National Electric Code Update—Arc Fault Circuit Interrupters

by Michael A. Anthony, P.E.

The competing requirements of safety and economy have manifested themselves again in a relatively new NEC requirement for arc fault circuit interrupters (AFCIs). These are a new type of protection device that detects hazards in frayed extension cords, for example, before a fire begins. The operating principle has been used in the protection of areas near fallen utility lines for many years but was scaled down and presented to the technical committees of the National Electric Code. AFCI in dwelling unit bedrooms became mandatory in Section 210-12 on January 1, 2002. I know that facility managers look forward to changes in the NEC as much as we all look forward to changes in the tax code.

The requirement for the application of AFCIs in the bedrooms of all dwelling units presents our industry with application decisions with respect to dormitory design. It makes sense that NEC code writers selected bedrooms as the first application point for AFCI; bedrooms are, after all, where most people spend one-third of their lives. Sleep-deprived students, making up a week's worth of lost sleep, can be rendered unable to respond to fire alarms or even a cold steady flow of water from a sprinkler head. The ratio of the bedroom space to the total area of living space is relatively large as compared to the ratio of the number of bedroom circuits to the total number of circuits. Thus, you get the most protection for the cost.

If a bed were positioned against an outlet like this, only an AFCI would be able to open the circuit before the bedding caught fire from a "spark" (or arc). A GFCI would not sense the spark. Older dormitories with aging and deteriorating wiring systems might extend their "safety life cycle" with the added protection of AFCIs. AFCIs should also be considered whenever adding or upgrading a panel box while using existing branch circuit conductors.

Credit: From Princeton University Student Handbook for Fire Safety

http://web.princeton.edu/sites/publicsafety/images/Dorm%20Fire%20Safety%20%20%20web%20version%20revised%202003.ppt#280,8,Control Sources of Ignition

The crux of the application problem for higher education lies in how the NEC defines "dwelling unit." Article 100 of the NEC defines a dwelling unit as an occupancy with permanent cooking facilities. Arguably, any dormitory room that does not have permanent cooking facilities is not required to have AFCIs. Knowledgeable facility executives know, however, that dormitory rooms are filled with surprises. The safest thing to do is make arc fault circuit interrupters mandatory in all dormitory sleeping quarters whether or not there is a defined kitchenette in the dormitory. For all practical purposes, any space within a dormitory room can turn into a kitchenette with a refrigerator, a hot plate, a coffee-maker, a popcorn popper, and a microwave.

Arc fault circuit protection is not cheap; at least not yet. While the cost of a standard circuit breaker may be $10 or less, the cost of arc fault protection is about five times this amount—depending upon the market and the manufacturer. Economies of scale are rapidly bringing the per unit cost down. The larger cost impact of AFCIs has to do with the implications it has for:

- The electrical design of the power system within the dormitory room
- Maintenance and operation cost to reset AFCI circuit breakers after they have opened.

Unlike ground fault circuit interrupters (GFCIs), arc fault protection

Annually, over 40,000 fires are attributed to home electrical wiring. These fires result in over 350 deaths and over 1,400 injuries each year.

—Ault, Singh, and Smith, "1996 Residential Fire Loss Estimates", October 1998, Product Safety Commission, Directorate for Epidemiology and Health Sciences.

Electrical fires are one of the leading causes of fires in student housing. Some universities have language in their dormitory room usage agreements that prohibit (or limit the wattages of) particular types of appliances such as halogen lamps.

Credit: Boston University

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	Activation threshold	Activation Point	Cost per unit	Remarks
Standard Circuit Breaker or Outlet	15A-20A for many hundreds of half-cycles	All areas/outlets not covered by GFCI or AFCI	$2 per outlet	Protects wire and insulation from heat damage due to excessive current
AFCI Circuit	50 A for 1/2 second.	Dwelling unit bedrooms. Protection for the entire supply circuit	$40 per circuit breaker	Available. AFCI outlets-just now entering market
GFCI Outlet	6 milliamperes or more (mA)	Near water; protects people. Protection for only the outlet	$10 per outlet	Available
GFI Circuit	30 milliamperes or more (mA)	Near water; protects equipment. Protection for only the outlet	$10 per circuit breaker	Available
AFCI/GFI	50A/30 mA as above	As above	$50	Available
AFCI/GFCI	50A/6 mA or more as above	As above	$50	Outlets only are available

Note: An AFCI does offer some ground fault protection. One of the more common wiring mistakes when installing an AFCI in a new or retrofit installation is a "shared neutral" condition (two black wires feeding circuits with a common white wire return). Two-pole AFCIs are available for this condition.

applies to the entire branch circuit. To use housing construction funding wisely, your electrical designers should make sure that all AFCI-protected outlets are on the same circuit. In the design of new dormitories it might not be wise to try to cut costs by sharing AFCI-protected circuits between dormitory rooms. If a dormitory room has a 125 VAC smoke detector or a window air conditioner outlet in it then the circuit supplying power to these types of loads requires AFCI. If a switch located in a bedroom controls lighting outlets for outdoor luminaries, closets, or other loads not terminated in bedroom space, then AFCI protection is not required because a switch is not considered an outlet.

Your design standards workgroups should be adjusting the instructions you give to your electrical professionals. Be aware that enforcement of the requirement is not the same everywhere in the United States. The state of Vermont, for example, has taken a slightly more aggressive stance. They are requiring that AFCIs be used in all circuits that feed residential living areas; not just bedrooms. The city of Atlanta, Georgia, now requires AFCIs for all retrofit/remodels. You should track AFCI-adoption programs with the authority having jurisdiction; typically the chief state electrical inspector or fire marshal.

Like the ground fault circuit protection that preceded it, AFCIs have experienced growing pains. They have frequently worked too well; sometimes not at all. Dimmable lighting circuits within bedrooms may trip when used with arc fault circuit interrupters. This nuisance tripping is dependent on the load wattage and the number of high wattage lamps on each AFCI. Within the past three years, one manufacturer had to recall some AFCIs and the problem was quickly resolved.

Some antagonists of the safety community assert that mandatory application of AFCIs is overzealous and too early; that the technology is still buggy. Starting from the late 1960s, it took ten years to get GFCIs to a point where they were not nuisance tripping all the time. Seldom does a new technology come along that is a sure bet to slowly, but surely, transform the basic power systems of residential occupancies. To paraphrase the philosopher Anatole France: I prefer the errors of enthusiasm to the indifference of wisdom.

Circuit breaker graphic from SQ-D

Note the similarity in size with a conventional 15A-20A circuit breaker. The microelectronics within these devices do generate more heat than conventional breakers, however. Until the recent development of the AFCI for residential occupancies, there was no way to protect against hazards that occurred at current levels below those at which circuit breakers were designed to operate. The AFCI senses the existence of a small plasma called an arc and will open an entire circuit. An arcing hazard happens between phases and/or neutral. (Note the white, coiled wire, identifying the neutral.) An AFCI is unlike the GFCI. A GFCI, which is applied near water, senses hazards between phase/neutral or ground. The coiled wire that accompanies a GFCI unit is green. A GFCI can be tested at the outlet within a given room. An AFCI outlet, however, must be tested back at the circuit breaker panel. This difference has policy and cost implications for student housing, security, maintenance, and operations.

Credit: Square-D