galvanometer circuit. The value of current applied to the galvanometer circuit shall result in a deflection of the galvanometer approximately equivalent to that which is expected when the same galvanometer is connected to the secondary of the current transformer and nominal short circuit current is flowing in the primary. Additional calibrations shall be made at approximately 50% and approximately 150% of the current used to obtain the deflection indicated above except that if the anticipated maximum deflection is less than 150%, such as in a symmetrically closed single-phase circuit, any other suitable calibration point shall be chosen. The sensitivity of the galvanometer circuit in rms amperes per millimeter (or amps per inch) shall be determined in each case and the results averaged. The average sensitivity shall be multiplied by the current-transformer ratio and by 1.414 to obtain peak amperes per millimeter (or amps per inch). This constant shall be used for the determination of the rms current as described in Clause 34.3.3.2.

34.3.4.6 All the galvanometer elements employed shall line-up properly in the oscillograph, or the displacement differences shall be noted and used as needed.

34.3.4.7 The sensitivity of the galvanometers and the recording speed shall be such that the values of voltage, current, and power factor can be determined accurately. The recording speed shall be at least 1.5 m (60 inches) per second.

34.3.4.8 With the test circuit adjusted to provide the specified values of voltage and current, and with a noninductive (coaxial) shunt that has been found acceptable for use as a reference connected into the circuit, the tests described in Clauses 34.3.4.9 and 34.3.4.10 shall be conducted to verify the accuracy of the manufacturer's instrumentation.

34.3.4.9 With the secondary open-circuited, the transformer shall be live and the voltage at the test terminals observed to see if rectification is occurring making the circuit unacceptable for test purposes because the voltage and current will not be sinusoidal. Six random closings shall be made to demonstrate that residual flux in the transformer core will not cause rectification. If testing is done by closing the secondary circuit, this check can be omitted providing testing is not commenced before the transformer has been live for approximately 2 seconds, or longer if an investigation of the test equipment shows that a longer time is necessary.

34.3.4.10 With the test terminals connected together by means of a copper bar, a single-phase circuit shall be closed as nearly as possible at the moment that will produce a current wave with maximum offset. The short circuit current and voltage shall be recorded. The primary voltage shall be recorded if primary closing is used. The current measured by the reference shunt shall be within 5% of that measured using the manufacturer's instrumentation, and there shall be no measurable variation in phase relationship between the traces of the same current. Controlled closing is not required for polyphase circuits.

34.3.4.11 When the verification of the accuracy of the manufacturer's instrumentation is completed, the reference coaxial shunt shall be removed from the circuit. The reference coaxial shunt shall not be used during the final calibration of the test circuit nor during the testing of devices.

35 Strength of Insulating Base and Support

35.1 A device for field connection of fixed wiring shall not be damaged when 110% of the specified terminal tightening torque as specified in Clause 14.3 is applied to the wire securing means of a pressure wire connector securing the maximum intended size conductor.

35.2 Damage shall be considered to have occurred if any cracking, bending, breakage or displacement of the insulating base, current carrying parts, assembly parts, or device enclosure reduces electrical clearances and creepage distances to less than those required, exposes live parts, or otherwise impairs the intended secure installation and use of the device.

36 Overload

36.1 Three sets of a receptacle or a cable connector, and a plug, with branch circuit switch ratings shall be subjected to the overload test described in Clauses 36.4 – 36.10.

36.2 There shall be no electrical or mechanical failure of the devices, no burning or pitting of the contacts that would affect the intended function, and no welding of the contacts. The line fuse or the grounding fuse described in Clauses 36.9 and 36.10 shall not open during the test.

36.3 Contacts of the plug or the receptacle are not to be adjusted, lubricated, or otherwise conditioned before or during the tests. An additional material intended to reduce or confine the arcing in the contact chamber of a plug and receptacle that decomposes or is otherwise affected by the arcing shall be removed for all of the overload tests.

36.4 The devices shall be subjected to the overload condition by manually or mechanically inserting and withdrawing the plug into and out of the receptacle or connector for 50 cycles of operation at a rate not higher than 10 cycles per minute.

36.5 The plugs shall be connected to a load such that the devices shall make and break 150% of the rated current. The test shall be conducted using direct current or be conducted using alternating current if the device is marked in accordance with Clause 47.5.1. When alternating current is used, the power factor of the load shall be from 0.75 – 0.80.

36.6 The potential of the test circuit is to be from 95 to 105% of the rating of the device in volts.

36.7 The test on a receptacle and a plug that have multiple voltage and ampere ratings shall be performed at:

a) 150% of the rated current that corresponds to the maximum rated voltage;

b) 150% of the maximum rated current at the corresponding rated voltage; and

c) 150% of the rated current at the corresponding rated voltage that results in maximum power per pole.

36.8 A test on alternating current may be waived if adequate results have been obtained from an equivalent or higher volt-ampere test at a direct current potential equal to or greater than the alternating current potential rating.

36.9 The device shall be mounted and wired to represent service conditions. Exposed metal parts shall be connected through a fuse to:

a) Ground;

b) The grounded conductor of the test circuit; or

c) A circuit conductor that differs by at least the rated potential from one or more of the remaining conductors in the circuit.

36.10 The fuses in the test circuit shall be non time-delay, general-use cartridge type fuses. The fuse in the grounding (bonding) conductor circuit shall have a 15 ampere rating if the device under test is rated at 30 amperes or less. If the device under test is rated at more than 30 amperes the grounding fuse shall have a rating of 30 amperes. For the line fuse, the next higher commercial fuse rating than the value.

37 Temperature Rise

37.1 If the tests outlined in Overload, Section 36 or in Horsepower Rated Locked Rotor, Section 39 are conducted at an ambient temperature of other than 25°C, the results shall be adjusted to an ambient temperature of 25°C by adding the appropriate variation between 25°C and the ambient.

37.2 The temperature rise of a device measured at the points described in Clause 37.3 shall not exceed 30°C when the device is carrying its maximum rated current. This temperature rise is based on devices intended to be wired with conductors rated 60°C. A temperature rise of 45°C shall be permitted when the device is intended to be wired with conductors rated 75°C or higher, and so marked. Devices intended for use with conductors rated 75°C or higher and so marked shall not intermate with similar devices not so marked. See Clauses 47.1.3 and 47.1.4.

37.3 The temperature measurement shall be made on the wiring terminals of the equipment, if they are accessible for mounting thermocouples. If the equipment has no wiring terminals or if they are inaccessible, temperatures shall be measured as close as possible to the face of the equipment on the plug contacts inserted in the receptacle.

37.4 The temperature test shall be made following the overload test on the equipment, and shall continue for 4 h or until thermal stabilization is attained. Thermal stabilization shall be considered to have occurred when three successive readings, taken at intervals of not less than 10 minutes, show no further increases. Each connection to the equipment under test shall be made by means of at least 0.46 m (18 inches) of the intended type and size of wire or cord (see Clauses 14.1 and 47.1.2) with the terminals of the device tightened using a torque as specified by the manufacturer's instructions. In the case of a connector body, conductors of the indicated ampacity shall be used regardless of the size of the cord that is intended to be used with the device. The contacts of equipment under test shall be connected together by means of an inserted plug. A previously untested plug may be used. The terminals of the plug shall be short circuited by means of the shortest feasible lengths of the wire as previously described.

38 Resistance to Arcing

38.1 If a material, other than ceramic, is used in the construction of the face of an outlet device in a way that the material is likely to be exposed to arcing while in service, the devices that were subjected to 50 cycles of operation in the overload test described in Section 36, shall perform acceptably when subjected to an additional 200 cycles of operation under the overload-test conditions following the temperature test. There shall be no electrical tracking, formation of a permanent carbon conductive path, or ignition of the material.

38.2 Alternatively, one set of devices may be subjected to the 50 cycles of operation in the overload test described in Overload, Section 36, followed by the temperature test on the devices, and then, to determine resistance to arcing, a second, previously untested set of devices may be subjected to 250 cycles of operation under the overload-test conditions.

39 Horsepower Rated Locked Rotor

39.1 Three devices with one or more motor circuit switch rating(s) shall perform in an overload test making and breaking the locked-rotor current corresponding to each horsepower rating of the device. There shall be no electrical or mechanical failure of the devices, no burning or pitting of the contacts that would affect the intended function, and no welding of the contacts.

39.2 The tests shall be conducted in accordance with Overload, Section 36, except that the value of the test current corresponding to a horsepower rating shall be six times the full load motor current for an alternating-current rating of more than two horsepower. The load for an alternating-current horsepower rating shall have a power factor of 0.40 – 0.50.

40 Endurance with Load

40.1 Devices shall withstand, without harmful effects as described in Clause 40.8, the mechanical, electrical, and thermal stresses occurring in normal use.

40.2 To achieve a motor circuit switch rating, one of the three devices used shall be from the horsepower locked rotor test. To achieve a branch circuit switch rating, one of the three devices used shall be from the overload test.

40.3 Devices under test shall be operated manually or mechanically at rated current and rated voltage at a rate no greater than 10 cycles per minute. Optionally if one of the devices used is from the horsepower overload test, it may be operated manually or mechanically at the full load motor current and rated voltage.

40.4 The test shall either be conducted using direct current or be conducted using alternating current if the device is marked in accordance with Clause 47.5.1. When alternating current is used, the power factor of the load shall be from 0.75 – 0.80.

40.5 For dual-rated devices, a test on ac may be waived if acceptable results have been obtained from an equivalent or higher volt-ampere test at a dc potential that is equal to or greater than the ac potential rating.

40.6 If the test is run mechanically, the rate of operation shall not be greater than 10 cycles per minute, with an average velocity of 760 ±80 mm (30 ±3 inches) per second in each direction.

40.7 A rate of operation having a lower average velocity may be used if agreeable to all parties concerned.

40.8 The total number of operating cycles shall be 6000.

40.9 During the test, sustained arcing shall not occur. After the test, the devices shall not show:

a) Wear impairing the further use of the device;

b) Deterioration of enclosures or barriers;

c) Damage to the entry holes for the contacts that impairs proper working; and

d) Loosening of electrical or mechanical connections.

41 Electromagnetic (Pilot Contacts)

41.1 The pilot contacts of a plug, connector, inlet, and receptacle for controlling a contactor, a relay, or other magnetically operated device shall perform satisfactorily when subjected to an overload test consisting of 50 operations, making and breaking the inrush current based on the contact rating, followed by 6,000 operations at normal rated current, in a circuit of 110% of the test potential indicated test in Table 41.1. The load shall be as indicated in Table 41.1 and shall consist of an electromagnet representative of the load that the device is intended to control.

41.2 A load other than one of those described in Table 41.1 may be used after due consideration of:

a) The need for a device to control an electromagnetic load having other characteristics;

b) The means utilized for matching the rating of the device to that of the load; and

c) The manufacturer's markings.

Table 41.1
Standard electromagnet loads[c]
(See Clauses 41.1 and 41.2)

Test potential in volts	Standard duty (Codes B and P)		Heavy duty (Codes A and N)	
	Normal current	Current inrush	Normal current	Current inrush
120 ac[a]	3.0	30	6.0	60
240 ac[a]	1.5	15	3.0	30
480 ac[a]	0.75	7.5	1.5	15
600 ac[a]	0.6	6	1.2	12
125 dc[b]	1.1	–	2.2	–
250 dc[b]	0.55	–	1.1	–
600 dc[b]	0.2	–	0.4	–

[a] Power factor 0.35 or lower.

[b] Inductive loads, as specified in the Standard for Industrial Control Equipment, UL 508.

[c] For other values, see the Standard for Industrial Control Equipment, UL 508.

42 Polarization Integrity

42.1 Compliance with the requirements specified in Clause 12.11 shall be determined by using the device assembled in its intended housing with the polarization feature removed. With the axis of the mating devices aligned the devices shall not be able to mate in any manner that would energize the grounding (bonding) feature of the device when a force of 180 N (40 lbf) is applied.

43 Resistance to Corrosion

43.1 Ferrous parts, including enclosures, shall be adequately protected against corrosion.

43.2 Compliance shall be checked by the following test. All grease shall be removed from the parts to be tested, by immersion in ethyl acetone, acetone or methylethyl ketone for 10 minutes. The parts are then to be immersed for 10 minutes in a 10% solution (by weight) of ammonium chloride in water at a temperature of 20 ±5°C.

43.3 The parts are then to be dried for 10 minutes in a heating cabinet at a temperature of 100 ±5°C, and their surfaces shall not show any signs of rust.

43.4 Traces of rust on sharp edges and yellowish film removable by rubbing shall be ignored.

43.5 Small helical springs and the like, and inaccessible parts exposed to abrasion, shall be considered protected against corrosion by a coating of grease. Such parts shall be tested only when the effectiveness of the grease film is in doubt, and the test is then to be made without previous removal of the grease.

44 Moisture Resistance

44.1 Details

44.1.1 Marine-type and water-tight plugs, receptacles, and connectors requiring a degree of moisture protection shall not permit the entrance of water when subjected to the tests associated with their classifications, as described in this Clause. Water shall not enter the devices to any appreciable extent, shall not interfere with the intended performance of the device, and, shall not reach live parts.

44.1.2 When tested as described in Clause 44.2.1, a device or assembly of parts, as mentioned in Clause 44.1.3, (hereinafter referred to as the test assembly) shall comply with Clause 44.2.1.

44.1.3 The test assembly shall be fitted with cable or conduit and installed as intended in actual service, in accordance with the assembly and installation instructions. Receptacles shall be mounted on a vertical surface, with any drains present in the lowest position.

44.2 Marine type (shipboard use)

44.2.1 The test assembly shall be subjected to a solid stream of water from a nozzle not less than 25.4 mm (1.0 in) inside diameter and under a pressure of 103 kP (15 pounds-per-square-inch). The nozzle shall be directed at the test assembly from a distance of 3.05 m (10 ft) for 5 minutes.

44.2.2 If the device employed in the test assembly is an outlet, the test described in Clause 44.2.1 shall be conducted both with and without an attachment plug in the outlet.

44.3 Watertight

44.3.1 The test assembly shall consist of a mated plug and receptacle, a mated plug and connector, a mated connector and power inlet, an individual device with a cap or cover, or any other combination of mating device.

44.3.2 The test assembly shall be immersed for 24 hours in water at a temperature of 25 ±5°C, the highest point of the assembly being approximately 51 mm (2.0 in) below the water level and the longitudinal axis being parallel to the surface of the water.

45 Environmental Enclosure Type Designators

45.1 A device marked with an enclosure type designation shall be subjected to the tests specified in the Standard for Enclosures for Electrical Equipment, UL 50 and shall comply with the construction requirements applicable to an enclosure of the type number or numbers with which it is marked. See Clauses 47.13.1 – 47.13.5.

45.2 A watertight connection at conduit entrances shall be a conduit hub or the equivalent, such as a knockout or fitting, located so that when conduit is connected and the enclosure is mounted in the intended manner, the enclosure is found to be acceptable when subjected to the tests specified in the Standard for Enclosures for Electrical Equipment, UL 50.

RATINGS

46 General

46.1 Devices shall be rated in amperes and in volts, ac or dc, or both. A device may have multiple voltage and current ratings unless designed for a single voltage and current rating.

46.2 If the contact configuration of the device is one of the configurations illustrated in the Standard for Pin and Sleeve Configurations, UL 1686, the device shall be given only the ratings shown in the figure.

46.3 A device may be rated in horsepower in addition to the required ampere rating.

46.4 If a device includes a switch that controls an outlet, the overall rating of the device shall not be higher than the rating of the switch.

46.5 A device shall be rated for disconnecting use only, not for current interrupting, if:

a) The voltage rating is higher then 250 V dc; or

b) The current rating is higher than 250 A for voltages up to 300 Vac, or 200 A for voltages over 300 Vac and for voltages up to 250 Vdc. See Clause 36.5.

MARKING

47 Details

47.1 Company name, catalog designation, electrical rating

47.1.1 A device shall be legibly and permanently marked, where readily visible after installation, with:

a) The manufacturer's name, trade name, trademark, or other descriptive marking which may identify the organization responsible for the device. The manufacturer's identification may be in a traceable code if the device is identified by the brand or trademark owned by a private labeler

b) The catalog number or an equivalent designation, where practicable. See Clause 47.7.1;

c) The electrical rating in both volts and amperes;

d) The motor rating(s) and associated electrical rating (voltage, no. of phases, etc.), if so rated;

e) Whether ac or dc or both, see Clause 47.5.1;

f) For devices incorporating either fuses or circuit breakers, the rating of the fuse or circuit breaker in rms symmetrical amperes such as ″Fuse Incorporated in Device is Rated _____ RMS″.

g) Ambient temperature rating, if higher than 40°C or if lower than -25°C

h) If intended for a specific location, the type of location in which the device is intended to be used; and

47.1.2 A device intended for use in the branch circuit for switching applications shall be marked ″Switch Rated Plugs and Receptacles for use in Branch Circuit Switching Applications″.

47.1.3 A device intended for use in the motor circuit for switching applications shall be marked ″Switch Rated Plugs and Receptacles for use in Motor Circuit Switching Applications″.

47.1.4 A device intended for use with flexible cord or cable shall be marked with the following:

a) The intended flexible cord or cable types;

b) Conductor size or sizes;

c) Total number of conductors; and

d) The overall cord diameter if the device is intended to be utilized with a limited range of cord diameters available for a cord.

The markings shall be indicated on the smallest unit shipping carton, on an instruction sheet provided in the carton, or on the device.

47.1.5 If the device is rated 100 A or less and is intended for use with conductors having 75°C or higher insulation, the device shall be marked with the temperature rating of the insulation.

47.1.6 If a device is intended for use with conductors having a temperature rating higher than 60°C but is intended to be used based on 60°C ampacities, the minimum conductor size shall be indicated on the device, as well as on the smallest unit shipping carton, or on an instruction sheet provided in the carton.

47.2 Multiple factories

47.2.1 If a manufacturer produces or assembles attachment plugs, receptacles, cord connectors, and the like at more than one factory, each finished device shall have a distinctive marking on the device, that may be in code, by which the device can be identified as the product of a particular factory.

47.3 Nonconductive mounting means

47.3.1 A receptacle or a flanged inlet as described in Clause 12.4 shall be plainly marked on the device where visible during installation as follows: ″CAUTION – Mounting means not grounded. Grounding (bonding) wire connection required″ or an equivalent wording following the word ″CAUTION″. See Clause 47.4.1.

47.4 Cautionary marking size

47.4.1 Markings containing the word ″CAUTION″ shall contrast sharply with the background and shall appear in lettering of a height not less than specified in Table 47.1. The word ″CAUTION″ shall be not less than twice the height specified in Table 47.1.

Table 47.1
Minimum lettering heights
(See Clause 47.4.1)

Device rating amperes	Minimum height of lettering	
	mm	inch
Less than 40	1.5	1/16
40 or more and under 150	3.0	1/8
150 or more and under 400	6.0	1/4
400 or more	12.0	1/2

47.5 AC only devices

47.5.1 A device that is intended for use on alternating current circuits only shall be identified as such by means of the letters ″AC″, or ″AC Only″, or an acceptable frequency marking (for example, ″60 Hz or 60 ~″), or a phase marking, which shall be a part of the electrical rating. For multiphase devices that are intended for use only on a Wye system, the marking shall include the word ″Wye″, or the equivalent.

47.6 Enclosure grounded (or bonded) devices

47.6.1 A metallic attachment plug or cord connector in which the enclosure is conductively connected to the grounding contact shall be marked on the device ″enclosure grounded″ or with an equivalent statement, unless the grounding (or bonding) connection is readily visible.

47.7 Catalog designation

47.7.1 If the product is too small, or where it would be difficult to legibly provide the complete catalog designation or an equivalent designation, or where several catalog numbers use common parts, the complete designation shall appear on the smallest unit container.

47.8 Fused devices

47.8.1 A device intended to accommodate fuses, other than a plug or cartridge fuse acceptable for branch circuit protection, shall be marked ″Use only with a ___ volt fuse″. The potential to be used in the marking shall be the voltage rating of the fuse for which the device is intended.

47.9 Locking-type devices

47.9.1 An attachment plug required to be given a twisting or turning motion, except for any locking retaining device, to lock or unlock it after the male contacts have been inserted into the female contacts, and a cord connector intended to accommodate such an attachment plug, shall be marked on the device ″Turn and pull″ or an equivalent wording or symbol. The marking shall be visible while the device is in use.

47.10 Receptacle marking location

47.10.1 The markings required in Clauses 47.1.1 and 47.5.1 shall be visible on the outside of a receptacle after installation.

47.11 Wiring information - field wiring terminals

47.11.1 The value of tightening torque assigned in accordance with Clause 14.3 shall be marked where readily visible:

a) On the device;

b) On the smallest unit container; or

c) On an information sheet packed in the smallest unit container.

47.11.2 If field wiring terminals employing solder connections are intended for solid, stranded tinned, or tin dipped stranded conductors only, instructions regarding the use of solid wire or the tinning of stranded wire shall be marked where readily visible:

a) On the device;

b) On the smallest unit container; or

c) On an information sheet packed in the smallest unit container.

47.11.3 Crimp terminal installations instructions, including conductor size(s) and type(s) and crimp tool(s) designation shall be marked where readily visible:

a) On the device;

b) On the smallest unit container; or

c) On an information sheet packed in the smallest unit container.

47.12 Overcurrent protection - motor rated devices

47.12.1 A device intended for use on general-purpose branch circuits having a motor rating over 1 horsepower (746 W) shall be marked ″Suitable For Use On A Circuit Capable Of Delivering Not More Than _____ rms Symmetrical Amperes, _____ Volts Maximum″. The ratings shall not to be more than the value for which the device was tested in accordance with Short Circuit Withstand and Closing, Section 34.

a) If tested only with non-time delay fuses, the marking shall also include the following or equivalent: ″When Protected by _____ Class Fuses″.

b) If tested with a time delay fuse, the marking shall also include the following or equivalent: ″When Protected by Time Delay _____ Class Fuses″.

c) If tested in accordance with Clause 34.2.2, the marking shall also include the following or equivalent: ″When Protected By A Circuit Breaker Having An Interrupting Rating Not Less Than _____ rms Symmetrical Amperes, _____ Volts Maximum″.

These markings shall be located on the device or in the installation instructions.

47.12.2 A motor rated device intended for use on general purpose branch circuits shall also be marked on the device with the following:

a) ″Maximum Overcurrent Protection Shall Not Exceed the Ampere Rating of This Device″ or the equivalent, or

b) ″Maximum Overcurrent Protection_____ Amperes″, or

c) ″Protect With Maximum _____ Ampere Fuses″, or

d) ″Protect With Maximum _____ Ampere Time Delay Fuses″.

The amperes rating shall not be more than the rating of the device.

47.12.3 A device intended only for use on a motor branch circuit having a motor rating over 1 horsepower (746 W) shall be marked ″Suitable For Use On A Circuit Capable Of Delivering Not More Than _____ rms Symmetrical Amperes, _____ Volts Maximum″. The ratings shall not be more than the value for which the device was tested in accordance with Short Circuit Withstand and Closing, Section 34.

a) If tested only with non-time delay fuses in accordance with Table 34.2, the marking shall also include the following or equivalent: ″When Protected by _____ Class Fuses″.

b) If tested with a time delay fuse in accordance with Table 34.2, the marking shall also include the following or the equivalent: ″When Protected by Time Delay _____ Class Fuses″.

c) If tested in accordance with Clause 34.2.2, the marking shall also include the following or the equivalent: ″When Protected By A Circuit Breaker Having An Interrupting Rating Not Less Than _____ rms Symmetrical Amperes, _____ Volts Maximum″.

These markings shall be located on the device or in the installation instructions.

47.12.4 A motor rated device intended only for use on a Motor branch circuit shall also be marked with the following:

a) ″Suitable for Use Only on Motor Branch Circuits″, or the equivalent, and

b) ″Maximum Overcurrent Protection _____ Amperes″, or

c) ″Protect With Maximum _____ Ampere Fuses″, or

d) ″Protect With Maximum _____ Ampere Time Delay Fuses″.

The ampere rating shall not be more than the value for which the device was tested in accordance with Clause 34.2.1 or Clause 34.2.2.

47.13 Environmental enclosures

47.13.1 A device enclosure type designation marking shall be one of those specified in the Standard for Enclosures for Electrical Equipment, UL 50. The marking shall be visible after installation and shall be permanent. See Clauses 47.13.6 and 47.13.7.

47.13.2 An enclosure that complies with the requirements for more than one type of enclosure may be marked with multiple designations.

47.13.3 Device enclosures that comply with the requirements of Environmental Enclosure Type Designators, Section 45 may be provided with the following additional markings:

a) A Type 4, 4X, 6, or 6P enclosure may be marked ″Watertight″.

b) A Type 4X or 6P enclosure may be marked ″Corrosion Resistant″.

47.13.4 If the acceptability of a Type 2, 3, or 3R enclosure is dependent upon a particular mounting orientation, the device enclosure shall be marked to indicate the required orientation.

47.13.5 A plug, receptacle, or connector that provides enclosure protection shall be legibly marked where visible during intended use ″To maintain enclosure rating, use only with a device with identical marking _____″ (specific identification) or the equivalent.

47.13.6 A marking identifying an environmental enclosure type or types shall be molded, die-stamped, paint-stenciled, stamped or etched metal that is permanently secured, or indelibly applied lettering on a label secured by adhesive that, upon investigation, is acceptable for the application. Ordinary usage, including likely exposure to weather and other ambient conditions, handling, storage, and the like of the equipment is considered in the determination of the acceptability of the application.

47.13.7 A pressure-sensitive label or a label secured by cement or adhesive shall comply with the applicable requirements for indoor or outdoor use labels in the Standard for Marking and Labeling Systems, UL 969.

47.14 Moisture-resistant devices

47.14.1 A device that complies with the requirements of Section 44.3 may be marked ″Watertight″.

47.14.2 A device that complies with the requirements of Section 44.2 may be marked ″Marine type″.

48 Identification and Marking of Terminals

48.1 General

48.1.1 Wiring terminals shall be marked to indicate the proper connections for the power, control circuits, and the like, or a wiring diagram coded to the terminal marking shall be provided with the product.

48.2 Grounded and grounding (or bonding)

48.2.1 Device wiring terminals intended for connection to grounded circuit conductors or grounding (or bonding) conductors shall be clearly and permanently identified on the device in accordance with Table 48.1 or Table 48.2. The colors or markings specified for this terminal identification shall not be applied to other than the designated terminals. The identifications shall be readily recognizable during wiring and relate directly to the appropriate terminals.

Table 48.1
Identification of wiring terminals
(See Clause 48.2.1)

Identification by:	Grounded terminal	Grounding terminal	All other terminals
Wire-binding screw	White metal or plating on screw head	Hexagonal, green-colored nutbor slotted screw head[b]	Other than white, gray, or green circular screw head
Pressure wire terminal-visible	White metal or plating on connector	Green-colored connector or appendage[b]	Other than white, gray, or green colored terminal
Pressure wire terminal concealed	Distinct white-colored area adjacent to wire entrance hole, or the word ″white″, or the letter ″W″ distinctively marked adjacent to wire entrance hole[c]	Distinct green-colored area adjacent to wire entrance hole, or the word ″green″ or ″ground″, the letters ″G″ or ″GR″, or the grounding symbol[d] distinctively marked adjacent to wire entrance hole[c]	Other than white, gray, or green area adjacent to wire entrance hole
Set screw	Distinct white-colored area adjacent to wire entrance hole, the word ″white″, or the letter ″W″ distinctively marked adjacent to wire entrance hole[c]	Distinct green-colored area adjacent to wire entrance hole, or the word ″green″ or ″ground″, the letters ″G″ or ″GR″, or the grounding symbol[d] distinctively marked adjacent to wire entrancehole[c]	Other than white, gray, or green area adjacent to wire entrance hole
Terminal plate[a]	White metal or plating	–	Other than white, gray, or green metal or plating
Insulating enclosure or terminal	The word ″white″ or the letter ″W″, marked on or directly adjacent to terminal[c], or white metal or plating on terminal	The word ″green″, the word ″ground″, or the letters ″G″ or ″GR″[c] marked on or directly adjacent to terminal, or green colored terminal, or the grounding symbol[d]	–
			Other than white, gray, or green-colored terminal

[a] Only if all line-terminal binding screws are of the same color.

[b] Not readily removable. See 48.2.2.

[c] In letters at least 1/16 inch (1.6 mm) high.

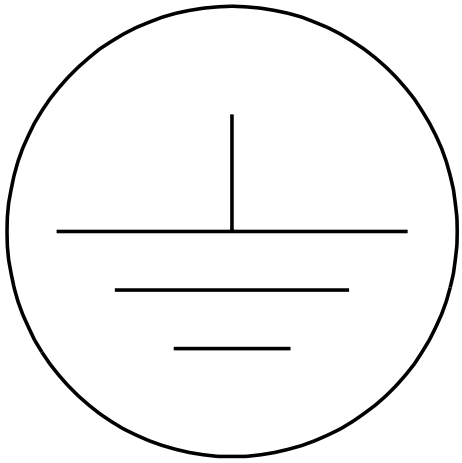
[d] The grounding symbol shown in Figure 48.1 is permitted.

Table 48.2
Identification of leads
(See Clause 48.2.1)

Identification by:	Grounded conductor	Grounding (or bonding) conductor	All other conductors
Color of braid[b]			White or gray with tracer in braid Or
	Solid white or gray (without tracer)	Not applicable	Solid color other than white, gray, or green[a] (without tracer)
	Color other than white, gray or green, with tracer in braid	Not applicable	Solid color other than white, gray, or green[a] (without tracer)
Color of insulation[b]	Solid white or gray; stripe, white or gray, on contrasting color other than green[a]	Green with or without one or more yellow stripes	Solid color other than white, gray, or green[a]
Color of separator[b]	Solid white or gray	Not applicable	Solid color other than white gray or green[a]
Conductor tinning[c]	Tin or other acceptable metal on all strands of the conductor	Not applicable	No tin or other white metal on the strands of the conductor

[a] A green wire, with or without one or more yellow stripes, shall be used only as an equipment grounding (bonding) conductor.
[b] If color of braid, insulation, or separator is used for identification, all conductors shall be either tinned or not tinned.
[c] If conductor tinning is used for identification, all braids and/or insulation shall have the same color and shape.

Figure 48.1
Grounding Symbol
(See Table 48.1)



GND1

48.2.2 Terminals for the grounded conductors may be permanently identified at the time of installation by a distinctive white marking or other equivalent means.

48.2.3 A part relied upon to provide the terminal identification required in Clause 48.2.1 shall not be readily removable if it can be replaced with a similar part of another wiring terminal of the device. A suitably staked terminal screw shall be considered not readily removable for this purpose. A surface of a permanent appendage to a wiring terminal may be used to mark the terminal identification.

48.3 Other terminals

48.3.1 Marking conventions, other than for those terminals described in Clause 48.2.1, shall be provided and shall be identical to the convention used on the mating device. The marking convention used shall be described in the wiring instructions provided with the device.

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APPENDIX A

Standards for Components

Standards under which components of the products covered by this Outline of Investigation are evaluated include the following:

Title of Standard − UL Standard Designation

UL Standards

Cables and Conduit, Fittings for – UL 514B
Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures, Molded-Case – UL 489
Enclosures for Electrical Equipment – UL 50
Flexible Cord and Fixture Wire – UL 62
Fuseholders – UL 512
Fuses, Low-Voltage – Part 1: General Requirements – UL 248-1
Fuses, Low-Voltage Fuses – Part 5: Class G – UL 248-5
Fuses, Low-Voltage Fuses – Part 6: Class H Non-Renewable – UL 248-6
Fuses, Low-Voltage Fuses – Part 7: Class H Renewable – UL 248-7
Fuses, Low-Voltage Fuses – Part 8: Class J – UL 248-8
Fuses, Low-Voltage Fuses – Part 9: Class K – UL 248-9
Fuses, Low-Voltage Fuses – Part 10: Class L – UL 248-10
Fuses, Low-Voltage Fuses – Part 12: Class R – UL 248-12
Fuses, Low-Voltage Fuses – Part 15: Class T – UL 248-15
Gaskets and Seals – UL 157
Grounding and Bonding Equipment – UL 467
Industrial Control Equipment – UL 508
Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment – UL 840
Marking and Labeling Systems – UL 969
Outlet Boxes, Metallic – UL 514A
Outlet Boxes – Nonmetallic, Flush-Devices Boxes, and Covers – UL 514C
Plastic Materials for Parts in Devices and Appliances, Tests for Flammability of – UL 94
Polymeric Materials – Fabricated Parts – UL 746D
Polymeric Materials – Long Term Property Evaluations – UL 746B
Polymeric Materials – Short Term Property Evaluations – UL 746A
Polymeric Materials – Use in Electrical Equipment Evaluations – UL 746C
Switches, Enclosed and Dead-Front – UL 98
Switches, General Use – Snap – UL 20
Tape, Polyvinyl Chloride, Polyethylene, and Rubber Insulating – UL 510
Terminal Blocks, Electrical – UL 1059
Terminals, Electrical Quick-Connect – UL 310
Tubing, Extruded Insulating – UL 224
Wire Connectors – UL 486A – 486B
Wire Connectors, Splicing – UL 486C
Wiring Terminals for Use with Aluminum and/or Copper Conductors – UL 486E
Electrical Wires, Cables, and Flexible Cords, Reference Standard for – UL 1581

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