Arc-Fault Circuit Interrupters

by Martin Holladay

In many parts of the country, electricians will soon begin installing a new type of circuit breaker: the arc-fault circuit interrupter, or AFCI. These safety devices are intended to detect the kind of electrical arcs that can cause fires. Both the 1999 and 2002 versions of the *National Electric Code* (*NEC*) require the installation, beginning January 1, 2002, of AFCIs on all residential bedroom circuits (*NEC* 210-12).

What Do AFCIs Do?

An AFCI will trip under different circumstances than a conventional circuit breaker or GFCI, neither of which is designed to protect a house from fire. The main purpose of a conventional circuit breaker is to protect wires from overheating, while GFCI breakers are intended to protect people from shock hazards. An AFCI, by contrast, is designed to trip when it detects a dangerous arc, either in the house wiring or in a defective extension cord or appliance. Among the possible causes of hazardous arcs are loose wire nuts, cords pinched by furniture, and wires in contact with vibrating machinery.

An AFCI breaker, like a GFCI breaker, is intended to replace a conventional circuit breaker in a load center. Several manufacturers are now selling AFCI breakers, with prices in the $20 to $35 range.

In many cases, an AFCI breaker can be retrofitted into an existing load center. Cutler-Hammer is now developing an AFCI breaker that will fit into the panels of other manufacturers. Eventually, receptacle-type AFCIs will be available, although no manufacturer offers one yet.

Why just bedrooms? Although fire-safety advocates would prefer to protect all residential circuits (not just bedroom circuits), many electricians, worried about nuisance tripping, have advised code committees to adopt a go-slow approach. "We would like to see some field experience with the devices before we expand the requirement," explains Mark Earley, assistant vice president and chief electrical engineer at the National Fire Protection Association. Earley expects that AFCIs will eventually be mandated for all residential circuits.

For the time being, AFCIs are not intended for kitchen or bath circuits, since combination AFCI-GFCI breakers are not yet available. But several manufacturers are close to announcing the development of combination breakers. Cutler-Hammer hopes to have one on the market by the end of the year.

In states that have not yet adopted the 1999 *NEC*, the requirement for bedroom AFCIs will be delayed. California, for example, is still working under the 1996 *NEC*. Moreover, code officials in some states have been reluctant to require AFCIs. "In the state of Wisconsin, we have specifically excluded the section of the 1999 *NEC* that requires AFCIs," says Joe Hertel, electrical and lighting systems program manager for the Wisconsin Department of Commerce. "There was a lot of concern that this product would undergo growth pains, as GFCIs did in the 1970s. Back in 1977, when I worked for a contractor, we used to get a lot of trouble calls on GFCI breakers with nuisance tripping. But GFCI breakers have come a long way in 20 years, and now they are almost foolproof."

Dangerous arcing can occur when wires are damaged — for example, when a drill bit nicks Romex cable (above). An arc-fault circuit interrupter, like the Arc-D-Tect from Square D (right), is designed to trip when it detects arcing that might cause a fire.

Too Soon?

Equipment manufacturers have not yet reached a consensus on AFCI technical standards, leading some critics to conclude that the code requirement for the devices is premature. In fact, the technical definition of an arc fault is still being hotly debated in standards-writing committees. The challenge is to come up with a definition that distinguishes between dangerous arcs — those capable of starting a fire — and "friendly" arcs, which occur when a plug is pulled from a receptacle, a switch is flipped, or brushes spark in a motor.

Instead of trying to define an arc fault, the *NEC* threw up its hands. In *NEC* 210-12, AFCIs are defined as devices that operate "by recognizing characteristics unique to arcing" — just as a clam digger looks for shellfish with characteristics unique to clams. A more technical definition can be found in the UL

standard for AFCIs (UL 1699). Even the UL standard, though, doesn't attempt to define which type of arc is most likely to cause fires. Instead, it defines an arc fault by working backward from the technical characteristics of existing AFCIs: If an AFCI can detect it, then it must have been an arc fault.

What do they detect? There are at least two kinds of electrical arcs: parallel arcs and series arcs. A parallel arc is a short from line to neutral or line to ground; this can occur when someone drives a nail through Romex cable or when a line wire in an electrical box contacts a bare ground wire. A series arc, on the other hand, is caused by a gap in a single conductor; this can occur when a wire is loosely connected to a receptacle screw, or when a single conductor in a power cord gets nicked.

Although the first generation of AFCI devices, including all those now available, provides adequate protection against parallel arcs, they are unable to detect low-current series arcs. Because of the limitations of available devices, the UL standard for branch-circuit devices (the only AFCIs now on the market) requires the devices to detect only parallel arcs above 75 amps, not low-current series arcs.

Meanwhile, the technology has been evolving. One manufacturer, Pass and Seymour, claims to have invented a receptacle-type AFCI that can detect not only 75-amp parallel arcs, but also series arcs at the 5-amp level. Square D is said to be developing a device with similar detection capabilities but intends to introduce it as a breaker, not a receptacle device.

Manufacturers promoting their products advocate modifications to the UL standard that will favor their own devices. Almost everyone involved in developing the UL standard recognizes that the existing standard will need to be modified, contributing to the impression that code mandates may have been premature.

Diagnostic Dilemmas

Once AFCIs become common, it's only a matter of time before electricians start getting calls from homeowners with tripped AFCI breakers. According to the manufacturers, the devices will trip only if dangerous arcing has occurred. "When that puppy trips, you have a problem," says Gary Forcey, commercial planning manager at Cutler-Hammer.

Homeowners who reset tripped AFCI breakers may cause a hazard. If the arc is behind a wall, some experts worry that resetting the breaker will allow dangerous arcing to resume long enough to cause a fire. Richard Schlieder, chief electrical inspector, Vermont Department of Labor and Industry, says that homeowners should not reset an AFCI breaker. "Once it is turned back on, you are reintroducing a hazard into the circuit, so that is not a good thing to do," he says. "I would investigate it using a meter. It will take a little bit of detective work."

According to Dave Castor, product line manager for circuit breakers at Square D, common multimeters won't be much use for diagnosing arc faults. "A hand-held multimeter device pushes very low voltages, and it would probably not push enough voltage to break the air gap where the arc occurred," says Castor. "However, as soon as you supply 120 volts, that may be enough to compromise the gap between the conductors." Since arc-fault diagnosis may take a while, electricians should be prepared to remind frustrated homeowners that their tripped AFCI may have just saved their house from fire.

Sources of Supply

AFCI breakers are available from Eaton Cutler-Hammer (800/525-2000; www.ch.cutler-hammer.com), General Electric (800/431-7867; www.geindustrial.com), and Square D (888/778-2733; www.squared.com). A fourth manufacturer, Pass and Seymour (800/223-4185; www.passandseymour.com), is developing an AFCI receptacle.