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Arc-Fault Circuit-Interrupters

Underwriters Laboratories Inc. (UL)
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UL Standard for Safety
for
Arc-Fault Circuit-Interrupters, UL 1699

First Edition, Dated February 26, 1999

The new requirements are substantially in accordance with UL's Bulletin on this subject dated October 19, 1998. The bulletin is now obsolete and may be discarded.

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New product submittals made prior to a specified future effective date will be judged under all of the requirements in this Standard including those requirements with a specified future effective date, unless the applicant specifically requests that the product be judged under the current requirements. However, if the applicant elects this option, it should be noted that compliance with all the requirements in this Standard will be required as a condition of continued Listing, Recognition, and Follow-Up Services after the effective date, and understanding of this should be signified in writing.

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Arc-Fault Circuit-Interrupters

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An effective date included as a note immediately following certain requirements is one established by Underwriters Laboratories Inc.

Revisions of this standard will be made by issuing revised or additional pages bearing their date of issue. A UL Standard is current only if it incorporates the most recently adopted revisions, all of which are itemized on the transmittal notice that accompanies the latest set of revised requirements.

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FOREWORD

A. This Standard contains basic requirements for products covered by Underwriters Laboratories Inc. (UL) under its Follow-Up Service for this category within the limitations given below and in the Scope section of this Standard. These requirements are based upon sound engineering principles, research, records of tests and field experience, and an appreciation of the problems of manufacture, installation, and use derived from consultation with and information obtained from manufacturers, users, inspection authorities, and others having specialized experience. They are subject to revision as further experience and investigation may show is necessary or desirable.

B. The observance of the requirements of this Standard by a manufacturer is one of the conditions of the continued coverage of the manufacturer's product.

C. A product which complies with the text of this Standard will not necessarily be judged to comply with the Standard if, when examined and tested, it is found to have other features which impair the level of safety contemplated by these requirements.

D. A product employing materials or having forms of construction which conflict with specific requirements of the Standard cannot be judged to comply with the Standard. A product employing materials or having forms of construction not addressed by this Standard may be examined and tested according to the intent of the requirements and, if found to meet the intent of this Standard, may be judged to comply with the Standard.

E. UL, in performing its functions in accordance with its objectives, does not assume or undertake to discharge any responsibility of the manufacturer or any other party. The opinions and findings of UL represent its professional judgment given with due consideration to the necessary limitations of practical operation and state of the art at the time the Standard is processed. UL shall not be responsible to anyone for the use of or reliance upon this Standard by anyone. UL shall not incur any obligation or liability for damages, including consequential damages, arising out of or in connection with the use, interpretation of or reliance upon this Standard.

F. Many tests required by the Standards of UL are inherently hazardous and adequate safeguards for personnel and property shall be employed in conducting such tests.

INTRODUCTION

1 Scope

1.1 The requirements of this Standard cover arc-fault circuit-interrupters (AFCIs) of the branch/feeder, outlet circuit, portable, and cord type intended for use in dwelling units. These devices are intended to mitigate the effects of arcing faults that may pose a risk of fire ignition under certain conditions if the arcing persists.

1.2 These devices have a maximum rating of 20 A and are intended for use in 120-V ac, 60-HZ circuits.

1.3 These devices are not intended to detect glowing connections.

1.4 In these requirements the term device is used generically to apply to all of the devices covered by these requirements and is modified when the requirement does not apply to all types.

1.5 An AFCI that is also intended to perform other functions, such as overcurrent protection, ground-fault circuit-interruption, surge suppression, any other similar functions, or any combination thereof, shall comply additionally with the requirements of the applicable Standard or Standards that cover devices that provide those functions.

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

2 Glossary

2.1 For the purposes of this Standard, the following definitions apply.

2.2 **ARCING** – A luminous discharge of electricity across an insulating medium, usually accompanied by the partial volatilization of the electrodes.

2.3 **ARCING FAULT** – An unintentional arcing condition in a circuit.

2.4 **ARC-FAULT CIRCUIT-INTERRUPTER (AFCI)** – A device intended to mitigate the effects of arcing faults by functioning to deenergize the circuit when an arc-fault is detected.

2.5 **BRANCH/FEEDER ARC-FAULT CIRCUIT-INTERRUPTER** – A device intended to be installed at the origin of a branch circuit or feeder, such as at a panelboard. It is intended to provide protection of the branch circuit wiring, feeder wiring, or both, against unwanted effects of arcing. This device also provides limited protection to branch circuit extension wiring. It may be a circuit-breaker type device or a device in its own enclosure mounted at or near a panelboard.

2.6 **CARBONIZED PATH** – A conductive carbon path formed through or over the surface of a normally insulating material.

2.7 COMBINATION ARC-FAULT CIRCUIT-INTERRUPTER – An AFCI which complies with the requirements for both branch/feeder and outlet circuit AFCIs. It is intended to protect downstream branch circuit wiring and cord sets and power-supply cords.

2.8 CORD ARC-FAULT CIRCUIT-INTERRUPTER – A plug-in device intended to be connected to a receptacle outlet. It is intended to provide protection to the power-supply cord connected to it against the unwanted effects of arcing. The cord may be integral to the device. The device has no additional outlets.

2.9 OPERATION INHIBITION – Denotes the concealment of an arcing fault by the normal operation of certain circuit components.

2.10 OUTLET CIRCUIT ARC-FAULT CIRCUIT-INTERRUPTER – A device intended to be installed at a branch circuit outlet, such as at an outlet box. It is intended to provide protection of cord sets and power-supply cords connected to it (when provided with receptacle outlets) against the unwanted effects of arcing. This device may provide feed-through protection of the cord sets and power-supply cords connected to downstream receptacles.

2.11 PORTABLE ARC-FAULT CIRCUIT-INTERRUPTER – A plug-in device intended to be connected to a receptacle outlet and provided with one or more outlets. It is intended to provide protection to connected cord sets and power-supply cords against the unwanted effects of arcing.

2.12 UNWANTED TRIP – A tripping function in response to a condition that is not an arcing fault but a condition that occurs as part of the normal or anticipated operation of circuit components.

3 Components

3.1 Except as indicated in 3.2, 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.

3.2 A component need not comply with a specific requirement that:

- a) Involves a feature or characteristic not needed in the application of the component in the product covered by this Standard, or
- b) Is superseded by a requirement in this Standard.

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

3.4 Specific components are recognized as being 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 for which they have been recognized.

4 Units of Measurement

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

5 References

5.1 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.

CONSTRUCTION

ALL DEVICES

6 General

6.1 An AFCI shall comply with the construction requirements in Sections 6 – 15.

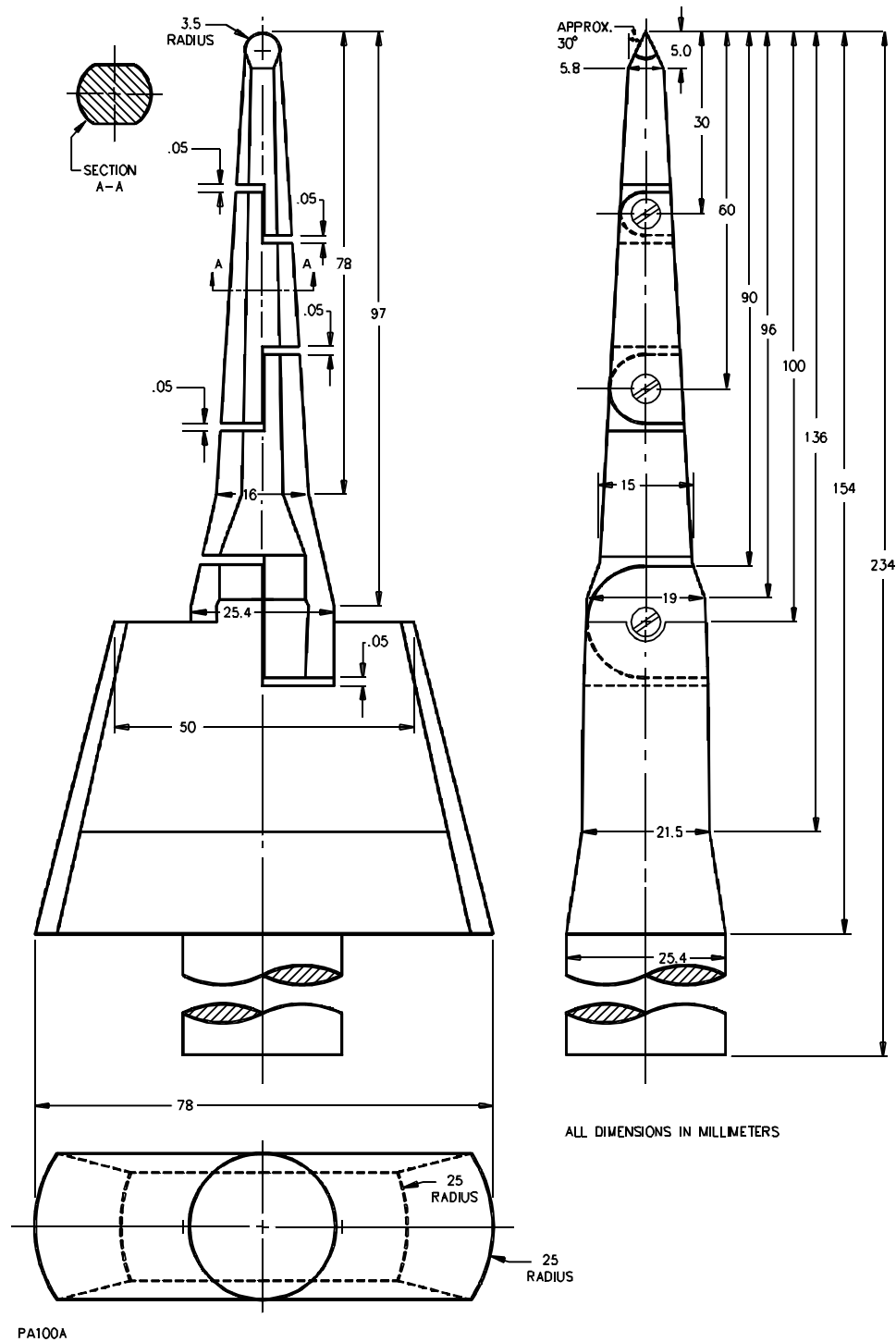
7 Accessibility of Energized Parts

7.1 Parts of a device shall not be accessible when they are installed as intended and energized.

7.2 Parts are considered to be accessible if they can be touched using the articulated probe. See Figure 7.1.

7.3 Access to the trip mechanism shall not be attainable with ordinary tools. Access to internal parts of portable devices shall be limited by use of tamper-resistant screws, rivets, welding or other equivalent means.

Figure 7.1
Articulated probe



8 Corrosion Protection

8.1 Parts, in addition to enclosures, shall be protected against corrosion if failure of such parts would be likely to result in a hazardous condition such as the inability of the device to perform its intended function.

9 Current Carrying Parts

9.1 Current-carrying parts shall be of silver, a silver alloy, copper, a copper alloy or other metal acceptable for the application. Screws, nuts, or wire binding screws made of iron or steel and corrosion protected, shall be permitted to be used to secure live parts, but shall not be depended upon to carry current.

10 Internal Wiring

10.1 The gauge and insulation of wires shall withstand the mechanical and electrical stresses of service. Wires smaller than No. 24 AWG (0.21 mm^2) shall be investigated for the application.

11 Insulation

11.1 A device shall have at least functional insulation throughout. Materials shall be suitable for the temperature, voltage and conditions of service.

12 Spacings

12.1 A device shall comply with the requirements shown in Table 12.1 except that at field-wiring terminals the spacings shall be not less than 1/4 inch (6.4 mm) between terminals not operating at the same potential for either a branch/feeder AFCI, or a cord AFCI without an integral cord, rated up to 200 v peak.

Table 12.1
Spacing in inches (mm)^{a,b}

Operating potential between parts					
70 V peak or less		71 – 200 V peak		201 – 400 V peak	
Through air	Over surface	Through air	Over surface	Through air	Over surface
1/16 (1.6)	1/16 (1.6)	1/8 (3.2)	1/4 (6.4)	1/4 (6.4)	3/8 (9.5)
^a Smaller spacings may be acceptable where they are inherent in a suitable component. ^b For printed wiring boards with suitable conformal coating which have been determined to comply with the requirements for conformal coatings in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, spacings may be reduced to 1/32 inch (0.8 mm), and may be reduced further if the coating is determined to be suitable and it is evaluated in accordance with UL 746C for the reduced spacing.					

12.2 Except as permitted in note a to Table 12.1, if a groove or a slot in insulating material is less than 1/64 inch (0.4 mm) wide, the contour of the slot or groove is to be disregarded in measuring spacings over the surface.

12.3 Spacings measured along the boundary of insulating materials that have been joined together are considered to be spacings over surface unless it can be shown that the dielectric strength of the boundary is not less than that of any of the materials joined.

12.4 Film-coated magnet wire is considered to be uninsulated in determining spacings.

12.5 As an alternative to the measurement method specified in 12.1 – 12.4, the minimum acceptable clearances (through air spacings) and creepage distances (over surface spacings) for a printed wiring board assembly may be evaluated as specified in 12.6 – 12.8 using the applicable requirements in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840.

12.6 When applying the requirements in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, the environment for a printed wiring board assembly within an arc fault circuit-interrupter is considered to be:

- a) Pollution degree 3 for an assembly without a conformal coating,
- b) Pollution degree 2 for
 - 1) An assembly with a coating,
 - 2) An assembly without a coating when the printed wiring board is contained in a sealed housing that complies with the Dust Test, Section 72, or,
- c) Pollution degree 1 for an assembly with a conformal coating complying with the Printed Wiring Board Coating Performance Test, in UL 840.

12.7 For Clearance B (controlled overvoltage) requirements in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, the applicable overvoltage category for line-voltage circuits is Category III for branch/feeder and outlet circuit AFCIs and Category II for portable and cord AFCIs. Category I is applicable to low-voltage circuits if short circuit between the parts involved may result in operation of the controlled equipment that increases the risk of fire or electric shock. Any overvoltage protection device needed to achieve these categories shall be provided as an integral part of the arc fault circuit-interrupter.

12.8 Where measurement of clearances and creepage distances is involved to establish the minimum spacings, the methods specified in Measurement of Clearance and Creepage Distances in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, shall be used.

13 Operating Mechanism

13.1 Compliance with the provisions of arcing fault interruption shall not be prevented by manipulation or restraint of accessible levers, knobs, and the like of a device.

13.2 A device that has tripped in accordance with the provisions of arcing fault interruption shall not be capable of automatic reclosure.

13.3 Except for an AFCI that is intended to be mounted in a panelboard, an AFCI shall operate to open both the ungrounded and grounded circuit conductors in the event of a fault.

14 Microprocessors

Reserved.

15 Test Circuit

15.1 An AFCI shall be provided with a test circuit that simulates the arc detection circuitry output to exercise the remaining parts of the device. An AFCI that also incorporates features of other devices that require a supervisory circuit, such as GFCIs, shall be provided with one or more test circuits that simulate the arc detection portion of the device as described in this Section, and comply with the test or supervisory circuit requirements for the additional device or features provided with the AFCI.

15.2 Operation of the test circuit shall cause the contacts of the device to open. The results of the test shall be made known to the user by a positive visual indication.

BRANCH/FEEDER ARC-FAULT CIRCUIT-INTERRUPTER

16 General

16.1 In addition to the construction requirements in Sections 6 – 15, a branch/feeder AFCI shall comply with the construction requirements in Sections 17 – 19.

17 Terminals

17.1 General

17.1.1 A device shall have terminals suitable for the application. Terminals that are intended to be wired in the field shall be in the form of terminal leads, wire binding screws or pressure-wire terminals.

17.2 Terminal leads

17.2.1 Terminal leads shall differ by no more than two wire sizes from the size that would have an ampacity in accordance with the National Electrical Code (NEC), ANSI/NFPA 70 for the rating of the device.

17.2.2 The insulation of lead type terminals shall be rated for the application and be of a color that conforms with the requirements of the NEC, that is white or natural grey for the grounded conductor and green or green with a yellow stripe for the grounding conductor.

17.2.3 The free length of a terminal lead shall be at least 6 inches (152 mm).

17.2.4 A conductor shall be constructed so as to withstand the stress of normal handling without damage to itself or the device. See Mechanical Tests, Section 69.

17.3 Wire binding screw terminals

17.3.1 A wire binding screw shall be permitted to be used at a field wiring terminal intended for the connection of a No. 10 AWG (5.3 mm²) or smaller wire if upturned lugs or the equivalent are provided to retain the wire under the head of the screw even though the screw becomes loosened.

17.3.2 A screw and washer construction used at a field wiring terminal shall not be smaller than No. 10 (4.8 mm) with no more than 32 threads per inch (25.4 mm).

17.3.3 A terminal plate tapped for a wire binding screw shall be of metal not less than 0.05 inch (1.27 mm) thick and shall have not less than 2 full threads in the metal; except that a plate made of a special alloy not less than 0.03 inch (0.76 mm) thick shall be permitted if the tapped threads have the necessary mechanical strength.

17.3.4 A terminal plate shall be permitted to have the metal extruded at the tapped hole so as to give the thickness necessary for at least 2 full threads provided that the thickness for the unextruded metal is not less than the pitch of the thread.

17.4 Pressure wire terminals

17.4.1 Pressure wire terminals provided with a device shall comply with the Standard for Wire Connectors and Soldering Lugs for Use with Copper Conductors, UL 486A, the Standard for Wire Connectors for Use with Aluminum Conductors, UL 486B, or the Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors, UL 486E.

17.4.2 The tightening torque for a field wiring terminal shall be in accordance with the Standard for Wire Connectors and Soldering Lugs for Use with Copper Conductors, UL 486A, the Standard for Wire Connectors for Use with Aluminum Conductors, UL 486B, the Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors, UL 486E, or as specified by the device manufacturer and the device shall be marked as required by 82.5. The specified tightening torque shall not be less than 90 percent and not more than 100 percent of the value used in the static heating test as specified in UL 486A, UL 486B, or UL 486E, for the wire size corresponding to the ampere rating of the device. See Mechanical Tests, Section 69. Torque values shall be permitted to be less than 90 percent if the connector is investigated in accordance with the lesser assigned torque value.

17.4.3 A pressure wire connector shall be prevented from moving (rotating) so as to strain connections or reduce spacings to unacceptable values.

18 Enclosure

18.1 When a branch/feeder AFCI that is not intended to be mounted in a panelboard is provided with its own enclosure, the enclosure shall comply with the requirements in the Standard for Enclosures for Electrical Equipment, UL 50, for the designated Type. There shall not be any unused openings.

19 Grounding

19.1 All accessible parts of a branch/feeder AFCI that are likely to become energized if there should be arc-over, insulation failure or the like, shall be connected together and to the terminals intended for the equipment grounding conductor.

OUTLET CIRCUIT ARC-FAULT CIRCUIT-INTERRUPTER

20 General

20.1 In addition to the construction requirements in Sections 6 – 15, an outlet circuit AFCI shall comply with the construction requirements in Sections 20 – 23.

20.2 An outlet circuit AFCI shall also comply with the construction requirements for receptacles, including the enclosure requirements, in the Standard for Attachment Plugs and Receptacles, UL 498.

21 Terminals

21.1 An outlet circuit AFCI shall comply with the terminal requirements in Terminals, Section 17, except that the minimum wire binding screw size is No. 8 (4.2 mm).

22 Housings

22.1 An outlet circuit AFCI shall comply with the materials requirements in Sections 8.1 – 8.5 of the Standard for Attachment Plugs and Receptacles, UL 498.

23 Grounding

23.1 An outlet circuit AFCI shall comply with the grounding requirements in Grounding, Section 19.

PORTABLE ARC-FAULT CIRCUIT-INTERRUPTER

24 General

24.1 In addition to the construction requirements in Sections 6 – 15, a portable AFCI shall comply with the construction requirements in Sections 24 – 30.

24.2 A portable AFCI shall provide protection in the event that the grounded conductor becomes open circuited.

25 Plugs/Receptacles

25.1 An outlet provided with a portable AFCI shall be either of the grounding or non-grounding type but in any case shall have the same configuration as the attachment plug of the AFCI. When the outlet is of the grounding type, the grounding terminal shall be conductively connected to the grounding circuit.

25.2 The attachment plug and any outlets provided with a portable AFCI shall comply with the dimensions and other appropriate construction requirements of the Standard for Attachment Plugs and Receptacles, UL 498.

25.3 The ampere rating of an outlet of a cord-connected portable AFCI shall not exceed the rating of the attachment plug.

25.4 The ampere rating of the outlet of a portable (direct plug-in or cord-connected) AFCI that has only a single outlet shall be equal to the ampere rating of the attachment plug.

26 Cords

26.1 A cord that is provided with a device shall be a type that has the number of conductors, insulation and electrical ratings suitable for the application.

26.2 Strain on the cord that may occur by way of pulling, pushing or twisting shall not be transmitted to cord-conductor termination in the device. See the Power-Supply Cord Strain Relief Test, Section 68.

27 Direct Plug-In

27.1 A device that is intended to plug directly into a receptacle shall comply with the weight and moment requirements in 27.2 – 27.5.

27.2 The maximum acceptable moment, center of gravity, dimensions, and weight of a direct plug-in unit shall comply with the requirements specified in (a), (b), (c) and (d). See 27.3 and 27.4 and Figure 27.1.

- a) The quotient of WY/Z shall not exceed 48 ounces (1361 g).
- b) The quotient of WY/S shall not exceed 48 ounces (1361 g).
- c) The product of WX shall not exceed 80 ounce-inches (0.56 N•m).
- d) The weight of a unit shall not exceed 28 ounces (794 g).

27.3 Definitions for the symbols used in 27.2 are as follows:

W is the weight of the unit in ounces (g).

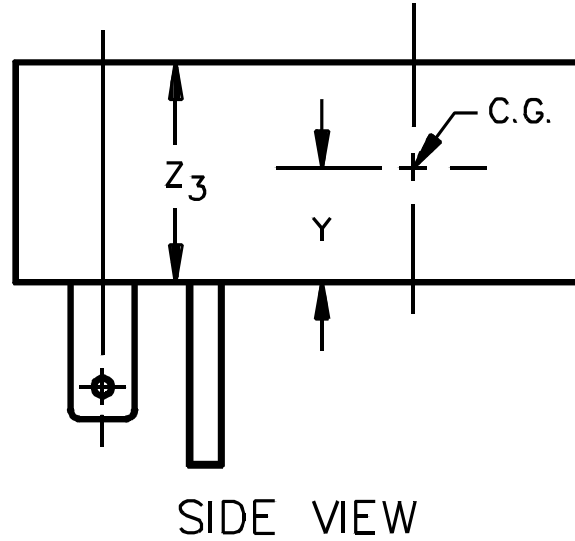
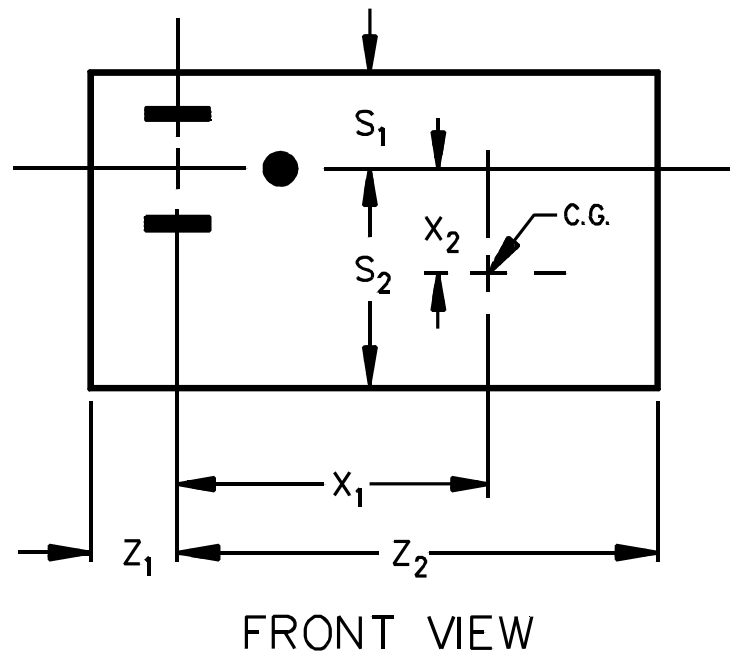
Y is the distance illustrated in Figure 27.1 in inches (mm).

Z is the lesser of the two distances, Z1 or Z2, as illustrated in Figure 27.1, in inches (mm).

S is the lesser of the two distances, S1 or S2, as illustrated in Figure 27.1, in inches (mm).

X is the greater of the two distances X1 or X2, as illustrated in Figure 27.1, in inches (mm).

Figure 27.1
Dimensions of a direct plug-in unit



C.G. = Center of Gravity

CP100

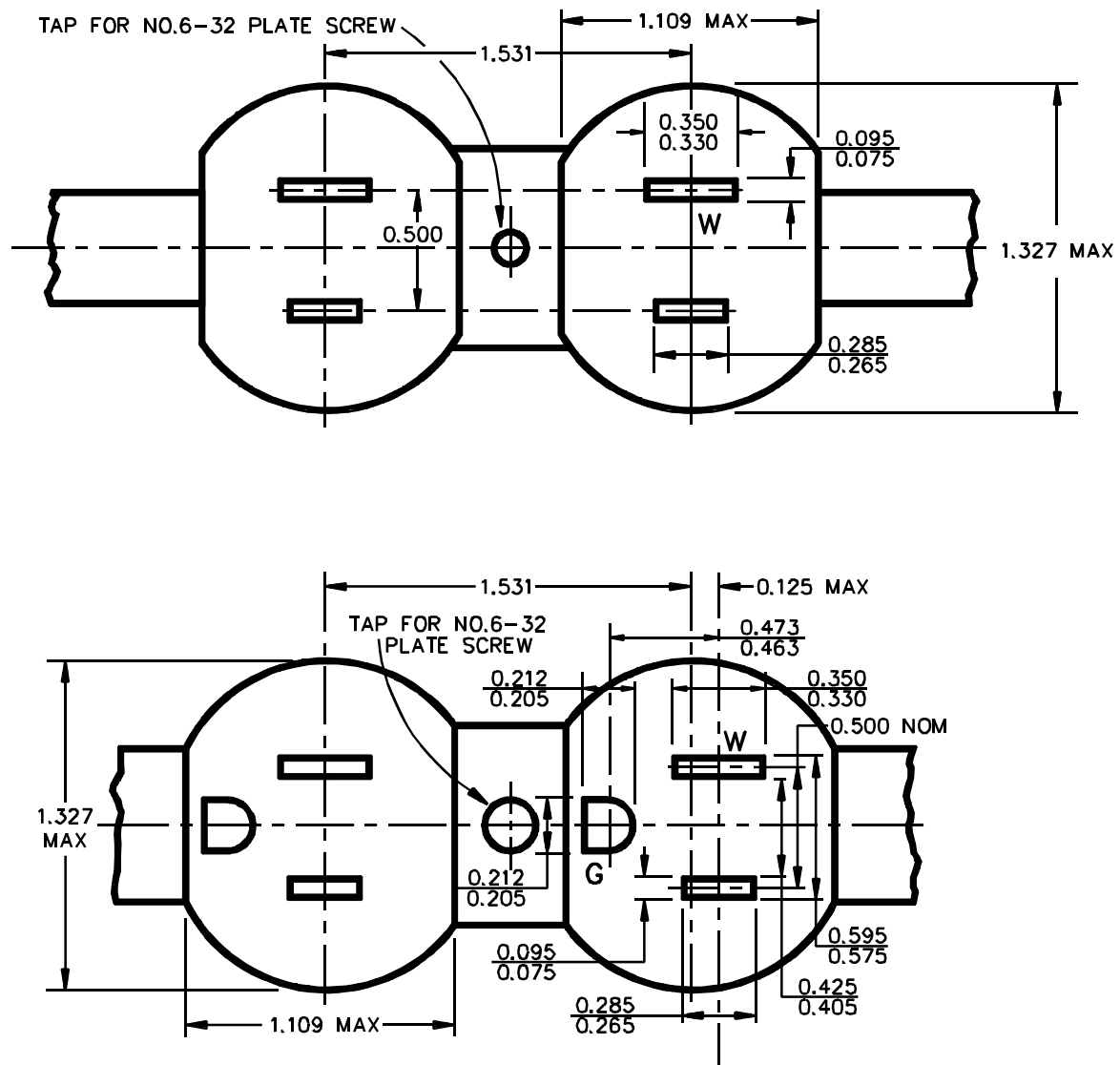
27.4 The moment and weight specified in 27.2 are to be determined as follows:

- a) For units with an output cord, the cord is to be cut off at the enclosure, or at the strain relief means if the strain relief means is outside the enclosure.
- b) For units with integrally mounted accessories or optional components, the values are to be measured with the accessories or components in place.

27.5 When inserted in a parallel-bladed duplex receptacle, any part of a unit, including output wiring, shall not interfere with full insertion of an attachment plug into the adjacent receptacle. See Figure 27.2.

Exception: A unit that renders the adjacent receptacle completely unusable in any one mounting position meets the intent of the requirement.

Figure 27.2
Parallel duplex receptacle



S3076

28 Grounding

28.1 When a portable AFCI is provided with a grounding-type attachment plug, the accessible conductive parts and the equipment grounding conductor of a cord-connected portable AFCI shall be conductively connected to the grounding contacts of the attachment plug and any the receptacle outlets.

29 Enclosures

29.1 The polymeric enclosure of a portable AFCI shall comply with the requirements of the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

30 Devices Rated Less than 15 A

Reserved

CORD ARC-FAULT CIRCUIT-INTERRUPTERS

31 General

31.1 In addition to the construction requirements in Sections 6 – 15, and Cords, Section 26 and Direct Plug-In, Section 27, a cord AFCI shall comply with the construction requirements in Sections 31 – 35.

31.2 A cord AFCI need not be provided with an integral cord.

31.3 A cord AFCI shall provide protection in the event that the grounded conductor becomes open circuited.

32 Plugs/Receptacles

32.1 A cord AFCI shall not be provided with any outlets.

32.2 The attachment plug provided with a portable AFCI shall comply with the dimensions and other appropriate construction requirements of the Standard for Attachment Plugs and Receptacles, UL 498.

33 Grounding

33.1 The accessible conductive parts and the equipment grounding conductor of a cord AFCI provided with a cord shall be conductively connected to the grounding contacts of the attachment plug.

34 Enclosures

34.1 The polymeric enclosure of a direct plug-in device shall comply with the requirements of the Standard for Polymeric Materials – Use in Electrical Equipment Evaluation, UL 746C and with the Crushing Test, Section 71.

35 Devices Rated Less than 15 A

Reserved

36 – 49 Reserved for Future Use