Arc-Fault Circuit Interrupters

by David Dini

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It is not often that a new safety device is introduced to protect individuals from the dangers that may be present in residential occupancies. Smoke alarms, carbon monoxide detectors, and ground-fault circuit interrupters are recognized as essential life saving devices. In 2002, the *National Electrical Code* (*NEC*) will require a new electrical safety device, the arc-fault circuit interrupter (AFCI), for added protection in certain dwelling unit branch circuits. Currently being incorporated into both residential circuit breakers and outlet receptacles, AFCIs incorporate very sophisticated electronics to recognize characteristics unique to arcing, and function to de-energize the circuit when a potentially damaging arc fault is detected.

When devices intended to provide for safety are first introduced, it is not unusual to find that there are differing viewpoints as to the added benefits these safety devices may or may not provide. These differences in viewpoints often carry over into the development of proposals for revision of codes and standards. Proposals to adopt required use of the new AFCIs have raised such differences in viewpoints. Various concerns have been expressed which if left unanswered, could give a false impression about the ability of AFCIs to properly perform their intended function and provide the added safety benefit for which they were designed. The following are responses to specific concerns to help clarify the record.

Concern — *NEC CMP-2 accepted adoption of this new requirement based on inaccurate and misleading documentation submitted by the manufacturers of these devices.*

Several documents were submitted to CMP-2 in substantiating the various proposals for the *NEC* Section 210-12 requirement for arc-fault protection. Included was a March 15, 1996, UL Report of Research on Arc-Fault Detection Circuit Breakers. This extensive work included development of arc-current versus time characteristics for ignition of materials by arcing faults, unwanted operation and operation inhibition considerations, and effects of building wire impedance. The results of UL's research

were used as a basis for the development of the Standard for Arc-Fault Circuit Interrupters, UL 1699. Proponents provided residential fire data provided by a major home insurance company that showed evidence of electrical arcing being common with many residential electrical fires.

Concern — *At a recent meeting of* NEC *CMP-2, UL made a presentation that demonstrated that the AFCI devices would not detect all arcing faults. The UL representative described the basic technical problems with the device. It will not be able to detect all arcs that may produce a fire. Asked if the device will detect all arcs between the breaker and the first outlet, the answer was no. The answer was the same for detecting arcs in an outlet, in the cord from the outlet to the appliance, and the appliance itself. Asked what the percentage of arcs may be detected, the answer was they do not know.*

The UL 1699 Standard describes several different types of AFCIs for different applications and areas of protection. For example, a branch/feeder type AFCI is intended to be installed at the origin of the branch circuit to protect the branch circuit wiring against the unwanted effects of arcing faults. There are also outlet branch-circuit AFCIs of the receptacle type that have been tested to protect the branch circuit wiring. AFCIs are tested to mitigate the effects of various types of arcing, including both contact and non-contact arcing, and series and parallel arcing. Surgical cotton is used as the fire indicator in many of the tests. Some electrical arcing, such as that which might ignite flammable gases or vapors, is beyond the capabilities of an AFCI.

Concern — *The UL Standard used to manufacture and test this product has only been in existence a short time. It was rushed through development only to satisfy the needs of the manufacturers as it related to their specific product.*

UL has been working with all interested parties involving AFCIs since 1994 to develop the requirements for UL 1699. The results of thousands of hours of research, development, and technical meetings

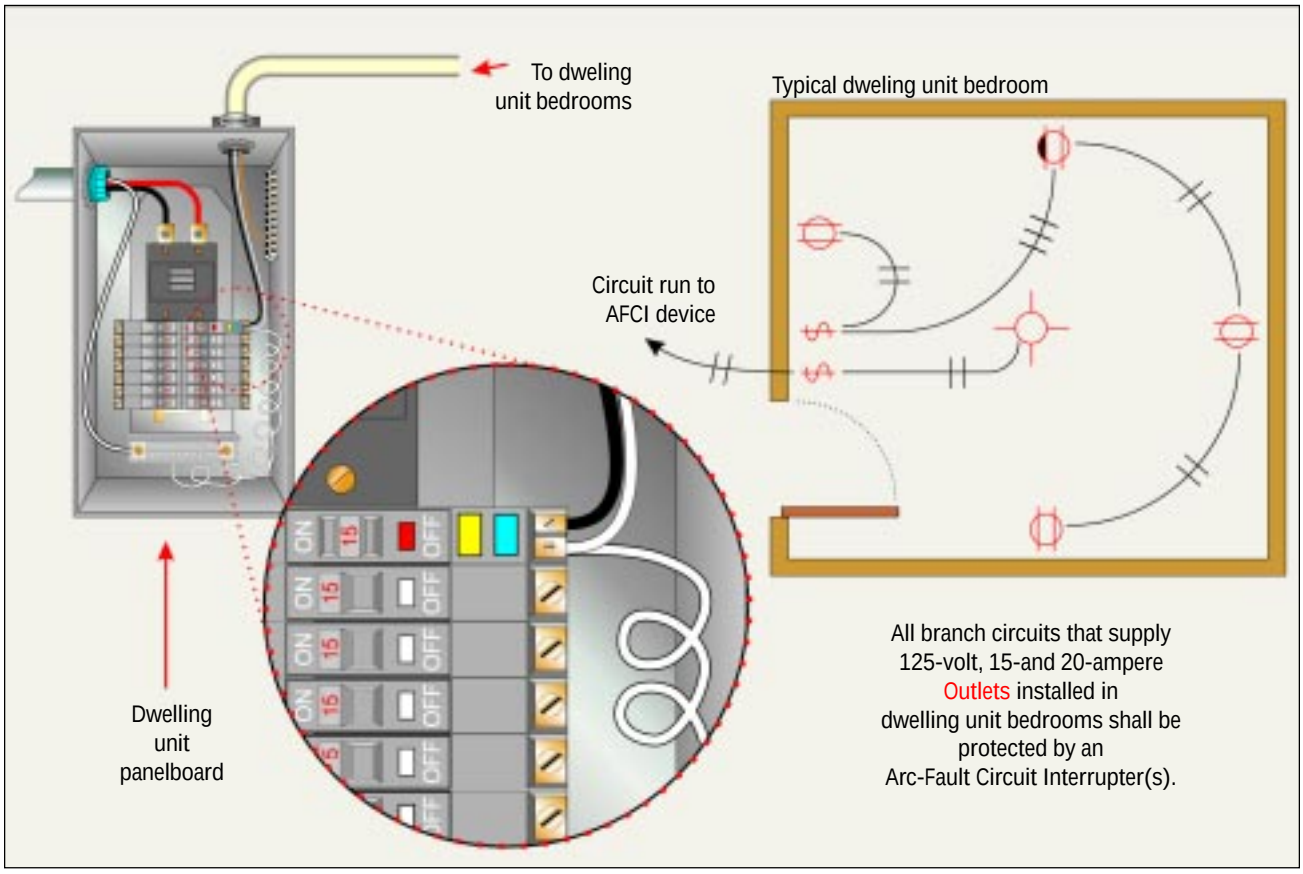

Figure 1. 210.12 Arc-Fault Circuit Interrupter Protection

culminated in the publishing of the UL 1699 Standard for AFCIs in February of 1999. Prior to publishing UL 1699, UL classified several AFCIs involved in beta site testing.

According to the 1998 Residential Fire Loss Estimates published by the CPSC and available on their web site (www.cpsc.gov), total residential electrical equipment resulted in $1.68 billion in fire losses in 1998, the latest year available.

Concern — *Unfortunately, the devices can pass only four of the tests, not the full 14 tests needed for this product to protect residential occupancies as outlined in a UL study for the U.S. Consumer Product Safety Commission (CPSC).*

The CPSC study referenced, "Technology for Detecting and Monitoring Conditions that Could Cause Electrical Wiring System Fires," involved an in-depth study of five different technologies to detect and monitor precursory conditions that could lead to fires in residential electrical wiring systems. Arc-fault detection technology was only one of the five technologies being studied. Not all of the 14 experimental tests described in that report were intended for arc-fault technology. For example, electrical ignition most frequently occurs as the result of Joule heating or electrical arcing. It should not be expected that those ignition scenarios representing Joule (I^2R) heating would necessarily be prevented by an AFCI. The UL 1699 Standard currently addresses four different types of arcing tests with different types of wires and insulation cuts, 15 different unwanted tripping tests, 9 different operation inhibition tests, and 14 additional tests representing environmental conditioning, overloads, short circuits, and mechanical testing, among others.

Concern — *The tests from the UL Standard only use NM cable with a grounding conductor, not the common single conductor concealed wiring method (knob and tube) installed in older dwellings. Most of the wiring fires included in the fire studies used by the proponents to support the requirement for AFCIs have occurred in older dwellings.*

The tests in UL 1699 for use with NM cable require NM cable with ground, as the *NEC* requirement in Section 210-12 would only apply to new construction where branch-circuit wiring with an equipment ground would be required. The tests in UL 1699 that use SPT flexible cord are conducted on cords without ground. Additional requirements are being proposed for UL 1699 for some types of AFCIs to be tested with NM cable without ground, as may be found in older homes.

Concern — *The claims that annual property losses are more than $1.5 billion are unsubstantiated.*

According to the 1998 Residential Fire Loss Estimates published by the CPSC and available on their web site (www.cpsc.gov), total residential electrical equipment resulted in $1.68 billion in fire losses in 1998, the latest year available. From this, electrical distribution equipment resulted in $680 million in losses. AFCIs are most effective in preventing fires within the electrical distribution system. This CPSC data came from the U.S. Fire Administration's (USFA) National Fire Incident Reporting System (NFIRS) and the National Fire Protection Association (NFPA).

Concern — *AFCIs are an unreliable product that should not be counted upon for public safety. The current requirements for smoke alarms are much more reliable and cost-effective in protecting occupants from residential fires.*

To compare AFCIs to smoke alarms would not be correct. A smoke alarm is a signaling device intended to warn people of a fire hazard that has already developed. A smoke alarm is intended to protect people, and not necessarily property. An AFCI is not a signaling device; however, it is a safety protective device. It functions by recognizing characteristics unique to arcing and de-energizing the circuit when an arc-fault is detected. By doing so, this device will safeguard persons and property by mitigating the unwanted effects of arcing, which can result in a fire.

Photographs and drawings provided courtesy of the IAEI education department.

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