UL 1640

STANDARD FOR SAFETY

Portable Power-Distribution Equipment

UL Standard for Safety for Portable Power-Distribution Equipment, UL 1640

Fourth Edition, Dated November 14, 2016

Summary of Topics

This revision of ANSI/UL 1640 dated July 14, 2021 includes the following changes in requirements:

– Revision of Criteria for the Use of "100 Percent Rated" Circuit Breakers; 15.2.1

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

The revised requirements are substantially in accordance with Proposal(s) on this subject dated May 7, 2021.

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UL 1640

Standard for Portable Power-Distribution Equipment

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First Edition – October, 1995
Second Edition – July, 2000
Third Edition – October, 2012

Fourth Edition

November 14, 2016

This ANSI/UL Standard for Safety consists of the Fourth Edition including revisions through July 14, 2021.

The most recent designation of ANSI/UL 1640 as an American National Standard (ANSI) occurred on July 14, 2021. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

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

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INTRODUCTION

1 Scope

1.1 These requirements cover portable power-distribution equipment rated 600 volts or less and 1600 amperes maximum. They are intended for either single- or multi-phase supply and are intended to distribute power in accordance with the National Electrical Code, NFPA 70 (NEC).

1.2 These requirements cover portable power-distribution equipment intended for use in the following locations:

a) Carnivals, circuses, fairs, and similar locations in accordance with Article 525 of the NEC;

b) Exhibition halls in accordance with Article 518 of the NEC;

c) Motion picture and television studios and similar locations in accordance with Article 530 of the NEC;

d) Theaters, audience areas of motion-picture and television studios, and similar locations in accordance with Article 520 of the NEC; and

e) Temporary installations at construction sites in accordance with Article 590 of the NEC.

1.3 These requirements do not cover portable power-distribution equipment:

a) Intended to be mounted above or adjacent to the lighting unit it supplies. These devices are covered by the Standard for Stage and Studio Luminaires and Connector Strips, UL 1573.

b) Intended to be connected to the load side of branch circuits, such as:

1) Relocatable power taps. These devices are covered by the Standard for Relocatable Power Taps, UL 1363;

2) Cord sets. These devices are covered by the Standard for Cord Sets and Power-Supply Cords, UL 817;

3) Convention-center Cord Sets. These devices are covered by the Standard for Exhibition Display Units, Fabrication and Installation, UL 2305; and

4) Current taps. These devices are covered by the Standard for Current Taps and Adapters, UL 498A.

2 Components

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

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

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

b) Is superseded by a requirement in this standard.

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

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

3 Units of Measurement

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

3.2 All applicable alternating-current electrical measurements are in root-mean-square (rms) units unless otherwise stated.

4 Undated References

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

5 Glossary

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

5.2 BUS BAR CLAMP (SISTER LUG) – A connector that terminates a single conductor cable and that is secured to a bus bar with an integral set screw. May secure the conductor by soldering, integral pressure wire connector, or by crimping of the clamp body.

5.3 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.

5.4 CABLE-SPLICING BLOCK – Power-distribution equipment intended to provide a termination for cable assemblies. Not provided with overcurrent protection; only provide a means to extend runs of single- or multi-conductor cable.

5.5 COVER – An unhinged, removable covering member that is a required part of the enclosure.

Note: Some standards for products used as components on or in portable power distribution units designate “cover” as “cap” or “closure”.

5.6 DAMP LOCATION – Protected locations outdoors and interior locations subject to moderate degrees of moisture. This would also include areas near where artificial rain is being produced, or when effect machines that utilize water vapor to generate fog or mist effects are being used. Damp Locations are not subject to direct water spray or rain.

5.7 DEAD-FRONT – A panel that may or may not form a part of the enclosure and that may be used behind a door, which may have openings for the passage of cords, to cover wiring and uninsulated live parts.

5.8 DOOR – A hinged, sliding, or similarly attached covering member that is capable of being removed only by the use of a tool and that is a required part of the enclosure.

Note: Some standards for products used as components on or in portable power distribution units designate “door” as “cover”, “hood”, or “lid”.

5.9 ENCLOSURE – That part of power-distribution equipment that:

a) Renders inaccessible all or any parts of the equipment that may otherwise present a risk of electric shock and/or

b) Retards propagation of flame initiated by an electrical fault occurring within the equipment.

5.10 FORMED HINGE – A strip of metal secured to or integral with the enclosure or trim and formed so that it will cooperate with a slot in a door to form a hinge.

5.11 INLET ASSEMBLY, INTERLOCKED – An assembly of locking-type, single-pole pin-and-sleeve inlets. The assembly is interlocked as specified under 5.18.

5.12 INLET ASSEMBLY, SEQUENTIALLY INTERLOCKED – An assembly of locking-type, single-pole pin-and-sleeve inlets. The assembly is sequentially interlocked as specified under 5.19.

5.13 INTERLOCKED INLET – An inlet having a device, either mechanical or electrical, that is intended to reduce the risk of energizing the contacts before complete engagement with a plug, and that either is intended to reduce risk of the plug being withdrawn while its contacts are energized or de-energizes the line contacts before separation.

5.14 PIN-AND-SLEEVE DEVICE – A plug or receptacle utilizing contacts which generally are cylindrical or circular in shape and telescoping and are shrouded by an extension of the enclosure of the mating devices.

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

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

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

5.18 RECEPTACLE ASSEMBLY, INTERLOCKED – An assembly consisting of a number of locking-type, single-pole pin-and-sleeve-type receptacles. Supply receptacles are interlocked to the source so it is not possible to connect or disconnect the plugs when the source of supply is energized.

5.19 RECEPTACLE ASSEMBLY, SEQUENTIALLY INTERLOCKED – An assembly consisting of a number of locking-type, single-pole receptacles that are electrically or mechanically interlocked in such a manner that plugs must be connected in the following sequence and disconnected in the reverse order:

a) Equipment-grounding conductor connection, if provided;

b) Grounded circuit conductor connection, if provided; and

c) Ungrounded conductor connection.

5.20 SHIELDING – A hinged or fixed member that is attached to the enclosure but is not a required part of the enclosure, such as a rain shield.

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

5.22 TERMINAL, SET SCREW – A terminal that provides clamping by the end of the screw bearing directly on the conductor.

5.23 TERMINAL, WIRE-BINDING SCREW – A terminal having the conductor bent around the screw and clamped directly under the head of the screw when it is tightened. The conductor is intended to encircle the terminal screw at least three-fourths the circumference without overlapping.

PART 1 – ALL EQUIPMENT

CONSTRUCTION

6 General

6.1 Portable power-distribution equipment shall be constructed and assembled so that it has the strength and rigidity necessary to resist the abuses to which it is likely to be subjected, without total or partial collapse resulting in a risk of fire, electric shock, or injury to persons due to the reduction of spacings, loosening or displacement of parts, or other serious defects.

6.2 Portable power-distribution equipment shall be constructed so as to reduce the risk of intentional contact with enclosed electrical devices and to provide internal devices with protection from specified external conditions.

6.3 Portable power-distribution equipment shall be complete when it is shipped from the factory and shall not have provisions for the mounting of additional equipment. Internal wiring and connections between components shall be completed at the factory.

7 Current-Carrying Parts

7.1 General

7.1.1 Current-carrying parts shall be of silver, copper, or alloys of these metals or others determined to be the equivalent. Current-carrying parts of other materials that are used in the construction of components shall comply with the appropriate requirements for that component as specified in Appendix A.

7.1.2 Iron or steel shall not be used for a part that is depended upon to carry current.

7.2 Bus bars

7.2.1 General

7.2.1.1 The bending of a bus bar shall not result in visible cracks, but roughening or slight surface checking is not prohibited.

7.2.2 Ampacity

7.2.2.1 Other than as covered in 7.2.2.4 and 7.2.2.5, the ampacity or size of a bus bar is considered sufficient if the current density is not more than as specified in Table 7.1 or the size is not less than as specified in Table 7.2.

Exception: Bus bars operated at ampacities greater than as specified in Table 7.1 shall be tested in accordance with and comply with the Temperature Test, Section 20.

Table 7.1
Ampacity of single or multiple bus bars and clamped joints

Bus bar material[a]	Current, amperes	Current density in amperes per square inch (6.45 square cm)	
		Bus bar cross section[b]	Contact area at clamped joints
Copper	0 – 600	1000[d]	200
Copper	601 – 1600	1000[d,e]	200[c]
Brass	0 – 600	500	200

[a] Multiple bus bars in parallel shall be of the same material and cross section.

[b] See 7.2.2.1 – 7.2.2.4 regarding the ampacity.

[c] Joints bolted and plated with silver, tin, nickel, or cadmium.

[d] See Table 7.2 for 800 ampere maximum single bus bars.

[e] Reference the Standard for Dead-Front Switchboards, UL 891, for 100 percent rated device rated 3,000 amperes or more.

Table 7.2
Rating and sizes of single bus bars – 800 amperes maximum

Current rating, amperes	Copper bus			
	Bus size[a],		Cross section,	
	inch	(mm)	inch^2	(mm^2)
225	0.125 by 0.875	(3.2 by 22.2)	0.109	(70.3)
400	0.250 by 1.500	(6.38 by 38.1)	0.375	(242.0)
600	0.250 by 2.000	(6.38 by 50.8)	0.500	(322.6)
800	0.250 by 3.000	(6.38 by 76.2)	0.750	(483.9)

NOTES

1 For multiple buses in parallel, refer to Table 7.1.

2 A bus connection to a fused power circuit device, to a transfer switch with Class L fuses, or to a molded case circuit breaker rated for continuous use at 100 percent of its rating shall be sized in accordance with Table 7.1 or shall be tested in accordance with the limitation on temperature rise specified in Table 20.1.

3 Joints bolted and plated with silver, tin, nickel, or cadmium.

A bus bar having other dimensions may also be used if it has not less than the cross-sectional area specified in the table and if it has been determined to have equivalent rigidity.

7.2.2.2 The material at any cross-section along the length of a bus bar shall have at least 70 percent of the required ampacity and the remaining metal in any 6 inch (152 mm) length of the bus bar shall have at least 93 percent of the metal of a bus bar having the required ampacity in accordance with Table 7.1.

Exception: Bus bars with a larger amount of material removed shall be tested in accordance with and comply with the Temperature Test, Section 20.

7.2.2.3 In determining the area of contact surfaces of bolted or riveted connections, no additions or subtractions for the diameters and areas of screws, bolts, or rivets shall be made.

7.2.2.4 The contact area shall not be less than the minimum 1 square inch (6.5 cm^2) per 200 amperes specified in Table 7.1 and Table 7.2 unless the construction complies with one of the following:

a) The contact area between a plated bus bar and circuit breaker or switch shall not be less than the area on the pressure wire connector that is supplied with a breaker or the full contact area on the circuit breaker, if no pressure wire connector is supplied.

b) If the full available contact area between a bus bar and pressure terminal connector is not used, the contact area shall not be less than the area that results when two of the same type connectors are bolted together back-to-back with wires leaving in opposite directions or at right angles, whichever results in the smallest area.

7.2.2.5 The limitations on current density mentioned in Table 7.1 and Table 7.2 do not apply to:

a) A connecting strap, bus bar, or the like, comprising all integral part of a circuit breaker, switch, or fuseholder.

b) A portion of a strap, bus bar, jumper, or the like, adjacent and connected to a terminal of a switch, circuit breaker or fuseholder [but not more than 1 inch (25.4 mm) from the terminal], when a reduced cross-section in that portion is necessary because of the recessing of the terminal or because of barriers adjacent to it.

7.2.2.6 A wire or bus bar leading to a noninterchangeable trip circuit breaker shall have an ampacity not less than the current rating of the breaker.

7.2.2.7 A wire or bus bar leading to a circuit breaker frame constructed for use with interchangeable trip equipment shall have an ampacity not less than the maximum current rating of the frame.

7.2.3 Bolted construction

7.2.3.1 A spring washer shall be used at one end of a bolt that secures current-carrying parts together.

Exception No. 1: A spring washer is not required in a construction that has been tested in accordance with and complies with the Clamped Joint Temperature Test, Section 21.

Exception No. 2: A spring washer shall not be replaced with a split-ring lockwasher and a flat washer unless all the current-carrying parts in the joint, including the tang of a pressure terminal connector, are copper.

Exception No. 3: A flat washer, a split-ring lockwasher, or a bolthead that has an outer diameter of at least 150 percent of the bolt shaft shall not be used in place of a spring washer unless the only aluminum in the joint is the tang of a pressure terminal connector.

7.2.3.2 Unless investigated for such use, a bolted connection between two bus bars or between a bus bar and another current-carrying part shall not depend upon any polymeric insulation to maintain the clamping force and shall not depend on thermoplastic material in any case.

7.2.3.3 A bolted joint in a bus bar shall be accessible for tightening without removing insulating tape or any other part.

7.2.4 Riveted construction

7.2.4.1 Each riveted connection involving current-carrying parts shall have a spring washer at one end and either a spring washer or a flat washer at the other end.

Exception No. 1: The washers are not required in a construction that has been tested in accordance with and complies with the Clamped Joint Temperature Test, Section 21.

Exception No. 2: The washers are not required in a connection rated 220 amperes or less having copper bus bars only.

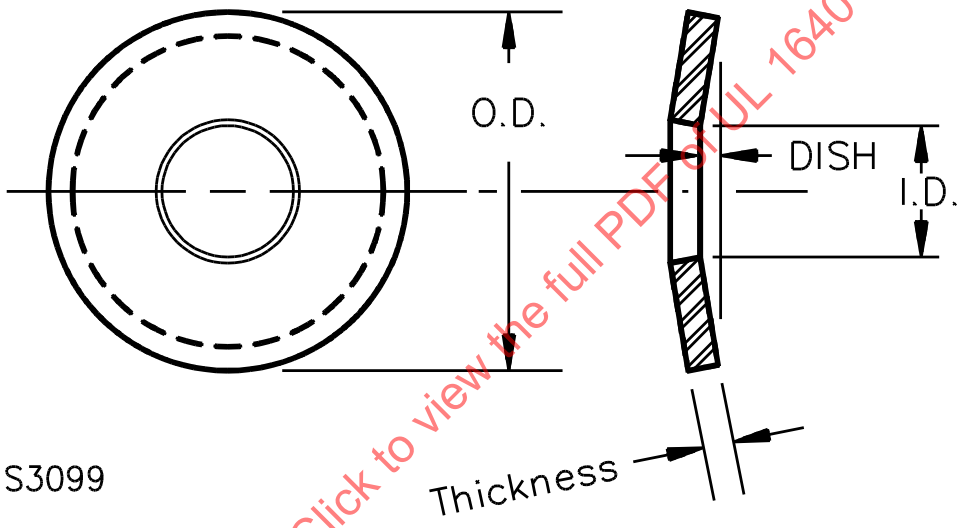
7.2.5 Washers

7.2.5.1 The flat washer as specified in 7.2.3.1 shall have a thickness of at least 1/6 of the diameter of the rivet shank or bolt and shall have an outer diameter of at least 150 percent of the rivet shank or bolt but not less than the outer diameter of the spring washer.

7.2.5.2 A spring washer as specified in 7.2.3.1 is a dished washer of stainless or hardened or tempered steel having an outer diameter of not less than 150 percent of the bolt diameter, having a thickness not less than 1/8 of the bolt diameter, and dished not less than 3-1/2 percent of the bolt diameter. A typical spring washer is shown in Figure 7.1. The intended orientation of the spring washer is shown in Figure 7.2.

Figure 7.1

Spring washer



NOTES

1 The spring washer shall comply with the following:

OD ≥ 1.5 D

T ≥ 0.125 D

H ≥ 0.035 D

in which:

OD is the outer diameter of washer,

D is the diameter of bolt or rivet shank,

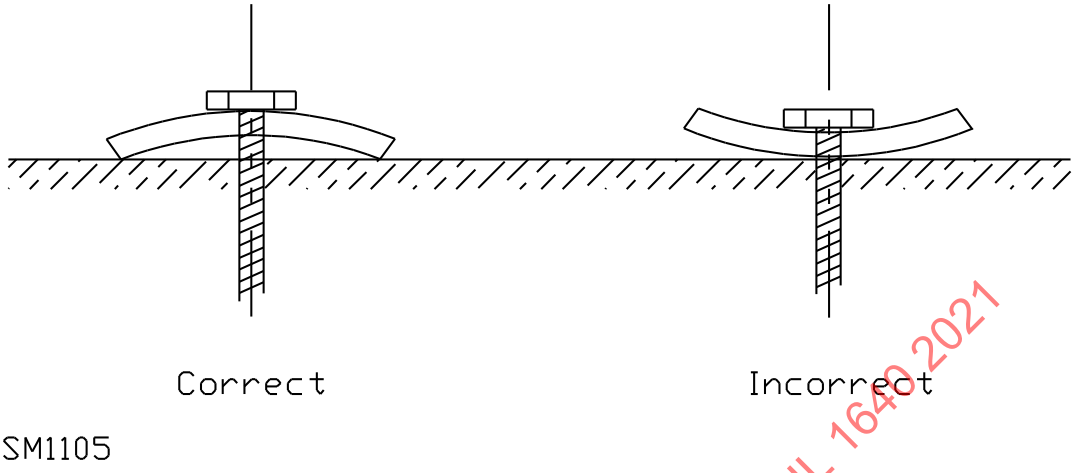
T is the thickness of washer, and

H is the depth of "dish" of spring washer.

2 Spring washers are also referred to as Belleville and ramp-conical washers.

Figure 7.2

Orientation of spring washer



7.3 Support and securement of live parts

7.3.1 A bus bar shall either be supported independently of any component to which it is connected (switch, circuit breaker, or the like) or shall be supported by parts that do not depend on a bus bar for support.

7.3.2 A bus bar or an insulated live part shall be secured so that ordinary vibration will not loosen the securing means and shall be prevented from turning or shifting in position if such turning or shifting would result in spacings less than 1/2 of those specified in Table 16.1.

7.3.3 Friction between surfaces is not intended as the sole means to prevent turning or shifting of an uninsulated live part. Turning or shifting shall be prevented by the use of two screws or rivets; by non-circular shoulders or mortises; by a dowel pin, lug, or offset; by a connecting strap or clip fitted into an adjacent part; or by another method determined to be the equivalent.

7.3.4 In evaluating means to prevent turning or shifting in regard to 7.3.3, any screw or nut is to be loosened and retightened fingertight without a tool. The bus bar is then to be pushed to the extent limited by the screws or other means and the resulting spacings checked.

7.4 Internal wiring

7.4.1 Type

7.4.1.1 All internal wiring shall be of copper conductors and have insulation rated 90°C (194°F) minimum and for the voltage involved.

Exception: This requirement does not apply to insulation rated less than 90°C that has been tested in accordance with and complies with the Temperature Test, Section 20.

7.4.2 Routing

7.4.2.1 Wires shall be routed away from sharp edges, screw threads, burrs, fins, or the like that are capable of abrading the wire insulation. A hole through which insulated wires pass in a sheet metal wall shall be provided with a smooth, well-rounded bushing or have smooth, well-rounded surfaces upon which the wires may bear to reduce the risk of abrasion of the insulation.

7.4.3 Terminations

7.4.3.1 A wire connector shall comply with:

a) The Standard for Wire Connectors, UL 486A-486B; or

b) The Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors, UL 486E.

Exception: A wire connector used at an equipment grounding terminal or bonding connection shall comply with 7.4.3.1 or the Standard for Grounding and Bonding Equipment, UL 467.

7.4.3.2 Open-type eyelets shall be of the type with upturned edges or of the type which crimp around the screw shank, or all wiring shall be done in harnesses or shall be formed so that loosening of the terminal screw will not result in the conductor coming away from the intended connection.

7.4.3.3 Quick-connect terminals shall be used under the following conditions:

a) They mate as intended with terminals integrally provided on components that have been investigated for the intended use;

b) They have a dimple, depression, or spring-type connection such that a snap-action connection is accomplished; and

c) They are suitable for the number and sizes of wires involved.

7.4.3.4 Wire-binding screws or studs and nuts shall be used to secure a 10 AWG (5.3 mm^2) or smaller conductor only.

7.4.3.5 A wire-binding screw or stud of a wiring terminal shall not be smaller than No. 10 (4.8 mm diameter) and shall not have more than 32 threads per inch.

Exception: This requirement does not apply to a No. 8 (4.2 mm diameter) machine screw having not more than 32 threads per inch used at a terminal intended only for the connection of a 14 AWG (2.1 mm^2) conductor.

7.4.3.6 Wire-binding screw terminals shall have upturned edges, cupped washers, or other means determined to be the equivalent to retain the conductor. No strands shall protrude from the terminal connector.

7.4.3.7 A wire-binding screw shall thread into metal.

7.4.3.8 A terminal plate tapped for a wire-binding screw shall be of non-ferrous metal not less than 0.030 inch (0.76 mm) thick. There shall be two or more full threads in the metal.

7.4.3.9 A splice shall be provided with insulation that has been determined to be equivalent to that of the wires involved.

7.4.3.10 Soldered connections shall be mechanically secure prior to soldering.

7.4.4 Size

7.4.4.1 The minimum conductor size shall be 18 AWG (1.82 mm^2).

Exception: Conductor size less than 18 AWG shall not be used unless investigated and determined to be rated for the purpose.

7.4.5 Ampacity

7.4.5.1 For circuits rated 100 amperes and larger, conductors of 75°C (167°F) ampacity shall be used. For circuits rated 100 amperes or less, conductors of 60°C (140°F) ampacity shall be used. See Table 7.4.

Exception: Higher ampacities shall not be used unless the assembly has been tested in accordance with and complies with the Temperature Test, Section 20. Higher ampacities shall not be used for conductors terminating to components unless the components have been evaluated for such use.

Table 7.4
Ampacity of insulated conductors

Wire size,		60°C (140°F)[a]	75°C (167°F)[a]	90°C (194°F)[a,b]
AWG	(mm^2)	Copper	Copper	Copper
14	(2.1)	15	15	15
12	(3.3)	20	20	20
10	(5.3)	30	30	30
8	(8.4)	40	50[c]	55
6	(13.3)	55	65[c]	75
4	(21.2)	70	85[c]	95
3	(26.7)	85	100[c]	110
2	(33.6)	95	115[c]	130
1	(42.4)	110	130[c]	150
1/0[d]	(53.5)[d]	See footnote e	150	170
2/0[d]	(67.4)[d]	See footnote e	175	195
3/0[d]	(85.0)[d]	See footnote e	200	225
4/0[d]	(107.2)[d]	See footnote e	230	260
kcmil		See footnote e		
250[d]	(127)[d]	See footnote e	255	290
300[d]	(152)[d]	See footnote e	285	320
350[d]	(177)[d]	See footnote e	310	350
400[d]	(203)[d]	See footnote e	335	380
500[d]	(253)[d]	See footnote e	380	430
600[d]	(304)[d]	See footnote e	420	475
700[d]	(355)[d]	See footnote e	460	520
750[d]	(380)[d]	See footnote e	475	535
800[d]	(405)[d]	See footnote e	490	555
900[d]	(456)	See footnote e	520	585
1000	(506)	See Footnote e	545	615
1250	(633)	See footnote e	590	665
1500	(760)	See footnote e	625	705
1750	(887)	See footnote e	650	735

Table 7.4 Continued on Next Page

Table 7.4 Continued

Wire size, AWG	Wire size, (mm^2)	60°C (140°F)[a]	75°C (167°F)[a]	90°C (194°F)[a,b]
		Copper	Copper	Copper
2000	(1013)	See footnote e	665	750

[a] The numbers 60°C (140°F), 75°C (167°F), and 90°C (194°F) indicate the wire temperature rating.

[b] Except as noted in the Exception to 7.4.5.1, the ampacity of 90°C (194°F) wire is to be considered the same as 75°C (167°F) wire.

[c] The ampacity of these sizes is to be considered the same as for 60°C (140°F) wire when connected to molded case circuit breakers unless the breaker is marked 75°C (167°F).

[d] For a multiple conductor connector at a terminal, the ampacity value is to be multiplied by the number of conductors that the terminal will accommodate [1/0 AWG (53.5 mm^2) and larger].

[e] For wire sizes 1/0 AWG (53.5 mm^2) and larger, it is assumed that wire with at least a 75°C (167°F) temperature rating will be used.

7.4.6 Neutral

7.4.6.1 The supply neutral input and any associated current-carrying parts shall have at least the ampacity of the largest ungrounded supply conductor.

Exception No. 1: Equipment intended for single conductor supply cables and that are rated for use with 3-phase, 4-wire with ground systems and are intended for use with electronic dimmers shall have the neutral input and any associated current-carrying parts with ampacity at least equal to 130 percent of the largest ungrounded supply conductor and be marked in accordance with 34.1. Also see 7.2.2.1 – 7.2.2.7 and 7.4.5.1 regarding ampacity of internal conductors.

Exception No. 2: Equipment rated for use on both 208Y-/120-volt, 3-phase, 4-wire, and 120-/240-volt, single-phase, 3-wire supplies at the same output rating shall have the neutral input and any associated current-carrying parts with ampacity at least equal to 200 percent of the largest ungrounded supply conductor and shall be marked in accordance with 34.2. Equipment using single-conductor feeders may use two neutral termination inlets for this purpose. Also see 7.2.2.1 – 7.2.2.7 and 7.4.5.1 regarding ampacity of internal conductors.

7.4.7 Plating

7.4.7.1 A plated steel screw, nut, and stud shall be used to secure a soldering lug, pressure wire connector, or bus bar.

7.4.7.2 Steel that is corrosion-resistant (stainless) or protected against corrosion by zinc plating, cadmium plating, silver plating, or an equivalent coating is not prohibited from being used for wire-binding screws and nuts and for a clamp and for stud terminals when the steel parts are not depended upon to carry current.

7.4.7.3 Copper and brass shall not be used for plating steel wire-binding screws, nuts, and stud terminals.

8 Electrical Insulation Material

8.1 An insulation material shall have a Performance Level Category (PLC) that does not exceed the value specified in Table 8.1. The specified values are derived from the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

Exception: This requirement does not apply to an insulation material that has been evaluated to and complies with the end-product tests specified in UL 746C.

8.2 Equipment with enclosure designation 3, 3R, 3X, 3RX, 3S, 3SX, 4, 4X, or marked "Suitable for Use in Damp Locations" shall use electrical insulation that does not exhibit a dimensional change greater than 2.0 percent after immersion for 168 hours in distilled water as described in the Standard for Polymeric Materials – Short-Term Property Evaluations, UL 746A. Untreated fiber and the like are examples of materials that shall not be used.

Table 8.1
Maximum performance level category (PLC) for insulation materials other than insulating barriers

Test specified[b]	Flammability rating of material[a]		
	V-0	V-1	V-2
Comparative tracking index under moist conditions (CTI)[d,e]	3[c]	3[c]	3[c]
High-current arc resistance to ignition (HAI)[d,f]	3	2	2
Hot wire ignition (HWI)[d,g]	4	3	2

[a] These flammability ratings are derived from the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

[b] The additional parameters specified in Table 8.2 shall be considered.

[c] A material having a comparative tracking index PLC of 4 shall not be used unless the voltage involved is 250 volts or less.

[d] See the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A, for this specified test.

[e] Refer to figurative examples 1 and 2 of Figure 8.1 for application of this requirement.

[f] Refer to figurative examples 1 – 3 of Figure 8.1 for application of this requirement.

[g] Refer to figurative examples 1 – 3 of Figure 8.1 for application of this requirement.

8.3 A base of a ceramic type material shall not be less than 1/2 inch (12.7 mm) thick.

8.4 With regard to footnote e to Table 8.1, a live screw head, rivet, or nut on the underside of a base intended for surface mounting shall be countersunk not less than 1/8 inch (3.2 mm) in the clear, and covered to a depth of not less than 1/8 inch with a waterproof, insulating, sealing compound that will not soften at a temperature of 90°C (194°F) as determined by the test method in Softening Point by Ring-and-Ball Apparatus in the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A.

Exception No. 1: The test is not required for a thermosetting material.

Exception No. 2: A sealing compound is not required if the live part specified in 8.4 is prevented from loosening by being staked or upset, by a lock washer or by other means. The spacings through air from the mounting surface to the live part shall comply with Table 16.1.

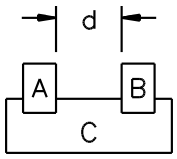
Table 8.2
Additional parameters

Property	Tests	Method	Units	Minimum levels related to flammability classification
Distortion under load and mold stress relief	Heat deflection temperature, or	UL 746A	Minimum °C	10°C (18°F) greater than use temperature but not less than 90°C (194°F), or
	Vicat softening point, or	UL 746A	Minimum °C	25°C (45°F) greater than use temperature but not less than 105°C (221°F), or
	Ball pressure temperature	UL 746A	Minimum °C	Greater than the use temperature by the difference between 40°C (72°F) and the ambient, but not less than 95°C (203°).

Figure 8.1

Figurative examples for Table 8.1

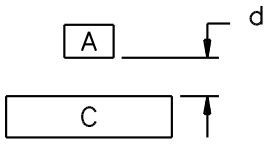
1.



In which:

d < 1/2 inch (12.7mm)
d = Over–surface spacing requirement

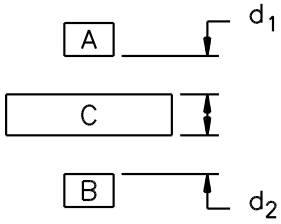
2.



In which:

d < 1/2 inch

3.



In which:

d_1 , d_2 = Through–air spacing
$d_1 + d_2 < Sa$

and Sa = Applicable through–air spacing requirement

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A – An uninsulated live part

B – (1) An uninsulated live part having a difference in potential from part A or, (2) A dead metal part that may be grounded in service or that is exposed to contact.

C – The polymeric material under consideration.

9 Enclosure

9.1 General

9.1.1 A portable power-distribution equipment enclosure shall be constructed and assembled so that it has the strength and rigidity necessary to resist the abuses to which it is likely to be subjected, without total or partial collapse resulting in a risk of fire, electric shock, or injury to persons due to reduction of spacings, loosening or displacement of parts, or other serious defects.

9.1.2 An enclosure shall be constructed so as to reduce the risk of unintentional contact with enclosed electrical devices, and to provide internal devices with protection from specified external conditions.

9.2 Specific enclosures

9.2.1 An enclosure shall comply with the construction requirements applicable to an enclosure of the type numbers or numbers with which it is marked. See 33.1.

9.2.2 TYPE 2 – A Type 2 enclosure shall have provision for drainage of water. The drainage opening(s) shall be located below the level of the lowest live part when the equipment is oriented in the intended manner.

9.2.3 An enclosure marked Type 3R, 3RX, or "Suitable For Use in Damp Locations" shall be provided with means for the drainage of water to the outside. The drainage opening(s) shall be located below the level of the lowest live part when the equipment is oriented in the intended manner.

9.3 Cast metal

9.3.1 A cast-metal enclosure shall be at least 1/8 inch (3.2 mm) thick at every point, and more than 1/8 inch thick at reinforcing ribs and door edges.

Exception: Malleable iron and die-cast or permanent mold cast aluminum, brass, bronze, or zinc shall be:

a) At least 3/32 inch (2.4 mm) thick for an area greater than 24 square inches (155 cm^2) or having any dimension more than 6 inches (152 mm) and

b) At least 1/16 inch (1.6 mm) thick for an area of 24 square inches or less having no dimension more than 6 inches. The area considered may be bounded by reinforcing ribs subdividing a larger area.

9.4 Sheet metal

9.4.1 General

9.4.1.1 The thickness of a sheet-metal enclosure shall not be less than that specified in Table 9.1 and Table 9.2.

Exception: Enclosure thickness need not comply with these requirements if the enclosure complies with the Comparative Deflection Test (Enclosure) in the Standard for Enclosures for Electrical Equipment, Non-Environmental Considerations, UL 50.

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

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]							
(Column 1)		(Column 2)		(Column 3)		(Column 4)		(Column 5)		(Column 6)	
Maximum width,[b]		Maximum length,[c]		Maximum width,[b]		Maximum length,		Minimum thickness uncoated,		Minimum thickness metal coated,	
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)	inch	(mm)	inch	(mm)
4.0	(10.2)	Not limited		6.25	(15.9)	Not limited		0.020	(0.51)	0.023	(0.58)
4.75	(12.1)	5.75	(14.6)	6.75	(17.1)	8.25	(21.0)				
6.0	(15.2)	Not limited		9.5	(24.1)	Not limited		0.026	(0.66)	0.029	(0.74)
7.0	(17.8)	8.75	(22.2)	10.0	(25.4)	12.5	(31.8)				
8.0	(20.3)	Not limited		12.0	(30.5)	Not limited		0.032	(0.81)	0.034	(0.86)
9.0	(22.9)	11.5	(29.2)	13.0	(33.0)	16.0	(40.6)				
12.5	(31.8)	Not limited		19.5	(49.5)	Not limited		0.042	(1.07)	0.045	(1.14)
14.0	(35.6)	18.0	(45.7)	21.0	(53.3)	25.0	(63.5)				
18.0	(45.7)	Not limited		27.0	(68.6)	Not limited		0.053	(1.35)	0.056	(1.42)
20.0	(50.8)	25.0	(63.5)	29.0	(73.7)	36.0	(91.4)				
22.0	(55.9)	Not limited		33.0	(83.8)	Not limited		0.060	(1.52)	0.063	(1.60)
25.0	(63.5)	31.0	(78.7)	35.0	(88.9)	43.0	(109.2)				
25.0	(63.5)	Not limited		39.0	(99.1)	Not limited		0.067	(1.70)	0.070	(1.78)
29.0	(73.7)	36.0	(91.4)	41.0	(104.1)	51.0	(129.5)				
33.0	(83.8)	Not limited		51.0	(129.5)	Not limited		0.080	(2.03)	0.084	(2.13)
38.0	(96.5)	47.0	(119.4)	54.0	(137.2)	66.0	(167.6)				
42.0	(106.7)	Not limited		64.0	(162.6)	Not limited		0.093	(2.36)	0.097	(2.46)
47.0	(119.4)	59.0	(149.9)	68.9	(172.7)	84.0	(213.4)				
52.0	(132.1)	Not limited		80.0	(203.2)	Not limited		0.108	(2.74)	0.111	(2.82)
60.0	(152.4)	74.0	(188.0)	84.0	(213.4)	103.0	(261.6)				
63.0	(160.0)	Not limited		97.0	(246.4)	Not limited		0.123	(3.12)	0.126	(3.20)
73.0	(185.4)	90.0	(228.6)	103.0	(261.6)	127.0	(322.6)				

NOTE – Sheet steel for a Type 3R, 3RX enclosure or one marked "Suitable for Use in Damp Locations" shall not be less than 0.034 inch thick when zinc coated and not less than 0.032 inch thick when uncoated.

[a] See 9.4.1.2 regarding sheet metal construction.

[b] See 9.4.2.1 regarding width of enclosure.

[c] "Not limited" applies only if the edge of the surface is flanged at least 1/2 inch (127 mm) or is fastened to adjacent surfaces not normally removed in use.

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

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]					
(Column 1) Maximum width,[b]		(Column 2) Maximum length,[c]		(Column 3) Maximum width,[b]		(Column 4) Maximum length,		(Column 5) Minimum thickness,	
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)	inch	(cm)
3.0	(7.6)	Not limited		7.0	(17.8)	Not limited		0.023	(0.58)
3.5	(8.9)	4.0	(10.2)	8.5	(21.6)	9.5	(24.1)		
4.0	(10.2)	Not limited		10.0	(25.4)	Not limited		0.029	(0.74)
5.0	(12.7)	6.0	(15.2)	10.5	(26.7)	13.5	(34.3)		
6.0	(15.2)	Not limited		14.0	(35.6)	Not limited		0.036	(0.91)
6.5	(16.5)	8.0	(20.3)	15.0	(38.1)	18.0	(45.7)		
8.0	(20.3)	Not limited		19.0	(48.3)	Not limited		0.045	(1.14)
9.5	(24.1)	11.5	(29.2)	21.0	(53.3)	25.0	(63.5)		
12.0	(30.5)	Not limited		28.0	(71.1)	Not limited		0.058	(1.47)
14.0	(35.6)	16.0	(40.6)	30.0	(76.2)	37.0	(94.0)		
18.0	(45.7)	Not limited		42.0	(106.7)	Not limited		0.075	(1.91)
20.0	(50.8)	25.0	(63.5)	45.0	(114.3)	55.0	(139.7)		
25.0	(63.5)	Not limited		60.0	(152.4)	Not limited		0.095	(2.41)
29.0	(73.7)	36.0	(91.4)	64.0	(162.6)	78.0	(198.1)		
37.0	(94.0)	Not limited		87.0	(221.0)	Not limited		0.122	(3.10)
42.0	(106.7)	53.0	(134.6)	93.0	(236.2)	114.0	(289.6)		
52.0	(132.1)	Not limited		123.0	(312.4)	Not limited		0.153	(3.89)
60.0	(152.4)	74.0	(188.0)	130.0	(330.2)	160.0	(406.4)		

[a] See 9.4.1.2 regarding sheet metal construction.

[b] See 9.4.2.1 regarding width of enclosure.

[c] For panels which are not supported along one side, for example, side panels of boxes, the length of the unsupported side.

9.4.1.2 With reference to Table 9.1 and Table 9.2, a supporting frame is a structure of angle or channel or folded rigid section of sheet metal that is rigidly attached to and has essentially the same outside dimensions as the enclosure surface and that has sufficient torsional rigidity to resist bending moments applied to the enclosure surface when it is deflected. A structure that is as rigid as one built with a frame of angles or channels is considered to have equivalent reinforcing. Constructions considered to be without supporting frames include:

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

b) A single sheet that is corrugated or ribbed;

c) An enclosure surface loosely attached to a frame, for example, with spring clips; and

d) An enclosure surface having an unsupported edge.

9.4.2 Instructions for using Table 9.1 and Table 9.2

9.4.2.1 The width is the smaller dimension of a rectangular sheet metal piece which is part of an enclosure. Adjacent surfaces of an enclosure are not prohibited from having supports in common and be made of a single sheet.

9.4.2.2 Determine if the portion of the enclosure is supported or unsupported using the following criteria:

a) Supported – Supported edges flanged at least 1/2 inch (12.7 mm) or fastened to adjacent surfaces not normally removed in use. (Surfaces A and C of Figure 9.1 are considered supported.)

b) Nonsupported –

1) A single sheet with formed flanges or formed edges;

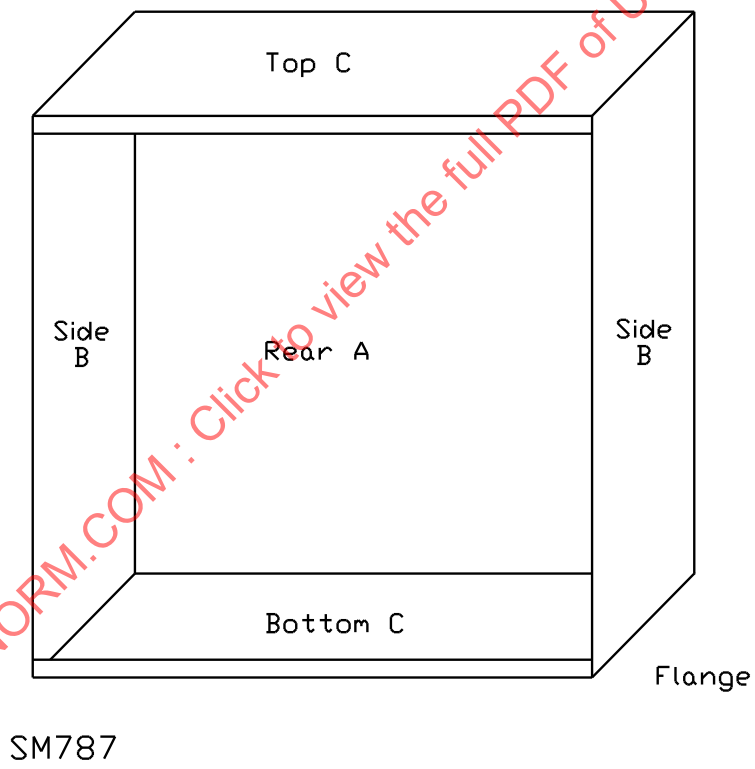
2) A single sheet that is corrugated or ribbed;

3) An enclosure surface loosely attached to its frame, for example, with spring clips; and

4) An enclosure surface having an unsupported edge. (Surface B of example Figure 9.1 is unsupported.)

Figure 9.1

Enclosure surfaces



9.4.2.3 For supported surfaces, measure width and enter table at Column 3. If dimension of Column 4 is "not limited", determine minimum thickness from Column 5 or 6, as appropriate. If dimension of Column 4 is numerical, the length may not exceed that value for the thickness of Column 5 or 6. If the length exceeds the numerical value, it is necessary to drop to the next line in column 5 or 6 to determine minimum thickness.

9.4.2.4 For nonsupported surfaces, measure width. Enter Table at Column 1. If dimension of Column 2 is "not limited", determine minimum thickness from Column 5 or 6, as appropriate. If dimension of Column 2 is numerical, the length shall not exceed that value for the thickness of Column 5 or 6. If the length exceeds the numerical value, it is necessary to drop to the next line in column 5 or 6 to determine minimum thickness.

9.4.2.5 If thickness determined is not provided, "Body Stiffeners," "Reinforcing Ribs," "Cross Frames," and the like shall not be used unless investigated and determined to be suitable for the purpose.

9.4.2.6 If two or more covers or panels are provided to close a single opening, the thickness of each cover or panel shall not be less than a single sheet as specified in Table 9.1 and Table 9.2. The adjacent edges of such multiple panels or covers shall:

a) Be flanged at least 1/2 inch (12.7 mm); or

b) Be supported against an inward force at 10 inch (254 mm) maximum intervals; or

c) Overlap each other at least 1/2 inch and be secured together at 10 inch (254 mm) maximum intervals.

9.5 Doors and covers

9.5.1 A door more than 48 inches (1.2 m) long on the hinged side shall have one of the following:

a) A two-point or three-point latch operated by a single knob or handle; or

b) Two or more snap latches or captive screws involving a simple one-fourth or one-half turn; or

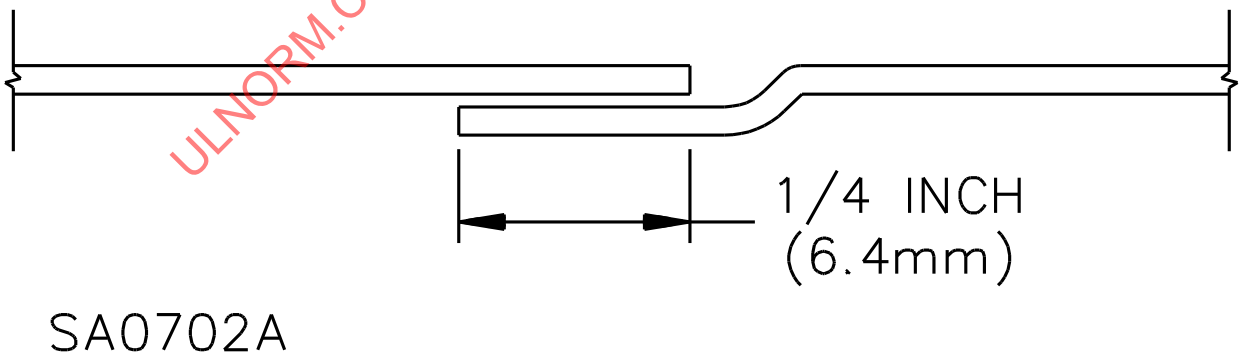
Exception: Multi-turn captive screws, having head diameter and grip to permit closing by hand, are not prohibited from being used in place of the captive screw involving a simple one-fourth or one-half turn.

c) One knob-operated latch and one snap latch or captive screw.

9.5.2 A door giving access to a fuse or any portion of a circuit breaker other than the operating handle shall shut closely against a 1/4-inch (6.4-mm) rabbet or that which has been determined to be the equivalent as illustrated in Figure 9.2.

Figure 9.2

Rabbet



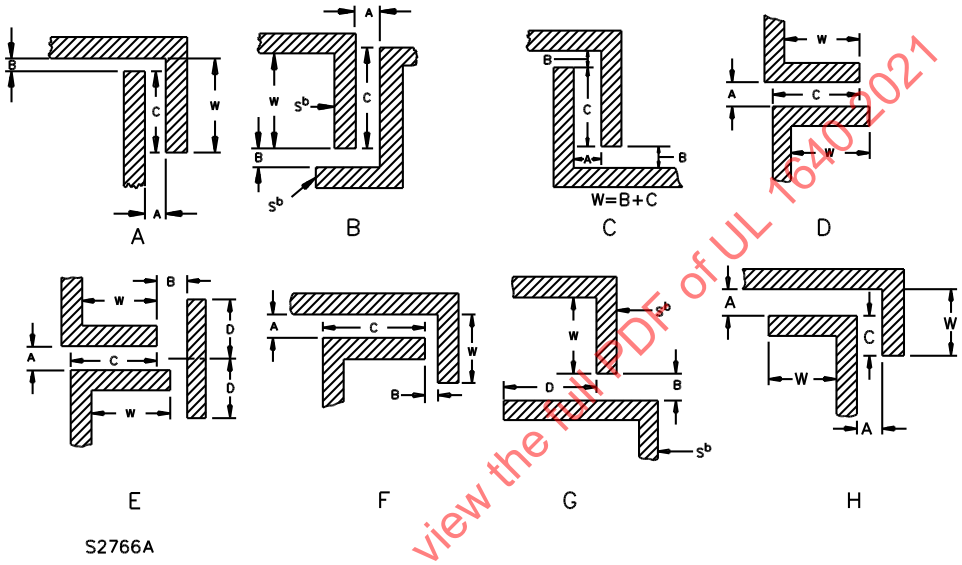
9.5.3 A cover giving access to a fuse or any position of a circuit breaker other than the operating handle shall have flanges for the full length of the four edges. Flanges on a cover shall fit closely with the outside

walls of the enclosure, and shall comply with Figure 9.3 and Table 9.3. A combination of flange and rabbet that has been investigated and determined to comply shall be used.

Exception: This requirement does not apply to the flange width less than that specified when the construction complies with the Deflection Test (Doors and Covers) in the Standard for Enclosures for Electrical Equipment, Non-Environmental Considerations, UL 50.

Figure 9.3

Flanged cover constructions



[a] See Table 9.3 for dimensions for sketches A – H.
[b] The surfaces "S" may be in line with one another – not as shown.

Table 9.3
Cover construction

Sketch – see Figure 9.3	Dimensions									
	W Minimum flange width[a],		A Maximum space between parts,		B Maximum gap,		C Minimum overlap,		D Minimum barrier extension,	
	inch	(mm)	inch	(mm)	inch	(mm)	inch	(mm)	inch	(mm)
A	1/2	(12.7)	1/8	(3.2)	1/8	(3.2)	7/16	(11.1)	–	–
A	3/4	(19.1)	3/16	(4.8)	3/16	(4.8)	5/8	(15.9)	–	–
A	1	(25.4)	1/4	(6.4)	1/4	(6.4)	7/8	(22.2)	–	–
B	1/2	(12.7)	1/8	(3.2)	1/8	(3.2)	7/16	(11.1)	–	–
B	3/4	(19.1)	3/16	(4.8)	3/16	(4.8)	5/8	(15.9)	–	–
B	1	(25.4)	1/4	(6.4)	1/4	(6.4)	7/8	(22.2)	–	–
C	1/2	(12.7)	3/16	(4.8)	3/16	(4.8)	1/4	(6.4)	–	–
C	3/4	(19.1)	1/4	(6.4)	1/4	(6.4)	7/16	(11.1)	–	–
D	1/2	(12.7)	3/32	(2.4)	–	–	7/16	(11.1)	–	–
E	1/2	(12.7)	1/8	(3.2)	1/8	(3.2)	7/16	(11.1)	1/4	(6.4)
F	1/2	(12.7)	1/8	(3.2)	1/4	(6.4)	7/16	(11.1)	–	–
G[b]	1/2	(12.7)	–	–	1/32	(0.8)	–	–	1/2	(12.7)
H	1/4	(6.4)	1/8	(3.2)	–	–	3/16	(4.8)	–	–

[a] Tolerance: minus 1/16 inch (1.6 mm)

[b] Equipment within the enclosure shall be located on the side of the barrier extension D that is opposite the gap B.

9.5.4 To determine whether a flanged cover complies with the requirement in 9.5.3 regarding width of flange, the distance between the flat portion of the cover – clear of forming radii, beads, draws, and the like – and a straight edge placed anywhere across any two flanges at any point is to be measured.

9.5.5 A flange on a door shall:

a) Fit closely with the outside wall of the box proper in accordance with Table 9.3;

b) Have a width in accordance with Table 9.3;

c) Be one of the constructions illustrated in Figure 9.3, unless the construction has been evaluated and determined to comply with the requirements for the application; and

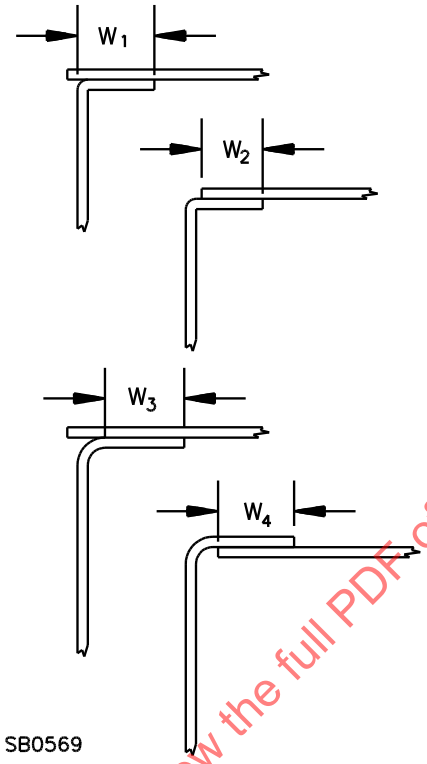
d) Where a telescoping cover meets the cabinet box of a surface-mounted enclosure, overlap all edges in accordance with Table 9.3.

Exception: A construction involving a gasketed joint that provides the intended tight fit shall be investigated to determine whether it meets the requirements for the application.

9.5.6 Figure 9.4 illustrates the method of determining the amount of overlap between a flat cover and a flanged box wall and the amount of overlap at a corner or box seam. When the radius of the flange bend is small, the flange width and overlap are considered to be W1 or W2, depending upon the actual construction, and shall be at least 1/2 inch (12.7 mm). When the radius of the flange bend is excessive or if the flat sheet is on the inside of the flange, the overlap, W3 or W4, is to be measured over only that portion where the two pieces of metal are actually in contact with each other, and shall be at least 1/2 inch.

Figure 9.4

Overlap between flat cover and box flange and at corner or box seam



9.5.7 To determine the overlap of a telescoping cover, the enclosure is to be placed on its back on a bench, with the cover in its normally closed position, and a mark is to be scribed on all walls of the box along the edge of the flange. The overlap is the measured distance between the scribe marks and the edges of the box walls, noted as W4 in Figure 9.4. In scribing the marks, the cover is to be held in a fixed position with sufficient firmness to prevent displacement of the cover by the scribing tool, but without bending or distorting any portion of the box, cover, or other part of the enclosure.

9.5.8 The overlap of a telescoping cover shall not be less than 1/4 inch (6.4 mm) if:

a) The cover is secured in place by screws or by a combination of hinges and screw and

b) The cover and the box wall are flanged in accordance with Sketch H of Figure 9.3.

9.5.9 A flat strip used to provide a rabbet, or an angle strip fastened to the edges of a door giving access to a fuse or any portion of a circuit breaker, other than the operating handle, shall be at least 60 percent of the required thickness of the metal of the box proper, but not less than 0.042 inch (1.07 mm) if of uncoated steel, not less than 0.045 inch (1.14 mm) if of zinc-coated steel, and not less than 0.058 inch (1.47 mm) thick if of nonferrous metal. It shall be secured at not fewer than two points. There shall not be more than 1-1/2 inches (38 mm) between an end of the strip and a point at which it is secured, and the distance between adjacent points at which the strip is secured shall not be more than 6 inches (152 mm).

9.6 Inlet and receptacle doors

9.6.1 Equipment with enclosures marked "3, 3R, 3X, 3RX, 3S, 3SX, 4, or 4X shall be subjected to the Resistance to Rain Test, Section 24. Spring-closing doors (see the Note for 5.8) protecting inlets and receptacles and relied upon to comply with the Resistance to Rain Test shall be made of a material that is

inherently resistant to corrosion and shall comply with the Spring-Closing Cycling Test, Section 27. The gaskets relied upon to comply with the Resistance to Rain Test shall meet requirements specified in Gasket Tests, Section 26.

Exception No. 1: Equipment provided with spring-closing outlet box doors (see the Note for 5.8) evaluated for use in wet locations are considered to comply with these requirements without performance of the Spring-Closing Cycling Test or Gasket Tests.

Exception No. 2: A multi-conductor receptacle or inlet of either the non-locking-blade-, locking-blade-, or pin-and-sleeve-type that:

a) Is provided with or integrates into its design a self-closing door (see the Note for 5.8) and

b) Has been evaluated as "watertight" or as any of Enclosure Types 3, 3R, 3X, 3RX, 3S, 3SX, 4, or 4X

is considered to comply with these requirements.

9.6.2 Equipment with enclosures marked “Suitable for Use in Damp Locations” or “Suitable for Use in Damp or Wet Locations” or “DWL” shall be provided with spring closing doors that are gasketed and tight fitting, and that comply with the Spring-Closing Cycling Test, Section 27. The gasket shall meet requirements specified in Gasket Tests, Section 26. The spring shall be made of a material that is inherently resistant to corrosion.

Exception No. 1: Equipment provided with spring-closing outlet box doors (see the Note to 5.8) evaluated for use in damp locations is considered to comply with these requirements.

Exception No. 2: A multi-conductor receptacle or inlet of either the non-locking-blade-, locking-blade-, or pin-and-sleeve-type that:

a) Is provided with or integrates into its design a self-closing door (see the Note to 5.8) and

b) Has been evaluated as “Suitable for use in Damp Locations”, “watertight”, or as any of Enclosure Types 3, 3R, 3X, 3RX, 3S, 3SX, 4, or 4X

is considered to comply with these requirements.

9.7 Polymeric

9.7.1 A polymeric enclosure shall be classed V-0, V-1 or V-2. A polymeric electrical enclosure or a polymeric part of an electrical enclosure shall comply with the applicable requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, and with the additional requirements specified in this standard.

Exception: A polymeric or other closure plug made of a material classed in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, assembled to a sheet-metal box to form a part of an enclosure shall not be used unless the closure is:

a) Not more than 1 square inch (65 cm^2) in area and is:

1) A pilot light lens classed V-0, V-1, V-2, or HB;

2) Classed V-0, V-1, V-2; or

3) Classed HB and rated in accordance with the flammability test requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C; or

b) More than 1 square inch in area; classed V-0, V-1, or V-2; and rated in accordance with the flammability and impact test requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

9.7.2 A polymeric enclosure having any single unbroken section, a projected surface area greater than 0.93 m^2 (10 ft^2), or a single linear dimension greater than 1.83 m (6 ft), shall have a maximum flame-spread rating of 200 as determined by the Standard for Test for Surface Burning Characteristics of Building Materials, UL 723. The Radiant Panel Flame Spread Test in Section 10 of the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, is not prohibited from being used as an optional method for determining the flame spread characteristics of the material.

Exception: When the projected surface area is broken with a minimum 305 mm (12 inch) fire separation, the Radiant Panel Flame Spread Test in UL 94 shall be used to determine the flame spread characteristics of the material. The material shall have a maximum Flame Spread Index of 200 as determined by the Radiant Panel Flame Spread Test.

9.8 Enclosure of switches, circuit breakers, or fuses

9.8.1 A switch or circuit breaker shall be operable from the outside of an enclosure and shall not be located behind a door unless live parts or wiring are not exposed during operation.

9.8.2 A circuit breaker or switch handle shall be protected or recessed below the plane of the enclosure to prevent unintended impacts.

9.8.3 The equipment enclosure shall completely enclose all parts that are live with an operating handle in any position.

9.8.4 No gap on any one side of a component shall exceed 3/32 inch (2.4 mm) and the total of the gaps on both sides of component shall not exceed 1/8 inch (3.2 mm) with the enclosure and the component in any position that results from ordinary assembly.

9.8.5 Fuses shall be replaceable without exposing live parts or wiring other than the screwshell of a Type S or Edison-base fuseholder.

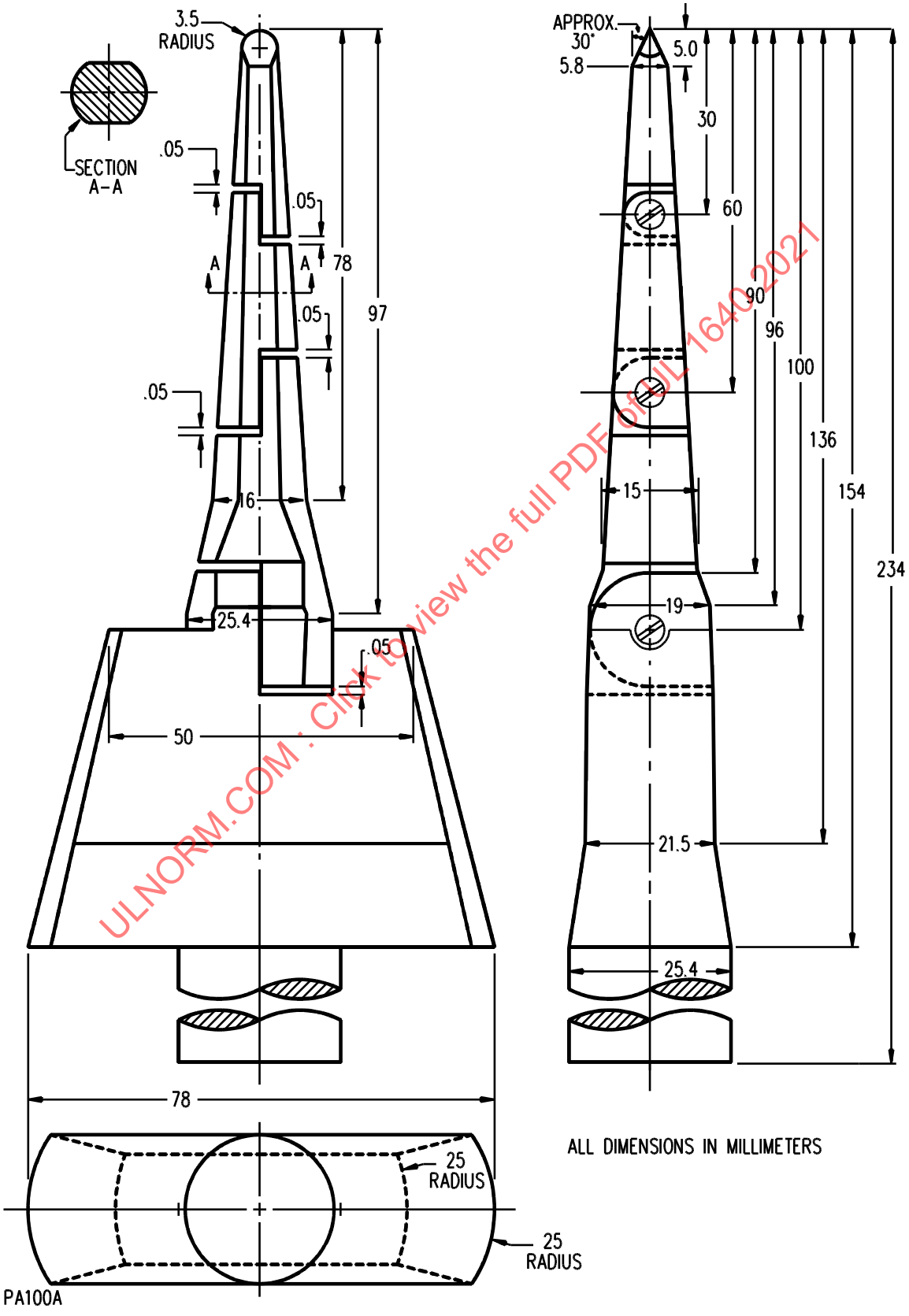
9.9 Accessibility of live parts

9.9.1 Openings in enclosure

9.9.1.1 An opening in an enclosure shall not permit the entrance of the probe specified in Figure 9.5 to contact uninsulated live parts. When a distance between an opening and the nearest live part is more than 4 inches (102 mm) the opening shall not permit the entrance of a 0.500-inch (12.7-mm) diameter rod.

Figure 9.5

Articulate probe with web stop



9.9.1.2 Openings in enclosures shall be filled by devices with suitable environmental ratings as specified in Table 9.4.

Table 9.4
Openings in enclosures

Enclosure type	Openings shall be closed by equipment rated for enclosure types
2	2, 3, 3X, 3R, 3RX, 3S, 3SX, 4, 4X, 12, 12K, 13
3	3, 3X, 3S, 3SX, 4, 4X
3X	3X, 3SX, 4X
3R	3, 3X, 3R, 3RX, 3S, 3SX, 4, 4X
3RX	3X, 3RX, 3SX, 4X
3S	3, 3X, 3S, 3SX, 4, 4X
3SX	3X, 3SX, 4X
4	4, 4X
4X	4X

9.9.2 Bus bars for supply or output

9.9.2.1 With no cables terminated, current-carrying parts shall be recessed from the plane of the opening for the cable by minimum 4 inches (102 mm).

9.9.3 Plugs and receptacles

9.9.3.1 An opening in a plug or receptacle shall not permit the entrance of the probe specified in Figure 9.5 to contact uninsulated live parts.

Exception: Equipment marked adjacent to the plug or receptacle to indicate that it is for use in areas not readily accessible by the general public is not required to to comply with this requirement. See 31.1.

9.9.4 Ventilation openings

9.9.4.1 When ventilation openings are provided, they shall comply with 9.9.4.2 – 9.9.4.10. See 9.1.1.

9.9.4.2 Ventilation openings shall be guarded so that there is no direct access to a live part as covered in 9.9.4.3 and 9.9.4.4.

9.9.4.3 Ventilation openings shall be:

a) Screened or louvered openings with internal barriers or

b) Hoods or stacks with labyrinth air passages.

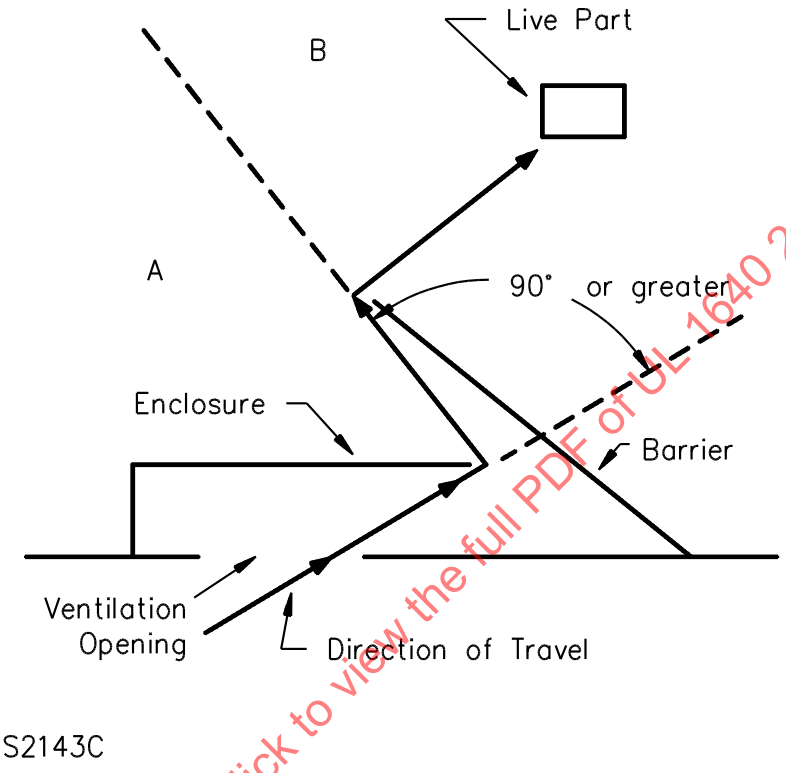
9.9.4.4 A barrier shall be of such dimensions and located so that a straight line drawn from any live part past the edge of the barrier intersects the enclosure minimum 1/4 inch (6.4 mm) from the edge of an opening.

9.9.4.5 A ventilation opening – slot, louver, or the like – shall be protected by one or more baffles, barriers, or other obstructions of such dimensions and locations that any access path to a live part requires at least two changes of direction, one of which involves an angle of 90 degrees or more from a straight

line, as shown in Figure 9.6. In addition, when the minor dimension of a ventilation opening is larger than 1/4 inch (6.4 mm), it shall be protected by a screen having a minor dimension no larger than 1/4 inch.

Figure 9.6

Angle of change of direction



9.9.4.6 The wires of a screen required to protect a ventilation opening shall be no smaller than 16 AWG (1.3 mm^2) and the openings in the screen shall not exceed 1/4 inch (6.4 mm) in any dimension.

9.9.4.7 Perforated sheet steel or expanded-steel mesh shall not be less than 0.042 inch (1.07 mm) thick when uncoated or 0.045 inch (1.14 mm) thick when zinc-coated, when the mesh openings or perforations are 1/2 square inch (3.23 cm^2) or less in area. For larger openings, the steel or mesh shall not be less than 0.080 inch (2.03 mm) thick when uncoated or 0.084 inch (2.13 mm) thick when zinc-coated.

Exception: When deflection of the expanded-steel mesh does not alter the clearance between uninsulated live parts and grounded metal and reduce the spacings to values below the minimum values specified in Table 16.1, expanded-steel mesh is not prohibited from being made of minimum 0.024-inch (0.61-mm) thick sheet steel when uncoated or 0.028-inch (0.71-mm) thick sheet steel when zinc-coated.

9.9.4.8 A grille construction complying with the intent of the requirements in the Exception to 9.9.4.7 is not prohibited from being used.

9.9.4.9 The width of ventilation louvers in an enclosure shall be such that at least 1/6 of the enclosure material remains at each end of the louver.

9.9.4.10 A separate, louvered panel that is riveted or welded in place over a ventilation opening in the enclosure shall not be less than 0.032-inch (0.81-mm) thick sheet steel.

10 Enclosure Performance

10.1 The performance requirements of an enclosure are determined by the specific environmental type designation and other features such as gasketing or use of materials thinner than required by Table 9.1 or Table 9.2.

10.2 An enclosure shall be subjected to the tests specified in the Standard for Enclosures for Electrical Equipment, Environmental Considerations, UL 50E, applicable to an enclosure of the type number or numbers with which it is marked.

Exception: The Rain Test in UL 50E shall be in accordance with the Resistance to Rain Test in Section 24 of this standard.

10.3 An external operating means – such as those for a disconnect or a resetting operation – mounted on or through an enclosure shall withstand the tests specified for the enclosure unless otherwise indicated.

10.4 A Type 4X enclosure intended for indoor use only and marked in accordance with 33.10:

a) Is not required to be subjected to the External Icing Test in the Standard for Enclosures for Electrical Equipment, Environmental Considerations, UL 50E, and

b) For a polymeric enclosure, is not required to have a material which is resistant to ultraviolet light weathering in accordance with the Standard for Polymeric Materials – Use in Electrical Evaluations, UL 746C.

11 Corrosion Protection

11.1 When aluminum or stainless steel is used, additional resistance to corrosion is not required.

11.2 When copper, bronze, or brass containing at least 80 percent copper is used, additional resistance to corrosion is not required. Other metal shall be a grade or alloy known to be nonsusceptible to corrosion, or shall be subjected to appropriate tests, additionally protected against corrosion, or both.

11.3 Metal shall not be used in combinations to cause galvanic action.

11.4 Equipment with a Type 1 enclosure shall be protected from corrosion by inherently resistant materials as specified in 11.1 and 11.2 or be painted or plated for protection. Any commercial paint or plating process is not prohibited from being used.

11.5 A sheet steel enclosure and other parts, including hinges and other attachments, of equipment with an enclosure designated 3, 3R, 3X, 3RX, 3S, 3SX, 4, 4X or marked “Suitable For Use In Damp Locations” shall be resistant to corrosion by one of the following coatings:

a) Hot-dipped, mill-galvanized sheet steel complying with the coating designation G90 in Table I of the Standard Specification for Steel Sheet Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process, ASTM A653/A653M, with not less than 40 percent of the zinc on any side, based on the minimum single-spot test requirement in this ASTM designation. The weight of the zinc coating may be determined by any acceptable method; however, in case of question, the weight of coating shall be established in accordance with the Standard Test Method for Weight (Mass) of Coating on Iron and Steel Articles with Zinc-Alloy Coatings, ASTM A90/A90M REV A.

b) A zinc coating, other than that provided on hot-dipped, mill-galvanized sheet steel, uniformly applied to an average thickness of not less than 0.00061 inch (0.015 mm) on each surface, with a minimum thickness of 0.00054 inch (0.014 mm). The thickness of the coating shall be established

by the metallic-coating-thickness test in the Standard Guide for Measurement of Electrodeposited Metallic Coating Thicknesses by the Dropping Test, ASTM B555. An annealed coating shall also comply with 11.6.

c) A coating complying with (1) or (2) with one coat of an organic finish of the epoxy or alkyd-resin type or other outdoor paint applied after forming on each surface. One method of determining the acceptability of the paint is by consideration of its composition or by corrosion tests, when these are considered necessary.

1) Hot-dipped, mill-galvanized sheet steel complying with the coating designation G60 or A60 in Table I of ASTM A653/A653M, with not less than 40 percent of the zinc on any side, based on the minimum single-spot test requirement in this ASTM standard. The weight of the zinc coating may be determined by any method; however, in case of question, the weight of coating shall be established in accordance with the test method in ASTM A90/A90M REV A.

2) A zinc coating, other than that provided on hot-dipped, mill-galvanized sheet steel, uniformly applied to an average thickness of not less than 0.00041 inch (0.010 mm) on each surface with a minimum thickness of 0.00034 inch (0.009 mm). The thickness of the coating shall be established by the Metallic Coating Thickness Test, Section 28.An annealed coating shall also comply with 11.6.

d) A cadmium coating not less than 0.0010 inch (0.025 mm) thick on both surfaces. The thickness of the coating shall be established by the Metallic Coating Thickness Test, Section 28.

e) A cadmium coating not less than 0.00075 inch (0.019 mm) thick on both surfaces with one coat of outdoor paint on both surfaces, or not less than 0.00051 inch (0.013 mm) thick on both surfaces with two coats of outdoor paint on both surfaces. The thickness of the cadmium coating shall be established by the Metallic Coating Thickness Test, Section 28, and the paint shall be as described in (c).

f) Other finishes, such as special metallic finishes, or metallic finish combined with paint are not prohibited from being used when comparative tests with galvanized sheet steel (without annealing, wiping, or other surface treatment) comply with (a), or when determined to provide equivalent protection after exposure to both of the following:

1) A 600-hour salt-spray test conducted in accordance with the Standard for Organic Coatings for Steel Enclosures for Outdoor-Use Electrical Equipment, UL 1332, and

2) A 1200-hour, moist carbon-dioxide/sulphur-dioxide air mixtures test conducted in accordance with UL 1332;

g) Paint is not prohibited from being used when the applicable requirements in UL 1332 indicate that it provides equivalent protection.

11.6 An annealed, a hot-dipped, mill-galvanized or other zinc coating, on sheet steel, shall not be damaged during handling or fabrication to the extent that the base metal is exposed.

Exception No. 1: Uncoated cross-sectional surfaces shall not be used unless at cut edges and drilled openings.

Exception No. 2: The base metal shall not be exposed unless:

a) The maximum width and length of the exposed metal does not exceed the thickness and length of any cut edge on the sheet or

b) The surface has one coat of an organic finish of the epoxy or alkyd-resin type, or other paint applied after fabrication.

11.7 Sheet steel that employs a hot-dipped, mill-galvanized G90 coating that is drawn, formed, extruded, or rolled shall be additionally painted with one coat of an organic finish of the epoxy or alkyd-resin type or other outdoor paint in the areas that are affected by a process that damages the coating as determined by the requirement in 11.6.

11.8 An enclosure of cast iron or malleable iron at least 1/8 inch (3.2 mm) thick shall be protected against corrosion by:

a) A 0.00015-inch (0.0038-mm) thick coating of zinc, cadmium, or other material determined to be the equivalent, on the outside surface and a visible coating of such metal on the inside surface or

b) One coat of an organic finish of the epoxy or alkyd-resin type or other outdoor paint on each surface. The acceptability of the paint is determined by consideration of its composition, if necessary, by corrosion tests.

12 Grounding and Bonding

12.1 General

12.1.1 All conductive parts of portable power-distribution equipment not intended to be electrically live that are accessible to persons (including during maintenance and repair) and could inadvertently become energized shall be grounded by being conductively bonded to the equipment-grounding conductor of the supply.

Exception: Equipment rated for use on direct-current systems only and operating at not over 150 volts DC to ground.

12.1.2 Equipment utilizing multi-conductor power-supply cord or cable for input or output shall include a grounding conductor that shall be:

a) Green with or without one or more yellow stripes;

b) Connected to the grounding blade or pin of an attachment plug or cord connector of the grounding type;

c) Connected to the enclosure of the product by means of a screw not likely to be removed during servicing not involving the supply cord or cable; and

d) Sized in accordance with Table 12.1 as determined by the input rating of the equipment.

Table 12.1
Minimum size of equipment-grounding conductor or bonding jumpers

Rating or setting of automatic overcurrent device in circuit ahead of equipment or receptacle, amperes	Size of equipment-grounding conductor or bonding jumper[a]	
	Copper wire,	
	AWG	(mm^2)
15	14	(2.1)
20	12	(3.3)

Table 12.1 Continued on Next Page

Table 12.1 Continued

Rating or setting of automatic overcurrent device in circuit ahead of equipment or receptacle, amperes	Size of equipment-grounding conductor or bonding jumper[a]	
	Copper wire,	
	AWG	(mm^2)
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)
1000	2/0	(67.4)
1200	3/0	(85.0)
1600	4/0	(107.1)

[a] Or determined to be equivalent cross-sectional area.

12.1.3 Equipment using panel-mounted inlets, single- or multi-pole, for supply input shall be provided with a bonding jumper from the inlet equipment grounding terminal to the enclosure of the equipment. The bonding jumper shall be stranded and insulated, and the outer covering shall be identified by a continuous green color with or without one or more yellow stripes. The minimum conductor size shall be in accordance with Table 12.1 as determined by the rating of the branch-circuit protection of the receptacle.

12.1.4 Equipment using single-pole plugs or cord connectors terminated to short lengths of extra-hard-service cable for the input to other equipment shall have a plug provided for connection to an equipment-grounding conductor. The body of the plug connector shall be green in color or the last 6 inches (152 mm) of the cable before the plug shall be wrapped in green tape or the equivalent. The cable shall terminate internally in accordance with 12.1.2 (c) and (d).

12.1.5 A single-pole inlet provided for the equipment-grounding conductor shall be green or green with yellow stripes.

12.1.6 Conductive metal parts specified in 12.1.9 shall be bonded together by conductive metal-to-metal mounting or by bonding conductors as specified in 12.1.3. The metal-to-metal connection shall be made by bolting, brazing, or welding. Metal screws shall not be used for metal-to-metal bonding connection unless retained by at least two full threads. All bonding connections shall penetrate paint and other nonconductive coatings.

12.1.7 Equipment-grounding conductors or bonding jumpers shall terminate to the enclosure by either of the means specified below:

a) If 10 AWG (5.3 mm^2) or smaller, to a wire-binding screw. The screw shall not be smaller than No. 10 (4.8 mm diameter), shall thread into metal using at least two full threads, and shall use a lockwasher or similar device.

b) To a pressure wire connector. The pressure wire connector shall be secured to the enclosure by a screw threading into metal at least two full threads and shall use a lockwasher or similar device.

12.1.8 Solder alone shall not be used for a grounding or bonding connection.

12.1.9 The removal or disconnection of any component from its mounting or grounding means shall not impair the grounding continuity of any other component or grounded dead-metal part.

12.2 Output receptacle grounding

12.2.1 Receptacles shall be grounded in accordance with 12.1.2 – 12.1.9. This connection shall not use the frame or yoke of the receptacle unless the receptacle has been investigated for such an installation.

Exception No. 1: Output receptacles on equipment rated for use on DC systems operating at not over 150 volts DC to ground only need not to be grounded.

Exception No. 2: Receptacles rated 15, 20, or 30 amperes and 125 or 250 V in accordance with the configuration specified in the Standard for Wiring Device Configurations, UL 1681, are not required to be provided with equipment-grounding conductors when both ends of the receptacle's yoke are in direct contact with the unpainted metal of their mounting surface, and this mounting surface is bonded to the main equipment-grounding conductor of the equipment.

13 Input Connections

13.1 General

13.1.1 Equipment shall be provided with one of the following supply connection means:

a) Integral, multi-conductor, extra-hard-usage power-supply cord;

b) A multi-pole power inlet;

c) A sequentially-interlocked inlet assembly;

d) An interlocked inlet assembly;

e) Separate, panel-mounted receptacles for locking-type, single-pole plugs;

f) Single-pole plugs terminated to extra-hard service cable or bus bars intended for bus bar clamps (also see 9.9.2.1);

g) Bus bars with integral threaded holes intended to terminate closed-loop wire connectors (also see 9.9.2.1);

h) Bus bars with pressure terminal connectors bolted in place (also see 9.9.2.1); or

i) Bus bars with integral threaded studs, nuts, and washers.

13.1.2 Equipment shall use a single source of supply only. Equipment shall not use parallel conductors for input unless they utilize single-pole feeders and are intended for minimum 1/0 AWG (53.5 mm^2) conductors.

13.2 Cord-connected equipment

13.2.1 Power-distribution equipment intended to be cord-connected to the power supply in accordance with 13.1.1(a) shall be provided with a length of multi-conductor flexible cord or cable:

a) Having a serviceability rating at least equal to extra-hard-usage types such as S, SE, SEO, SEOO, SO, SOO, ST, STO, STOO, G, W, SC, SCE, or SCT, or PPE;

b) Sized to have an ampacity that corresponds to the electrical rating of the equipment but not smaller than 18 AWG (0.82 mm^2). See Table 13.1 and Table 13.2. Cords and cables terminating to components shall be sized as specified in 7.4.5.1;

c) Terminated by an attachment plug that is of the grounding type.

Exception: The length of multiconductor flexible cord or cable is not required to terminate in an attachment plug when the equipment is marked in accordance with Supply Cord Without Attachment Plug, Section 39;

d) Having a strain-relief means that complies with the Strain-Relief Test, Section 23;

e) Sized based on 60°C (140°F) ampacity and having insulation rated 90°C (194°F) minimum; and

Exception: Lower temperature ratings or higher ampacity shall not be used unless the assembly is evaluated in accordance (and complies) with the Temperature Test, Section 20. Higher ampacities shall not be used for conductors terminating to components unless the components have been evaluated for such use.

f) Suitable for the environmental rating of the equipment. See 13.2.2.

1) Types G, PPE, and W: "Wet" and "Sunlight Resistant" or "Sun Res;"

2) Types SC, SCE, SCT: "Water Resistant"; and

3) Types SOW, SOOW, SEW, SEOW, SEOOW, STW, STOW, and STOOW.

See also 13.4.1 – 13.4.5 regarding single-conductor cable.

Table 13.1
Ampacity for flexible cords and cables based on ambient temperature of 30°C (86°F)

Size, AWG	Thermoset types S, SO, SOO and thermoplastic types SE, SEO, SEOO, ST, STO, STOO	
	A[a]	B[b]
18	7	10
17	–	12
16	10	13
15	–	–
14	15	18
12	20	25
10	25	30
8	35	40
6	45	35
4	60	70
2	80	95

[a] The currents specified under subheading A apply to 3-conductor cords and other multi-conductor cords where only three conductors are current-carrying.

[b] The currents specified under subheading B apply to 2-conductor cords and other multi-conductor cords connected to utilization equipment so that only two conductors are current-carrying.

Table 13.2
Ampacity of cable types SC, SCE, SCT, G, and W based on ambient temperature of 30°C (86°F)

Size, AWG/kcmil	60°C (140°F)			75°C (187°F)			90°C (194°F)		
	A	B	C	A	B	C	A	B	C
8	60	55	48	70	65	57	80	74	65
6	80	72	63	95	88	77	105	99	87
4	105	96	84	125	115	101	140	130	114
3	120	113	99	145	135	118	165	152	133
2	140	128	112	170	152	133	190	174	152
1	165	150	131	195	178	156	220	202	177
1/0	195	173	151	230	207	181	260	234	205
2/0	225	199	174	265	238	208	300	271	237
3/0	260	230	201	310	275	241	350	313	274
4/0	300	265	232	360	317	277	405	361	316
250	340	296	259	405	354	310	455	402	352
300	375	330	289	445	395	346	505	449	303
350	420	363	318	505	435	381	570	495	433
400	455	392	343	545	469	410	614	535	468
500	515	448	392	620	537	470	700	615	536

NOTES

1 The ampacities under subheading A apply to single-conductor Types SC, SCE, SCT, and W cable only where the individual conductors are not installed in raceways and are not in physical contact with each other except in lengths not to exceed 24 inches (610 mm) where passing through the wall of an enclosure.

2 The ampacities under subheading B apply to 2-conductor cables and other multi-conductor cables connected to utilization equipment so that only two conductors are current-carrying. The ampacities under subheading C apply to 3-conductor cables and other multi-conductor cables connected to utilization equipment so that only three conductors are current-carrying. In 3-phase, 4-wire equipment, the neutral is considered a current-carrying conductor only if the equipment is intended for use with electronic dimmers and is marked in accordance with 34.1.

13.2.2 Cord-connected equipment marked with an environmental rating of Type 3, 3R, 3X, 3RX, 3S, 3SX, 4, 4X, or "Suitable for use in Damp Locations", shall be provided with a cord or cable marked as noted in Table 13.3.

Table 13.3
Required markings for cords and cables

Environmental rating of portable power distribution equipment	Cord or cable type designation	Required marking on cord or cable
Type 3, 3R, 3X, 3RX, 3S, 3SX, 4, or 4X	G, PPE, W	"Wet," and "Sunlight Resistant" or "Sun Res"
	SC, SCE, SCT	"Water Resistant"
	S, SO, SOO, SE, SEO, SEOO, ST, STO, STOO	"Outdoor" or "W," and "Water Resistant"
"Suitable for use in Damp Locations"	G, PPE, W	"Sunlight Resistant" or "Sun Res"
	SC, SCE, SCT	No special markings required
	S, SE, SEO, SEOO, SO, SOO, ST, STO, STOO	"Outdoor" or "W"

13.2.3 Means shall be provided to prevent the flexible cord from being pushed into the enclosure of the equipment through the cord-entry hole, when such displacement is capable of subjecting the cord to mechanical damage or exposing the cord to a temperature higher than that for which it is rated, or when it is capable of reducing spacings below the minimum required values.

13.3 Multi-conductor inlet input

13.3.1 A multi-conductor input means shall be suitable for the voltage and current involved. The inlet shall be polarized and be of a configuration in which the grounding conductor makes contact first and breaks contact last.

13.4 Single-conductor inlets and plugs

13.4.1 Single-conductor inlets or plugs on lengths of cable shall be of the locking, pin-and-sleeve type and shall be suitable for the voltage and current involved.

13.4.2 The inlet or plug provided for the equipment-grounding conductor shall be green or green with yellow stripes. An inlet or plug, when provided, for the grounded supply conductor shall be white or gray. Ungrounded phase conductor inlets or plugs shall be a male configuration.

13.4.3 When single-pole plugs are provided on a length of cable, the cable shall be rated 90°C (194°F) minimum, and shall be sized based on the 60°C (140°F) column of Table 7.4, when the equipment is rated less than 100 amps, or the 75°C (167°F) column when rated 100 amps or more.

Exception: A higher ampacity or a lower temperature rating is not prohibited when the assembly has been evaluated in accordance with the Temperature Test, Section 20.

13.4.4 Single-conductor inlets shall be mounted to panels not having magnetic properties. Metals with magnetic properties include iron and steel.

Exception No. 1: This requirement does not apply to single-conductor inlets mounted to panels having magnetic properties where the openings for each receptacle are connected by slots cut in the metal panel. Single-conductor inlets shall not be mounted to an insulating block unless no metal bracket, brace, or the like is placed across the insulating material between the individual receptacles.

Exception No. 2: This requirement does not apply to single-conductor inlets mounted to panels having magnetic properties where the combination has been investigated in accordance with and complies with the Temperature Test, Section 20.

13.4.5 Equipment with single-conductor inlet inputs shall not be used for parallel conductors unless marked in accordance with 31.1.

13.5 Interlocked inlet assemblies

13.5.1 Interlocked inlet assemblies shall comply with the requirements specified in 13.4.1 and 13.4.2 and have features defined in 5.18.

13.6 Sequentially-interlocked inlet assemblies

13.6.1 Sequentially-interlocked inlet assemblies shall comply with the requirements specified in 13.4.1 and 13.4.2 and have features defined in 5.19.

13.7 Bus bars

13.7.1 Bus bars shall be suitable for the current involved and shall be sized to mate with the bus bar clamp recommended by the manufacturer.

14 Output Connections

14.1 General

14.1.1 Equipment shall be provided with the output connection options specified in (a) – (h). They shall also comply with the corresponding parts of Input Connections, Section 13.

a) Grounding-type receptacles with configurations as described in the Standard for Wiring Device Configurations, UL 1681, or the Standard for Pin and Sleeve Configurations, UL 1686;

b) Other multi-conductor receptacles that are polarized with the grounding conductor making contact first and breaking contact last;

c) An interlocked receptacle assembly;

d) A sequentially-interlocked receptacle assembly;

e) Separate, panel-mounted, locking-type, single-pole, pin-and-sleeve-type receptacles;

f) Separate, panel-mounted, non-locking, single-pole receptacles;

g) Single-pole, cord-connectors terminated to extra-hard-service cable; and

h) Bus bars.

14.1.2 Equipment with single-conductor receptacle outputs may be intended for parallel conductors on the output when marked in accordance with 32.1.

14.2 Receptacles

14.2.1 Non-locking, single-pole receptacles shall be used for branch-circuit output only and the equipment shall be marked in accordance with 36.2.

14.2.2 After installation, the face of a receptacle shall project at least 0.015 inch (0.38 mm) from a conductive mounting surface.

14.2.3 A receptacle mounted on a raised outlet box cover shall be secured by at least two screws (or a means determined to be equivalent) that reduces the risk of the receptacle loosening, turning, being pushed back, or the like.

14.2.4 All 15- and 20-ampere, 125- and 250-volt nonlocking receptacles with configurations specified in the “Note” to this paragraph, and used in equipment marked as having a Type 3R enclosure or other Type designation intended for outdoor use, or marked “Suitable for Use in Damp Locations” or “Suitable for Use in Damp or Wet Locations” or “DWL” shall be rated as “weather-resistant” type in accordance with the Standard for Attachment Plugs and Receptacles, UL 498. See the Notes to 5.5 and 5.8.

Note: NEMA configurations that are subject to this requirement are identified as 5-15, 5-20, 6-15, and 6-20 in the Standard for Dimensions of Attachment Plugs and Receptacles, ANSI/NEMA WD 6.

15 Overcurrent Protection

15.1 General

15.1.1 A fuse or circuit breaker suitable for branch-circuit protection shall be provided for the protection of each ungrounded, branch-circuit conductor.

15.1.2 The ampere rating of a receptacle shall not be less than that of the overcurrent protection provided in the circuit in which it is used.

15.1.3 No overcurrent protection device shall be placed in any permanently grounded circuit conductor unless its simultaneously opens all conductors of the circuit.

15.1.4 Any overcurrent protection provided shall be suitable for the voltage and current involved and have an interrupting rating of at least 10,000 amperes.

15.2 Circuit breakers

15.2.1 Circuit breakers shall not be operated continuously at 100 percent of their marked ampere rating unless the breaker and the portable power-distribution equipment have been evaluated and determined to be suitable for the purpose.

Exception: This requirement does not apply to circuit breakers operated at 100 percent of their marked rating continuously where the circuit breaker is rated for continuous use and the size of the current carrying parts are sized in accordance with 7.2.2 for 100 percent rated devices.

15.2.2 A circuit breaker shall be connected to open all ungrounded conductors of the circuit. Multi-pole circuit breakers shall be the common-trip type.

Exception: Individual, single-pole circuit breakers are not prohibited from being used in a 4-wire, 3-phase system when:

a) The receptacle is not of the standard configuration specified in the Standard for Wiring Device Configurations, UL 1681;

b) The mating plug does not mate with any receptacle specified in UL 1681; and

c) The marking "For single-phase loads only" is provided.

15.2.3 Circuit breakers shall be used within their rated marked voltage rating. When the voltage rating does not include the terms AC or DC, the breaker is rated for both AC and DC voltages. A circuit breaker shall not be used at frequencies other than 60 Hz unless so marked.

15.2.4 Single-pole breakers rated 120 V AC or 120/240 V AC and 2-pole, independent-trip breakers rated 120/240 V AC shall be used on 1-phase, 3-wire circuits, where the neutral is connected to the load and the voltage to ground does not exceed 120 V. Single-pole breakers rated 125 V AC, 125 V DC, 125/250 V DC, and 2-pole independent-trip breakers rated 125/250 V AC or 125/250 V DC, shall be used on 1-phase and DC, 3-wire circuits, where the neutral is connected to the load and the voltage to ground does not exceed 125 V.

15.2.5 Two- and 3-pole, common-trip breakers rated 120/240 V AC shall be used on 1-phase, 3-wire circuits, with or without the neutral connected to the load, and where the voltage to ground does not exceed 120 V.

15.2.6 Two- and 3-pole common-trip breakers rated 120/250 V or 125/250 V DC shall be used on 1-phase and DC, 3-wire circuits, with or without the neutral connected to the load, and where the voltage to ground does not exceed 125 V.

15.2.7 "Slant-rated" breakers (120/240, 480Y/277 V, and the like, as opposed to 240, 480 V, and the like) shall not be used on "slant-rated" delta systems. For example, a 3-pole, 120-/240-V breaker shall not be

used on a 240-/120-V, 3-phase, 4-wire, delta system, since the voltage on the high leg the voltage to neutral is 208 V. In this instance, a 3-pole, 240 V breaker shall be used.

15.2.8 Three-pole, "slant-rated" circuit breakers rated 120/240 V AC shall not be used on 3-phase, 4-wire, "Y" systems.

15.2.9 “Slant-rated” breakers with a rating such as 480/277 V shall be used in circuits where the circuit voltage does not exceed the higher of the two voltages and the voltage to ground does not exceed the lower of the two voltages.

15.2.10 Three-pole circuit breakers shall be used on 3-phase systems only, unless marked to indicate use on single-phase systems with a phrase such as “For single-phase connections, use two outside poles” or other statement determined to be equivalent.

15.2.11 A circuit breaker shall be installed in accordance with its marked line and load identification. When a circuit breaker does not have such a marking line and load, it is not prohibited from going to either terminal.

15.2.12 Circuit breakers rated 125 A or less shall be installed using conductors of ampacity as marked on the circuit breaker: 60°C (140°F), 60/75°C (140/167°F) or 75°C (167°F) wire. See Table 7.4 for conductor ampacities.

15.2.13 Breakers rated greater than 125 A shall be installed using conductors sized for an ampacity of 75°C (167°F).

15.2.14 Circuit breakers shall be installed using a conductor not larger than one size greater than that used based on its rating and appropriate ampacity.

Exception: A circuit breaker is not prohibited from being installed using the maximum wire size as marked on the circuit breaker.

15.2.15 Three-pole circuit breakers shall be used on 3-phase systems only, unless marked to indicate use on 1-phase systems, such as, "For 1-phase connections, use two outside poles," or other statement determined to be an equivalent.

15.3 Fuses

15.3.1 Fuses shall be a standard Class CC, G, H, J, K, RK, or T cartridge fuses or Type S or Edison base plug fuses.

Exception: Fuses other than as specified in 15.3.1 shall not be used unless the fuse is not providing overcurrent protection in accordance with 15.1.1 and the fuse complies with 15.1.4.

15.3.2 The arrangement of electrical connections for a fused switch shall be such that, when the device is connected as intended, current flow to the fuse terminals is interrupted when the switch is opened.

15.4 Fuseholders

15.4.1 A fuseholder shall be suitable for the voltage, current, and type of fuse involved. The construction shall reject a fuse not suitable for branch-circuit protection.

15.4.2 A fuseholder shall be constructed and installed so that no uninsulated live part other than the screw shell is exposed to contact by persons removing or replacing fuses.

15.4.3 The screw shell of a plug-type fuseholder and the accessible contact of an extractor fuseholder shall be connected toward the load.

16 Spacings

16.1 The electrical spacings in equipment shall be at least those specified in Table 16.1.

Table 16.1
Minimum spacings

Point of application	Voltage range[a] volts	Minimum spacings[b,c]					
		Through air,		Over surface,		Short distance	
		inch	(mm)	inch	(mm)	inch	(mm)
Between any uninsulated live part and an uninsulated live part of opposite polarity, uninsulated grounded part other than the enclosure, or exposed metal part.[a]	51 – 150	1/8	(2.3)	1/4	(6.4)	–	–
	151 – 300	1/4	(6.4)	3/8	(9.6)	–	–
	301 – 600	3/8	(9.5)	1/2	(12.7)	–	–
Between any uninsulated live part and the walls of a metal enclosure.[b]	151 – 150	–	–	–	–	1/2	(12.7)
	151 – 300	–	–	–	–	1/2	(12.7)
	301 – 600	–	–	–	–	1/2	(12.7)

[a] For the purpose of this requirement, a metal piece attached to the enclosure is considered to be a part of the enclosure when deformation of the enclosure is likely to reduce spacings between the metal piece and uninsulated live parts.

[b] These spacings do not apply between uninsulated live parts of a receptacle or inlet to its mounting surface.

16.2 In applying Table 16.1, all of the following are to be assumed:

a) The voltage from a live part (other than the neutral) to grounded dead metal equals the line-to-line voltage of the system.

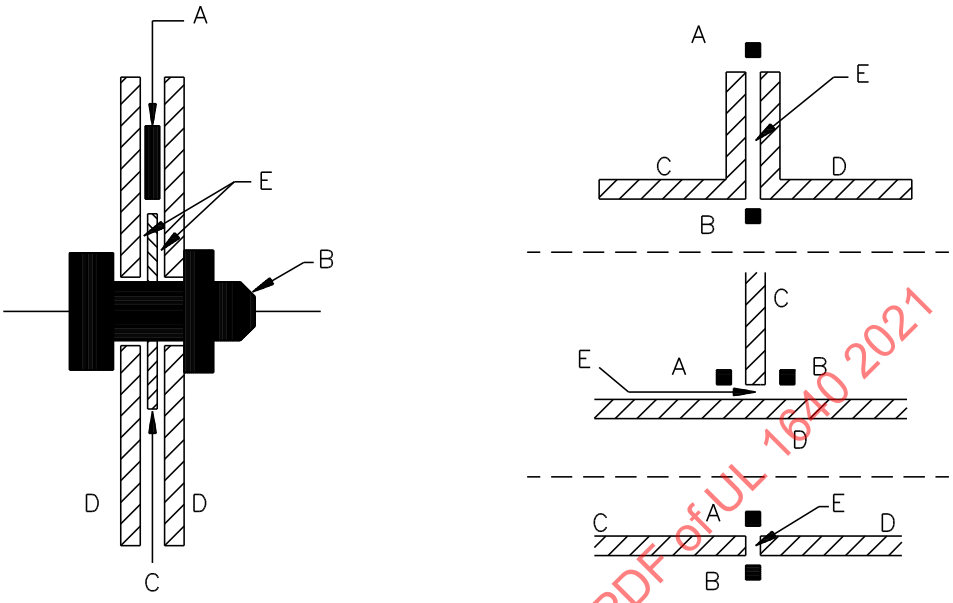
b) The voltage from a neutral live part to grounded dead metal equals the line-to-neutral voltage of the system.

c) Spacings at a fuseholder are to be measured with a fuse of the maximum standard dimensions (including the maximum projections for assembly screws and rivets) in place. Dimensions of fuses and fuseholders are specified in the UL 248 series of Standards and UL 4248 series of Standards; respectively.

d) Spacings are to be measured through cracks unless a clamped joint has passed the test described in 22.2.1. A clamped joint is a joint between two pieces of insulation that are under pressure as shown in Figure 16.1. Adhesives, cements, and the like, when used to effect a seal in place of a tightly-mated joint, shall comply with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

Figure 16.1

Clamped joint



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Parts A, B – Live parts of opposite polarity, or a live part and grounded metal part with spacing through the crack between C and D less than required in Table 16.1.

Parts C, D – Insulating barriers clamped tightly together so that the dielectric strength between A and B is greater than air spacing without the barriers in place.

Part E – The clamped joint.

16.3 A barrier that comprises the sole separation or is used in conjunction with an air space less than 0.013 inch (0.33 mm) shall comply with (a) and (b). The barrier shall:

a) Be of insulation material as covered in 8.1 and 8.2 and as shown in example 1 of Figure 8.1. However, with regard to the flammability rating in Table 8.1, the rating is not prohibited from being VTM-0 rather than V-0, VTM-1 rather than V-1, or VTM-2 rather than V-2.

Exception No. 1: A barrier located between the enclosure and an uninsulated live part electrically connected to a grounded circuit conductor (neutral) is not prohibited from being made of vulcanized fiber.

Exception No. 2: A barrier shall not be used unless the barrier complies with the end-product tests specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, shall be used.

b) Have a minimum thickness of 0.028 inch (0.71 mm).

Exception: A barrier of insulating material other than vulcanized fiber covered by the Exception No. 1 to 15.3(a) shall not have a thickness less than 0.028 inch (0.71 mm) unless it withstands a 60-hertz dielectric-withstand voltage of 5000 volts applied in accordance with 22.3.1.

16.4 A barrier used in conjunction with a minimum air space of 0.013 inch (0.33 mm) shall comply with (a) – (e).

a) The barrier shall be of material that has insulating properties as covered in 8.1 and 8.2 and as shown in example 1 of Figure 8.1 or material other than vulcanized fiber complying with Table 16.2.

Exception No. 1: Vulcanized fiber with a minimum thickness of 0.028 inch (0.71 mm) and used in conjunction with a minimum 0.028 inch (0.71 mm) air space need not comply with 8.1.

Exception No. 2: This requirement does not apply to a barrier that complies with the end-product tests specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

b) It shall be of such strength to withstand exposure to mechanical damage.

c) It shall be secured in place.

d) It shall be located so that it is not adversely affected by operation of the equipment in service.

e) It shall be minimum 0.028 inch (0.71 mm) thick.

Exception No. 1: Material other than vulcanized fiber shall not have a thickness less than 0.028 inch (0.71 mm) unless it withstands a 60-hertz dielectric-withstand voltage of 5000 volts applied in accordance with the requirements in 22.3.1.

Exception No. 2: Material other than vulcanized fiber used in conjunction with an air space of 1/2 or more of the required through air spacing shall not have a thickness either not less than 0.013 inch (0.33 mm) or less than 0.013 inch (0.33 mm) unless it withstands a 60-hertz dielectric-withstand voltage of 2500 volts applied in accordance with the requirements in 22.3.1.

Table 16.2
Maximum performance level category (PLC) for a barrier used in place of spacings in conjunction with minimum air space of 0.013 inch (0.33 mm)

Test specified	Flammability rating of material		
	V-0 or VTM-0	V-1 or VTM-1	V-2 or VTM-2
Comparative tracking index under moist conditions (CTI)[a]	4	4	4
High-current arc resistance to ignition (HAI)[a]	3	2	2
Hot wire ignition (HWI)[a]	4	3	2
NOTE – The additional parameters specified in Table 16.3 shall be considered.			
[a] See the Standard for Polymeric Materials– Short Term Property Evaluations, UL 746A.			

16.5 Thermoplastic tubing shall not be used unless spacings would otherwise be less than the minimum required values and it complies with all of the following conditions:

a) It is not subjected to compression, repeated flexure, or sharp bends.

b) All edges of the conductor covered with the tubing are rounded and free from sharp edges.

c) For chemically-dilated tubing, a solvent recommended by the tubing manufacturer is used.

d) Its wall thickness (after assembly) is not less than 0.022 inch (0.56 mm) for tubing 1/2 inch (12.7 mm) or less in diameter, not less than 0.027 inch (0.69 mm) for tubing 9/16 or 5/8 inch (14.3 or 15.9 mm) in diameter, and not less than 0.028 inch (0.71 mm) for larger tubing.

Table 16.3
Test parameters

Property	Test	Method	Units	Minimum levels related to flammability classification
Distortion under load and mold stress relief	Heat deflection temperature, or	UL 746A	Minimum °C	10°C (18°F) greater than use temperature but not less than 90°C (194°F), or
	Vicat softening point, or	UL 746A	Minimum °C	25°C (45°F) greater than use temperature but not less than 105°C (221°F), or
	Ball pressure temperature	UL 746A	Minimum °C	Greater than the use temperature by the difference between 40°C (72°F) and the ambient, but not less than 95°C (203°F)

17 Switches

17.1 The switching means and mechanisms for the main disconnect or the branch circuits of equipment shall be a general-use-type switch, molded-case switch, or circuit breaker and shall have a current and voltage rating not less than that of a circuit it controls.

17.2 When a circuit breaker or switch is mounted so that the movement of the operating handle, either vertically or rotationally, between the on and off positions results in one position being above the other position, then the upper position shall be the on position.

18 Transformers

18.1 A transformer shall comply with the Standard for Dry-Type, General-Purpose, and Power Transformers, UL 1561, or the Standard for Specialty Transformers, UL 506. Alternatively, transformers may comply with the Standards for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1 and the applicable part: Standard for Low Voltage Transformers – Part 2: General Purpose Transformers, UL 5085-2, or the Standard for Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3.

18.2 A transformer shall have a maximum available short circuit current of not more than 10,000 amps.

18.3 A transformer shall be protected by an individual branch circuit type overcurrent device on the primary side rated or set at not more than 125 percent of the rated primary current of the transformer.

Exception No. 1: Where the rated primary current of a transformer is 9 amps or more and 125 percent of this current does not correspond to a standard rating of a fuse or nonadjustable circuit breaker, the next higher standard rating may be used. Where the rated primary current is less than 9 amps, an overcurrent device rated or set at not more than 167 percent of the primary current may be used. Where the rated primary current is less than 2 amps, an overcurrent device rated or set at not more than 300 percent shall be used.

Exception No. 2: An individual primary side overcurrent device is not required where the feeder circuit overcurrent device provides the protection specified in 18.3.

Exception No. 3: When the primary feeder or current device corresponding to the input rating of the equipment is not more than 250 percent of the rated primary current of the transformer, an individual device in the primary connection is not required as specified in 18.4.

18.4 Equipment with an overcurrent device in the secondary connection, rated for or set at not more than 125 percent of the rated secondary current of the transformer, are not required to have an individual overcurrent device in the primary connection if the primary feeder overcurrent device corresponding to the input rating of the equipment is not more than 250 percent of the rated primary current of the transformer.

Exception: Unless the rated primary current of a transformer is 9 amps or more and 125 percent of this current does not correspond to a standard rating of a fuse or nonadjustable circuit breaker, the next higher standard rating shall not be used. Where the rated primary current is less than 9 amps, an overcurrent device rated or set at not more than 167 percent of the primary current shall be used.

18.5 Standard ampere ratings for fuses are: 1, 3, 6, 10, 15, 20, 25, 30, 35, 40, 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, 4000, 5000, and 6000.

18.6 Standard ampere rating 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, 4000, 5000, and 6000.

18.7 With regard to 15.1.1, a conductor on the secondary side of a transformer can be considered protected by an overcurrent device in the primary circuit if both of the following conditions are met:

a) The transformer is single phase with a 2-wire (single-voltage) secondary,

b) The primary protection is in accordance with 18.3 and does not exceed the value required as determined by multiplying the secondary conductor ampacity by the secondary to primary voltage ratio.

PERFORMANCE

19 General

19.1 The performance of portable power-distribution equipment shall be investigated by subjecting a representative sample or samples in commercial form to the tests described in Sections 20 – 28.

19.2 All tests are to be conducted with the equipment connected to a power supply of rated frequency and a voltage as follows:

a) When rated 110 – 120 volts, 120 volts;

b) When rated 220 – 240 volts, 240 volts;

c) When rated 254 – 277 volts, 277 volts;

d) When rated 440 – 480 volts, 480 volts;

e) When rated 560 – 600 volts, 600 volts.

19.3 Unless indicated otherwise, the tests are to be conducted at any ambient temperature with the range of 10 – 40°C (50 – 104°F). The ambient temperature is to be determined using either thermometers or thermocouples placed in the vicinity of the equipment being tested.

19.4 Temperatures are to be measured by thermocouple consisting of wires not larger than 24 AWG (0.21 mm^2) and not smaller than 30 AWG (0.05 mm^2). When thermocouples are used in determining temperatures in electrical equipment, it is standard practice to use thermocouples consisting of 30 AWG iron and constantan wire and a potentiometer-type instrument, and such equipment will be used whenever referee temperature measurements with thermocouples are necessary. The thermocouples and related instruments are to be accurate and calibrated. The thermocouple wire is to comply with the requirements for special tolerance thermocouples as listed in the Tolerances on Initial Values of EMF versus Temperature tables in the Standard Specification and Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples, ANSI/ASTM E230/E230M.

Exception: The temperature of a coil shall be determined by the change-of-resistance method.

19.5 A thermocouple junction and adjacent thermocouple lead wire are to be securely held in thermal contact with the surface of the material for which the temperature is being measured. In most cases, effective thermal contact results from securely taping or cementing the thermocouple in place. If a metal surface is involved, brazing or soldering the thermocouple to the metal may be used.

20 Temperature Test

20.1 Equipment is to be tested under the conditions specified in 20.2 – 20.5. The results are in compliance when:

a) The temperature at any point is not sufficiently high to cause a fire or to adversely affect any material used;

b) The temperature rises at specific points are not higher than those specified in Table 20.1; and

c) No overcurrent device trips.

Exception: Equipment that complies with the following requirements in (a) – (e) is not required to be subjected to temperature testing.

a) Equipment that utilizes bus bars at or below the ampacity in Table 7.1 and Table 7.2;

b) Equipment that utilizes internal wiring rated 90°C (194°F) minimum, at 60°C (140°F) or 75°C (167°F) ampacities in accordance with Table 7.4;

c) Equipment that utilizes supply or output cords or cables rated 90°C (194°F) minimum, at ampacities specified in 13.2.1 and 13.4.3;

d) Equipment that utilizes switches and receptacles within their marked ratings; and

e) Equipment that utilizes circuit breakers within their marked ratings and in a way that is consistent with the requirements in Overcurrent Protection, Section 15.

Table 20.1
Maximum temperature rises

Materials and components	°C	(°F)
1. Unplated bus bar at a joint except as covered in item 2	50	(90)
2. Any bus within 6 inches (152 mm) of a fuseholder along the current path when tested with dummy fuses	30	(54)
3. Pressure terminal connectors used in circuits rated 110 amperes or less and marked for use with 75°C (167°F) wire	65[a]	(117)[a]
4. Pressure terminals or wire connectors for internal wiring involving aluminum conductors unless the connector has been investigated for higher temperatures	50[b]	(90)[b]
5. Plated bus bar at the point of connection to a molded case circuit breaker	55[c]	(99)[c]
6. Plated bus bar except as covered in items 2 and 5	65[b]	(117)[b]
7. Wire insulation or insulating tubing	35[b,d]	(63)[b,d]
8. Electrical tape	55[b,d]	(99)[b,d]
9. Varnished cloth insulation	60[b,d]	(108)[b,d]
10. Fiber used as electrical insulation	65[b,d]	(117)[b,d]
11. Sealing compound	50[b,d,e]	(90)[b,d,e]
12. Phenolic composition used as electrical insulation or as a part whose failure would result in an undesired condition	125[b,d]	(225)[b,d]
13. Other insulating materials	See footnote f	
14. External metal handles, knobs, and other surfaces subject to contact by a person	35	(63)
15. External nonmetallic handles, knobs, and other surfaces subject to contact by a person	60	(108)
16. Coil winding by change-of-resistance method except as specified in item 17:		
a) Relay and solenoids:		
(1) Class 105 insulation system	85	(153)
(2) Class 130 insulation system	105	(189)
b) Transformers 10 kVA or less:		
(1) Class 105 insulation system	70	(126)
(2) Class 130 insulation system	95	(171)
c) Transformers greater than 10 kVA:		
(1) Class 105 insulation system	55	(99)
(2) Class 130 insulation system	60	(108)
(3) Class 155 insulation system	85	(153)

Table 20.1 Continued on Next Page

Table 20.1 Continued

Materials and components	°C	(°F)
(4) Class 180 insulation system	110	(198)
(5) Class 200 insulation system	130	(234)
(6) Class 220 insulation system	150	(270)
17. Coil winding by change-of-resistance method for transformers with encapsulated coils or that are compound filled:		
a) Class 105 insulation system	70	(126)
b) Class 130 insulation system	95	(171)
c) Class 155 insulation system	115	(207)
d) Class 180 insulation system	135	(243)
e) Class 200 insulation system	150	(270)
f) Class 220 insulation system	165	(297)

[a] Applicable to a connector for copper wire. Also applicable to an aluminum bodied connector if the connector is marked AL9CU.

[b] In equipment tested with dummy fuses, the recorded temperature rise shall be increased 20°C (36°F) to represent the heating of fuses except that where only a few fuses such as control circuit fuses are involved, the increase shall only apply to parts within 12 inches (305 mm) of the fuses.

[c] A plated bus may have a 65°C (117°F) rise at the point of connection to a molded-case circuit breaker if the circuit breaker is marked for and tested with 75°C (167°F) wire for circuits rated 110 amperes or less or marked for use and tested at 100 percent of its continuous rating.

[d] This limitation does not apply to an insulated conductor or other material that has been investigated and rated for a higher temperature.

[e] The softening point as covered in 8.4 shall be at least 40°C (72°F) higher than the temperature rise but not less than 90°C (194°F) in any case.

[f] See 20.2 for other insulating materials.

20.2 The acceptability of insulating materials, other than those specified in Table 20.1, is to be determined with regard to properties such as flammability, arc resistance, and the like, based on the temperature rise plus 40°C (104°F).

20.3 A resistive load is to be connected to each receptacle or cord connector involved using a minimum 3-foot (0.91-m) length of flexible cord or cable that terminates in an assembled-on attachment plug. The attachment plug is to have a current rating that matches the current rating associated with the blade or pin configuration of the receptacle or cord connector to which it is connected.

Exception: A low-voltage current source is not prohibited from being used.

20.4 Each output with overcurrent protection suitable for continuous use and marked "Suitable for Continuous Use " in accordance with 36.3 is to be loaded to 100 percent of its marked rating and operated continuously in this manner until maximum temperatures are recorded.

20.5 Each output not marked "Suitable for Continuous Use " is to be loaded to 80 percent of its marked rating and operated in this manner until maximum temperatures have been recorded.

20.6 With regards to 20.4 and 20.5, the total load shall not exceed the input rating of the equipment. The number and ratings of outputs may necessitate multiple tests be conducted.

21 Clamped-Joint Temperature Test

21.1 Equipment that has a clamped-joint construction is to be subjected to the test described in 21.2. The temperature rise at the joint during the 500th cycle shall not be more than 15°C (27°F) higher than the temperature rise at the 25th cycle.

21.2 The test sample is to consist of an assembly of bus bars connected together to form a series circuit. The bus bars are to be clamped together with the joint construction used in actual production. The number and size of the bus bars are to represent the maximum ampere rating and the maximum current density in which the joint construction is used. This may necessitate more than one test. The length of each bus bar is to be 2 feet (610 mm). The bus bars are to be connected to a power supply by any convenient means that will not affect the joint temperature. The power supply is to be adjusted to deliver a value of current that will result in a temperature of 75°C (135°F) above room temperature at the joint. The assembly is then to be subjected to a 500 cycle test. At the end of the 24th cycle, the current is to be re-adjusted to bring the temperature of the joint to 75°C above room temperature. At the end of the 25th and 500th cycles, the temperatures are to be recorded. The temperatures are to be measured on both sides of the joint as close as possible to the bolt or rivet. The cycling rate is to be 3 hours on and 1 hour off. The on period during which temperatures are recorded shall be extended to more than 3 hours if necessary for the joint to attain thermal equilibrium.

Exception: The length of bus bar shall not be less than 2 feet unless with the concurrence of those concerned.

22 Dielectric Voltage-Withstand Test

22.1 General

22.1.1 The equipment is to be subjected for 1 minute to the application of a 60-hertz essentially sinusoidal potential of 1000 volts plus twice the rated voltage under the following conditions. A transformer or other device connected between lines of opposite polarity is to be disconnected from one side of the line during the test in (b). There shall be no dielectric breakdown between a live part and a dead-metal part with all switching devices closed, or between live parts of opposite polarity with all switching devices closed.

Exception: Equipment utilizing components and wiring (which are separately investigated and suitable for the installation) are not required to be subjected to this test.

22.1.2 When the overcurrent devices (such as fuses or interchangeable trip units) are not in place during the tests described 22.1.1 (a) and (b), it is necessary to repeat these tests on the load side of the switching devices or to install shorting links in place of the missing fuses or trip units during the tests.

22.1.3 The test potential is to be supplied from a 500-volt-ampere or larger capacity testing transformer, the output voltage of which can be varied. The applied potential is to be increased from zero at an essentially uniform rate and as rapidly as is consistent with its value being correctly indicated by the voltmeter until the required test value is reached; it is to be held at that level for 1 minute. The voltage is then to be reduced to zero at the same uniform rate.

Exception: A 500-volt-ampere or larger capacity transformer is not required to be used when the transformer is provided with a voltmeter to directly measure the applied output potential.

22.1.4 When practicable, the dielectric voltage-withstand test on equipment is to be made with current-carrying parts at operating temperature.

22.2 Clamped insulating joint

22.2.1 With regard to 16.2(d), a clamped joint between two insulators is to be tested using two samples.

a) The first sample is to have the clamped joint opened up to produce a space 1/8 inch (3.2 mm) wide. One method to accomplish this is by loosening the clamping means or by drilling a 1/8 inch diameter hole at the joint between the insulators at a point of minimum spacing between the metal parts on the opposite sides of the joint. The drilled hole shall not decrease spacings between the opposite polarity parts as measured through the crack between the insulators. The 60-hertz dielectric breakdown voltage through this hole is then determined by applying a gradually increasing voltage (500 volts per second) until breakdown occurs.

b) The second sample with the clamped joint intact is to be subjected to a gradually-increasing, 60-hertz voltage until 110 percent of the breakdown voltage of 22.1.1(a) has been reached. If the breakdown voltage of 22.1.1(a) was less than 4600 volts rms, the voltage applied to the second sample is to be further increased to 5,000 volts rms and held for 1 second. There shall be no dielectric breakdown of the second sample.

22.3 Insulating barriers

22.3.1 With regard to 16.3, the barrier material is to be placed between two metal electrodes. The electrodes are to be cylindrical brass or stainless steel rods 1/4 inch (6.4 mm) in diameter with edges rounded to a 1/32 inch (0.8 mm) radius. The test potential is to be increased to the test value and is to be maintained for 1 second. There shall be no dielectric breakdown.

23 Strain-Relief Test

23.1 A strain-relief device is to be tested by the application of a 35-pound-force (156 N) pull on the power supply cord for 1 minute. The pull shall not be transmitted to terminals, splices, or internal wiring.

23.2 The conductors of the cord are to be severed immediately adjacent to the terminals or splices. The pull is to be applied to the cord or wire in a direction perpendicular to the plane of the entrance to the fixture. There shall be no movement of any conductor to indicate that stress on the connections has resulted.

24 Resistance to Rain Test

24.1 An enclosure is to be tested both with and without all inputs and outputs terminated to appropriate plugs or cord connectors. Equipment with doors over more than one receptacle at a time is to be tested both without any attachment plugs and with only a single plug placed in the receptacle that results in the greatest risk of water entering a wiring device. Prior to each test, all doors, guards, shields, or the like are to be opened, then allowed to assume their natural position. A self-closing door is to be allowed to close, a door with a detent or other feature intended to hold it open is not to be manually closed, and an input or output without a self-closing door is to be tested without the door in place.

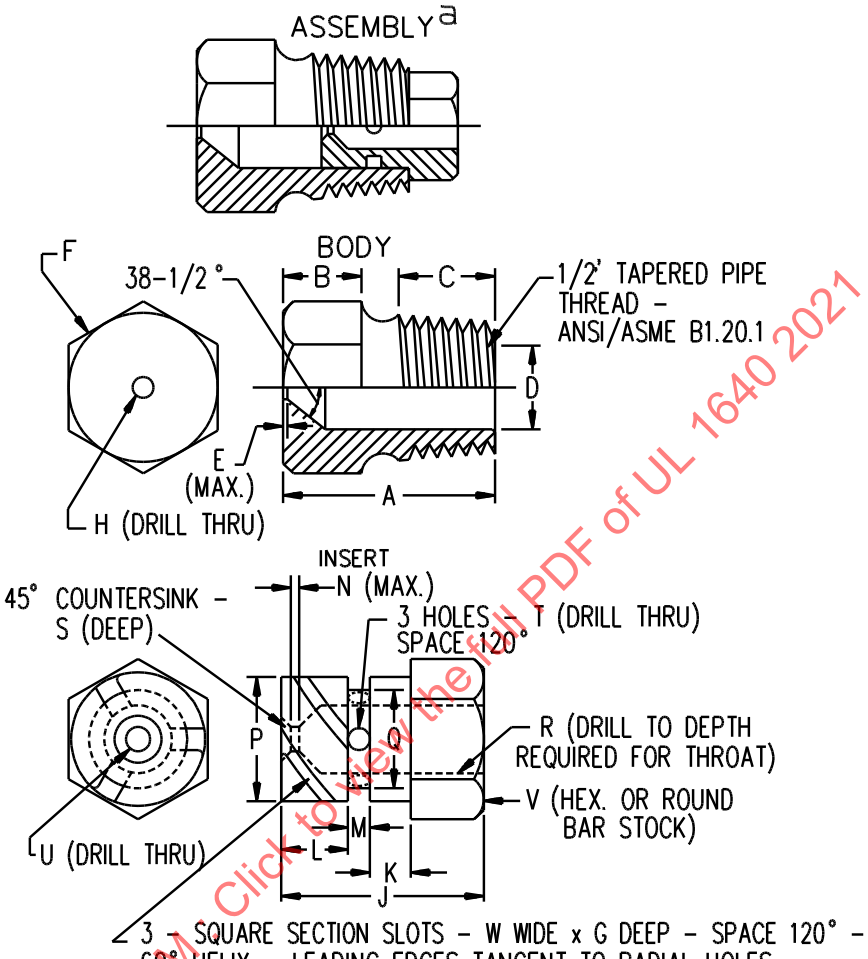
Exception: Doors (see the Note to 5.8) that do not protect inlets and receptacles against water ingress by means of spring-closing doors and that are provided on equipment marked for use by qualified personnel in accordance with Qualified Personnel, Section 35 shall be permitted to be manually closed during this test.

24.2 A complete enclosure is to be oriented as intended. A water spray is then to be applied to the enclosure, using the spray head and spray head piping depicted in Figure 24.1 and Figure 24.2, from the top and sides for 1 hour. The water pressure for the test is to be maintained at 5 psi (34.5 kPa) at each spray head. The distance from the center nozzle and the equipment under test is to be 3 feet (0.9 m). The

equipment is to be brought into the focal area of the three spray heads in such a position that the greatest quantity of water enters the equipment. The spray is to be directed at an angle of 45 degrees to the vertical toward the equipment.

Figure 24.1

Spray head



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

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

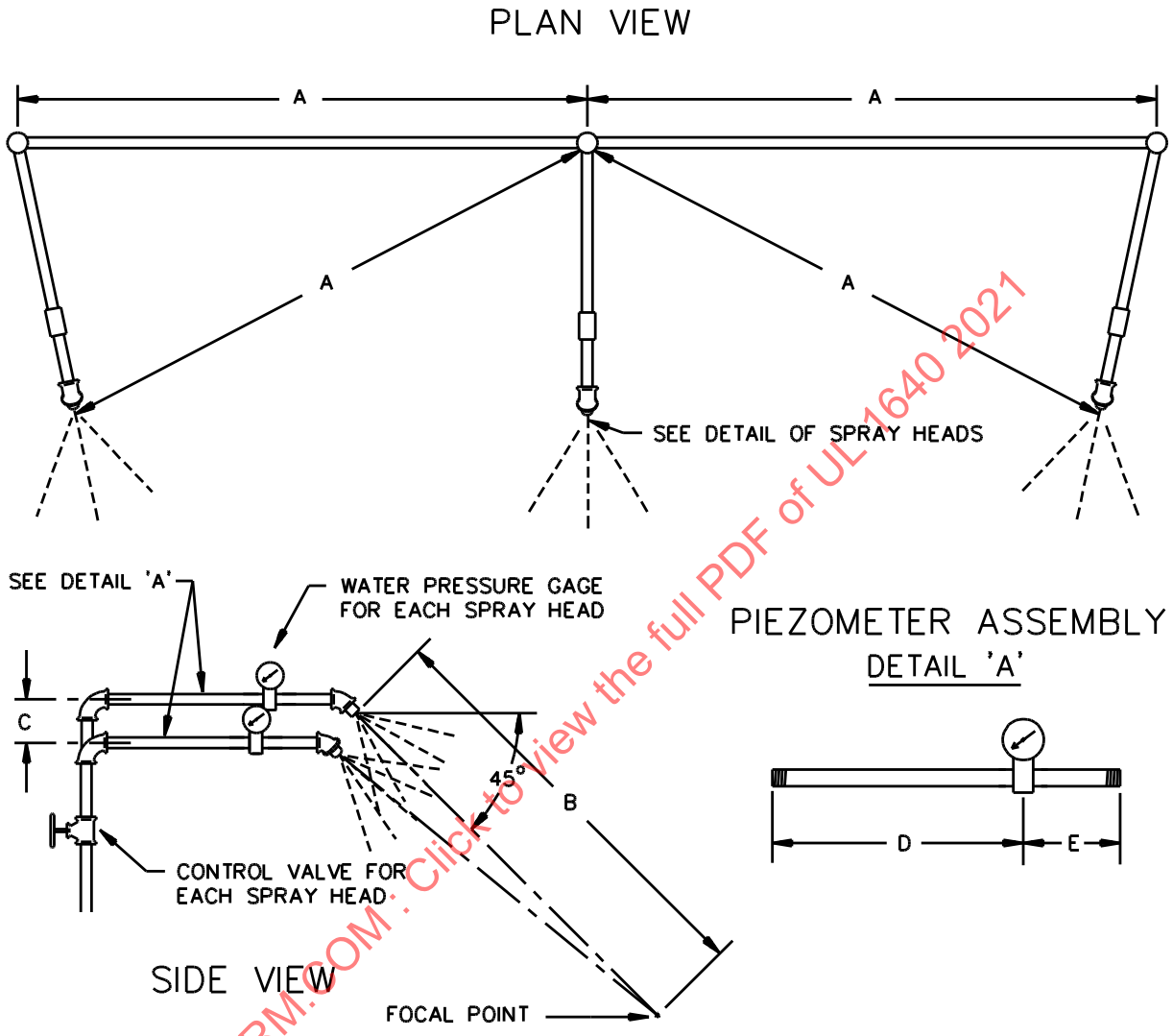
[b] ANSI B94.11M Drill Size

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

RT100E

Figure 24.2

Spray head piping



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

RT101E

24.3 An enclosure shall be considered to have met the requirements if at the conclusion of the test:

a) There is no accumulation of water within the enclosure and

b) No water has entered the enclosure at a level higher than the lowest live part.

25 Icing Test

25.1 An enclosure marked Type 3R shall not be damaged after the ice has melted at the conclusion of the test specified in 25.2. An enclosure that has no external cavities that trap water is considered to comply with 25.2 without being tested.

25.2 The enclosure is to be mounted in a room that can be cooled to 20°F (minus 6.7°C). A metal test bar, 1 inch (25.4 mm) in diameter and 2 feet (610 mm) long, is to be mounted in a horizontal position in a location where it will receive the same water spray as the enclosure being tested. Provisions are to be made for spraying the entire enclosure from above with water at an angle of approximately 45 degrees from the vertical. The water temperature is to be 32 – 37°F (0 – 2.8°C). Spraying facilities that provide 1 – 2 gallons (3.8 – 7.6L) per hour per square foot (928 cm^2) of area to be sprayed are acceptable. The room temperature is to be lowered to 35°F (1.7°C). The spray of water is to be started and continued for at least 1 hour, maintaining the room temperature at 33 – 37°F (0.56 – 2.8°C). The room temperature is then to be lowered to 20 – 27°F (minus 6.7 – minus 2.8°C) while continuing the water spray. The rate of change in room temperature is not critical and is to be whatever is obtainable with the cooling method used. The water spray is to be controlled to cause ice to build up on the bar at a rate of approximately 1/4 inch (6.4 mm) per hour and is to be continued until 3/4 inch (19 mm) of ice has formed on the top surface of the bar. The spray is then to be discontinued, but the room temperature is to be maintained at 20 – 27°F (minus 6.7 – minus 2.8°C) for 3 hours so that all parts of the enclosure and the ice coating have reached the same temperature.

26 Gasket Tests

26.1 A gasket of an elastomeric or thermoplastic material or a composition gasket utilizing an elastomeric material used to comply with the requirements for equipment marked "Suitable for Use In Damp Locations" or one with a Type designation 3, 3R, 3X, 3RX, 3S, 3SX, 4, or 4X, is to be subjected to the tests specified in 26.2 – 26.4.

26.2 The requirements in this section apply to a gasket that is required for an electrical enclosure to maintain a tight fit or to comply with the enclosure performance requirements.

26.3 A gasket shall be secured with adhesive or by mechanical means. The gasket and its securing means shall not be damaged when the joint is opened.

26.4 Gaskets shall be of such quality that samples subjected to a temperature of 69 – 70°C (156 – 158°F) in circulating air for 168 hours have a tensile strength of not less than 75 percent and an elongation of not less than 60 percent of values determined for unaged samples. At the conclusion of the tests, there shall be no visible deterioration, deformation, melting, or cracking of the material and the material shall not harden as determined by normal hand flexing.

27 Spring-Closing Cycling Test

27.1 When subjected to the cycling test described in 27.2, a door protecting inlets or receptacles shall not crack, deform, or otherwise be damaged so as to allow the entrance of water as verified by the appropriate environmental test outlined in Enclosure Performance, Section 10. Verification of door performance is to be conducted with the door opened completely and then allowed to assume its natural position. See the Note to 5.8.

27.2 A door shall be subjected to 1000 cycles of operation. One cycle of operation is considered to be complete opening of the door followed by allowing the door to assume its natural position. See the Note to 5.8.

28 Metallic Coating Thickness Test

28.1 The method of determining the thickness of the zinc or cadmium coating mentioned in 11.5 is detailed in 28.2 – 28.9.

28.2 The solution to be used for the test is to be made from distilled water and is to contain 200 grams per liter of reagent grade chromic acid ($HCrO_3$) and 50 grams per liter of reagent grade, concentrated sulfuric acid (H_2SO_4). The latter has been determined to be equivalent to 27 milliliters per liter of reagent grade, concentrated sulfuric acid, specific gravity 1.84, containing 96 percent H_2SO_4.

28.3 The test solution is to be contained in a glass vessel such as a separatory funnel with the outlet equipped with a stopcock and a capillary tube having an inside bore of 0.025 inch (0.64 mm) and a length of 5.5 inches (139.7 mm). The lower end of the capillary tube is to be tapered to form a tip, the drops from which are about 0.025 milliliters each. To preserve an effectively constant level, a small glass tube is to be inserted in the top of the funnel through a rubber stopper and its position is to be adjusted so that, when the stopcock is open, the rate of dropping is 100 ±5 drops per minute. If desired, an additional stopcock is to be used in place of the glass tube to control the rate of dropping.

28.4 The sample and the test solution are to be kept in the test room long enough to acquire the temperature of the room, which is to be noted and recorded. The test is to be conducted at a room temperature of 21.1 – 32.2°C (70 – 90°F).

28.5 Each sample is to be cleaned before testing. All grease, lacquer, paint, and other nonmetallic coatings are to be removed using solvents. Samples are then to be thoroughly rinsed in water and dried with clean cheesecloth. Care is to be exercised to avoid contact of the cleaned surface with the hands or any foreign material.

28.6 The sample to be tested is to be supported 0.7 – 1 inch (17.8 – 25.4 mm) below the orifice, so that the drops of solution strike the point to be tested and run off quickly. The surface to be tested is to be inclined about 45 degrees from the horizontal.

28.7 The stopcock is to be opened and the time in seconds until the dropping solution dissolves the protective metal coating, exposing the base metal, is to be measured. The end point is the first appearance of the base metal recognizable by a change in color at that point.

28.8 Each sample of a test lot is to be subjected to the test at three or more points, excluding cut, stencilled, and threaded surfaces, on the inside surface and at an equal number of points on the outside surface, at places where the metal coating is expected to be the thinnest. On enclosures made from precoated sheets, the external corners that are subjected to the greatest deformation are likely to have thin coatings.

28.9 To calculate the thickness of the coating being tested, select from Table 28.1 the thickness factor appropriate for the temperature at which the test was conducted and multiply by the time in seconds required to expose base metal as described in 28.7.

Table 28.1
Coating thickness factors

Temperature,		Thickness factors, 0.00001 inches (0.0003 mm) per second	
°F	(°C)	Cadmium plating	Zinc plating
70	(21.1)	1.331	0.980
71	(21.7)	1.340	0.990
72	(22.2)	1.352	1.000
73	(22.8)	1.362	1.010
74	(23.3)	1.372	1.015
75	(23.9)	1.383	1.025
76	(24.4)	1.395	1.033
77	(25.0)	1.405	1.042
78	(25.6)	1.416	1.050
79	(26.1)	1.427	1.060
80	(26.7)	1.438	1.070
81	(27.2)	1.450	1.080
82	(27.8)	1.460	1.085
83	(28.3)	1.470	1.095
84	(28.9)	1.480	1.100
85	(29.4)	1.490	1.110
86	(30.0)	1.501	1.120
87	(30.6)	1.513	1.130
88	(31.1)	1.524	1.141
89	(31.7)	1.534	1.150
90	(32.2)	1.546	1.160

RATINGS

29 Details

29.1 The input of equipment shall be rated in amperes and volts. A direct-current rating shall include the designation DC. An alternating-current rating shall include the number of phases and the frequency in hertz.

Exception: For single-phase equipment, the single-phase designation is not prohibited from being omitted when the designation AC is provided.

29.2 Equipment additionally may be provided with a current or power rating which represents the total current or power available from the outputs of the equipment.

29.3 The symbol "ø" may be used in place of the word "phase" or "phases."

29.4 Equipment for use on a supply circuit involving two different potentials (such as 120-/240-volt, 3-wire or 208Y-/120-volt, 3-phase, 4-wire circuits) shall have an appropriate combination voltage rating. Examples of commonly used voltages are:

a) 208Y-/120-volt, 60-Hz, 3-phase, 4-wire;

b) 480Y-/277-volt, 60-Hz, 3-phase, 4-wire;

c) 120-/240-volt, 60-Hz, single-phase, 3-wire; and

d) 125-/250-volt DC, 3-wire.

29.5 The input current rating shall not be higher than the smaller of the following:

a) The current rating of the main switch and fuseholders, or the current (trip) rating of the main circuit breaker;

b) The ampacity of the supply cord or supply receptacle; and

c) The ampacity of supply or through bus bars.

29.6 Equipment for use on 208Y/120-volt, 3-phase, 4-wire systems is not prohibited from having a second reduced rating for 120/240 volt, single phase, 3-wire systems. Equipment with a 200 percent neutral in accordance with 7.4.6.1 and marked in accordance with 34.2 is not prohibited from having the same input rating for both 208Y/120-volt, 3-phase, 4-wire and 120/240-volt, single-phase, 3-wire systems.

29.7 Equipment rated for use on 208Y-/120-volt, 3-phase, 4-wire systems and also on 120-/240-volt, single-phase, 3-wire systems shall be marked with the intended connections for single-phase use.

MARKINGS

30 General

30.1 Equipment shall be permanently marked in such a location that the marking will be plainly visible with the manufacturer's name, trademark or other identifying marking, the catalog number or other identifier determined to be the equivalent, and the electrical rating.

30.2 A required marking shall be molded, die stamped, paint-stenciled, stamped or etched on metal or be indelibly stamped or printed on pressure-sensitive labels.

30.3 When a marking is specified as "permanent," and a pressure-sensitive label system used, the combination of a label material and printed ink used shall be permanent and rated for the type of surface and the temperature of the surface to which it will be affixed in accordance with the Standard for Marking and Labeling Systems, UL 969. Labels on equipment with Type designation 3, 3R, 3X, 3RX, 3S, 3SX, 4, 4X, or enclosures marked "Suitable For Use In Damp Locations" shall comply with the requirements for outdoor labels in UL 969. Equipment not subjected to temperature testing in accordance with the Exception to 20.1 shall utilize labels suitable for at least 75°C (167°F). Equipment with Type 1 enclosures shall utilize labels suitable for temperatures of 0°C (32°F) or less. Equipment with 3, 3R, 3X, 3RX, 3S, 3SX, 4, or 4X enclosures or marked "Suitable For Use In Damp Locations" shall utilize labels suitable for minus 35°C (minus 31°F) or less.

Exception No. 1: Labels not on the outside surface of equipment with Type 3, 3R, 3RX, 3S, 3SX, 4, or 4X enclosures, or equipment marked "Suitable For Use In Damp Locations" are not required to comply with the resistance to ultraviolet radiation requirement of outdoor-use labels.

Exception No. 2: An adhesive label adhered to a cord or cable is not required to have an adhesive evaluated for use on the cord or cable surface when the label is wrapped around the cord or cable and a minimum of 50 percent of the adhesive surface of the label is adhered to itself.

Exception No. 3: Heat-shrinkable tubing around cord or cables is not required to be evaluated for label permanency.

30.4 When the manufacturer produces equipment at more than one factory, each piece of equipment shall be marked to identify it as the product of a particular factory.

31 Public Access

31.1 Equipment with input or output means that have current-carrying parts accessible by the finger probe specified in Figure 9.5 shall be permanently marked: "For Use in Areas Not Readily Accessible by the General Public." Letters shall be minimum 1/8 inch (3.2 mm) high.

32 Conductors in Parallel

32.1 Equipment utilizing single-conductor inlets or receptacles intended to have paralleled conductors on a single circuit shall be permanently marked: "WARNING – Risk of Fire – Not For Multiple Circuits. Single Circuit With Parallel Conductors Only." The marking shall be adjacent to the receptacles. The word "WARNING" shall be in minimum 1/8 inch (3.2 mm) high letters and the remaining text in minimum 1/16 inch (1.6 mm) high letters.

33 Enclosure Type

33.1 An enclosure shall be permanently marked with a type designation indicating the external conditions for which it is intended as specified the Standard for Enclosures for Electrical Equipment, Environmental Considerations, UL 50E, or "Suitable For Use In Damp Locations." An enclosure that complies with the requirements for more than one type of enclosure may be marked with multiple designations.

33.2 If the acceptability of an enclosure type designation is dependent upon a particular mounting orientation or upon manual closure and fastening of doors or covers, the enclosure shall be marked to indicate the required orientation or required manual closure and fastening. Where this marking appears on products employed as components on or in equipment and the standards governing those products identify the terms “door” or “cover” with other terms (see the Note to 5.8 and the Note to 5.5), markings on such products shall not be required to be revised to the terms “door” or “cover”.

33.3 Equipment that requires specific inlets or receptacles to maintain its enclosure rating shall be marked "To maintain enclosure rating use only identical replacement parts" or other markings determined to be the equivalent.

33.4 A Type 1 enclosure is not prohibited from being additionally marked "Indoor Use Only."

33.5 With reference to 10.4, a Type 4X enclosure intended for indoor use only shall be permanently marked "4X Indoor Use Only" in letters at least 5/32 inch (4.0 mm) high.

33.6 A Type 3, 3X, 3S, 3SX, 4, or 4X enclosure may be marked "Raintight."

33.7 A Type 3R or 3RX enclosure may be marked "Rainproof."

33.8 A Type 4 or 4X enclosure may be marked "Watertight."

33.9 A Type 4X enclosure may be marked "Corrosion Resistant."

33.10 A Type 3, 3X, 3S, or 3SX enclosure may be marked "Dust Tight."

34 Neutral Connection

34.1 Equipment rated for use on 3-phase, 4-wire with ground supplies and intended for use with electronic dimmers shall be marked "130 Percent Neutral – Suitable For Use With Electronic Dimmers" or other marking determined to be the equivalent.

34.2 Equipment rated for use on both 208Y-/120-volt, 3-phase, 4-wire and 120-/240-volt, single-phase supplies at the full current rating on both systems shall be marked "200 Percent Neutral" or other marking determined to be the equivalent.

35 Qualified Personnel

35.1 All equipment shall be permanently marked with the following or other marking determined to be the equivalent: "FOR USE BY QUALIFIED PERSONNEL ONLY" and "The routing of portable supply conductors, the making and breaking of supply connectors, and the energization and de-energization of supply services shall be performed by qualified personnel only." This marking shall be in minimum 1/16 inch (1.6 mm) high letters. The words "FOR USE BY QUALIFIED PERSONNEL ONLY" shall be in minimum 1/8 inch (3.2 mm) high letters.

Exception: The marking is not required on equipment with the following features:

a) Input current rating is 150 amperes or less.

b) Supply connection is through a polarized multi-pole inlet or supply cord with attachment plug, in which the grounding conductor makes contact first and breaks contact last.

35.2 Equipment subjected to the Resistance to Rain Test with doors (see the Note to 5.8) closed, as permitted in the Exception to 24.1, shall be marked with the following or other marking determined to be equivalent: ″FOR USE BY QUALIFIED PERSONNEL ONLY″ and ″All doors must be closed and fastened prior to leaving the equipment unattended.″ This marking shall be in minimum 1/16 inch (1.6 mm) high letters. The words ″FOR USE BY QUALIFIED PERSONNEL ONLY″ shall be in minimum 1/8 inch (3.2 mm) high letters.

36 Receptacle Ratings

36.1 The rating of each individual external load in volts and amperes shall be permanently marked on the equipment.

Exception: The voltage is not required for receptacle configurations specified in the Standard for Wiring Device Configurations, UL 1681, or the Standard for Pin and Sleeve Configurations, UL 1686.

36.2 Equipment using non-locking, single, conductor pin-and-sleeve-type output receptacles shall be permanently marked near the output receptacles "For Branch Circuit Use Only." Minimum letter height is 1/16 inch (1.6 mm).

36.3 Equipment with outputs provided with overcurrent protection suitable for continuous use shall be marked "Suitable for Continuous Use at Full-Rated Output." The marking shall be near each receptacle with such a rating. The marking may be part of the electrical rating in 29.1 when all outputs are suitable for continuous use.

36.4 Equipment with any receptacles not suitable to be disconnected under load shall be permanently marked near the output receptacles with "Do Not Disconnect Under Load." This marking shall be modified to reflect the limitation of the receptacle such as "Do Not Disconnect Under DC Load." The marking shall be visible with the mating plug in place.

37 Multi-Pole Receptacle Configuration

37.1 The intended connection for each pin of a multi-pole receptacle shall be permanently marked on the equipment.

Exception: Receptacle configurations specified in the Standard for Safety for Wiring Device Configurations, UL 1681.

38 Single-Pole Inlets or Output Receptacles

38.1 Equipment which either uses separate, single-pole devices for input or output; or has inlet or receptacle assemblies that do not comply with the interlocking or sequential interlocking requirements specified in the Glossary, Section 5, shall be permanently marked adjacent to the receptacles with the word "WARNING" and the following or equivalent wording: "Risk of Electric Shock. Plug connection should be in the following order:

a) Equipment grounding conductor connectors,

b) Grounded circuit conductor connectors, and

c) Ungrounded conductor connectors.

Disconnection should be in the reverse order." The word "WARNING" shall be in minimum 1/8-inch (3.2-mm) high letters, the remaining text in minimum 1/16-inch (1.6-mm) high letters.

39 Supply Cord Without Attachment Plug

39.1 Portable power-distribution equipment that is not provided with an attachment plug on the flexible power-supply cord or cable shall be marked with the word "WARNING" and the following or equivalent wording: "Risk of Fire. Assemble a grounding-type attachment plug with integral cord grip that is rated for ___ volts and ___ amperes." The two blanks are to be filled in, respectively, with the voltage and current rating of the equipment.

40 Switches or Circuit Breakers

40.1 A manually-operable switching means such as a switch or circuit breaker shall be plainly marked to indicate its on and off positions.

40.2 When the handle of a circuit breaker, or a simple extension of such a handle, is capable of being in other than the normal off position when the breaker is tripped, that position shall be marked to indicate that the breaker has tripped. The method of resetting the breaker shall be described on the marking.

Exception: Marking to indicate the tripped position is not required in the case of a separate external operating handle (other than a simple handle extension), when such a separate handle is not part of the breaker. Such a handle is not required to remain in the off position.

40.3 When there are two or more switches or circuit breakers, a switch or circuit breaker that controls all load circuits shall be marked "Main," and no other switching device shall be so marked.

PART 2 – BUS BAR CLAMPS

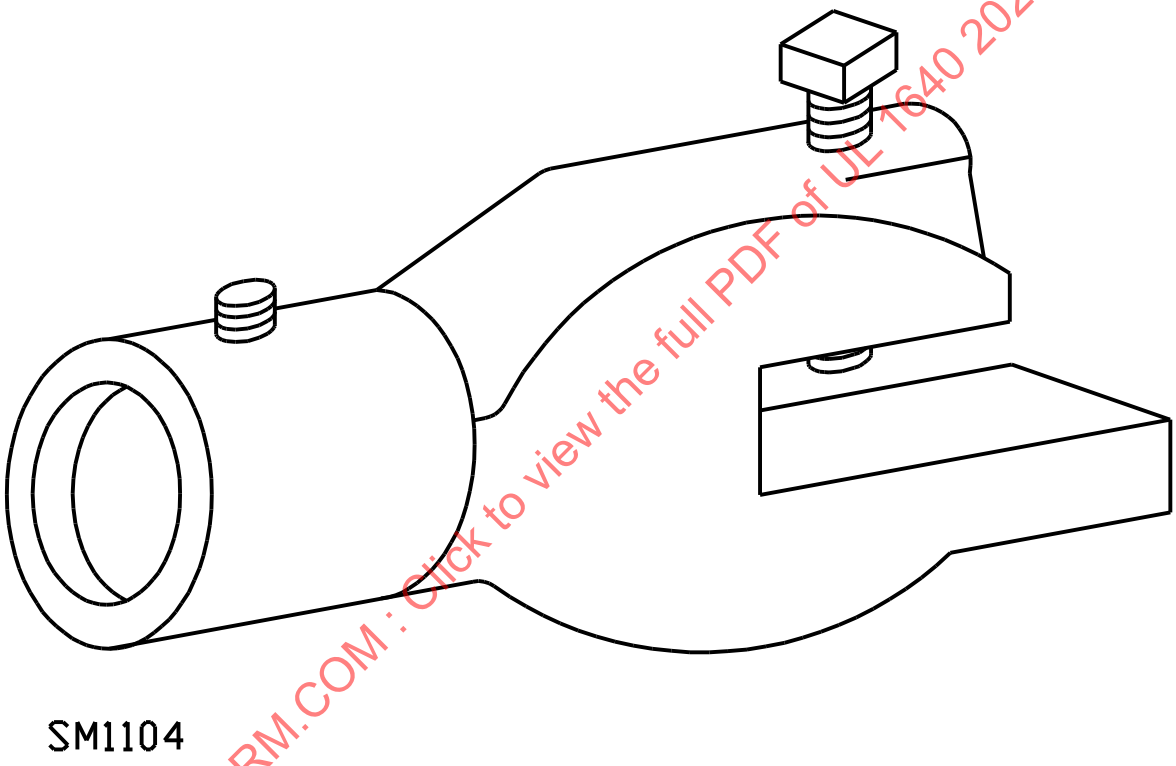
CONSTRUCTION

41 General

41.1 Bus bar clamps, a typical construction as illustrated in Figure 41.1, shall comply with the construction requirements specified in the Standard for Wire Connectors, UL 486A-486B.

Figure 41.1

Bus bar clamp



41.2 Bus bar clamps shall be rated for use with copper conductors only.

PERFORMANCE

42 General

42.1 Except as described in 42.2 and 42.3 bus bar clamps shall comply with the Static-Heating Sequence in the Standard for Wire Connectors, UL 486A-486B.

Exception: Solder lug constructions are not required to comply with the secureness and pullout tests.

42.2 The conductors used for testing are to be new, previously unused, Type G, W, SC, SCE, or SCT cable.