



# UL 1699

## STANDARD FOR SAFETY

### Arc-Fault Circuit-Interrupters

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UL Standard for Safety for Arc-Fault Circuit-Interrupters, UL 1699

Third Edition, Dated May 3, 2017

### **SUMMARY OF TOPICS**

***This revision of ANSI/UL 1699 dated September 26, 2023 is issued to include a patent claim on the title page.***

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**Standard for Arc-Fault Circuit-Interrupters**

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## 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 AFCIs have a maximum rating of 20 A and are intended for use in 120-V ac, 60-HZ circuits. Cord AFCIs are rated up to 30 A.

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 This standard contains a supplement covering the requirements for Leakage-Current Detector-Interrupters.

### 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 MICROELECTRONICS – Monolithic, hybrid, or module circuits, where the internal circuit connections are not accessible exclusive of provided external connection pins or pads. The circuits are capable of functioning in the analogue mode, digital mode, or a combination of the two modes. Examples of microelectronics include: ASICs, ROMs, RAMs, PROMs, EPROMs, PALs, and PLDs. See [2.13](#).

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

2.11 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.

2.12 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.

2.13 PROGRAMMABLE COMPONENT – Any microelectronic hardware that can be programmed in the design center, the factory, or in the field. Here the term "programmable" is taken to be "any manner in which one can alter the software wherein the behavior of the component can be altered." The microelectronics defined in [2.9](#) are examples of programmable components.

2.14 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 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.

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

3.4 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.

### 4 Units of Measurement

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

## 5 Undated 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

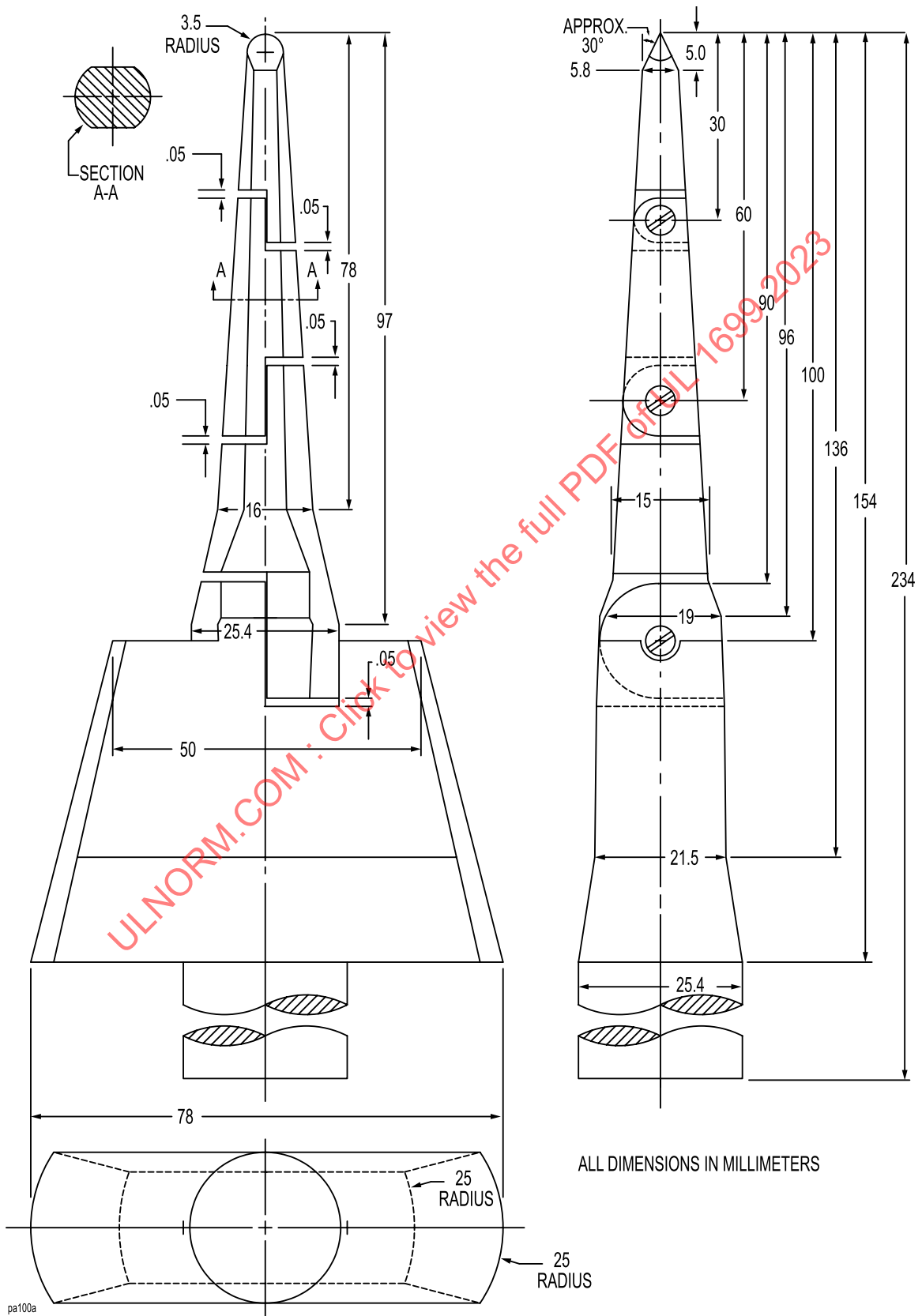
7.1 Parts of a device shall not be accessible when they are installed as intended and energized.

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.

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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 24 AWG (0.21 mm<sup>2</sup>) 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)<sup>a,b</sup>**

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)

<sup>a</sup> Smaller spacings may be acceptable where they are inherent in a suitable component.

<sup>b</sup> 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 [57](#), 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.

13.4 An AFCI device that contains separate line and load terminals, intended for mounting in an outlet box, and that is powered through its load terminals, shall not reset and supply power to its line terminals. See Reverse Line – Load Miswire Test, Section [59](#).

### 14 Programmable Components

14.1 An arc-fault circuit-interrupter that employs a programmable component such as a microprocessor shall be investigated in accordance with the Standard for Software in Programmable Components, UL 1998, as defined in [14.2](#) – [14.8](#).

14.2 All of the requirements of the Standard for Software in Programmable Components, UL 1998, apply to programmable components employed in an arc-fault circuit-interrupter, except as modified by [14.3](#) – [14.9](#).

14.3 The risks to be considered for the Risk Analysis portion of UL 1998 include the following scenarios:

- a) Unwanted tripping;
- b) Failure to trip under conditions where tripping should occur; and
- c) Failure of test circuit to complete evaluation.

14.4 The Tool Qualification requirements from UL 1998 are modified in [14.5](#) and [14.6](#).

14.5 All tools used in the design, implementation, and verification of software shall be documented. The documentation shall include:

- a) The name of the tool supplier or developer;
- b) The model, application, or trade name of the tool;
- c) The tool version identification;
- d) A description of the purpose for which the tool is used; and
- e) A list of known errors, faults or failures of the tool performance, such as a "bug list".

14.6 Software tools are defined as software or hardware used in the development, testing, analysis, or maintenance of a program or its documentation. Examples include compilers, assemblers, timing analyzers, logic analyzers, test case generators, simulators, emulators, and similar tools.

14.7 Means shall be employed to address all microelectronic hardware failure modes identified in the Risk Analysis of [14.3](#). The analysis shall consider all possible combinations of microelectronic hardware failures, software faults, and other events that are capable of resulting in a risk. This includes, for example, microelectronic hardware failures that cause software faults that are capable of resulting in a risk. Detection of failure modes shall be at a frequency and adequacy suitable for the application.

14.8 One approach to comply with [14.7](#) is for the manufacturer to:

- a) Identify failure modes;
- b) Determine safety impact of failure modes;
- c) Design and provide means to detect the failure modes that have an impact on safety;
- d) Demonstrate that coverage provided by detection means is at a frequency and effective level suitable for the application; and
- e) Provide evidence that the failure rate of microelectronic components is suitable for the application.

14.9 The requirements in UL 1998 addressing User Interfaces do not apply.

## 15 Test Circuit

15.1 An AFCI shall be provided with a test circuit that simulates an arc such that the arc detection circuit or software is caused to detect the simulated arc. 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 gray 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 [55](#).

#### 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 10 AWG (5.3 mm<sup>2</sup>) 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.