UL 231

STANDARD FOR SAFETY

Power Outlets

UL Standard for Safety for Power Outlets, UL 231

Tenth Edition, Dated October 5, 2016

SUMMARY OF TOPICS

This revision of ANSI/UL 231 dated March 29, 2022 includes requirements for Metallic Mounting Posts and Pedestals; 7.1.1, 7.1.3, and 7.1.4

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 new and revised requirements are substantially in accordance with Proposal(s) on this subject dated December 24, 2021 and February 18, 2022.

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UL 231

Standard for Power Outlets

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The most recent designation of ANSI/UL 231 as an American National Standard (ANSI) occurred on March 29, 2022. 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 power outlets, with or without integral mounting posts or pedestals, and power outlet fittings for use in accordance with the National Electrical Code, NFPA 70.

1.2 A power outlet covered by these requirements, although not restricted to such use, is intended for use:

a) At outdoor locations such as on farms, at building sites, and the like, where power is required to operate portable, mobile, or temporarily installed equipment,

b) To supply power to a mobile home or a recreational vehicle, and

c) To supply shore power to boats.

1.3 A power outlet may contain:

a) Attachment plug receptacles,

b) Circuit breakers,

c) Fuseholders,

d) Fused switches and facilities for watt-hour meters, and

e) Provisions for field installed circuit breakers or switches and fuses.

1.4 Power outlet fittings covered by these requirements are intended for factory or field assembly into or in conjunction with power outlets designed for such assembly. Fittings may be panels or combination units incorporating receptacles, disconnecting means, overcurrent protection or other devices that have been determined to be equivalent. A separable mounting post or pedestal to which power outlets are to be mounted is also a fitting.

1.5 In addition to or instead of mounting to a post or pedestal fitting as mentioned in 1.4, a power outlet may be constructed for mounting on and connection to a mounting post or pedestal also designed to be used with other types of distribution equipment.

1.6 Some power outlets may have special features and markings to indicate their acceptability for use as service equipment.

1.7 A power outlet with a mounting post is intended for mounting in concrete. A power outlet with a mounting pedestal is intended for mounting on a concrete slab. Unless marked otherwise, a mounting post or pedestal fitting is not intended to serve as the sole support of a mast for overhead wiring.

2 General

2.1 Components

2.1.1 Except as indicated in 2.1.2, 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 generally used in the products covered by this standard.

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

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

b) Is superseded by a requirement in this standard.

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

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

2.1.5 A component not marked with a short-circuit current rating is considered rated for use in a circuit having a maximum available fault current as shown in Table 2.1.

2.1.6 The short-circuit current available in the secondary circuit of a transformer rated 10 kVA or less is considered to be 5000 amperes or less.

2.1.7 The short-circuit current available on the load side of a 15 ampere current-limiting circuit breaker or Class CC, G, J, RK1, RK5, or T fuse is considered to be 5000 amperes. In a single phase 120-volt circuit, the short-circuit current available on the load side of a 20 ampere circuit breaker or Class CC, G, J, RK1, RK5, or T fuse is considered to be 10,000 amperes or less.

2.1.8 For a power outlet having a short circuit rating exceeding 5000 amperes rms symmetrical, a luminaire as covered in item 4 of Table 2.1 shall be located in the secondary circuit of a maximum 10 kVA transformer as specified in 2.1.6 or on the load side of a 15 ampere current-limiting circuit breaker or fuse as specified in 2.1.7 that is provided in the power outlet or power outlet fitting.

Exception: The transformer, circuit breaker, or fuse may be remotely located if the power outlet or power outlet fitting is marked as specified in 35.73.

2.2 Units of measurement

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

Table 2.1
Assumed maximum short-circuit current rating for unmarked components

Component	Short-circuit current rating, kA
1. Circuit breaker (including GFCI type)	5
2. Clock-operated switch	5
3. Fuseholder	10
4. Lighting fixture (circuit) internal	5
5. Miniature fuse	10[a]
6. Plug fuse	10
7. Industrial control equipment:	
a. Auxiliary device	5

Table 2.1 Continued on Next Page

Table 2.1 Continued

Component	Short-circuit current rating, kA
b. Motor controllers or switches (other than mercury tube type)	5
c. Mercury tube switches:	
Rated over 60 amperes or over 250 volts	5
Rated 250 volts or less, 60 amperes or less, and over 2 kVA	3.5[b]
Rated 250 volts or less and 2 kVA or less	1[b]
8. Meter socket base	10
9. Photoelectric switches	5
10. Receptacle (GFCI type)	2[c]
11. Receptacle (other than GFCI type)	10
12. Snap switch	5
13. Terminal block	10
14. Thermostat	5

[a] The use of these fuses is limited to 125-volt circuits as specified in the Exception to 14.5.

[b] This rating is below the minimum specified in Table 33.1 and the component shall either:

1) Be investigated for the minimum short-circuit current rating specified in Table 33.1 or
2) Be located on the load-side of a suitable current-limiting overcurrent protective device.

[c] A GFCI type receptacle is restricted for use in power outlets rated no more than 20 amperes (See 32.1(d)) unless:

1) The power outlet and GFCI type receptacle comply with the short-circuit current test specified in the Short-Circuit Current Test, Section 26 or
2) The receptacle is located in the 120-volt secondary circuit of a transformer rated 5 kVA or less (a circuit considered to have a short-circuit current available of 2 kA or less) and is provided with suitable overcurrent protection.

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

2.3 Undated references

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

3 Glossary

3.1 For the purposes of these requirements, the following definitions shall apply.

3.2 COVER – An unhinged, removable covering part.

3.3 DOOR – A hinged, sliding, or similarly attached covering part that can be removed only by the use of a tool.

3.4 FILLED OPENING – An opening that has been closed with a filler plate.

3.5 FILLER PLATE – A part intended for closing an opening that would otherwise be closed by subsequent installation of a circuit breaker or other device.

3.6 KNOCKOUT – A factory closed opening with a nonreplaceable closure provided for subsequent installation of a:

a) Conduit,

b) Circuit breaker,

c) Other device, or

d) Wiring system.

3.7 LOOP FEED – An installation arrangement whereby an electrical supply circuit is wired in series to a string of power outlets. In this arrangement, the supply circuit conductors connect to the power outlet and then continue on to the next power outlet in the loop. Each power outlet is connected to the loop feed by means of a tap conductor.

3.8 RESTRICTING BARRIER – A barrier used to prevent the entry of rain or direct access to a live part through a ventilation opening in the enclosure.

CONSTRUCTION

4 General

4.1 A power outlet shall not have provision for the mounting of additional receptacles unless the receptacles are part of a power outlet fitting.

4.2 A knockout or filled opening may be provided in a power outlet only if intended to accommodate:

a) A circuit breaker or fused switch;

b) A combination unit as described in 4.6; or

c) Specific additional equipment that has been determined to be equivalent.

4.3 A knockout or filled opening that is intended to accommodate a receptacle shall not be used in a power outlet or power outlet fitting.

4.4 A panel (power outlet fitting) shall not require the use of a tool or the provision of wiring for connecting the supply or ground. The grounding connection shall comply with 17.8.1.

Exception No. 1: A metal dead front or cover that does not include a receptacle may be grounded by the mounting screws.

Exception No. 2: A panel (power outlet fitting) marked as noted in 35.78 may be constructed such that the use of a tool or the provision of wiring is required for connecting the supply or ground.

4.5 A mounting means shall be provided for connecting:

a) A panel to a power outlet and

b) A power outlet to a mounting post or pedestal.

Such means shall be determined for equivalence in security to that provided by four machine screws.

Exception: A panel that is not more than 6 inches (152 mm) in width or length may be secured with two machine screws.

4.6 A combination unit (power outlet fitting) consisting of a receptacle and overcurrent protection and intended to be field or factory installed in a power outlet shall not require the use of a tool or the provision of wiring for effecting supply and grounding connections and shall be provided with a mounting means at

the receptacle that does not depend solely upon the plug-in connection. The grounding connection shall comply with 17.8.1.

Exception No. 1: A metal cover that is not part of the grounding path for a receptacle may be grounded by the mounting screws.

Exception No. 2: A combination unit (power outlet fitting) marked as noted in 35.78 may be constructed such that the use of a tool or the provision of wiring is required for connecting the supply or ground.

4.7 Field installation of an individual circuit breaker or fused switch in a power outlet shall not require the use of a tool or the provision of wiring in making supply connections directly to the circuit breaker or switch and shall be intended only for field connection to a permanently wired load circuit.

4.8 A circuit breaker or fused switch intended for field connection to a permanently wired load circuit shall be mounted to the panel dead front only if all electrical connections to the panel are made by stabs and jaws.

4.9 A power outlet or panel (power outlet fitting) with provision for the field installation of additional circuit breakers or fused switches shall contain a dead front with filled openings or knockouts for the circuit breaker handles or fused switches that will cover all wiring and live parts.

4.10 A power outlet marked for use with a power outlet fitting described in 4.4, 4.6, and 4.9 shall be shipped:

a) With a power outlet fitting installed;

b) With a dead front having knockouts or filled openings for the field installation of additional circuit breakers or fused switches; or

c) With a blank dead front without knockouts or openings for circuit breakers or fused switches that will cover all wiring and live parts and prevent the entrance of rain above live parts.

4.11 A filler plate shall be judged according to the Standard for Panelboards, UL 67. Marking requirements for dead fronts using filler plates are contained in 35.32.

4.12 A power outlet intended for mounting to a separable field-installed mounting post or pedestal may be provided with an opening for the mounting post or pedestal. If the power outlet can be mounted so that field-installed conduit could interfere with access to field-wiring terminals, the mounting post shall be marked in accordance with 35.30.

5 Enclosure

5.1 General

5.1.1 Unless specified otherwise in this standard, a metallic enclosure shall comply with the Standard for Enclosures for Electrical Equipment, Non-Environmental Considerations, UL 50. A non-metallic enclosure shall comply with 5.5.1 and 5.5.2. Provisions for a conduit hub need not be provided if the enclosure is marked in accordance with 35.53.

5.1.2 A power outlet, including any external operating mechanism, such as for a disconnect, mounted on or through the enclosure shall withstand the environmental tests specified in the Standard for Enclosures for Electrical Equipment, Environmental Considerations, UL 50E, for the enclosure type marked in accordance with 35.2. The enclosure type selected from UL 50E shall be a type that is suitable for outdoor use.

5.1.3 A power outlet marked in accordance with 35.2 with a Type 3S or Type 3SX enclosure designation and provided with an external operating mechanism shall be capable of supporting the weight of any ice build-up, being operated as intended, and withstanding removal of the ice by a tool or auxiliary means to gain access to the interior of the enclosure. Determination of these characteristics is to be made in accordance with 21.1 for each maintained position of the external operating mechanism.

5.1.4 Internal wiring and live parts, other than those associated with exposed parts of fuseholders and receptacles, shall not be exposed during fuse replacement or insertion or removal of attachment plugs as specified in 14.11.

5.1.5 In addition to withstanding the environmental tests as specified in 5.1.2, the enclosure shall be constructed to withstand beating rain and splashing water as determined by application of the requirements specified in the Rain and Splash Test, Section 22. The Rain and Splash Test in Section 22 replaces the Rain Test requirements from the Standard for Enclosures for Electrical Equipment, Environmental Considerations, UL 50E. A power outlet marked for marine use, shall additionally be subjected to the Spray Test, Section 23. If there is an opening for a ringless type meter without a viewing pane in front of the meter, the enclosure shall be provided with a permanent structural system to channel any accumulation of water to the outside of the enclosure. During the tests specified in the Rain and Splash Test, Section 22, and the Spray Test, Section 23, a meter having the dimensions specified in Figure 5.1 shall be installed in place.

5.1.6 A receptacle or circuit breaker, including a handle opening, that is located in the bottom end wall of the enclosure shall be shielded by an extension of each side of the enclosure. The shielding shall extend a minimum of 1/2 inch (12.7 mm) below the face of any receptacle or circuit breaker (excluding the handle).

Exception: A minimum of 1/8 inch (3.2 mm) extension of any side of the enclosure may be provided if no part of a receptacle or circuit breaker face is closer that 1 inch (25.4 mm) to that vertical side of the enclosure.

5.1.7 The various parts of a power outlet as covered in these requirements are illustrated in Figure 5.2.

5.1.8 Means for mounting shall be external to the enclosure.

Exception No. 1: A metal enclosure designated as Type 3R or Type 3RX may be provided with internal means for mounting consisting of no more than two openings above the level of any live part or any terminal for a neutral or grounding conductor. More openings may be provided if all such openings:

a) Are closed at the factory; and

b) While in the as-received condition, exclude water when subjected to the test described in the Rain and Splash Test, Section 22.

Exception No. 2: Internal mounting means may be provided in a nonmetallic enclosure if the construction is in accordance with Exception No. 1 and if means to reduce the risk of contact between internal conductors and the mounting means is provided in accordance with 5.1.9.

5.1.9 To reduce the risk of contact between a supporting screw and conductors within an enclosure as required in Exception No. 2 to 5.1.8, a hole in an enclosure for a screw shall be located in a recess constructed so that there will be a spacing of not less than 1/32 inch (0.8 mm) between the plane of the top of the recess and the head of the largest screw that is provided with the enclosure. If a screw is not provided with the enclosure, this spacing shall be measured using the largest round-head screw, as specified in Table 5.1, that can be inserted in a hole that is not chamfered; or the largest flat-head screw that can be inserted in a hole that is chamfered.

5.1.10 In a power outlet marked for marina and boatyard use, internal mounting holes located above live parts shall be gasketed.

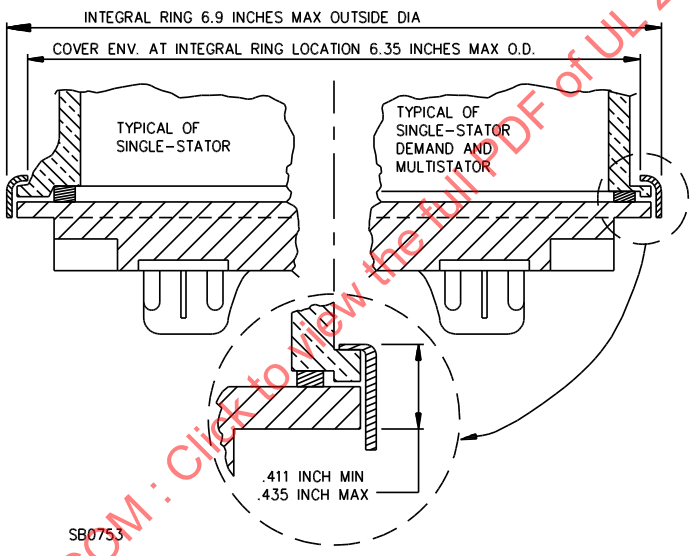
5.1.11 There shall be provision for drainage of the enclosure. In a mounting post the drain hole shall be located directly above the moisture seal and shall drain to the outside.

5.1.12 An edge, projection, or corner of an enclosure, opening, frame, guard, knob, handle, or the like of a power outlet shall not be sufficiently sharp to constitute a risk of injury to persons during intended use or user maintenance.

5.1.13 Metals shall not be used in such combination as to cause galvanic action that will affect adversely any part of the device.

Figure 5.1

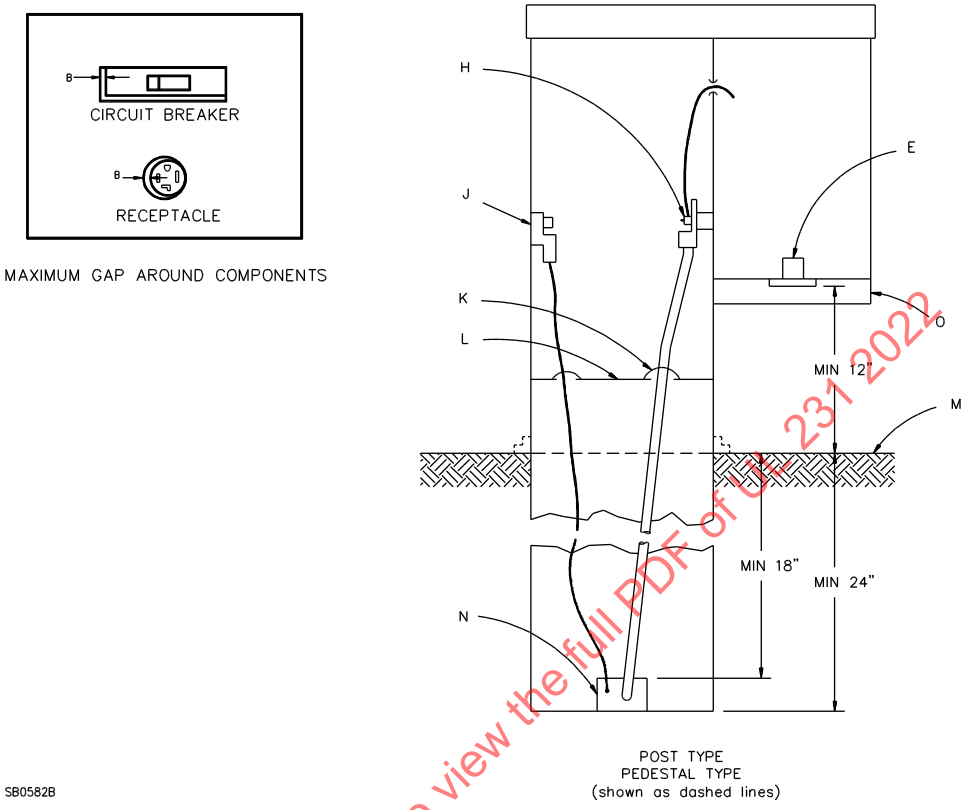
Dimensions of test meter



inches	(mm)
6.9	175
6.35	161
0.411	10.4
0.435	11.0

Figure 5.2

Typical power outlet construction features



A – Maximum 1/8-inch (3.2-mm) gap, top of dead front to edge of open door (see 5.6.7).
B – Maximum gap 3/32 inch (2.4 mm) each side (maximum 1/8 inch total) between component and edge of opening in dead front, or between dead front and wall of enclosure (see 5.6.3 and 5.6.8).
C – Fuseholder in compartment (see 5.3.2).
D – Barrier (see 5.3.3).
E – Receptacle.
F – 1- by 1-inch (25.4- by 25.4-mm) end wall extension (see 5.6.5).
G – 1/2-inch (12.7-mm) wall extension (see 5.6.5).
H – Line terminals (see 7.3.1 and 10.2.1).
J – Enclosure grounding terminal (see 7.3.1).
K – Sealing material, applied during installation (Optional).
L – Sealing provision (Optional).
M – Marked grade level (see 35.13).
N – Conductor entrance (see 7.4.1).
O – Receptacle or circuit breaker rain shield extension (see 5.1.6).
P – Distance between a receptacle or a live part and grade level (see 7.3.1 and 12.6).

Table 5.1
Supporting screw hole dimensions

Nominal screw size	Diameter of hole,		Minimum dimensions of recess			
			Diameter,		Depth,	
	inch	(mm)	inch	(mm)	inch	(mm)
6	0.138	3.51	1/4	6.4	4/32	3.2
8	0.164	4.17	19/64	7.5	9/64	3.6
10	0.190	4.83	11/32	8.7	5/32	4.0
12	0.216	5.49	25/64	9.9	11/64	4.4
1/4	0.250	6.35	29/64	11.5	13/64	5.2
5/16	0.313	7.95	9/16	14.2	15/64	6.0

5.2 Enclosure of switches and circuit breakers

5.2.1 A switch or circuit breaker shall be operable from outside the enclosure.

Exception: A switch or circuit breaker may be located behind a door if live parts or wiring are not exposed during operation.

5.2.2 An enclosure involving a pull-out switch member shall completely enclose any part that may be live when a hinged pull-out switch member is in the closed position or when the door over a detachable pull-out member is closed. A pull-out switch member shall be designed so that no live part will be exposed to unintentional contact with the operator when the pull-out switch member is in any position.

5.2.3 The accessibility of a live part with respect to unintentional contact as mentioned in 5.2.2 is evaluated with reference to any actual operating condition and with the pull-out member tilted at any angle at which it can be inserted. If the protection of a live part against unintentional contact is accomplished by means of a shield, barrier, or the like, that may be moved or deflected under pressure so as to affect either the width of the opening or the recessing of the live part, the dimensions specified are to be investigated with pressure applied.

5.2.4 A live part is not considered to be exposed to unintentional contact if it is recessed or set back 1/8 inch (3.2 mm) or more from the plane of an opening having at least one dimension not greater than 3/8 inch (9.6 mm), as shown in Figure 5.3. If the recessing or set-back is more than 1/8 inch, a larger opening may be used if the construction provides protection against unintentional contact with the live part and has been determined to be at least equivalent to that just described.

5.2.5 With respect to Figure 5.4, the dimensions specified in 5.2.4 apply also to live parts on a pull-out switch member.

Exception: The blades or other current-carrying parts may be recessed or set back less than 1/8 inch (3.2 mm) if their exposure while live is not more than 1/8 inch.

5.2.6 The enclosure of a power outlet not employing a pull-out switch member shall completely enclose all parts that may be live regardless of any switch position.

5.2.7 The enclosure described in 5.2.6 shall not have any open hole or slot to provide for movement of an operating handle.

Exception: An opening may be provided for a closely fitting operating handle if the opening is closed when the handle is in the operating position, and the clearance between the edge of the hole and the handle does not exceed 3/32 inch (2.4 mm) on either side (one side only) and 1/8 inch (3.2 mm) total (both sides).

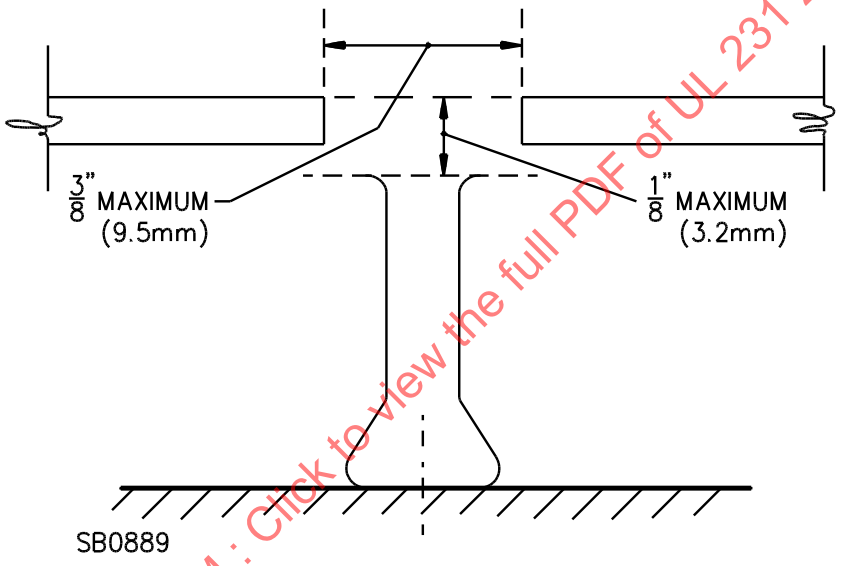
The clearances are measured with the handle in the on and off positions, but with the handle and its supporting member assembled in any position that results from ordinary factory assembly.

5.2.8 A power outlet shall be designed so that during the installation of circuit breakers or fused switches and panels as mentioned in 4.4 and 4.7, the exposure of live parts shall not be greater than necessary to permit the installation of the number of circuit breaker or fused switch poles for which the assembly is intended.

5.2.9 No live parts other than load and neutral terminals shall be exposed to unintentional contact by the installer during the wiring of permanently installed load circuits.

Figure 5.3

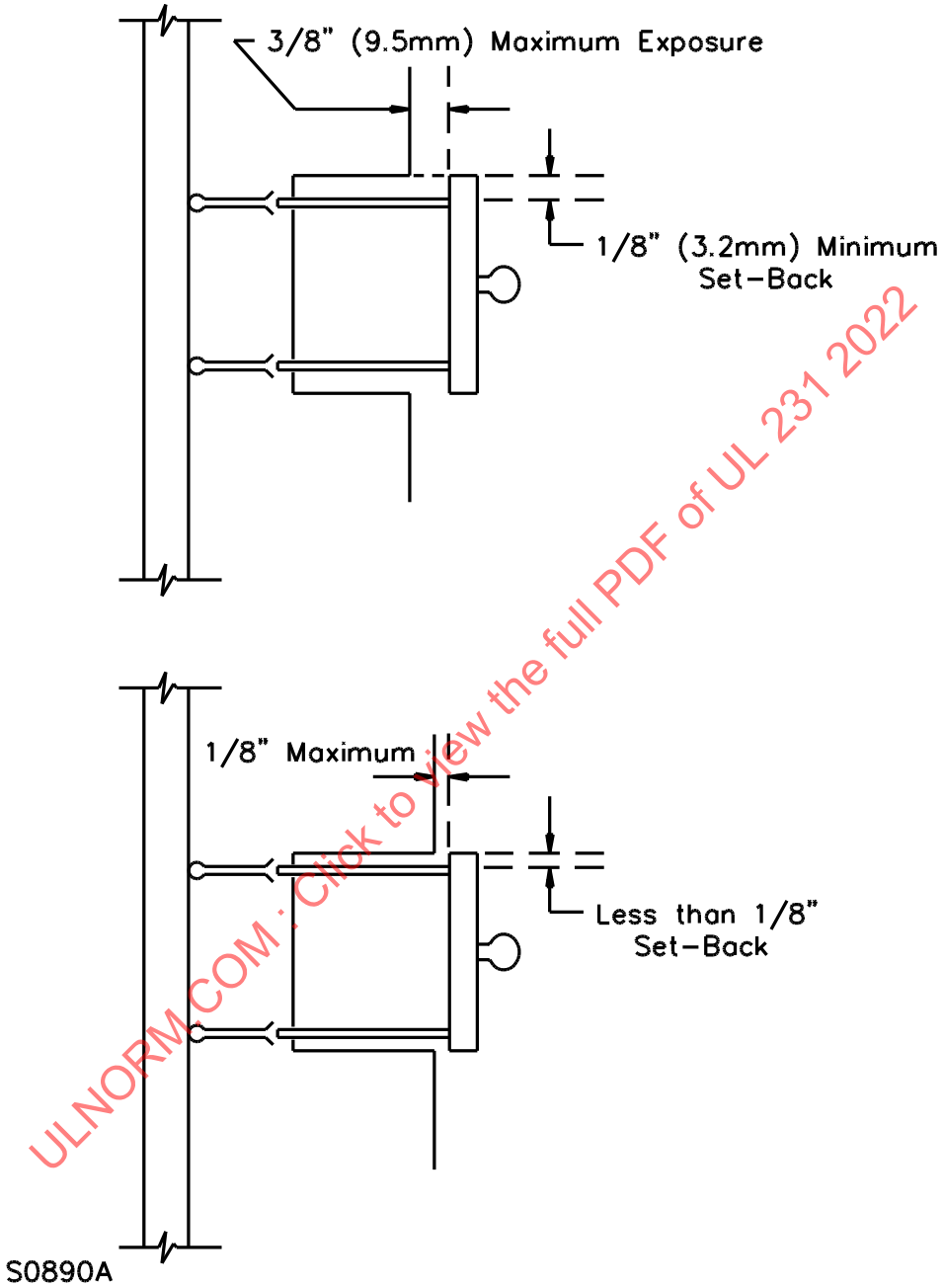
Recessing of live parts



inch	(mm)
3/8	9.5
1/8	3.2

Figure 5.4

Recessing of pull-out switch



5.3 Enclosure of fuses

5.3.1 A fuse, fuseholder, or fusible switch shall be located inside an enclosure but shall be accessible for fuse replacement.

5.3.2 The portion of the enclosure containing any component described in 5.3.1 shall be closed off by a barrier of at least 0.053-inch (1.35-mm) thick sheet steel, or that which has been determined to be equivalent for polymeric materials, from that space behind a door containing any opening such as for cord passage.

5.3.3 With respect to 5.3.2, a joint between the barrier and the adjacent dead front, enclosure door, and sides need not be flanged, but shall have as close a fit as practicable. With the door fully closed a maximum 1/16-inch (1.6-mm) gap may exist between adjacent flat surfaces, or a maximum 3/32-inch (2.4-mm) gap between adjacent curved surfaces.

5.4 Opening for cord

5.4.1 A power outlet that will require the passage of flexible cord from an interior receptacle to supply an external load shall be provided with one or more smooth openings in the bottom of the enclosure or the door. The door shall close completely with all cords and plugs in place.

5.5 Nonmetallic enclosures

5.5.1 A nonmetallic enclosure shall comply with the requirements for outdoor nonmetallic enclosures for fixed equipment specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. However, with regard to the reference to Table 8.1 in 6.1 of UL 746C, the electrical properties shall be those applicable to indirect support material as specified in 9.1 and Table 9.1 and Table 9.2. The relative thermal index shall be equal to or greater than the sum of 40°C (72°F) and the temperature rise on the enclosure during a temperature test; or, if a temperature test is not conducted, the relative thermal index shall be at least 80°C (176°F). The oven temperature for the mold stress test shall be equal the maximum use temperature [40°C (104°F) plus the temperature rise] plus 10°C (50°F) but not less than 70°C (158°F); or, if a temperature test is not conducted, the oven temperature shall be 90°C (194°F).

Exception: Compliance with the requirements in Enclosure Flammability– Large Surface Area Considerations of UL 746C is not required.

5.5.2 A nonmetallic enclosure intended for connection to a rigid conduit system shall be subjected to the tests described in the Conduit Connection Tests, Section 27.

5.6 Dead front

5.6.1 A dead front supporting no components shall have a thickness not less than:

a) 0.032 inch (0.81 mm), excluding coatings, if of steel, or

b) 0.050 inch (1.27 mm) if of aluminum.

5.6.2 A dead front supporting components shall comply with the general enclosure requirements specified in 5.1.1 – 5.1.13.

5.6.3 A dead front with or without a 1/2-inch (12.7-mm) integral flange shall form a close fit with the walls (sides and bottom) of the enclosure [within 3/32 inch (2.4 mm) on bottom or either side (one side only) and 1/8 inch (3.2 mm) total on sides (both sides) with the dead front assembled in any intended position] or

shall overlap a flange, projection, or that which has been determined to be equivalent, on the enclosure walls so that no direct opening into the area behind the dead front will result.

5.6.4 A dead front is a panel used behind a door (that may have openings for the passage of cords) to cover wiring and uninsulated live parts that would otherwise be exposed. Portions of a component involving mechanical operation (handles of circuit breakers or switches, fuseholders, and receptacle faces) may project through the dead front.

5.6.5 If a door has an opening for cord passage, and the dead front is not constructed with the 1/2-inch (12.7-mm) flange and does not overlap a flange on the enclosure walls as specified in 5.6.3, the bottom end wall of the enclosure shall extend horizontally forward from the dead front. The extension shall be at least 1/2 inch at all points, but at the bottom end of each side wall the extension shall be at least 1 inch (25.4 mm) for a distance of 1 inch from each side wall.

5.6.6 The 1/2-inch (12.7-mm) horizontal dimension referred to in 5.6.5 may be reduced to a value of 3/8 inch (9.6 mm) at a cord opening if the edge of such an opening is turned up a minimum of 1/8 inch (3.2 mm).

5.6.7 A dead front shall form a close fit that is within 1/8 inch (3.2 mm) from the top surface of the door when the door is in the open position.

5.6.8 A gap may exist between the body of a component (such as a circuit breaker or a receptacle) that projects through an opening in the dead front and the metal of the dead front, but such a gap shall not exceed 3/32 inch (2.4 mm) on either side (one side only) and 1/8 inch (3.2 mm) total (both sides) with the dead front panel and the component assembled in any position that will result from ordinary assembly.

5.7 Doors and covers

5.7.1 An opening in an enclosure giving access to a live part or wiring shall be closed by a door or cover. An opening giving access to a fuse or pull-out fuseholder shall be closed by a door.

5.7.2 A door or cover over an opening in the enclosure as well as a door or cover provided to keep rain from a receptacle or a switch and circuit breaker handle shall comply with the requirements for doors and covers. Outlet box hoods installed for this purpose shall comply with requirements for "Extra-Duty" outlet box hoods in the Standard for Cover Plates for Flush-Mounted Wiring Devices, UL 514D.

5.7.3 A door or cover shall have flanges for the full length of all edges. The flanges shall:

a) Not be less than 1/2 inch (12.7 mm) deep;

b) Make a close telescoping fit with the outside walls of the enclosure; and

c) Overlap the enclosure edges not less than 7/16 inch (11.1 mm).

Exception No. 1: Openings for the cord may be used under the provisions of 5.4.1 and 5.6.5.

Exception No. 2: The flange on the bottom edge of the door or cover may be omitted or reduced in depth if the test described in 5.7.5 is successfully completed, and if:

a) All sides of the dead front are flanged at least 1/2 inch (12.7 mm) and, with the dead front in any position that might result from assembly, no single gap between any side of the front and the adjacent enclosure wall exceeds 3/32 inch (2.4 mm), and the total of the gaps between two opposite dead-front sides and their adjacent walls do not exceed 1/8 inch (3.2 mm);

b) The enclosure walls have flanges, projections, or that which has been determined to be equivalent, to provide minimum 1/2 inch overlaps with the dead front; or

c) The construction uses combinations of such flanges and overlaps (such as two walls with flanges and two with overlaps).

Exception No. 3: The flange on the upper edge of a door or cover may be reduced in depth or may be omitted if the door or cover in combination with the top wall of the enclosure and a flange formed from the top wall overlaps the door or cover at least 1/2 inch in accordance with either of the following conditions:

a) If the width of the door or cover is 10 inches (254 mm) or less.

b) If the width of the door or cover is at least 10 inches but no more than 18 inches (457 mm) and complies with the tests specified in 5.7.6.

Exception No. 4: A door is not required to comply with these requirements if the door serves only as a rain shield for a receptacle or for a switch or circuit-breaker handle.

5.7.4 To determine if a flanged door or cover complies with the requirement in 5.7.3 regarding depth of flange, the distance between the flat portion of the door or cover (clear of forming radii, beads, draws, or the like) and a straight-edge placed across any two flanges at any point is to be measured.

5.7.5 If the flange is omitted in accordance with Exception No. 2 to 5.7.3, the construction shall comply with 5.7.6 except the deflection under the load may exceed 1/8 inch (3.2 mm). However, there shall not be permanent deflection greater than 1/8 inch in the door or cover or in its supporting structure after the test load is removed.

5.7.6 A door or cover as described in Exception No. 3(b) to 5.7.3, or a cover or cap as described in the Exception to 7.2.1, may be used if it is not deflected more than 1/8 inch (3.2 mm) when subjected to a force created by placing a 30-pound (13.6-kg) weight at any point 1 inch (25.4 mm) from the edge. The test is to be conducted with the cover mounted on the enclosure in the intended manner. The force is to be applied through the end of a steel probe having a square face 1/2 by 1/2 inch (12.7 by 12.7 mm). The box is to be on its back on a horizontal surface that is smooth and firm.

5.7.7 If the top of the door or cover has an inward flange and the front of the top end wall has an overlapping downward flange of not less than 1/4 inch (6.4 mm), the 1/2-inch (12.7-mm) overlap may consist of the sum of the overlaps of the two adjacent flanges if the cover flange is within 1/8 inch (3.2 mm) of the top wall with the door or cover closed.

5.8 Meter socket base

5.8.1 Any live part within a 3-inch (76.2-mm) radius of the center of a meter socket base shall be recessed not less than 1/2 inch (12.7 mm) behind the front plane of:

a) The meter mounting rim of a ring-type meter socket as shown in Figure 5.5 or

b) The meter support of a ringless-type meter socket.

5.8.2 A meter-socket base shall be mounted independently of the cover unless it is intended to be used with a current transformer.

5.8.3 If a meter socket base is secured independent of the cover, the construction of a ring-type meter socket shall be such that removal of the cover necessitates a procedure tending to guide the cover clear of any uninsulated part.

Exception: The guiding means is not required if the jaws or other live part of the meter socket are recessed at least 1/16 inch (1.6 mm) behind the front plane of the meter socket cover.

5.9 Ventilation openings

5.9.1 If ventilation openings are provided, they shall comply with 5.9.2 – 5.9.12.

5.9.2 Ventilation openings shall be guarded so that there is no direct access to a live part as covered in 5.9.3 and 5.9.4.

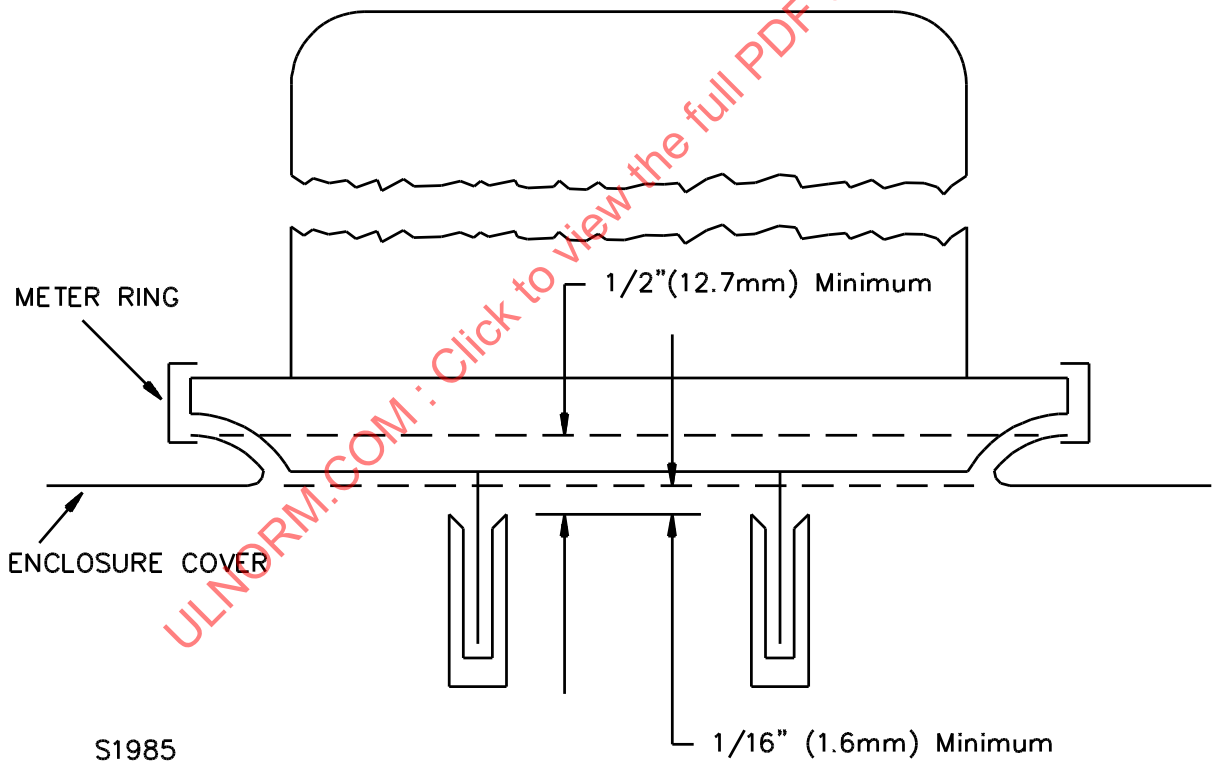
5.9.3 Ventilation openings shall be:

a) Screened or louvered openings with internal barriers or

b) Hoods or stacks with labyrinth air passages.

Figure 5.5

Ring-type meter socket



5.9.4 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 will intersect the enclosure minimum 1/4 inch (6.4 mm) from the edge of an opening.

5.9.5 A ventilation opening – slot, louver, or the like – shall be protected by:

a) One or more baffles;

b) Barriers; or

c) Other obstructions

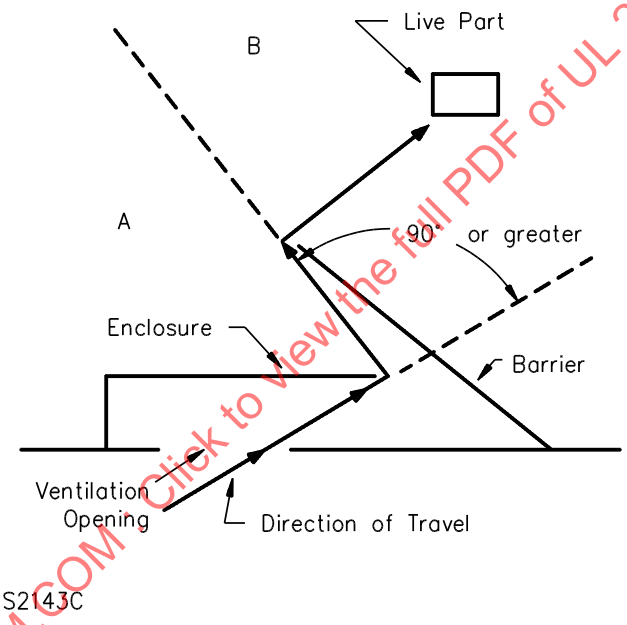
of such dimensions and locations that any access path to a live part requires at least two changes of direction, one of which involves an angle of 90 degrees or more from a straight line, as shown in Figure 5.6. In addition, if the minor dimension of a ventilation opening is larger than 1/4 inch (6.4 mm), it shall be protected by a screen having a minor dimension no larger than 1/4 inch.

5.9.6 The size, shape, and location of a screened opening shall not weaken the overall enclosure.

5.9.7 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.

Figure 5.6

Angle of change of direction



A – No live parts permitted in this area.

B – Live parts may be present in this side of barrier.

5.9.8 Perforated sheet steel or expanded-steel mesh shall not be less than 0.042 inch (1.07 mm) thick if uncoated or 0.045 inch (1.14 mm) thick if zinc-coated, if 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 be no less than 0.080 inch (2.03 mm) thick if uncoated or 0.084 inch (2.13 mm) thick if zinc-coated.

Exception: If deflection of the expanded-steel mesh will not alter the clearance between uninsulated live parts and grounded metal so as to reduce the spacings to values below the minimum values specified in Table 15.1, expanded-steel mesh may be made of minimum 0.024-inch (0.61-mm) thick sheet steel if uncoated or 0.028-inch (0.71-mm) thick sheet steel if zinc-coated.

5.9.9 A grille construction complying with the intent of the requirements in the Exception to 5.9.8 may be used for a particular application.

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

5.9.11 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.

5.9.12 A louver in the enclosure for ventilation shall be located and arranged so that the entrance of water will be controlled in accordance with the requirements in Exception No. 1 to 22.1.1 and the accessibility of live parts will be in accordance with the requirements in 5.2.2.

6 Connections for Wiring Systems

6.1 Facilities shall be provided for accommodating permanently connected line or load conductors of the required ampacity by means of one of the wiring systems rated for the application.

6.2 If provided, a knockout shall be located so that the installation of a bushing for conduit of the size required to accommodate conductors having the ampacities necessary for line or load connections will result in spacings complying with the requirements in this standard.

6.3 If provided, a hole for conduit shall be threaded unless it is located where not exposed to rain or spray or is wholly located below the lowest terminal lug or other live part within the enclosure and shall be provided with a conduit end stop unless the thread is tapered.

6.4 Removal of a cover for making or inspecting line and load connections shall not require removal or disturbing of a permanently connected wiring system.

6.5 A conduit hub in an enclosure shall be threaded and shall have a wall thickness before threading no less than that of the corresponding trade size of conduit. A conduit hub shall not depend upon friction alone to prevent its turning, and shall be capable of withstanding the torque specified in Table 6.1 applied to a short length of rigid conduit threaded into the hub in the intended manner, without turning in the enclosure and without stripping of any threads. The enclosure shall be securely (rigidly) mounted or supported.

Table 6.1
Applied torque for conduit threaded into hub

Conduit trade size, inch	Torque, lb-inch	Torque, (N·m)
3/4 and smaller	800	90
1, 1-1/4, or 1-1/2	1000	113
2 and larger	1600	181

6.6 If threads for the connection of conduit are tapped all the way through a hole in an enclosure, or if a construction that has been determined to be equivalent is used, there shall not be less than 3-1/2 threads in the metal, and the construction shall be such that a conduit bushing can be attached as intended. If threads for the connection of conduit are not tapped all the way through a hole in an enclosure wall, conduit hub, or the like, there shall be no less than five full threads in the metal and there shall be a smooth, well-rounded inlet hole for the conductors which shall afford protection to the conductors that has been determined to be equivalent to that provided by a standard conduit bushing, and which shall have an internal diameter approximately the same as that of the corresponding trade size of rigid conduit.

6.7 Separable conduit hubs and closure fittings shall be designed so that the combination will comply with the requirements in 6.3, 6.5 and 6.6.

6.8 An opening in metal for the passage of conductors (internal or field-installed) shall be such as to minimize inductive heating.

7 Mounting Posts and Pedestals

7.1 General

7.1.1 A metallic mounting post or pedestal shall not be less than 12 square inches (77 cm^2) in cross section and 2-1/2 inches (63.5 mm) deep, and at least three sides shall be fabricated of galvanized or stainless steel no less than 0.070 inch (1.8 mm) thick, or of aluminum no less than 0.095 inch (2.41 mm) thick.

Exception No. 1: The enclosure may be less than 2-1/2 inches deep, less than 12 square inches in cross-sectional area, or less than 0.070 inch thick steel, if the mounting post or pedestal is tested in accordance with 29.1 – 29.3 and 30.1 – 30.3, and if it is fabricated of steel not less than 0.056 inch (1.42 mm) thick or of a non-metallic material.

Exception No. 2: The enclosure may be less than 2-1/2 inches deep, less than 12 square inches in cross sectional area, or less than 0.095 inch thick aluminum, if the mounting post or pedestal is tested in accordance with 29.1 – 29.3 and 30.1 – 30.3, and if it is fabricated of aluminum not less than 0.075 inches (1.9 mm) thick.

7.1.2 A non-metallic mounting post or pedestal shall be subjected to the torque deformation and beam loading deflection tests specified in 29.1 – 29.3 and 30.1 – 30.3.

7.1.3 That portion of a steel post located below grade level and up to 12 inches (305 mm) above grade level shall be painted on both the inside and outside surfaces in addition to being stainless or galvanized – Designation G90 or equivalent as covered in the Standard for Enclosures for Electrical Equipment, Environmental Considerations, UL 50E.

Exception: Painting is not required on austenitic stainless steel designated as American Iron and Steel Institute (AISI) Type 302, 303, 304, 305, 309, or 316.

7.1.4 Aluminum in a pedestal shall not be in contact with the concrete mounting pad unless a coating is used to separate the aluminum from the concrete pad. Aluminum in a post shall not extend below a level 12 inches (305 mm) above the marked grade level unless a coating is used on both the inside and outside of those surfaces that extend below 12 inches above the marked grade level. The coating shall be tested to demonstrate resistance to corrosion that has been determined to be equivalent to that of galvanized (G90 zinc coating) steel 0.061 inch (1.55 mm) thick.

7.2 Cover

7.2.1 A cover or cap for a mounting post or pedestal shall be of metal not thinner than as required in 5.1.1 or other material rated for the purpose. A cover or cap fabricated from 0.056-inch (1.4-mm) thick steel may be any length if its width does not exceed 10 inches (254 mm).

Exception: A cover or cap provided on a mounting post or pedestal to close unused openings intended to accommodate a field-installed separable power outlet may be thinner than specified herein if the construction complies with the test described in 5.7.6.

7.3 Electrical connections

7.3.1 The distance between the marked final grade level of a mounting post as covered in 35.13 or the bottom of the base of a mounting pedestal and the lowest uninsulated live part, receptacle face, or splicing area shall not be less than 1 foot (305 mm) nor less than specified in 12.6 if applicable.

7.4 Wire opening

7.4.1 The opening provided in the base of a mounting post for the entrance of underground wiring shall be rolled, flanged, or equipped with a bushing so that there will be a smoothly rounded surface against which the cables can bear. The opening shall be at least 18 inches (457 mm) below the marked final grade level.

7.5 Bonding

7.5.1 Means shall be provided for bonding a metal raceway to a post or pedestal, and there shall be grounding continuity from the post to the power outlet.

7.6 Overlap

7.6.1 A power outlet intended for mounting on a separable mounting post or pedestal shall be provided with an opening having side extensions that will overlap the metal of the post or pedestal not less than 1 inch (25.4 mm). The two enclosures shall be secured at the overlap by not less than two screws on each side exceeding 4 inches (102 mm) in width and by not less than one screw on each side 4 inches or less in width.

7.7 Instructions

7.7.1 With respect to 1.7, a power outlet provided with a mounting post or pedestal shall be provided with instructions indicating the correct mounting procedure. A mounting post shall be provided with installation instructions in accordance with Mounting in Concrete, Section 37.

7.8 Pedestal

7.8.1 A mounting pedestal shall have mounting holes or similar provision in the base for securing the pedestal to a concrete slab. Aluminum in a pedestal enclosure shall not be in contact with the concrete mounting pad. A metallic or nonmetallic coating used to separate aluminum from a concrete pad shall be tested to demonstrate resistance to corrosion that has been determined to be equivalent to that of galvanized (G90 zinc coating) steel 0.061 inch (1.55 mm) thick.

8 Wiring Devices

8.1 General

8.1.1 Not more than six 10 AWG (5.3 mm^2) or smaller, four 6 AWG (13.3 mm^2), or 8 AWG (8.4 mm^2) insulated, stranded conductors shall be used to supply or ground components (switches, receptacles, circuit breakers, or the like) mounted on a panel that must be or is likely to be moved during installation or for making field connections. Only pressure wire-connector terminals or wire-binding screw terminals shall be used on components so mounted.

Exception: More than six but not more than ten 10 AWG or smaller conductors may be used to supply or ground components mounted on a panel or a hinged top of a pedestal if the conductors are bound

together or otherwise caused to retract into the enclosure in an orderly fashion when the dead front is mounted in place or the top is closed.

8.2 Receptacles

8.2.1 A receptacle in a power outlet shall be a grounding type having a voltage rating appropriate for the voltage rating of the power outlet.

8.2.2 A grounding-type receptacle has:

a) The grounding contact terminal identified by a green color and

b) A single ampere and a single voltage rating.

8.2.3 A power outlet shall be limited in number and type of receptacles only as indicated in 8.2.4, Table 8.1, and Figure 8.1. References in the table and figure are to the Standard for Wiring Devices – Dimensional Specifications, ANSI/NEMA WD 6.

Table 8.1
Required receptacle patterns

Power outlet or power outlet fitting marking[a]	Non-locking grounding type receptacle configurations (see Figure 8.1)					Locking and grounding type receptacle configurations (see Figure 8.2)				Pin-and-sleeve type configurations (see Figure 8.3)
	5-15R[b] 15 A, 125 V	5-20R[b] 20 A, 125 V	TT-30R[b] 30 A, 125 V	14-50R[b] 50 A, 125 – 250 V	Other types	30 A, 125 V	50 A, 125 – 250 V	Other types	Other ratings	60 – 100 A, 125 – 250 V
No marking for service equipment	A[c]	A[c]	A[c]	A[c]	A[c]	A[c]	A[c]	A[c]	A[c]	A[c]
Temporary site service equipment	A[c]	A[c]	A[c]	A[c]	A[c]	A[c]	A[c]	A[c]	A[c]	A[c]
Mobile home service equipment	A[c]	A[c]	A[c]	A[e]	A[c, e]	A[e]	A[e]	A[c, e]	A[c, e]	A[e]
Recreational vehicle site supply equipment	A[c]	R[c, f]	R[c, f]	R[e, f]	A[c, e]	A	A[e]	A[c, e]	A[c, e]	A[e]
Marina and boatyard service equipment; marina type equipment	A[c, g]	A[c, g]	N[d, g]	N[d, g]	A[c, g]	R[h]	R[h]	A[j]	N	R[h]
Service equipment	N[i]	N[i]	N[i]	N[i]	N[i]	N[i]	N[i]	N[i]	N[i]	N[i]

NOTE– The letter coding used in this table is defined as follows:
A – May be used; N – Shall not be used; R – Required to be used

[a] When marked for any combination of services, the receptacles provided shall include those required for each use.

[b] Receptacle pattern as specified in the Standard for Wiring Devices – Dimensional Specifications, ANSI/NEMA WD 6.

[c] Ground-fault circuit protection for personnel shall be provided as specified in Ground-fault circuit protection for personnel, Section 8.5.

[d] The receptacle patterns may be used if the power outlet is not restricted to use only as temporary site, mobile home, or marina and boatyard service equipment.

[e] 125/240 volt receptacles are to be marked in accordance with 35.18.

[f] A receptacle to supply electric power to a recreational vehicle shall be one of the three configurations noted with the letter code "R."

[g] These receptacles shall be marked as described in 35.59 as not to be used to supply power to boats.

[h] Receptacles provided to supply shore power to boats shall be one or more of the following types: A receptacle of the locking and grounding type shall be rated not less than 30 A or more than 50 A, and shall be one of the configurations shown in Figure 8.2. Receptacles of the pin and sleeve type shall be rated 60 A or higher, and shall be one of the configurations shown in Figure 8.3.

[i] Receptacles may be provided only in accordance with 8.2.4.

[j] Other locking and grounding type receptacles, with 30 A, 125 V or 50 A 125 – 250 V ratings, that are marked for use in marina or boatyard applications, may be provided in addition to the required receptacle configurations.

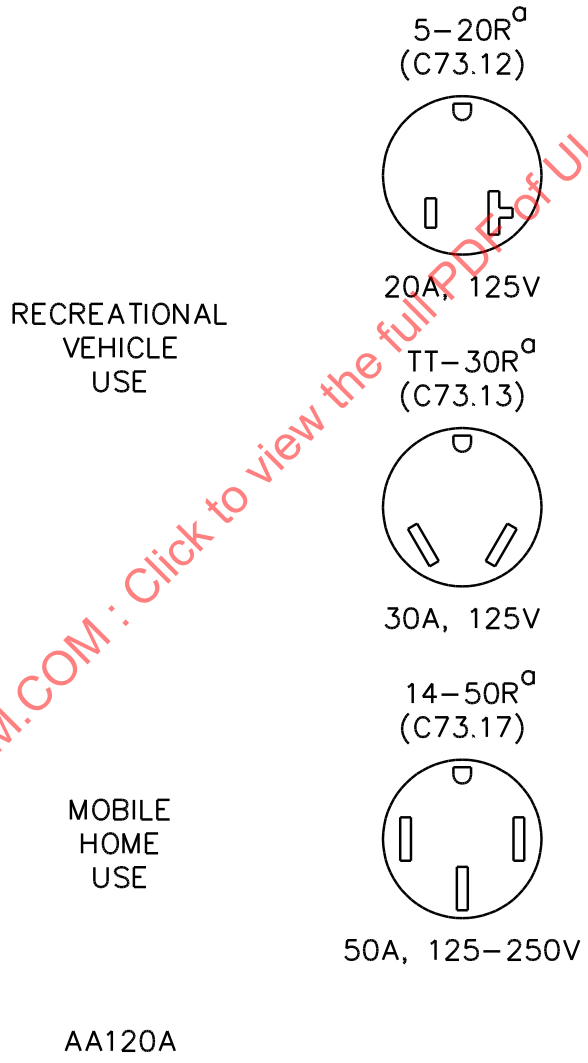
8.2.4 A power outlet marked "Suitable for use as service equipment" or "Suitable only for use as service equipment" but not marked for a specific type of service, such as mobile home, temporary site, or the like, shall not be provided with receptacles.

8.2.5 The ampere rating of a receptacle shall be no less than that of the overcurrent protection provided in the circuit in which it is used.

Exception: Two or more 15-ampere receptacles may be used on a 20-ampere circuit.

Figure 8.1

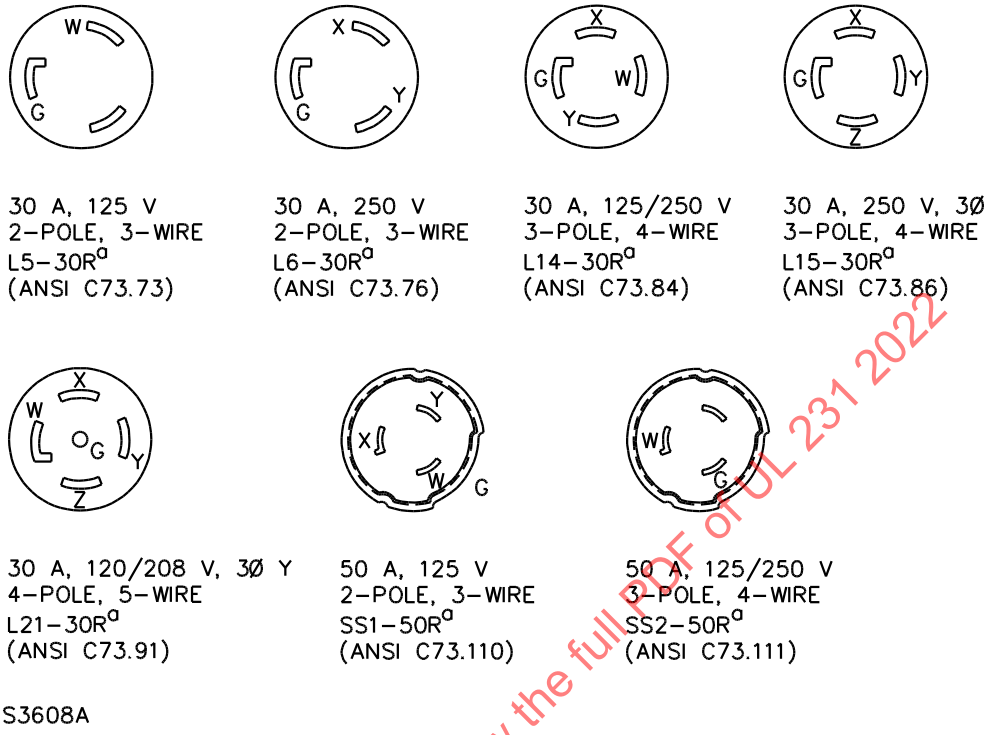
Three American National Standard WD-6 receptacle patterns



[a] Receptacle pattern as specified in the Standard for Wiring Devices – Dimensional Specifications, ANSI/NEMA WD 6.

Figure 8.2

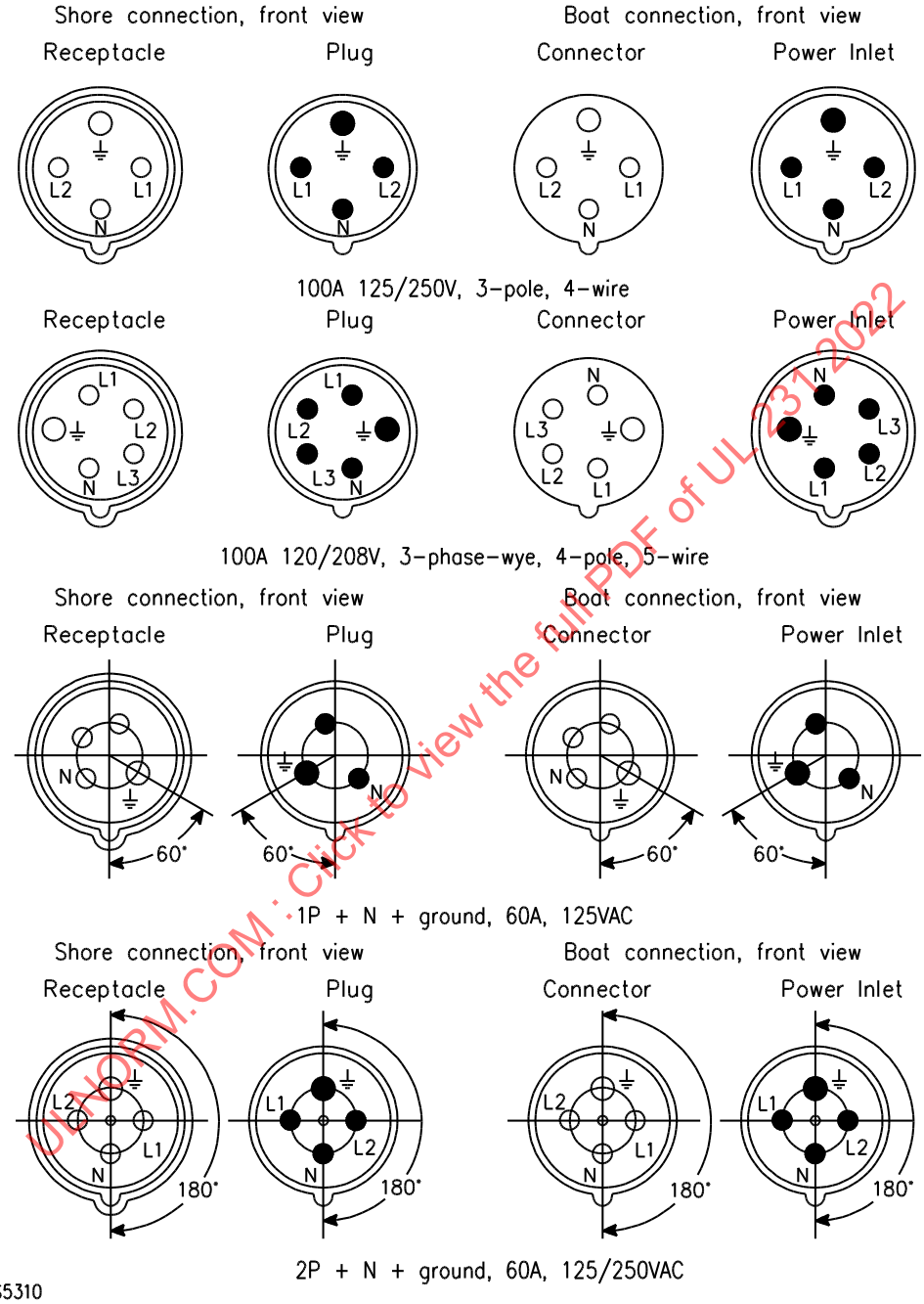
Receptacle patterns for marina and boatyard use



[a] Receptacle pattern as specified in the Standard for Wiring Devices – Dimensional Specifications, ANSI/NEMA WD 6.

Figure 8.3

Common pin-and-sleeve type configurations



8.2.6 A marking shall be provided adjacent to a fuseholder indicating the maximum ampere rating of a fuse to be used to provide receptacle overcurrent protection if the fuseholder rating exceeds that of the receptacle.

8.2.7 As used in 8.2.5, the term "a receptacle" is defined as an accommodation for only one attachment plug and the term "two receptacles" is defined as an accommodation for two attachment plugs.

8.2.8 A receptacle shall be positioned so that when the mating attachment plug, including a right-angled attachment plug for non-locking configurations, is inserted, neither the attachment plug nor the flexible cord blocks access to any component such as a switch, circuit-breaker handle, other receptacles or the like. For the purpose of this requirement, access shall be considered blocked if the location of the attachment plug or cord requires the user to reach behind the plug or cord to access the component, or obscures the "on-off" markings of the component to a point where they are not clearly identifiable.

Exception: This requirement does not apply to controls and indicators that are an integral part of the receptacle, such as the test and reset button on a duplex type receptacle with integral GFCI protection.

8.2.9 After installation, the face of a receptacle shall project a minimum of 0.015 inch (0.38 mm) from a conducting mounting surface.

8.2.10 All receptacles on the same branch circuit shall have the same voltage rating.

8.2.11 All 15- and 20-ampere, 125- and 250-volt nonlocking receptacles, including receptacles with integral Class A ground-fault circuit protection for personnel, shall be rated as "weather-resistant" type in accordance with the Standard for Attachment Plugs and Receptacles, UL 498.

8.3 Operating mechanism

8.3.1 The operating mechanism shall be constructed so as to provide strength and rigidity. Screws and nuts serving to attach operating parts to crossbars or other moveable members shall be staked, upset, or otherwise locked in position to prevent loosening under continued use. Stops shall be provided to prevent stress on switch parts.

8.3.2 A handle shall be provided for safe and convenient manipulation of a switch. An operating handle of metal (other than for a detachable pull-out member) shall be in electrical connection with the enclosure.

8.3.3 A metal rod using the wall of the box as a bearing is considered to be in electrical connection with the enclosure.

8.3.4 A detachable pull-out switch member shall not be insertable in a holder for a detachable pull-out switch member in the same device having a lower current rating.

8.3.5 If the position of a switch is indicated by the position of the operating handle, there shall be definite off and on positions for the handle and the design of the operating mechanism shall be such that the handle cannot be left readily at or near the off position when the switch is on.

8.3.6 A hinged pull-out switch shall be constructed so that it will not tend to close by gravity unless it is provided with a latch that will automatically engage the pull-out member and hold it in the open position.

8.3.7 The intended operation of a switch shall not cause the wiring space to be exposed.

8.3.8 All metal parts, unless of corrosion-resistant material, shall be galvanized, enameled, or otherwise determined to be treated to prevent corrosion.

8.3.9 Metal parts that are zinc or cadmium plated, painted, or enameled are considered to be protected against corrosion.

8.4 Switches

8.4.1 The switching means and mechanism for the main or a branch circuit of a power outlet shall be rated for the particular application and shall have a current and voltage rating no less than that of the circuit it controls. The ordinary form of snap switch shall not be used as a main switch.

8.4.2 A circuit breaker used in a 240-volt, 2-wire circuit or a 120/240-volt single phase, 3-wire circuit shall be of a two-pole common trip type.

Exception: Two single-pole circuit breakers having alternating-current ratings of 120/240 volts may be used as a pair with handle ties if the circuit supplies power only to 120-volt receptacles.

8.4.3 A power outlet with a molded case switch or a pull-out switch not provided with overcurrent protection integrally or in the power outlet shall be marked on or adjacent to the switch in accordance with 35.8.

8.4.4 A switch shall indicate whether the circuit is open or closed.

8.4.5 If a circuit breaker or a switch handle is operated vertically rather than horizontally or rotationally, the up position of the handle shall be the on position.

8.5 Ground-fault circuit protection (GFCI) for personnel and ground-fault protection of equipment (GFPE)

8.5.1 Unless modified by provisions in 8.5.3 – 8.5.7, all 125-volt through 250-volt receptacles intended to be supplied by a circuit rated 150 volts or less to ground and provided in a power outlet or fitting shall be provided with ground-fault circuit protection (GFCI) for personnel that complies with the Standard for Ground-Fault Circuit-Interrupters, UL 943. See markings in 35.57 – 35.60.

Exception: Receptacles of the TT-30R pattern may omit ground-fault protection if marked as specified in 35.77.

8.5.2 *Deleted*

8.5.3 Power outlets or fittings marked for use as temporary site service equipment may omit GFCI protection for receptacles rated other than 125-volt, single-phase, 15-, 20-, and 30-amperes. Power outlets or fittings without GFCI protection on all receptacles shall be marked as specified in 35.75.

8.5.4 Power outlets or fittings marked for use in recreational vehicle site applications may omit GFCI protection for personnel for receptacles other than receptacles rated 125-volt, 15- and 20-amperes.

8.5.5 Power outlets or fittings marked for use as mobile home service equipment may omit GFCI protection for personnel for receptacles other than receptacles rated 125- volt, 15- and 20-amperes.

8.5.6 Power outlets or fittings marked for use in marina and boatyard applications may omit GFCI protection for receptacles providing shore power to boats.

8.5.7 Power outlet or fittings marked for use in marina and boatyard applications shall be provided with GFCI protection for personnel on receptacles not intended to provide shore power to boats as follows:

a) All non-shore power receptacles rated 125-volt through 250-volt, intended to be supplied by a single-phase circuit rated 150 volts or less to ground and 50 amperes or less; and

b) All non-shore power receptacles intended to be supplied by three-phase circuits rated 150 volts or less to ground and 100 amperes or less.

Receptacles not intended to provide shore power to boats shall be marked in accordance with 35.79.

8.5.8 Receptacles on power outlets or fittings marked for use in marina and boatyard applications shall be provided with ground-fault protection of equipment (GFPE) that complies with the Standard for Ground-Fault Sensing and Relaying Equipment, UL 1053. Each receptacle shall be protected by a GFPE set to open at currents not exceeding 30 milliamperes.

9 Insulating Material

9.1 An insulating material used in contact with or for support of uninsulated live parts shall have a Performance Level Category (PLC) that does not exceed the value specified in Table 9.1. The specified values are derived from the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. The Relative Thermal Index (RTI) of the material shall be at least 105°C (221°F).

Exception No. 1: A material may be used based on end-product testing as specified in UL 746C.

Exception No. 2: The RTI may be 90°C (194°F) for an indirect support material that is spaced at least 1/2 inch (12.7 mm) from insulated or uninsulated live parts.

Table 9.1
Maximum performance level category (PLC) for insulating material used in contact with or for support of live parts

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

Note – Additional parameters provided in Table 9.2 shall be considered.

[a] As specified in the Standard Tests For Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

[b] If the material is used for indirect support and is spaced from uninsulated live parts by at least 1/2 inch (12.7 mm), the flammability rating may be HB if the PLC level for this test (HAI) is 1.

[c] See the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A.

[d] If the material is used for indirect support and is spaced form uninsulated live parts by at least 1/2 inch (12.7 mm), this test (CTI or HWI) is not required.

[e] A material having a comparative tracking index PLC of 4 may be used if the voltage involved is 250 or less.

9.2 A live screwhead or nut on the underside of a base designed for surface mounting shall be countersunk not less than 1/8 inch (3.2 mm) in the clear and covered to a depth of no less than 1/8 inch with a waterproof insulating sealing compound.

Exception: If the screw or nut is prevented from loosening by being staked or upset by a lock washer or by other means, it may be insulated from the mounting surface by material other than sealing compound or by providing a spacing from the mounting surface not less than that indicated in Table 15.1.

9.3 In the case of a power outlet that has been determined to be acceptable without a heating test and a power outlet incorporating fuseholders, the sealing compound mentioned in 9.2 shall not soften at a temperature of 90°C (194°F).

9.4 During the heating test on a power outlet incorporating circuit breakers, the sealing compound mentioned in 9.2 shall not soften at the temperature observed during the test at the point where the compound is used.

9.5 A determination of the softening point of a sealing compound is to be made in accordance with the test for softening point by ring and ball apparatus in the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A.

Table 9.2
Additional requirements for insulating material used in contact with or for support of live parts

Property	Test	Method	Units	Minimum levels related to flammability classification
Distortion under load and mold stress relief	Heat Deflection Temperature, or	UL 746A [a]	Minimum °C	10°C greater than use temperature but no less than 90°C, or
	Vicat Softening Point, or	UL 746A [a]	Minimum °C	25°C greater than use temperature but not less than 105°C, or
	Ball Pressure Temperature	UL 746A [a]	Minimum °C	(40°C minus the ambient temperature) greater than the use temperature but no less than 95°C

[a] See the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A.

10 Current-Carrying Parts

10.1 General

10.1.1 A current-carrying part shall be of:

a) Silver;

b) Copper;

c) Aluminum;

d) Alloys of these metals; or

e) A material that has been determined to be the equivalent.

and shall be of rigid construction.

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

10.1.3 Plated-steel screws, nuts, and studs may be used to secure:

a) Soldering lugs;

b) Pressure wire connectors; and

c) Bus bars.

No. 10 (4.8-mm diameter) and larger plated-steel wire-binding screws may be used at terminals, in connection with a nonferrous terminal plate. Bolts, washers, and nuts at the hinges of knife switches are considered to be parts that are not depended upon to carry current.

10.1.4 Copper and brass shall not be used for plating wire-binding screws, nuts and stud terminals, but a plating of cadmium, zinc, tin, silver, or the like may be used.

10.1.5 An uninsulated live part shall be secured to the base or mounting surface so that it will be prevented from turning or shifting.

10.1.6 Friction between surfaces shall not be relied upon as a means to prevent turning of uninsulated live parts, but a lock washer that has been determined to be properly applied may be used. Turning may be prevented by:

a) The use of two screws or rivets;

b) Square shoulders or mortises;

c) A dowel pin, lug, or offset;

d) A connecting strip or clip fitted into an adjacent part; or

e) Means determined to provide equivalent resistance to turning.

10.1.7 If bus bars are held together by screws, a threaded part shall have no fewer than two full, clean cut threads, no finer than the requirements of the Standard for Unified Inch Screw Threads, ANSI/ASME B1.1-1989, for coarse threads, if the screw passes entirely through the bus bar. If the screw does not pass entirely through the threaded part, it shall engage full, clean cut threads for a distance no less than the diameter of the screw.

10.1.8 The ampacity of a bus bar, wiring connection, or the like shall be judged under the applicable requirements in the Standard for Panelboards, UL 67.

10.1.9 A power outlet marked with a loop feed current rating, as specified in 32.3, shall be provided with a means to interconnect the loop feed conductors and the tap conductors that connect to the power outlet. The ampacity of the connection means of the loop feed conductor shall be suitable for the loop feed current rating, and the ampacity of the tap conductor shall be suitable for the power outlet being connected.

10.1.10 Insulated wire used for internal connection shall be Type RH, TW, THW, or a type that has been determined to be equivalent.

10.1.11 A wire within an enclosure, compartment raceway, or the like shall be located or protected to prevent contact with any sharp edge, burr, fin, moving part, or the like that can damage the conductor insulation.

10.1.12 With regard to 8.1.1, internal wiring to a component or a compartment that is mounted on a panel or a hinged top of a pedestal that must be moved during installation of a field connection or replacement or servicing of a component shall have insulated, stranded conductors.

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

10.1.14 If a pressure wire connector is used as a terminating device for aluminum, it shall be rated for use with aluminum under the conditions involved (for example temperature, heat cycling, or the like).

10.1.15 Unless it is tested as described in the Standard for Panelboards, UL 67, a power outlet shall comply with all of the following:

a) The current from a terminal through an insulated conductor (that is factory-installed or will be field-installed) shall be no more than the value indicated in Table 10.1, in accordance with the size and material of the conductor.

b) The current density shall not be more than:

1) 1000 amperes per square inch (645 mm^2) of cross section for solid copper.

2) 200 amperes per square inch (645 mm^2) of contact area at bolted contacts between copper bus bars and connecting straps, lugs, or connectors. (In determining the area of contact surfaces of bolted or riveted connections, no additions or subtractions are to be made for the area of screws, bolts, or rivets.)

3) 75 amperes per square inch (645 mm^2) of contact area at contact surfaces of copper switch blades and jaws.

Exception No. 1: The limitations on current density do not apply to a connecting strap, bus, or the like, comprising a part of a circuit breaker, switch, or fuseholder used in the power outlet.

Exception No. 2: The limitations on current density do not apply to a portion of a strap, bus, jumper, or the like, adjacent to and connected to a terminal of a switch, circuit breaker, or fuseholder [but not for more than 1 inch (25.4 mm) from the terminal] if a reduced cross section in that portion is necessary because of the recessing of the terminal or because of barriers adjacent to it.

Exception No. 3: The limitations on current density do not apply at a lug or connector if the entire normal contact surface is in contact with the bus, terminal, or other surface to which the lug or connector is connected.

c) The power outlet shall not be rated for more than 60 hertz.

d) A power outlet rated 110 amperes or less or having any circuit rated 110 amperes or less shall be marked to indicate use of only 60°C (140°F) conductors for a circuit rated 110 amperes or less and 75°C (167°F) conductors for a circuit rated more than 110 amperes.

10.1.16 The size and assumed type of field-installed conductors, as covered in (a) and (b) respectively, shall be:

a) For currents as indicated in Table 10.1 and Table 10.2:

1) Wire rated at 75°C (167°F) in 1/0 AWG (53.5 mm^2) and larger sizes.

2) Wire rated at 60°C (140°F) in the 1 AWG (42.4 mm^2) size.

Exception: Other than as covered in 16.1.2, 75°C wire may be used if the power outlet is marked for 75°C wire in accordance with 35.39.

3) Wire rated at 60°C in the 2 AWG (33.6 mm^2) and smaller sizes.

Exception No. 1: Other than as covered in 16.1.2, 75°C wire may be used if the power outlet is marked for 75°C wire in accordance with 35.39.

Exception No. 2: 2 AWG (33.6 mm^2) aluminum wire as mentioned in footnote d to Table 10.1, with a temperature of 75°C, may be used if the power outlet has been determined to comply with requirements of a heating test.

b) With respect to 35.41 – 35.45, aluminum wire at any terminal identified on a wiring diagram or the like as being rated for use with such wire, whether or not that terminal is also identified as being rated for use with copper wire.

Table 10.1
Ampacity of insulated conductors

Wire size,		60°C (140°F)		75°C (167°F)	
AWG	(mm^2)	Copper	Aluminum	Copper	Aluminum
14	2.1	15	–	15	–
12	3.3	20	15	20	15
10	5.3	30	25	30	25
8	8.4	40	30	45	40
6	13.3	55	40	65	50
4[a]	21.2[a]	70	55	85[a]	65
3[a]	26.7[a]	85	65	100[a]	75
2[a]	33.6[a]	95	75	115[a]	90[a]
1[a,b]	42.4[a,b]	110[b]	85[b]	130[a,b]	100[a,b]
1/0[a]	53.5[a]	–	–	150[a]	120[a]
2/0[a]	67.4[a]	–	–	175[a]	135[a]
3/0[a]	85.0[a]	–	–	200[a]	155[a]
4/0[a]	107.2[a]	–	–	230[a]	180[a]
kcmil					
250	127	–	–	255[a]	205[a]
300	152	–	–	285[a]	230[a]
350	177	–	–	310[a]	250[a]
400	203	–	–	335[a]	270[a]
500	253	–	–	380	310[a]
600	304	–	–	420	340[a]

NOTES

1 For conductors in multiple, the value is to be multiplied by the number of conductors so connected. Minimum conductor size 1/0 AWG (53.5 mm^2).

2 These values of ampacity apply only where no more than three conductors will be field-installed in a conduit.

[a] See Table 10.2.

[b] If the power outlet is marked in accordance with 35.39 to indicate that 75°C (167°F) wires are to be used at a terminal, the terminal size and wire bending space may be based upon the ampacity of 75°C wires.

10.1.17 Table 10.3 indicates ampacities of some of the more common sizes of copper bus bars.

Table 10.2
Ampacity of main terminals of a single-phase, 120/240 volt, 3-wire power outlet marked in accordance with 35.37

Ampacity, amperes	75°C (167°F) conductor size (AWG or kcmil)	
	Copper	Aluminum
100	4	2
110	3	1
125	2	1/0
150	1	2/0
175	1/0	3/0
200	2/0	4/0
225	3/0	250
250	4/0	300
300	250	350
350	350	500
400	400	600

Table 10.3
Ampacity of copper bus bars

Bus-bar width,		Bus-bar thickness, inch (mm)											
inches	(mm)	3/64 (1.2)	0.051 (1.3)	1/16 (1.6)	0.064 (1.6)	5/64 (2.0)	0.081 (2.1)	3/32 (2.4)	1/8 (3.2)	5/32 (4.0)	3/16 (4/8)	7/32 (5.6)	1/4 (6.4)
3/8	9.5	18	19	23	24	29	30	35	47	59	70	82	94
7/16	11.1	21	22	27	28	34	35	41	55	68	82	96	109
1/2	12.7	23	26	31	32	39	41	47	63	78	94	109	125
9/16	14.3	26	29	35	36	44	46	53	70	88	105	123	141
5/8	15.9	29	32	39	40	49	51	59	78	98	117	137	156
11/16	17.5	32	35	43	44	54	56	64	86	108	129	150	172
3/4	19.1	35	38	47	48	59	61	70	94	117	141	164	188
7/8	22.2	41	45	55	56	68	71	82	109	137	164	191	219
1	25.4	47	51	63	64	78	81	94	125	156	188	219	250
1-1/8	28.6	53	57	70	72	88	91	105	141	176	211	246	281
1-1/4	31.8	59	64	78	80	98	101	117	156	195	234	273	313
1-3/8	34.9	64	70	86	88	102	111	129	172	205	258	301	344

10.2 Terminals

10.2.1 A power outlet shall be provided with wiring terminals for the connection of conductors having an ampacity not less than the rating of the device or circuit in question. A wiring terminal intended for the connection of a conductor larger than 10 AWG (5.3 mm^2) shall be provided with a pressure wire connector. A wiring terminal intended for the connection of a 10 AWG or smaller conductor may consist of a wire-binding screw and an upturned lug or a combination that has been determined to be the equivalent that will retain the conductor under the head if the screw should become loosened to permit shifting of the conductor.

Exception No. 1: Pressure terminal connectors for field connection (line or load) need not be provided if all of the following conditions are met:

a) Component terminal assemblies are available from the equipment manufacturer, or one or more pressure terminal connectors are specified for field installation on the equipment.

b) Fastening devices such as studs, nuts, bolts, spring or flat washers, or the like, as required for an effective installation, are either provided as part of the component terminal assembly or are mounted on or separately packaged with the equipment.

c) The installation of the terminal assembly will not involve the loosening or disassembly of parts giving access to the terminal location. The means for securing the terminal connector shall be readily accessible for tightening before and after installation of conductors.

d) If the pressure terminal connector provided in a component terminal assembly requires the use of a specific tool for securing the conductor, any necessary instructions are included in the component assembly package or with the equipment.

e) Installation of the pressure terminal connectors in the intended manner will result in a product meeting the requirements of this standard.

f) The equipment is marked in accordance with 35.47.

Exception No. 2: A power outlet not marked for service equipment use may use pigtail leads or the terminals of a fuseholder or wiring device in lieu of separate wiring terminals for connection to the supply conductors.

10.2.2 A pressure wire connector provided with or specified for use with a power outlet 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,

whichever is applicable.

10.2.3 A power outlet provided with equipment wiring terminals that comply with the Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors, UL 486E, shall have a short-circuit current rating not greater than 10,000 amperes unless the power outlet complies with the Short-Circuit Current Test, Section 26, with the particular equipment wiring terminals.

10.2.4 A wire connector intended for field wiring shall be tested as covered in the Strength Test of Insulating Base and Support, Section 20.

10.2.5 The tightening torque for a field-wiring pressure terminal connector shall be as specified by the power outlet manufacturer and shall be marked as required in 35.49. The specified tightening torque shall not be less than 90 percent nor more than 100 percent of the value used in the static heating test as specified in:

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

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

for that wire size corresponding to the ampere rating of the power outlet.

Exception No. 1: The torque value may be less than 90 percent if the connector is investigated for the marked torque value in accordance with UL 486A-486B, or UL 486E.

Exception No. 2: For a connector requiring a specific tool as covered in Exception No. 1(d) to 10.2.1, instructions for use of the tool shall replace the specified torque values.

10.2.6 A wiring terminal provided for the connection of a service conductor to a power outlet for service equipment use rated at 40 amperes or less shall be capable of accommodating a 8 AWG (8.4 mm^2) conductor.

10.2.7 A wire-binding screw shall not be smaller than No. 10 (4.8 mm diameter), with not more than 32 threads per inch (25.4 mm).

Exception: The requirement does not apply to a terminal of a receptacle or of a 15-ampere Type S fuseholder.

10.2.8 A soldering lug or other connection that depends upon solder shall not be provided for the connection of the service conductors or the service grounding conductor.

10.2.9 A wiring terminal for connection of the grounded neutral conductor and a wiring terminal for connection of a neutral grounding conductor shall be readily accessible so that the wires can be disconnected after installation.

10.2.10 Individual wiring terminals shall be provided in a readily accessible location for the connection of neutral load conductors and of equipment grounding conductors.

10.2.11 A pressure wire connector that is not intended to be removed or interchanged shall be capable of receiving and holding the wires of any size with which the device will be used.

10.2.12 A wire-binding screw shall thread into metal.

10.2.13 A terminal plate tapped for a wire-binding screw shall be of metal no less than 0.030 inch (0.76 mm) thick. There shall be two or more full threads in the metal, which may be extruded if necessary to provide the threads.

10.2.14 The point of attachment of a pressure wire connector or wire-binding screw terminal shall not overhang its support unless the design is such as to provide physical strength to prevent any reduction of required spacings.

10.2.15 With respect to Exception No. 2 to 10.2.1, if the construction is intended to accommodate field-made splices inside the enclosure, such splices shall not be in an area containing uninsulated live parts.

10.3 Spring washers

10.3.1 A 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: Other constructions as described in 10.3.5 may be used.

10.3.2 A spring washer shall be used at one end of a bolt securing current-carrying parts together.

Exception No. 1: A spring washer may be replaced with a split ring lock washer and flat washer if each aluminum bus in the joint has a tensile yield strength of at least 20,000 pounds per square inch (138 MPa).

Exception No. 2: A flat washer that complies with 10.3.4, a split-ring lock washer, or a bolthead may be used in place of a spring washer if the joint does not include any aluminum or if aluminum bolts are used with aluminum bus bars.

Exception No. 3: A type of fastening that has been determined to be equivalent to that used as a component in accordance with the requirements for wire connectors may be used.

Exception No. 4: A spring washer is not required at a bolted contact of an aluminum alloy conductor used in the grounding circuit for an application such as:

a) The service-grounding electrode;

b) A neutral-bonding conductor; or

c) An equipment-grounding conductor.

Exception No. 5: Other constructions as described in 10.3.5 may be used.

10.3.3 A spring washer as mentioned in 10.3.1 and 10.3.2 is a dished washer of stainless, or hardened and tempered, steel, having an outer diameter not less than 150 percent of the bolt diameter, a thickness not less than 1/8 of the bolt diameter, and dished not less than 3-1/2 percent of the bolt diameter.

10.3.4 The flat washer covered in 10.3.2 and 10.3.3 shall have a thickness of at least one-sixth 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 and not less than the outer diameter of the spring washer.

10.3.5 A construction other than as described in 10.3.1 and 10.3.2 may be used if it has been investigated in accordance with the applicable requirements in the Standard for Panelboards, UL 67.

11 Service Equipment Use

11.1 General

11.1.1 A power outlet intended for use as service equipment shall comply with the applicable requirements in the Reference Standard for Service Equipment, UL 869A.

11.1.2 A power outlet may be marked to indicate its acceptability for use as service equipment for:

a) Mobile home;

b) Temporary-site;

c) Marina and boatyard; or

d) Any combination of these.

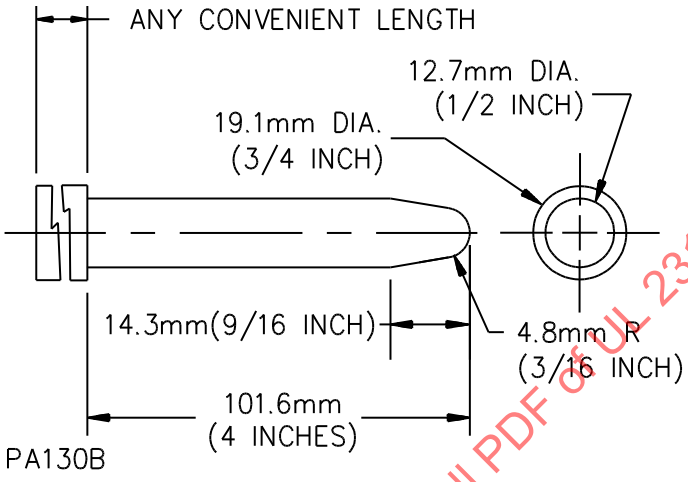
A power outlet so marked shall be provided with both overcurrent protection and disconnection facilities for the service conductors, as well as means for grounding the service neutral conductor.

11.1.3 Power outlets marked for a service application shall be constructed such that, with the service disconnect in the off position, no ungrounded uninsulated live part is exposed to inadvertent contact by persons while servicing any field connected load terminal, including a neutral load terminal, a branch circuit equipment grounding terminal, or the neutral disconnect link. Exposure to inadvertent contact is determined by use of the probe illustrated in Figure 11.1. If restriction to the line-side of the service disconnect is dependent on the installation of field installed service conductors, conductors sized in

accordance with 10.1 shall be installed in the terminals when determining exposure to inadvertent contact. All live parts of the line side service terminal, including the connector body and pressure screw, shall be evaluated.

Figure 11.1

Straight Probe



11.1.4 Metal barriers provided to limit exposure to inadvertent contact shall:

a) Have a thickness not less than 0.032 inch (0.81 mm) if uncoated, not less than 0.034 inch (0.86 mm) if galvanized, and not less than 0.050 inch (1.27 mm) if aluminum.

b) Be constructed so that it can be readily removed or repositioned, and then reinstalled, without the likelihood of contacting bare live parts or damage the insulation of any insulated live part.

Exception: Factory installed barriers that limit access to factory installed wiring and terminations are not required to be constructed so that they can be removed or repositioned.

11.1.5 Nonmetallic barriers provided to limit exposure to inadvertent contact shall:

a) Comply with requirements in 15.2 for insulating barriers.

b) Be constructed so that it can be readily removed or repositioned, and then reinstalled, to allow access to the terminal for servicing.

Exception: Factory installed barriers that limit access to factory installed wiring and terminations are not required to be constructed so that they can be removed or repositioned.

11.1.6 Power Outlets marked “Suitable for use as service equipment” shall be permitted to provide the protection from inadvertent contact in 11.1.3 in a field installable kit when marked in accordance with 35.26A.

11.2 Mobile home service equipment

11.2.1 A power outlet marked for use as mobile home service equipment shall have provision for connecting at least one 100-ampere or greater feeder circuit by a permanent wiring method.

11.2.2 In addition to the feeder circuit covered in 11.2, a power outlet marked for use as mobile home service equipment shall have provision for one or more feeders or branch circuits for connecting a mobile home accessory building or structure or additional electrical equipment located outside a mobile home by a fixed wiring method.

12 Disconnecting Means

12.1 A power outlet intended and marked for use as service equipment shall be constructed so that all ungrounded load conductors can be disconnected from the source of supply by the operation of one operating handle. The operation of the handle shall simultaneously disconnect all ungrounded conductors of the power outlet. Markings in accordance with 35.17 – 35.26A shall be provided.

12.2 The disconnecting means referred to in 11.1 and 12.1 may be either a manually operable switch or circuit breaker. Handle ties, or means determined to be the equivalent, may be used as covered in the Exception to 8.4.2 to form a single operating handle.

12.3 In a power outlet having provision for the connection of a grounded service conductor, the disconnecting means referred to in 12.1 shall simultaneously interrupt the grounded conductor, or other means shall be provided for disconnecting the grounded service conductor from the interior wiring.

12.4 The disconnecting means required in 12.3 may consist of a terminal plate or stud provided with a wire connector. The disconnecting means is considered to be the joint between the load conductors and the connectors.

12.5 If a disconnecting means is provided as described in 12.3, there shall be provision for the separate connection of the grounded service conductor, and there also shall be provision for the connection of the service grounding electrode conductor. The means for such grounding shall not depend upon solder for the connection.

12.6 A power outlet that is marked "Suitable for recreational vehicle site supply equipment" and provided with an integral mounting post or is marked for use with a particular post shall be constructed so that any receptacle, meter, circuit breaker, switch, or fuse will be located no lower than 24 inches (610 mm) nor higher than 78 inches (2 m) above the marked ground level.

12.7 A power outlet that is marked:

a) "Suitable for use as service equipment" or "Suitable for use only as service equipment;"

b) "Suitable for use as mobile home service equipment" or "Suitable for use only as mobile home equipment;" or

c) "Suitable for recreational vehicle site supply equipment"

and that is either of the pedestal type, is provided with an integral mounting post, or is marked for use with a particular post, shall be constructed so that any receptacle, meter, circuit breaker, switch, or fuse will not be located lower than 24 inches (610 mm) nor higher than 78 inches (2 m) above the bottom of the pedestal or the marked ground level of a post.

13 Alternate Source Switching Means

13.1 A power outlet that has provision for an alternate source of supply shall have a disconnecting means for each source. The disconnecting means shall be mechanically interlocked so that the sources cannot be paralleled. Each of the disconnecting means shall be of a type that is suitable for reversed line and load connection.

14 Overcurrent Protection

14.1 If a power outlet incorporates overcurrent protection, a fuse or circuit breaker pole shall be provided for the protection of each ungrounded conductor.

14.2 Overcurrent protection provided in a marina type power outlet having a gasketed enclosure cover shall be provided by circuit breakers of the fully magnetic type; fuses or thermal type circuit breakers shall not be used.

14.3 In a power outlet intended for use as service equipment, the overcurrent protection required in 14.1 shall consist of a main overcurrent device (a fuse or a circuit-breaker pole) in series with each ungrounded service conductor.

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

14.5 A cartridge fuseholder shall be a type that accommodates only branch circuit type fuses (Class CC, G, H, J, K, RK1, RK5, or T).

Exception: A fuseholder in a maximum 125-volt circuit that does not leave the power outlet may accommodate a miscellaneous or miniature fuse.

14.6 A fuseholder shall be of the cartridge type, Type S, or Edison-base plug type with a factory-installed Type S adapter.

Exception: A fuseholder for a single, permanently wired branch circuit may be of the Edison-base plug type without a factory-installed Type S adapter.

14.7 A disconnecting means shall be provided on the supply side of each cartridge fuse. The disconnecting means shall be such that each individual circuit can be independently disconnected from the source of supply.

14.8 With regard to 14.7, an extractor-type fuseholder shall not be used as a disconnecting means and shall be located on the load side of a disconnecting means.

14.9 The arrangement of electrical connections for a fused switch shall be such that, if the device is properly connected, fuse terminals will be dead when the switch is open.

14.10 If a Type S fuseholder or Edison-base plug type fuseholder with or without a Type S adapter is used, the line connection shall be made to the center contact.

14.11 A power outlet shall be constructed so that fuses will be readily accessible when the switch is open so that they may be replaced without a person touching any live part as specified in 5.1.4. This requirement does not affect or modify the requirements in 5.2.1 and 5.2.5.

14.12 A plug fuse is considered to be accessible if, when the switch is in the off position, the test gauge described in 14.13 can be inserted and properly bottomed in each plug fuseholder by using the fingers of one hand and without causing a reduction in the break distance between the stationary and moving switch contacts to less than 1/2 inch (12.7 mm).

14.13 The test gauge mentioned in 14.12 is to be in the form of a plug fuse having the dimensions specified for plug fuses and having an overall height of 1-3/4 inches (44.5 mm) and a diameter of 1-1/4 inches (31.8 mm) at the section above the male screw shell.

14.14 It is recommended that, if an interlock is provided between a door or cover and the switching mechanism, provision be made for unlatching the interlock for inspection purposes while the switch is in the on position.

15 Spacings

15.1 General

15.1.1 The spacings in a power outlet shall be as indicated in Table 15.1.

Exception No. 1: The spacing (through air and over surface) shall not be less than 1/8 inch (3.2 mm) between uninsulated live parts of the same polarity:

a) On the load side of their respective switches or circuit breakers for parts in different circuits and

b) On the line and load sides of a fuseholder, switch, or circuit breaker.

Exception No. 2: The requirements do not apply to the inherent spacings of a component part of a power outlet. Such spacings are evaluated to the requirements for the component.

Exception No. 3: The distance between a door or cover over a fuseholder and:

a) The center contact of an Edison-base fuseholder shall not be less than 1-9/16 inches (39.7 mm).

b) The center contact of a Type S fuseholder shall not be less than 1-5/16 inches (33.3 mm).

Exception No. 4: The spacings between screw shells of plug fuseholders that are protected by surrounding walls of insulating material and between such screw shells and a metal cover plate, may be minimum 1/4 inch (6.4 mm) if the depth of the receptacle, as measured from the top of the wall to the plane of the center contact, is not less than 3/4 inch (19.1 mm).

15.1.2 In applying Table 15.1 it is to be assumed that:

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-line neutral voltage of the system.

c) Spacings at a fuseholder will 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 covered in the applicable requirements for fuses and in the Standard for Fuseholders – Part 1: General Requirements, UL 4248-1; Standard for Fuseholders – Part 12: Class R, UL 4248-12; Standard for Fuseholders – Part 15: Class T, UL 4248-15; respectively.

d) Spacings will be measured through cracks unless a clamped joint complies with the test covered in 24.1. (With respect to Figure 15.1, a clamped joint is a joint between two pieces of insulation that are under pressure.) Adhesives, cements, or the like, if used to effect a seal in lieu of a tightly mated joint, shall be rated for the purpose.

Table 15.1
Minimum spacings

Voltage		Between uninsulated live parts of opposite polarity				Through air or over surface between uninsulated live parts and grounded dead metal,	
		Through air,		Over surface,[a]			
		inch	(mm)	inches	(mm)	inch	(mm)
0	125	1/2	12.7	3/4	19.1	1/2	12.7
125	250	3/4	19.1	1-1/4	31.8	1/2	12.7
250	600	1	25.4	2	50.8	1[b]	25.4

NOTE – An isolated dead metal part (such as a screw head or washer) interposed between uninsulated live parts of opposite polarity or between an uninsulated live part and grounded dead metal part is considered to reduce the spacing by an amount equal to the dimension of the interposed part along the path of measurement.

[a] In measuring over-surface spacings, any slot, groove, or the like, 0.013-inch (0.33-mm) wide or less in the contour of insulating material is to be disregarded.

[b] A through air spacing of not less than 1/2 inch (12.7 mm) may be provided:
1) At a circuit breaker or a switch, other than a snap switch;
2) Between uninsulated live parts of a meter mounting base and grounded dead metal; and
3) Between grounded dead metal and the neutral of a 277/480 volt, 3-phase, 4-wire power outlet.

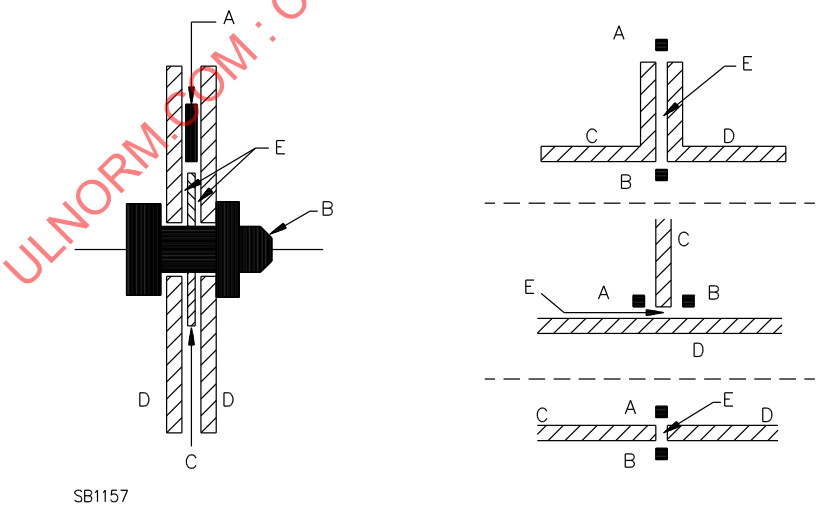
15.1.3 Spacings shall be measured with all terminals:

a) Unwired and

b) Wired with conductors determined in accordance with 10.1.16.

Exception: No conductor smaller than 12 AWG (3.3 mm^2) shall be used.

Figure 15.1
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 15.1.

Parts C, D – Insulating barriers clamped tightly together so that the dielectric strength between A and B is greater than the equivalent air spacing.

Part E – The clamped joint.

15.1.4 In measuring between an uninsulated live part and a bushing installed at a knockout, a bushing having the dimensions indicated in Table 15.2 (but without a locknut inside the enclosure) shall be in place.

15.1.5 Spacings in a pull-out switch shall be measured with the moveable member in both the on and off positions.

15.1.6 A pressure wire connector shall be prevented from turning that would result in spacings less than the minimum required. The means for turn prevention shall be determined to be reliable, such as a shoulder or boss. A lock washer alone shall not be used.

Exception: Means to prevent turning need not be provided if spacings are not less than the minimum required values:

a) When the lug or connector, and any lug or connector of opposite polarity, have each been turned 30 degrees toward the other and

b) When the lug or connector has been turned 30 degrees toward other opposite-polarity live parts and toward grounded dead-metal parts.

15.1.7 All screws and nuts, in addition to those mentioned in 8.3.1 and 9.2 shall be staked, headed over, upset, or otherwise prevented from loosening unless it can be shown that no reduction of spacings can result from the loosening or falling out of such threaded parts.

Exception: Screws and nuts that are intended to be loosened or removed during installation and servicing need not be prevented from loosening.

Table 15.2
Bushing dimensions

Trade size of conduit, inches	Overall diameter,		Height,	
	inches	(mm)	inches	(mm)
1/2	1	25.4	3/8	9.5
3/4	1-15/64	31.4	27/64	10.7
1	1-19/32	40.5	33/64	13.1
1-1/4	1-15/16	49.2	9/16	14.3
1-1/2	2-13/64	56.0	19/32	15.1
2	2-45/64	68.7	5/8	15.9
2-1/2	3-7/32	81.8	3/4	19.1
3	3-7/8	98.4	13/16	20.6
3-1/2	4-7/16	112.0	15/16	23.8
4	4-31/32	126.0	1	25.4
4-1/2	5-35/64	140.0	1-1/16	27.0
5	6-7/32	158.0	1-3/16	30.2
6	7-7/32	183.0	1-1/4	31.8

15.1.8 A lock washer may be used as intended for prevention of loosening of screws and nuts to comply with the requirement in 15.1.7.

15.2 Insulating barriers

15.2.1 In 15.2.2 and 15.2.3, the liner or barrier referred to is insulating material that separates uninsulated live parts or separates an uninsulated live part and a grounded dead-metal part (including the

enclosure), where the through-air spacing between the parts would otherwise be less than the minimum required value.

15.2.2 A barrier that provides sole separation or that is provided in addition to a through air spacing less than 0.013 inch (0.33 mm) shall:

a) Be of a material that complies with the requirements in 9.1 for contact with an uninsulated live part. However, with regard to the flammability rating in Table 9.1, the rating may be:

1) VTM-0 rather than V-0;

2) VTM-1 rather than V-1; or

3) VTM-2 rather than V-2.

Exception No. 1: A barrier located between the enclosure and an uninsulated metal part electrically connected to a grounded circuit conductor (neutral) may be of vulcanized fiber.

Exception No. 2: A barrier may be used based on compliance with the end-product tests specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

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

Exception: Insulating material having a thickness less than that indicated may be used if it complies with 15.2.4.

15.2.3 A barrier used in conjunction with a minimum through air spacing of 0.013 inch (0.33 mm) shall have a minimum thickness of 0.028 inch (0.71 mm). If the barrier is of vulcanized fiber, the minimum air space shall be 1/8 inch (3.2 mm).

Exception No. 1: A barrier used in conjunction with a through air spacing of one-half or more of the minimum required through air spacing may have a minimum thickness of 0.013 inch (0.33 mm) or as specified in 15.2.4 if it is:

a) Of material suitable for direct contact with uninsulated live parts as specified in 15.2.2 or that is in compliance with 15.2.5 and Table 15.3 and Table 15.4;

b) Of such strength to withstand exposure to mechanical damage;

c) Secured in place; and

d) Located so that it will not be adversely affected by operation of the equipment in service.

Exception No. 2: A barrier of material having a thickness less than that indicated may be used if it complies with 15.2.4.

15.2.4 A barrier, other than vulcanized fiber, less than 0.028 inch (0.71 mm) thick that is used in accordance with the Exception to 15.2.2(b) or Exception No. 2 to 15.2.3 shall be subjected to the application of a 5000 volt, 60 hertz potential in accordance with the Dielectric Voltage-Withstand Test, Section 25. A barrier, other than vulcanized fiber, less than 0.013 inch (0.33 mm) thick that is used in accordance with Exception No. 1 to 15.2.3 shall be subjected to the application of a 2500 volt, 60 hertz potential in accordance with the Dielectric Voltage-Withstand Test, Section 25. There shall be no dielectric breakdown of the material following application of the potential. The mechanical strength and flammability of the barrier material shall be determined to be acceptable for the particular application.

15.2.5 If the barrier specified in 15.2.3 is of material (other than vulcanized fiber) that is not suitable for direct contact with uninsulated live parts as specified in 15.2.2, the material and air spacings shall comply

with the barrier requirements specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, and as specified in Table 15.3 and Table 15.4. The relative thermal index shall be at least 90°C (194°F).

15.2.6 For a power outlet provided with a mounting post or pedestal, fiber used as an insulating barrier shall be waxed, varnished, or otherwise treated to prevent the absorption of moisture and, following such treatment, shall comply with the applicable requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

15.2.7 A wrap of thermoplastic tape that has been determined to be acceptable for use as sole insulation may be used if:

a) The tape is not subjected to compression;

b) The tape is not wrapped over a sharp edge;

c) The tape is not subjected to temperatures higher than those for which it is rated; and

d) At a point where the spacing prior to the application of the tape is not less than half the required through-air spacing, the wrap is not less than 0.013 inch (0.33 mm) thick and is applied in two or more layers; or

e) At a point where the spacing prior to the application of the tape is less than half the required through-air spacing, the wrap is not less than 0.028 inch (0.71 mm) thick.

Table 15.3
Maximum performance level category (PLC) for barrier used in place of spacing 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	HB
Comparative tracking index under moist conditions (CTI)[a]	4	4	4	4
High-current arc resistance to ignition (HAI)[a]	3	2	2	1
Hot wire ignition (HWI)[a]	4	3	2	2

NOTES

1 Refer to 15.2.2 if a barrier is located within 0.013 inch (0.33 mm) of contact with live parts.

2 Additional parameters described in Table 15.4 shall be considered.

[a] See the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A.

Table 15.4
Additional requirements for barriers used in the manner specified in Table 15.3

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 greater than use temperature but not less than 90°C, or
	Vicat Softening Point or		Minimum °C	25°C greater than use temperature but not less than 105°C, or
	Ball Pressure Temperature		Minimum °C	(40°C minus the ambient temperature) greater than the use temperature but not less than 95°C

15.2.8 If spacings would otherwise be less than those required by 15.1.1, thermoplastic tubing may be used if:

a) It has been investigated and determined to be acceptable for use in this application;

b) It is not subject to temperatures higher than those for which it was investigated;

c) It is not subject to compression, repeated flexure, or sharp bends;

d) All edges of the conductor covered with the tubing are well rounded and free from sharp edges;

e) For chemically dilated tubing, a solvent recommended by the tubing manufacturer is used; and

f) Its wall thickness (after assembly) is not less than:

1) 0.022 inch (0.56 mm) for tubing 1/2 inch (12.7 mm) or less in diameter,

2) 0.027 inch (0.69 mm) for tubing 9/16 and 5/8 inch (14.3 and 15.9 mm), and

3) 0.028 inch (0.71 mm) for larger tubing sizes.

15.2.9 In a power outlet using insulating material as a covering or protection of uninsulated live parts, the head of a screw or rivet that:

a) Engages the mounting strap of a switch or

b) May become live through failure of the switch

shall be located or protected by countersinking, or by a method that has been determined to be the equivalent, so that it will not be exposed to unintentional contact from the front of the device.

16 Wiring Space

16.1 General

16.1.1 The space within the enclosure shall provide room for the field installation of wires and cables.

16.1.2 A wiring space shall be judged using the wire size indicated in 10.1.16. However, for ampacities of 110 amperes or less, the size is to be based on the use of 60°C (140°F) or 75°C (167°F) rated wire although the marking specifies 75°C rated wire.

16.1.3 If knockouts are provided in a side-wiring space, the width of such a space shall accommodate bending of the maximum size of wire likely to be used.

Exception: A side-wiring space of less width may be provided if knockouts of required size are located elsewhere and if they can be used in the wiring of the device.

16.1.4 The clear wiring space shall be free of all projections and obstructions, including interference from moving parts of the switching mechanism. Such space shall not be less in total area than 250 percent of the total cross-sectional area of the maximum number of wires that may be used in such space.

16.1.5 With reference to 16.1.4, minimum areas for some of the more common multiple-wire combinations are given in Table 16.1.

Table 16.1
Wire space

Maximum size of wire or cable,		Minimum width and depth of wiring space,		Minimum area required for multiple wires based on factor of 2.5											
				Two wires,		Three wires,		Four wires,		Five wires,		Six wires,		Seven wires,	
AWG or kcmil	(mm^2)	inches	(mm)	$in.^2$	(cm^2)	$in.^2$	(cm^2)	$in.^2$	(cm^2)	$in.^2$	(cm^2)	$in.^2$	(cm^2)	$in.^2$	(cm^2)
12	3.3	3/8	9.5	0.14	0.9	0.21	1.4	0.28	1.8	0.35	2.3	0.42	2.7	0.49	3.2
10	5.3	3/8	9.5	0.23	1.5	0.34	2.2	0.46	3.0	0.57	3.7	0.68	4.4	0.80	5.2
8	8.4	1/2	12.7	0.43	2.8	0.64	4.1	0.85	5.5	1.07	6.9	1.28	8.3	1.50	9.7
6	13.3	5/8	15.9	0.62	4.0	0.93	6.0	1.24	8.0	1.55	10.0	1.86	12.0	2.17	14.0
4	21.2	3/4	19.1	0.80	5.2	1.20	7.7	1.60	10.3	2.00	12.9	2.40	15.5	2.80	18.1
3	26.7	3/4	19.1	0.91	5.9	1.36	8.8	1.82	11.7	2.27	14.6	2.72	17.6	3.18	20.5
2	33.6	7/8	22.2	1.03	6.6	1.55	10.0	2.06	13.3	2.58	16.6	3.10	20.0	3.61	23.3
1	42.4	1	25.4	1.36	8.8	2.04	13.2	2.72	17.6	3.40	21.9	4.08	26.3	4.76	30.7
1/0	53.5	1	25.4	1.55	10.0	2.33	15.0	3.10	20.0	3.88	25.0	4.66	30.1	5.43	35.0
2/0	67.4	1	25.4	1.79	11.6	2.68	17.3	3.58	23.1	4.47	28.8	5.36	34.6	6.26	40.4
3/0	85.0	1-1/8	28.6	2.08	13.4	3.11	20.1	4.16	26.8	5.19	33.5	6.22	40.1	7.27	46.9
4/0	107.2	1-1/4	31.8	2.42	15.6	3.63	23.4	4.84	31.2	6.05	39.0	7.26	46.8	8.47	54.6
250	127	1-3/8	34.9	2.96	19.1	4.44	28.6	5.92	38.2	7.40	47.7	8.88	57.3	10.36	66.8

16.1.6 Space inside the enclosure intended for field-installed, low-voltage wiring, such as:

a) Telephone or other communication circuits,

b) Class 2 or Class 3 wiring, or

c) Community antenna television cable,

shall be separated by barriers from space containing power-circuit components or wiring. The space shall be marked in accordance with 35.76.

16.2 Wire-bending space

16.2.1 Wire-bending space shall be provided at the field-wiring terminals for the largest conductor that enters or leaves the enclosure. The wire-bending space shall be sized in accordance with Table 16.2. If a power outlet is provided with subfeed terminals, the assumed size and number of supply and subfeed conductors shall be the maximum accommodated by the wire connectors unless the power outlet is marked as specified in 35.51. The number of wires per terminal in Table 16.2 shall be the sum of the supply and subfeed conductors if they both are likely to leave through the same side of the enclosure. If subfeed terminals are not provided, in applying Table 16.2, the assumed size and number of conductors for each field wiring terminal shall be as specified in 16.1.2.

Exception: The wire-bending space may be provided in accordance with Table 16.3 if the conductor does not enter or leave the enclosure wall opposite its terminal.

16.2.2 With respect to the requirement in 16.2.1, if a hole, knockout, or other provision for connection of a wiring system for the main conductors is provided in the wall opposite the main terminals, the construction shall be such that it will be obvious that the main conductors will enter or exit the enclosure through that wall, and the wire-bending space for those conductors shall be as specified in Table 16.2.

16.2.3 The wire-bending space from a connector, or from a hole, knockout, or other provision for connection of a wiring system, to any barrier or other obstruction that is part of a power outlet shall be as specified in Table 16.3.

16.2.4 If a wire is restricted by barriers, branch-circuit units, or other means, from being bent in a 90-degree or S bend from the terminal to any usable location in the wall of the enclosure, the distance is to be measured from the end of the barrier or other obstruction.

16.2.5 The distance mentioned in 16.2.1 – 16.2.3 is to be measured in a straight line from the edge of the wire terminal closest to the wall in a direction perpendicular to the box wall or barrier. The wire terminal shall be constructed such that when turned in any possible position, there shall be no defeating of any reliable means provided to prevent its turning, such as a:

a) Boss;

b) Shoulder;

c) Walls of a recess;

d) Multiple bolts securing the connector, or the like.

A barrier, shoulder, or the like is to be disregarded when the measurement is being made if it does not reduce the radius to which the wire must be bent. The main connection for a neutral is considered to be a pole – that is, neutral branch terminals are not counted in this determination.

Exception: Side bending space may be measured in a straight line from the center of the wire opening in the direction the wire leaves the terminal. However, it is assumed that the connector is not oriented so that the wire will be directed into a corner to such extent that the transverse wall would necessitate additional bending. If a terminal is provided with one or more lugs or connectors for the connection of conductors in multiple, the distance is to be measured from the wire opening closest to the wall of the enclosure. If the connectors for a circuit are fixed in position (for example, by the walls of a recess) so that they are turned toward each other, the distance is to be measured at the wire opening nearest to the wall, in a direction perpendicular to the wall.

Table 16.2
Minimum wire-bending space at terminals, inches

Wire size, AWG or kcmil	Wires per terminal (pole)[a]							
	1		2		3		4 or more	
14 – 10	Not specified		–		–		–	
8	1-1/2		–		–		–	
6	2		–		–		–	
4	3		–		–		–	
3	3		–		–		–	
2	3-1/2		–		–		–	
1	4-1/2		–		–		–	
1/0	5-1/2		5-1/2		7		–	
2/0	6		6		7-1/2		–	
3/0	6-1/2	(1/2)	6-1/2	(1/2)	8		–	
4/0	7	(1)	7-1/2	(1-1/2)	8-1/2	(1/2)	–	

Table 16.2 Continued on Next Page

Table 16.2 Continued

Wire size, AWG or kcmil	Wires per terminal (pole)[a]							
	1		2		3		4 or more	
250	8-1/2	(2)	8-1/2	(2)	9	(1)	10	
300	10	(3)	10	(2)	11	(1)	12	
350	12	(3)	12	(3)	13	(3)	14	(2)
400	13	(3)	13	(3)	14	(3)	15	(3)
500	14	(3)	14	(3)	15	(3)	16	(3)
600	15	(3)	16	(3)	18	(3)	19	(3)
700	16	(3)	18	(3)	20	(3)	22	(3)
750	17	(3)	19	(3)	22	(3)	24	(3)
800	18		20		22		24	
900	19		22		24		22	
1000	20		–		–		–	
1250	22		–		–		–	
1500	24		–		–		–	
1750	24		–		–		–	
2000	24		–		–		–	

NOTE – For SI units 1 inch = 25.4 mm

[a] Wire-bending space may be reduced by the number of inches shown in parentheses under the following conditions:

1) Only removable or lay-in wire connectors receiving one wire each are used (there may be more than one removable or lay-in wire connector per terminal), and

2) The removable wire connectors can be removed from their intended location without disturbing structural or electrical parts other than a cover, and can be reinstalled with the conductor in place.

Table 16.3
Wire bending space at terminals

Size of wire,		Minimum bending space, terminal to wall									
		Wires per terminal									
		1		2		3		4		5	
AWG or kcmil	(mm^2)	inches	(mm)	inches	(mm)	inches	(mm)	inches	(mm)	inches	(mm)
14 – 10	2.1 – 5.3	Not specified		–		–		–		–	
8 – 6	8.4 – 13.3	1.5	38.1	–		–		–		–	
4 – 3	21.1 – 26.7	2	50.8	–		–		–		–	
2	33.6	2.5	63.5	–		–		–		–	
1	42.4	3	76.2	–		–		–		–	
1/0 – 2/0	53.5 – 67.4	3.5	88.9	5	127	7	178			–	
3/0 – 4/0	85.0 – 107	4	102	6	152	8	203			–	
250	127	4.5	114	6	152	8	203	10	254	–	
300 – 350	152 – 177	5	127	8	203	10	254	12	305		
400 – 500	203 – 253	6	152	8	203	10	254	12	305	14	356
600 – 700	304 – 355	8	203	10	254	12	305	14	356	16	406

NOTES

1 Table 16.3 applies as covered in the Exception to 16.2.1.

2 For power outlets rated 110 amperes or less and marked to indicate use of both 60°C (140°F) and 75°C (167°F) wire, the wire bending space is based on the use of 60°C insulated wire.

16.3 Barriers

16.3.1 A nonmetallic barrier shall be:

a) Of material that complies with 15.2.1 – 15.2.6;

b) Not less than 1/4 inch (6.4 mm) thick; and

c) Supported to provide physical strength and rigidity.

Exception No. 1: The thickness of the nonmetallic barrier may be less than 1/4 inch if the barrier is located so that it will not be subjected to mechanical abuse during installation or servicing or replacement of components of the power outlet and is located and supported so that it will provide physical strength and rigidity.

Exception No. 2: If the barrier is spaced away from live parts by the minimum distance specified in Table 15.1 for live parts to grounded metal, the material is only required to comply with the "physical barrier only" requirements specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

16.3.2 An opening in a metal barrier through which a factory-installed wire or cable passes, or through which a field-installed wire can pass, shall be provided with a bushing or shall be formed so that there will be no sharp edges with which insulated conductors may come in contact.

16.4 Bushings

16.4.1 A bushing used at the opening mentioned in 16.3.2 may be of:

a) Glass,

b) Porcelain,

c) Hard fiber,

d) Phenolic composition, or

e) Cold-molded composition.

A metal eyelet or grommet having a smoothly rounded surface on which the wire or cable can bear may be used in place of a bushing. A bushing of rubber, neoprene, polyvinyl chloride, or of hot-molded shellac and tar composition shall not be used.

16.4.2 The bushing may be of material other than those specified in 16.4.1 if the material complies with the requirements specified in 15.2.1 – 15.2.6.

17 Grounding and Bonding

17.1 Ground bus

17.1.1 A power outlet or post-type of power outlet fitting shall have a copper or plated aluminum ground bus, ground bar, or terminal. The bus, bar, or terminal shall be bonded to the enclosure if the enclosure is of metal. The size of the bus or bar shall be as indicated for the main bonding jumper in Table 17.1 based on the main ampere rating of the power outlet or fitting or footnote a to Table 17.1 if applicable. In a post-type power outlet or fitting, the bus bar or terminal shall be mounted on a vertical wall of the enclosure above any provision for a moisture seal and at a point accessible during and after installation.

Exception: The grounding terminal may be sized in accordance with Table 17.2 if:

a) The power outlet or fitting is not intended for use as service equipment and

b) The power outlet is not provided with sub-feed terminals.

17.2 Terminal for neutral service conductor

17.2.1 A power outlet marked for service equipment use shall have a terminal for a grounded service conductor, even though it has no provision for a grounded load conductor. If there is no provision for a grounded load conductor, the grounded service conductor terminal shall:

a) Accommodate a conductor of the same size as the grounding electrode conductor shown in Table 17.1;

b) Be bonded to the enclosure; and

c) Be connected to the grounding electrode conductor terminal.

Table 17.1
Size of grounding electrode conductor and main bonding jumper

Ampere rating not exceeding	Size of line terminal conductor[a]				Minimum size of grounding electrode conductor and main bonding jumper				Minimum cross section of main bonding jumper			
	Copper,		Aluminum,		Copper,		Aluminum,		Copper,		Aluminum,	
	AWG or kcmil	(mm^2)	AWG or kcmil	(mm^2)	AWG	(mm^2)	AWG	(mm^2)	$inch^2$	(mm^2)	$inch^2$	(mm^2)
90	2	33.6	1/0	53.5	8	8.4	6	13.3	0.013[b]	8.4	0.021[b]	13.5
150	1/0	53.5	3/0	85.0	6	13.3	4	21.2	0.021[c]	13.5	0.033[c]	21.3
200	3/0	85.0	250	127	4	21.2	2	33.6	0.033[c]	21.3	0.052[c]	33.6
300	350	177	500	253	2	33.6	1/0	53.5	0.052[d,e]	33.6	0.083[d,e]	53.5
400	600	304	900	456	1/0[f]	53.5	3/0[f]	85.0	0.083[e,f]	53.5	0.132[e,f]	85.0

[a] The terminals may accommodate larger wires than shown, but if so, the size of the main bonding conductor and the grounding electrode conductor shall be based on the size of the maximum line conductors that can be connected to the line terminal in compliance with 17.5.1 and Table 17.3.

[b] A No. 8 (4.2 mm diameter) or larger brass or No. 10 (4.8 mm diameter) or larger steel screw, the head of which is colored green and is visible after installation, may be used.

[c] A No. 10 or larger brass or steel screw, the head of which is colored green and is visible after installation, may be used.

[d] A No. 10 or larger brass screw, the head of which is colored green and is visible after installation, may be used in a power outlet having:

1) An ampere rating not exceeding 225 amperes or
2) Line terminals rated for accepting conductors not exceeding 4/0 AWG copper or 300 kcmil aluminum.

[e] A 1/4 inch (6.4 mm) diameter or larger brass or steel screw, the head of which is colored green and is visible after installation, may be used.

[f] When the ampere rating is 400 amperes, and the wire terminal connectors for the main service conductors are rated for two 3/0 AWG copper or two 250 kcmil (127 mm^2) aluminum conductors but will not accept a 600 kcmil (304 mm^2) conductor, these values may be reduced to 2 AWG (0.052 square inch) copper or 1/0 AWG (0.083 square inch) aluminum.

17.2.2 The grounding electrode conductor terminal, covered in 17.2.1 and 17.3.1 and the main bonding jumper, covered in 17.4.1, shall connect to the neutral on the supply side of the service disconnecting means for the neutral as covered in 12.3 – 12.5.

17.3 Grounding electrode conductor terminal

17.3.1 A grounding electrode conductor terminal sized in accordance with Table 17.1 for the main ampere rating of the power outlet (or footnote a to Table 17.1, if applicable) or fitting shall be mounted on the ground bus or bar or be part of the terminal mentioned in 17.1.1.

Exception No. 1: The grounding electrode conductor terminal may be mounted on the neutral in a power outlet or power outlet fitting marked for use only as some type of service equipment.

Exception No. 2: In addition to the required terminal, a second grounding electrode conductor terminal may be mounted on the neutral in a power outlet or fitting marked as being suitable for use as service equipment.

17.4 Main bonding jumper

17.4.1 If the power outlet or fitting is marked for use only as some type of service equipment, a main bonding jumper sized in compliance with Table 17.1 for the ampere rating of the power outlet or fitting (or footnote a to Table 17.1, if applicable) shall be connected between the neutral conductor and the bus, bar, or terminal mentioned in 17.1.1.

17.4.2 If the power outlet or fitting is marked for use as any type of service equipment, but not for use only as service equipment, a main bonding jumper as covered in 17.4.1 shall be provided but not connected between the neutral and the ground bus, bar, or terminal. The construction shall be such that when the bonding means is not used, the minimum required spacings will exist. Unless the intended use and method of installation of the bonding means are obvious, instructions for its installation shall be provided. The power outlet shall be marked to indicate that the bonding means shall not be used in a power outlet intended for use as recreational vehicle site supply equipment.

17.4.3 A neutral conductor or terminal shall be insulated or isolated from grounded metal and shall not be bonded to the enclosure when it is shipped from the factory.

Exception: The conductor or terminal may be mounted to the enclosure as covered in 17.4.1.

17.5 Grounding electrode conductor and main bonding jumper when sub-feed terminals are provided

17.5.1 A power outlet provided with sub-feed terminals shall be provided with a grounding electrode conductor and main bonding jumper sized in compliance with Table 17.3 based on the maximum size conductor that is accommodated by the line terminals.

Exception: If marked as covered in 35.51 the size of grounding electrode conductor and main bonding jumper, in accordance with Table 17.3, shall be based on the maximum size line conductor specified in the markings.

17.6 Equipment grounding terminal for 100-ampere rated mobile home

17.6.1 If a power outlet is marked for mobile home service equipment use and thereby has provision for supplying the mobile home with fixed wiring, a pressure-wire connector sized in accordance with Table 17.2 shall be mounted on the bus, bar, or terminal mentioned in 17.1.1 for securing the equipment grounding conductor from the mobile home. This connector shall be in the vicinity of the location of the terminal for connecting the neutral conductor from the mobile home.

Exception: The terminal may be separated from the bus, bar, or terminal mentioned in 17.1.1 if the terminal is connected to such bus, bar, or terminal by a wire sized in compliance with Table 17.2 or a bus sized in accordance with Table 17.1, or if the path is tested as covered in 19.1.1 and the Short Time Fault Current Test, Section 28.

Table 17.2
Size of bonding conductor

Maximum rating or setting of automatic overcurrent device in circuit ahead of equipment, amperes	Size of bonding conductor[a]			
	Copper wire,		Aluminum wire,	
	AWG	(mm^2)	AWG	(mm^2)
15	14	2.1	12	3.3
20	12	3.3	10	5.3
30	10	5.3	8	8.4
40	10	5.3	8	8.4
60	10	5.3	8	8.4
100	8	8.4	6	13.3
200	6	13.3	4	31.2
300	4	31.2	2	33.6
400	3	26.7	1	42.4

[a] Or equivalent cross-sectional area.

Table 17.3
Size of grounding electrode conductor and main bonding jumper for sub-feed power outlets

Maximum size of line conductor				Minimum size of grounding electrode conductor and main bonding jumper				Minimum cross section of main bonding jumper			
Copper,		Aluminum,		Copper,		Aluminum,		Copper,		Aluminum,	
AWG or kcmil	(mm^2)	AWG or kcmil	(mm^2)	AWG	(mm^2)	AWG or kcmil	(mm^2)	$inch^2$	(mm^2)	$inch^2$	(mm^2)
2	33.6	1/0	53.5	8	8.4	6	13.3	0.013	8.4	0.021	13.5
1/0	53.5	3/0	85.0	6	13.3	4	21.2	0.021	13.5	0.033	21.3
3/0	85.0	250	127	4	21.2	2	33.6	0.033	21.3	0.052	33.6
350	177	500	253	2	33.6	1/0	53.5	0.052	33.6	0.083	53.5
600	304	900	456	1/0	53.5	3/0	85.0	0.083	53.5	0.132	85.0
1100	557	1750	887	2/0	67.4	4/0	107	0.105	67.4	0.166	107
over 1100	557	over 1750	887	3/0	85.0	250	127	0.132	85.0	0.196	127

17.7 Receptacle grounding

17.7.1 A receptacle shall be grounded by a wire to the bus, bar, or terminal specified in 17.1.1 as required in 17.7.2. If the receptacle is located on a plug-in fitting, a single jaw assembly complying with 17.8.2 may be used for all wires to the receptacles mounted on the fitting. The other part of the jaw assembly shall be wired to the bus, bar, or terminal mentioned in 17.1.1.

Exception: Part of the power outlet or fitting enclosure may be in the bonding path if the path is tested as covered in 19.1.1 and the Short Time Fault Current Test, Section 28.

17.7.2 If wire is used for the conductive connection required by 17.7.1 and 17.7.3 it 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 17.2 as determined by the maximum ampere rating of any component conductively connected to it. However, in a power outlet marked for marina and boatyard service equipment use, the wire shall be copper and no smaller than 12 AWG (3.3 mm^2). The conductor length shall be such as to permit ready servicing.

17.7.3 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.

17.8 Bonding

17.8.1 All exposed metal of the power outlet or fitting enclosure and all dead metal that is exposed when a door or cover is open or closed shall be conductively connected to the bus, bar, or terminal specified in 17.1.1.

17.8.2 A power outlet fitting (as mentioned in 4.4 and 4.6) or a power outlet is intended to automatically receive its power supply when plugged into its intended energized receiving device, the dimensions of the grounding means shall be such that grounding continuity (if applicable) between the enclosures will be established 1/8 inch (3.2 mm) before live contacts are energized. The resistance of the grounding connection shall not be more than 0.06 ohm in accordance with 19.1.1.

Exception: The 1/8-inch dimension is not required if the plug-in unit has a nonmetallic base or enclosure such that there is no exposed grounded metal.

17.8.3 A plug-in or bolted joint in the grounding path between a power outlet and a power outlet fitting shall be subjected to the test specified in the Short Time Fault Current Test, Section 28.

Exception: A bolted connection between two ground busses need not be tested.

17.9 Bonding means for metallic conduit

17.9.1 A nonmetallic enclosure shall have a bonding means provided to maintain continuity of grounding between all conduit openings. For a construction having a threaded opening or nipple for metal conduit, the bonding means shall be completely assembled to the product. For a construction having a non-threaded opening, the bonding means may be provided as separate parts for field installation. An enclosure designed for field assembly of the bonding means shall be provided with complete instructions for installation. The instructions shall include the identification of the parts and their method of installation.

Exception: The bonding means need not be provided in a nonmetallic enclosure not intended for use with a metallic conduit system or metal clad cable if the enclosure is marked as covered in 35.56.

17.9.2 If the bonding means is not assembled to the product, the product shall be marked in accordance with 35.45.

17.9.3 The grounding continuity of the conduit system shall be a metal-to-metal contact not relying on the insulating-material enclosure in any manner. Bonding between the parts of the conduit system at all places where conduit may be connected shall be investigated with the insulation material in place or removed as specified in 19.3.1.

17.9.4 A separate bonding conductor shall be copper, a copper alloy, or other material that has been determined to be equivalent for use as an electrical conductor. Ferrous metal parts in the grounding path shall be protected against corrosion by enameling, galvanizing, plating, or other means that have been determined to be equivalent. A separate bonding conductor shall:

a) Be protected from mechanical damage or be located within the confines of the outer enclosure or frame and

b) Not be secured by a removable fastener used for any purpose other than bonding unless the bonding conductor is unlikely to be omitted after removal and replacement of the fastener. The ends of the bonding conductor shall be in metal-to-metal contact with the parts to be bonded.

17.9.5 The size of a separate component bonding conductor shall not be less than specified in Table 17.2 or less than the size of the conductor supplying the component, whichever is smaller. For power outlets or power outlet fittings marked for marina or boatyard applications, a separate component bonding conductor shall be copper, minimum 8 AWG (8.4 mm^2), and not less than specified in Table 17.2.

Exception: Other than power outlets or power outlet fittings marked for marina or boatyard applications, the size of the bonding conductor may be reduced if it complies with requirements specified in 19.2.1.

17.10 Grounding and bonding connections

17.10.1 Screws used for the connection of bus, bar, or terminals to the enclosure shall have no more than 32 threads per inch (25.4 mm). There shall be two or more full threads in the metal to which the screw is connected. The metal may be extruded if necessary to provide the threads.

17.10.2 The resistance between two parts connected by a bonding conductor shall not be more than 0.1 ohm in accordance with 19.3.1.

18 Luminaires

18.1 A power outlet provided with a luminaire shall comply with the requirements specified in 18.2 – 18.3. Figure 18.1 shows examples of a power outlet provided with a lighting fixture.

18.2 A luminaire supplied by the same source as the power outlet, as shown in Example 1 of Figure 18.1, shall be provided with overcurrent protection as specified in Overcurrent Protection, Section 14.

18.3 For a luminaire supplied by a separate source from the power outlet, as shown in Example 2 of Figure 18.1, the power outlet and the luminaire shall comply with the following:

a) *Deleted*

b) The power outlet shall be marked to specify two ratings and to specify a multiple source warning as specified in 35.4 and 35.11, respectively.

c) The luminaire shall be provided with branch circuit type overcurrent protection rated a maximum of 20 amperes as specified in Overcurrent Protection, Section 14. Regarding short circuit ratings, the construction shall comply with 2.1.8.

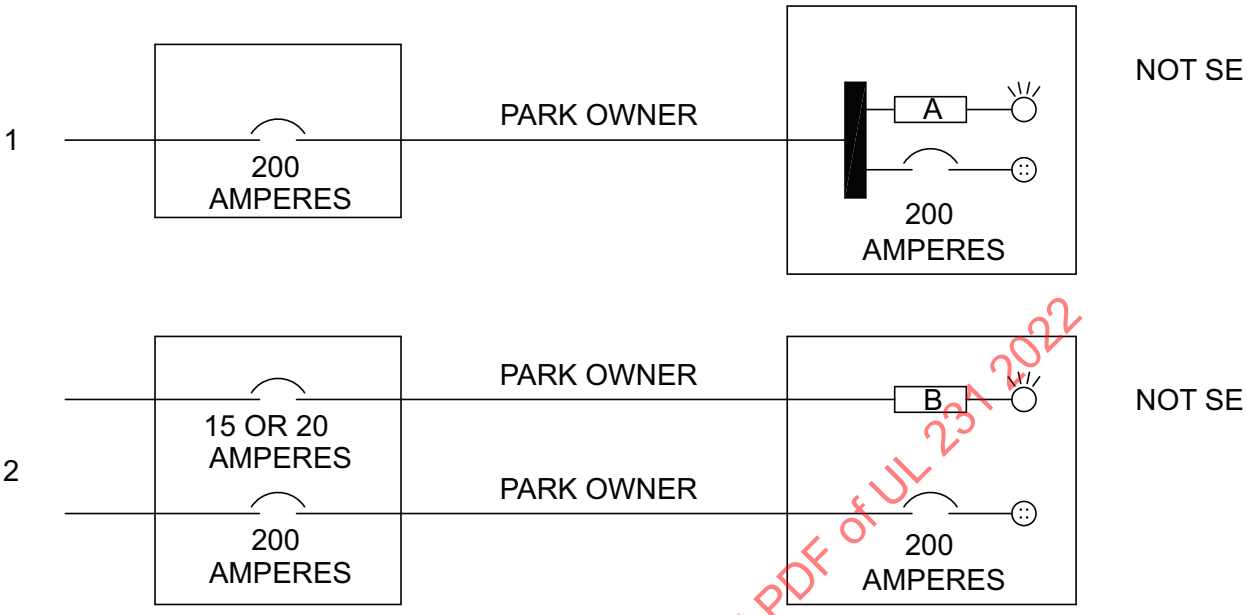
Exception: The luminaire need not be provided with the overcurrent protection specified if the power outlet is marked as indicated in 35.12 and 35.74.

18.4 *Deleted*

18.5 *Deleted*

Figure 18.1

Examples of a power outlet provided with a luminaire



s3609a

A – A 15- or 20-ampere rated switch (may be a snap switch) and a cartridge fuse, a plug fuse, or a circuit breaker as specified in 18.2.

B – A 15- or 20-ampere rated switch (may be a snap switch) and a cartridge fuse, a plug fuse, a circuit breaker, or no overcurrent protection, if marked as specified in 18.3.

NOT SE – Not Service Equipment. Enclosure not bonded to neutral.

PERFORMANCE

19 Bonding Resistance and Conductor Tests

19.1 Plug-in grounding means

19.1.1 The 0.06-ohm value of bonding resistance specified in 17.8.2 is to be determined by measuring the millivolt drop across the joint while passing a known current, usually 30 amperes, through the joint.

19.2 Reduced size bonding conductor

19.2.1 A bonding conductor that does not comply with the requirement in 17.9.5 may be used if:

a) The bonding conductor does not open when carrying, for the time specified in Table 19.1, a current of twice the branch-circuit overcurrent-device rating but not less than 40 amperes; and

b) None of three samples of the bonding conductor, selected at random, opens during a limited short circuit test with a current as specified in Table 19.2 when in series with a fuse as described in 19.2.2.

Table 19.1
Duration of current flow for bonding-conductor test

Overcurrent device rating, amperes	Minimum duration of current flow, minutes
30 or less	2
31 – 60	4
61 – 100	6
101 – 225	8
226 – 400	10

Table 19.2
Bonding conductor short circuit test

Maximum rating, amperes	Circuit capacity, amperes
0 – 100	5000
over 100	10000

19.2.2 The circuit for the test described in 19.2.1 is to have a power factor of 0.9 – 1.0 and is to be limited to the current specified in Table 19.2. The open circuit voltage of the test circuit is not to be less than 100 percent nor more than 105 percent of the specified voltage. The circuit is to be connected through a nonrenewable fuse, with design characteristics such that the fuse will not open in less than 12 seconds when carrying twice the rated fuse current. One test is to be performed on each of three samples of the bonding conductor. The fuse rating shall be that of the branch circuit overcurrent device to which the equipment will be connected but not less than 20 amperes.

19.3 Bonding connection

19.3.1 If the bonding connection resistance as determined by an instrument does not comply with the requirement in 17.10.1, an alternating or direct current of at least 20 amperes from a power supply of not more than 12 volts is to be passed from the point of connection of the equipment-grounding means to the metal part in the grounding circuit and the resulting drop in potential is to be measured between the two

points. The resistance in ohms is to be determined by dividing the drop in potential in volts by the current in amperes passing between the two points.

20 Strength Test of Insulating Base and Support

20.1 An insulating base or support and the bus or strap upon which wire connectors for field wiring are mounted shall be subjected to the force created when the connectors, securing short lengths of conductors of rated ampacity, are torqued to 110 percent of the value marked on the power outlet. The base shall not be damaged as defined in 20.2.

Exception: The test is not required for wire connectors that are part of a unit (circuit breaker, switch, or the like) installed in the field.

20.2 Damage is considered to have occurred when:

a) The base insulating material cracks or rotates;

b) Bosses, recesses, or other means to prevent turning do not perform their intended function;

c) Straps or bus bars bend or twist; or

d) Members other than the wire connector move at electrical joints.

Minor chipping or flaking of brittle insulating material or momentary flexing of metallic members without deformation may occur if the performance is not otherwise impaired.

21 External Operating Mechanism Test

21.1 Following the icing test specified in the Standard for Enclosures for Electrical Equipment, Environmental Considerations, UL 50E, an enclosure marked with a Type 3S or Type 3SX enclosure designation shall:

a) Be inspected for ice build-up;

b) Have the ice removed; and

c) Be operated as intended in service.

There shall not be damage to the enclosure following this test.

22 Rain and Splash Test

22.1 General

22.1.1 To determine if an enclosure complies with 5.1.5, the enclosure shall be subjected to the rain and splash test described in 22.2.1 – 22.2.5. Following the test, there shall not be water:

a) On any electrical device and

b) That enters the enclosure above the level of the lowest terminal lug or other live part.

Exception No. 1: Water may enter an enclosure through a ringless type meter opening, but there shall be a permanent structural system to channel any accumulation of water to the outside of the enclosure. The diameter of the meter opening shall not be less than 6.55 inches (166 mm).

Exception No. 2: Water may be on the face but shall not be in the interior of a receptacle.

22.2 Test description

22.2.1 The complete enclosure with conduit connections (without pipe thread compound) is to be mounted as in actual service with cord-connected attachment plugs installed in receptacles and a meter installed in any enclosure having a ringless type meter opening. The dimensions of the meter are to be in accordance with Figure 5.1. A meter opening for a ring type meter socket is to be sealed so as to prevent entrance of water during the test.

22.2.2 An attachment plug is to be inserted into each receptacle after fully opening the cover, guard, shield, or the like of the test assembly. The cover, guard, shield, or the like is then to be allowed to assume its natural position – that is, a self-closing cover is to be allowed to close on the attachment plug and a cover with a detent or other feature intended to hold it open is not to be manually closed on the attachment plug. The insertion of the attachment plug and positioning of a shield or other device other than a cover, that is used to protect the wiring device is to be accomplished with the degree of misuse likely to be encountered in actual service. If a duplex receptacle is used, the test is to be conducted using only one attachment plug in either position.

22.2.3 A flat surface extending 1 foot (0.3 m) beyond the power outlet in all directions is to be positioned:

a) At the marked ground level of a post type power outlet;

b) At the bottom of a pedestal type power outlet; or

c) 1 foot below a nonpost or nonpedestal type power outlet.

Exception: The flat surface may be omitted for a:

a) Power outlet marked for use as recreational vehicle supply equipment and mobile home equipment;

b) Post or pedestal type power outlet with no live parts within 24 inches (610 mm) of the ground level; or

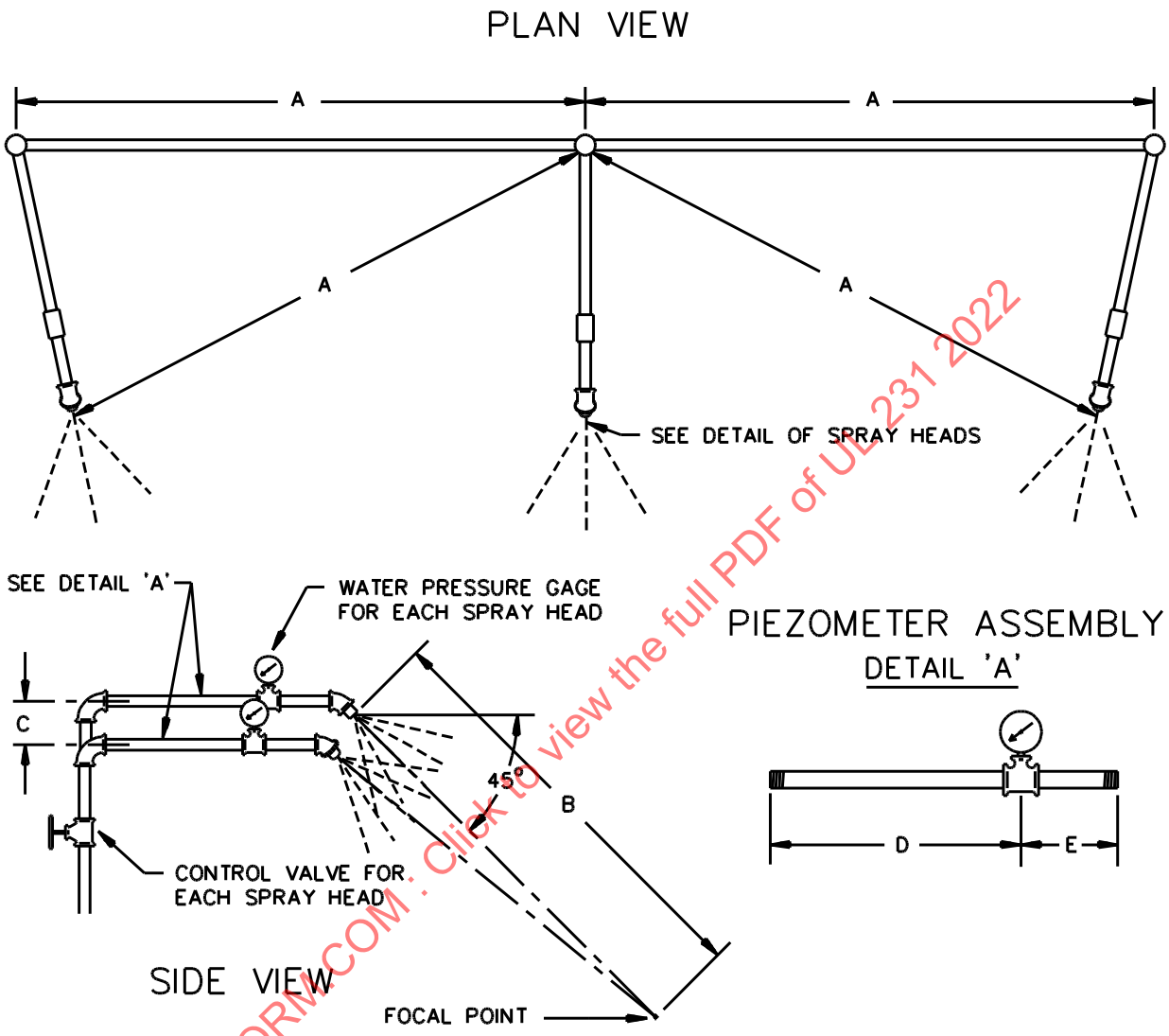
c) Power outlet other than a post or pedestal type marked as covered in 35.16.

22.2.4 The water-spray test apparatus is to consist of three spray heads mounted in a water pipe rack as shown in Figure 22.1. Spray heads are to be constructed in accordance with the details shown in Figure 22.2. The water pressure is to be maintained at 5 pounds per square inch (34.5 kPa) at each head.

22.2.5 The water spray is to be applied to the enclosure from above to all four sides for 1 hour on each side (4 hours total).

Figure 22.1

Spray head piping

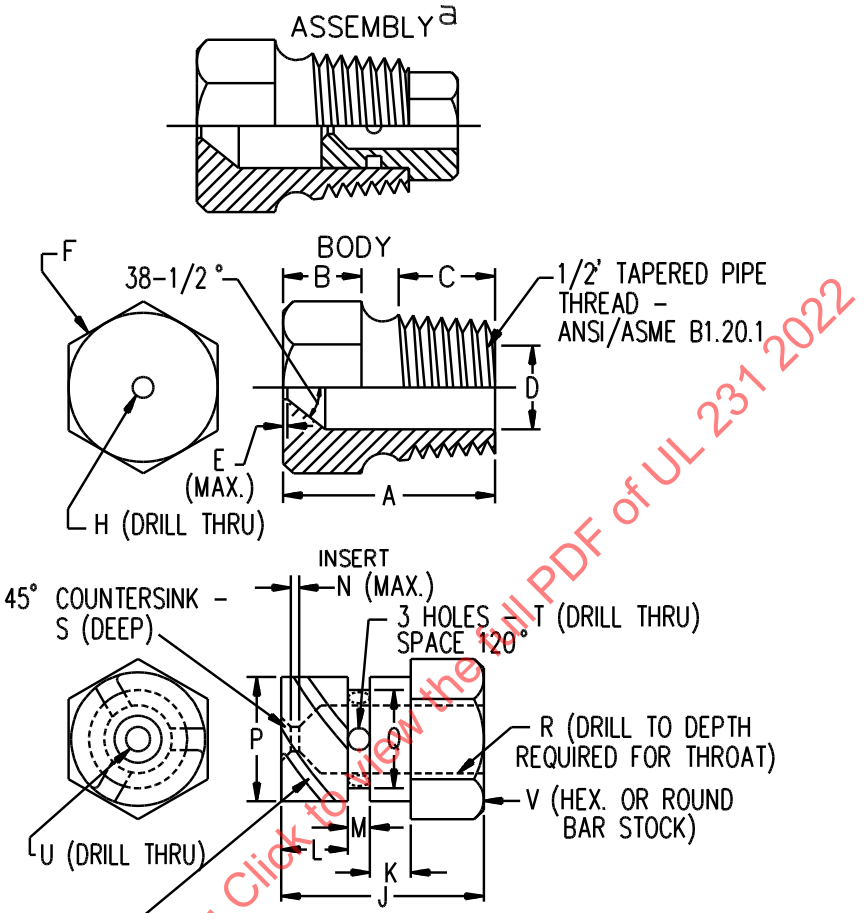


Item	inch	mm
A	28	710
B	55	1400
C	2–1/4	55
D	9	230
E	3	75

RT101D

Figure 22.2

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

23 Spray Test

23.1 A marina type power outlet is to be located with the bottom corner of the enclosure 3 feet (0.9 m) horizontally from and 2 feet (0.6 m) above a spray head of the type illustrated in Figure 22.2. The spray head is to be positioned so that the spray is aimed directly at the test assembly. The water pressure during the test is to be maintained at 15 pounds per square inch (103.4 kPa). The receptacle cover, guard, shield, or the like is to be opened completely, and then allowed to assume its natural position; that is, a self-closing cover is to be allowed to close. However, a cover with a detent or other feature designed to hold it open is not to be assisted in closing. The test is to be conducted without an attachment plug in the receptacle. The spray is to be applied to the enclosure for 1 hour on each side (4 hours total). After application of the spray, the test assembly is to be examined to determine if it complies with the requirements in 22.1.1.

24 Dielectric Test of Clamped Joint

24.1 With respect to 15.1.2(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. This may be accomplished 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 described in (a) has been reached. If the breakdown voltage described in (a) was less than 4600 volts rms, the voltage applied to the second sample is to be further increased to 5000 volts rms and held for 1 second. There shall not be electrical breakdown of the second sample.

25 Dielectric Voltage-Withstand Test

25.1 With respect to 15.2.4, the test specimen is to be placed between two opposing 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 upper moveable electrode is to weigh 50 ±2 grams to exert pressure on the specimen to provide electrical contact.

25.2 The applied test potential is to be increased at a uniform rate of approximately 500 volts per second from zero to the applicable value specified in 15.2.4 and held at that value for 1 minute. The potential is to be essentially sinusoidal and have a frequency of 60 hertz. There shall not be dielectric breakdown.

26 Short-Circuit Current Test

26.1 General

26.1.1 A power outlet or fitting with a short-circuit current rating shall comply with the applicable requirements in the Standard for Panelboards, UL 67, modified as specified in this standard.

26.2 Testing of receptacles

26.2.1 A non-GFCI-type receptacle in a power outlet is to be tested as specified in 26.3.1 – 26.3.3. The results of the tests are to be evaluated as specified in 26.4.1.

Exception: A non-GFCI-type receptacle in a power outlet marked with a short-circuit current rating of 10,000 amperes or less need not be tested if the overcurrent protective device ahead of the receptacle has a minimum short-circuit current rating of 10,000 amperes.

26.2.2 A GFCI-type receptacle in a power outlet is to be tested with a short-circuit current rating of 10,000 amperes in accordance with the Standard for Ground-Fault Circuit-Interrupters, UL 943.

Exception: A GFCI-type receptacle in a power outlet need not be tested if the power outlet has a short-circuit current rating of 2,000 amperes as specified in Table 33.1.

26.3 Short circuit procedure

26.3.1 With respect to the tests specified in 26.3.2 and 26.3.3, the attachment plug is to be wired with 10 inches (254 mm) per terminal of the minimum- and maximum-sized cord, respectively, as specified in Table 26.1. At the end of the cord opposite from the attachment plug, the conductors of the cord are to be joined in a pressure wire connector rated for the size of conductors involved.

Exception: An attachment plug connected into a receptacle rated greater than 50 amperes is to be wired with only the maximum-sized conductor as determined by its rating.

Table 26.1
Wire size for attachment plug test leads

Rating of receptacle accommodating attachment plug, amperes	Single phase test leads				3-Phase test leads			
	Minimum,		Maximum,		Minimum,		Maximum,	
	AWG	(mm^2)	AWG	(mm^2)	AWG	(mm^2)	AWG	(mm^2)
15	18	0.82	14	2.1	18	0.82	14	2.1
20	18	0.82	12	3.3	18	0.82	12	3.3
30	16	1.3	10	5.3	18	0.82	8	8.4
40	12	3.3	8	8.4	12	3.3	6	13.3
50	12	3.3	6	13.3	12	3.3	4	21.1

NOTE – Type SJ cord for sizes 18 – 10 AWG and Type SO cord for 8 AWG and larger.

26.3.2 The branch circuit overcurrent protective device, consisting of either a fused switch or a circuit breaker, and all the main overcurrent protective devices, integral or separate, are to be in the fully closed position. The attachment plug is to be wired with the minimum-sized cord and inserted in the receptacle as intended in service. The test circuit is to be closed on the power outlet by an external switching means.

26.3.3 All switches and overcurrent protective devices, integral or separate, are to be in the fully closed position. The attachment plug, wired with the maximum-sized cord, is to close the circuit by being mechanically inserted into the receptacle.

26.4 Evaluation of test results

26.4.1 The results of the tests specified in 26.3.2 and 26.3.3 are considered to be in compliance with the applicable requirement if:

a) They comply with the criteria specified in the Standard for Panelboards, UL 67;

b) Not greater than 30 pounds (133 N) is required to break any welding between the attachment plug blades and receptacle contacts; and

c) The cord is not visibly damaged and, after removing the shorting pressure wire connector, the cord can withstand the dielectric voltage specified in the Standard for Panelboards, UL 67, applied between the individual conductors;

27 Conduit Connection Tests

27.1 General

27.1.1 A polymeric enclosure intended for connection to a rigid conduit system shall withstand, without pulling apart or damage such as cracking and breaking, the pullout test, torque test, and bending test described in 27.2.1 – 27.4.2.

Exception: The torque test does not apply to an enclosure that is not provided with a preassembled hub and that has instructions stating that the hub is to be connected to the conduit before being connected to the enclosure.

27.2 Pullout

27.2.1 The enclosure is to be suspended by a length of rigid conduit installed in one wall of the enclosure and a direct pull of 200 pounds (890 N) is to be applied for 5 minutes to a length of conduit installed in the opposite wall.

27.3 Torque

27.3.1 The enclosure is to be mounted as intended in service. A torque is to be applied to a length of installed conduit in a direction tending to tighten the connection. The lever arm is to be measured from the center of the conduit. The tightening torque for rigid conduit threaded into the opening in the enclosure is to be 800 pound-inches (90.4 N·m) for 1-, 1-1/4-, and 1-1/2-inch trade sizes, and 1600 pound-inches (181 N·m) for 2-inch and larger trade sizes.

27.4 Bending

27.4.1 A length of conduit at least 1 foot (305 mm) long of the intended size is to be installed in the center of the largest unreinforced surface or in a hub or an opening if provided as part of the enclosure. The enclosure is to be mounted as intended in service, but positioned so that the installed conduit extends in a horizontal plane. The weight necessary to produce the desired bending moment when suspended from the end of the conduit is to be determined from the formula:

$$W = \frac{M - 0.5CL}{L}$$

in which:

W is the weight, in pounds (kg), to be hung at the end of the conduit;

M is the bending moment required in pound-inches (N·m). (1 N·m is equal to 9.8 kg·m);

C is the weight, of the conduit, in pounds (kg); and

L is the length of the conduit, in inches (m), from the wall of the enclosure to the point at which the weight is suspended.

27.4.2 The bending moment for the test described in 27.4.1 shall be as specified in Table 27.1. If the enclosure surface may be installed in either a vertical or horizontal plane, the vertical bending moment value shall be used.

Table 27.1
Bending moment

Normal mounting plane of enclosure	Conduit size, inches	Bending moment			
		Metallic conduit,		Nonmetallic conduit,	
		Lb-inch	(N·m)	Lb-inch	(N·m)
Horizontal	All	300	33.9	300	33.9
Vertical	1/2 – 3/4	300	33.9	300	33.9
	1 – up	600	67.8	300	33.9
NOTE – The test may be terminated prior to attaining the values specified if the deflection of the conduit exceeds 10 inches (254 mm) for a 10 foot (3.05 m) length of conduit.					

27.5 Knockouts

27.5.1 If knockouts are incorporated in the design of an enclosure made of polymeric material, they shall remain in place when subjected to a force of 20 pounds (89 N) applied at right angles by means of a mandrel with a 1/4 inch (6.4 mm) diameter flat end. The mandrel shall be applied at the point most likely to cause movement of the knockout.

28 Short Time Fault Current Test

28.1 A plug-in or bolted joint in the grounding path between a power outlet and a power outlet fitting shall be subjected to the current specified in Table 28.1 for the time indicated. The test is also to be conducted if part of the enclosure is in the grounding path as covered in the Exception to 17.7.1.

28.2 After having carried the current specified in 28.1, there shall be electrical continuity that exists between the power outlet and the power outlet fitting.

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

Table 28.1
Short time fault current

Maximum amperes rating of overcurrent protection	Size of equivalent grounding conductor[a]		Time, seconds	Amperes
	Copper,			
	AWG	(mm^2)		
15	14	2.1	4	300
20	12	3.3	4	470
60	10	5.3	4	750
100	8	8.4	4	1180
200	6	13.3	6	1530
300	4	21.2	6	2450
400	3	26.7	6	3100
[a] Minimum conductor size that would be required if a metal-to-metal joint did not exist.				