

Arc Fault Testing and Arc Fault Scenarios

January 28, 2002

At the present time there are six (6) different product categories for arc-fault circuit interrupter (AFCI) devices, as well as a similar product referred to as a leakage-current detection and interruption (LCDI) device. Each of these devices is intended for different applications and/or protection of different aspects of the branch circuit and extension wiring. The following explains these AFCI and LCDI devices in greater detail:

- **Branch/Feeder AFCI** – This device is installed at the origin of a branch circuit or feeder, such as at a panelboard, 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 (e.g. cord sets and power supply cords). These may be circuit-breaker type devices or a device in its own enclosure mounted at or near a panelboard. The category control number for Branch/Feeder AFCIs is **AVZQ**.
- **Outlet Circuit AFCI** – This device is installed at a branch circuit outlet, such as at an outlet box, 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. The category control number for Outlet Circuit AFCIs is **AWCG**.
- **Combination AFCI** – This is an AFCI which complies with the requirements for both branch/feeder and outlet circuit AFCIs. It is intended to protect downstream branch circuit wiring, cord sets and power-supply cords. The category control number for Combination AFCIs is **AWAH**.
- **Outlet Branch Circuit AFCI** – This device is intended to be installed as the first outlet in a branch circuit. It is intended to provide protection to downstream branch circuit wiring, cord sets and power-supply cords against the unwanted effects of arcing. These devices also provide protection to upstream branch circuit wiring. The category control number for Outlet Branch Circuit AFCIs is **AWBZ**.
- **Portable AFCI** – This is a plug-in device for connection 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. The category control number for Portable AFCIs is **AWDO**.

- **Cord AFCI** – This is a plug-in device for connection to a receptacle outlet, to provide protection to the power-supply cord connected to it against the unwanted effects of arcing. The cord may be part of the device. The device has no additional outlets. The category control number for Cord AFCIs is **AWAY**.
- **Leakage-Current Detection And Interruption (LCDI)** – This is a device provided in a power supply cord or cord set that senses leakage current flowing between or from the integral cord conductors and interrupts the circuit at a predetermined level of leakage current. The category control number for Leakage-Current Detection and Interruption (LCDI) is **ELGN**.

Additional Guide Information for each specific category control number (CCN) can be found on the [AFCI Product Categories](#) page.

The basic standard used to evaluate arc-fault protection devices is UL1699, Arc-Fault Circuit Interrupters. The performance requirements for these devices include four different types of arc fault detection tests as described in Section 56 of that standard. Table 1 describes these tests, and illustrates how the various types of AFCI devices are subjected to certain of these tests depending upon the extent and manner in which they protect various regions of the circuit.

Table 1

UL1699 Arc Fault Test	Branch Feeder	Combination	Outlet Circuit	Outlet Branch Circuit	Cord, Portable or LCDI
56.2 Carbonized Path Arc Ignition Test - This test is a non-contact arcing test conducted with NM-B cable with a series cut through the insulation and conductor. Tests are conducted with arcing currents of 5A, 10A, rated current, and 150% rated current. Acceptable performance is interruption of the circuit to the load prior to ignition of a cotton fire indicator.					
NM-B	X	X		X'	
NM-B without and				X'	
56.3 Carbonized Path Arc Interruption Test - This test is a non-contact arcing test conducted with NM-B cable and SPT-2 flexible cord with a parallel insulation cut. Tests are conducted with arcing currents of 75A and 100A. Acceptable performance is clearing of the arcing fault if 8 half-cycles of arcing occur within a period of 0.5 seconds.					
SPT-2	X	X		X	
NM-B	X	X		X	
56.4 Carbonized Path Arc Clearing Time Test - This test is a non-contact arcing test conducted with SPT-2 flexible cord and NM-B cable. For test purposes a parallel insulation cut is made, but test currents are limited to series (load) current values. Tests are conducted with arcing currents of 5A, 10A, rated current, and 150% rated current. Acceptable performance is clearing the arc fault in a specified time ranging from 1 second at 5A to less than 200 milliseconds at 150% of rated current.					
SPT-2		X	X	X	X
NM-B				X'	
56.5 Point Contact Arcing Test - This test is a contact arcing test conducted with NM-B cable and SPT-2 flexible cord with a parallel insulation cut. Tests are conducted with arcing currents of 75 A through 500 A. Acceptable performance is clearing of the arcing fault if 8 half-cycles of arcing occur within a period of 0.5 seconds.					
SPT-2	X	X	X	X	X
NM-B	X	X		X	

Notes to Table 1 -

X - indicates test conducted with type of cord or cable as specified.

X' - indicates that the arcing test is also conducted on the line side (upstream) wiring.

Outlet Circuit AFCIs may be provided with or without feed-through terminals.

Outlet Branch Circuit AFCIs would be installed as the first outlet in the branch circuit.

Cord and Portable AFCIs, and LCDIs are only intended to protect the cords connected to them.

Unless indicated otherwise, NM-B cable includes an uninsulated grounding conductor.

The SPT-2 flexible cord indicated is a 2-conductor cord (without ground), and for testing purposes represents both flexible cord and branch circuit wiring (eq. NM-B cable) without ground.

Arc Fault Scenarios

In any given arc fault scenario, conditions exist within the circuit environment that could affect the extent and means by which the arc fault protection device may or may not respond to the fault condition. These conditions include factors such as:

- 1) The location of the protection device within the electrical circuit,
- 2) whether the fault is occurring within the fixed branch circuit wiring, or at a cord set or power supply cord extending beyond an outlet,
- 3) whether the arcing is occurring as a series arc, or a parallel arc (line-to-line or line-to-ground), and
- 4) if the circuit contains a grounding conductor or ground path.

Figure 1 illustrates a typical branch circuit, including outlets and cords (eg – cord sets and power supply cords) that extend beyond the branch circuit to cord- and plug-connected equipment. Table 2 describes various arc fault scenarios, and where applicable, whether or not arc fault protection is being provided by the specific type of AFCI device or LCDI involved.

Figure 1

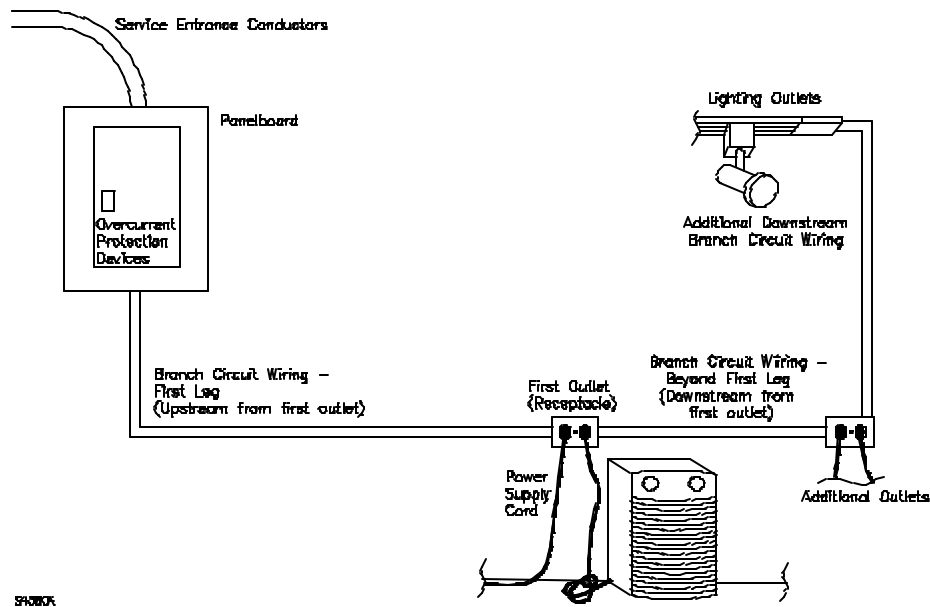


Table 2

Arc Fault Scenario	Branch Feeder	Combination	Outlet Circuit	Outlet Branch Circuit	Cord, Portable or LCDI
Branch Circuit Wiring - First Leg					
Parallel Arcing Detection	Y	Y	n/a	N	n/a
Series Arcing Detection (With Ground)	Y	Y	n/a	Y	n/a
Series Arcing Detection Without Ground (#)	N	Y	n/a	Y	n/a
Branch Circuit Wiring - Beyond First Leg					
Parallel Arcing Detection	Y	Y	n/a	Y	n/a
Series Arcing Detection (With Ground)	Y	Y	n/a	Y	n/a
Series Arcing Detection Without Ground (#)	N	Y	n/a	Y	n/a
Cord Sets (Extension Cords), Power Supply Cords					
Parallel Arcing Detection	Y	Y	Y	Y	Y
Series Arcing Detection	N	Y	Y	Y	Y

Notes to Table 2 -

Y - Arc fault protection provided

N - Arc fault protection not provided

n/a - Not applicable

(#) - Branch circuit wiring systems without ground were permitted prior to the 1962 NEC.

Parallel arcing detection includes arcing line-to-line and line-to-ground.

Cord and Portable AFCIs, and LCDIs are only intended to protect the cords connected to them.

Combination AFCIs located at other than the origin of the branch circuit do not protect upstream branch circuit wiring, cord sets, or power supply cords.