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Details: Additional Materials

(FORM UPDATED: 08/11/2010)

WISCONSIN STATE LEGISLATURE ...
PUBLIC HEARING - COMMITTEE RECORDS

2007-08
(session year)

Assembly
(Assembly, Senate or Joint)

Committee on ... Housing
(AC-Ho)

COMMITTEE NOTICES ...

- Committee Reports ... **CR**
- Executive Sessions ... **ES**
- Public Hearings ... **PH**
- Record of Comm. Proceedings ... **RCP**

INFORMATION COLLECTED BY COMMITTEE FOR AND AGAINST PROPOSAL

- Appointments ... **Appt**
- Clearinghouse Rules ... **CRule**
- Hearing Records ... bills and resolutions

(**ab** = Assembly Bill)	(**ar** = Assembly Resolution)	(**ajr** = Assembly Joint Resolution)
(**sb** = Senate Bill)	(**sr** = Senate Resolution)	(**sjr** = Senate Joint Resolution)

- Miscellaneous ... **Misc**

* Contents organized for archiving by: Mike Barman (LRB) (Aug/2010)

arc fault circuit interrupter safety information

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION
Low Voltage Distribution Equipment Section

RECOGNIZING ARCING FAULTS AS A TRUE ELECTRICAL SAFETY HAZARD

The National Electrical Manufacturers Association (NEMA), along with other safety minded organizations, supports the need to increase residential safety through the use of enhanced protective devices.

The Arc Fault Circuit Interrupter (AFCI) is the next generation of circuit protection using advanced electronic detection techniques to disconnect the power should an arcing fault occur.

This packet contains information relevant to the arc fault dangers so you can be more informed as to the issues involved. When the safety of people and their property can be significantly improved, objective analysis and understanding helps to weigh the total investment cost against the loss of life and home.

Key Arc Fault Circuit Interrupter Facts

- Multiple safety organizations support their use within the home as an important fire prevention device.
- Residential fire safety is the primary purpose for the development of this product by the AFCI manufacturers after the hazard was identified.
- AFCI manufacturers have made significant investments that will improve electrical safety
- AFCIs use advanced electronic technologies to detect dangerous arcs and interrupt the circuit. They also provide standard overload and short circuit protection. This technology can also detect the difference between dangerous arc fault conditions and those that are "normal" as part of standard equipment operation.

You can learn more about AFCIs at **www.afcisafety.org**.

NEMA AND ELECTRICAL SAFETY

For more than 80 years, manufacturers of low voltage distribution equipment have been working to ensure public safety through standards writing efforts and the dissemination of important industry information through the National Electrical Manufacturers Association (NEMA), one of the most respected standards development organizations in the world.

Headquartered in Rosslyn, Virginia, NEMA has approximately 400 electroindustry companies, including large, medium and small businesses. To learn more about NEMA visit **www.nema.org**.

To learn more about AFCIs, visit our AFCI web site at **www.afcisafety.org**.

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION
Low Voltage Distribution Equipment Section

1300 North 17th Street, Suite 1752 • Rosslyn, Virginia 22209
(703) 841-3200 Fax: (703) 841-5900
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PRODUCT FEATURE

AFCIs to the Rescue

Electrical fires can cause misery and damage. The technology of arc-fault circuit interrupters combined with proper wiring and maintenance techniques may help prevent residential fires.

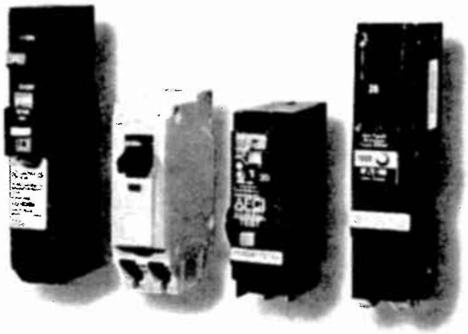
BY **NICK BAJZEK,** *PRODUCTS EDITOR*

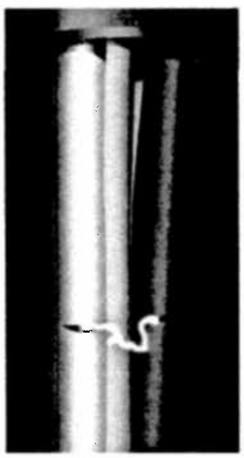
There are few things more devastating to a homeowner than a fire. Despite best efforts from manufacturers, installers and inspectors, home electrical problems cause an estimated 67,800 home fires and $868 million in property losses annually, according to the most recent data from the U.S. Fire Administration.

But there are steps builders can take to prevent electrical fires, which lead to an estimated 485 deaths and 2,300 injuries annually, according to the USFA. That includes using arc-fault circuit interrupters (AFCIs), which the U.S. Department of Housing and Urban Development listed as one of the many devices that can be used to prevent residential electrical fires.

Whereas conventional circuit breakers only respond to overloads and short circuits, they don't prevent arcing conditions that produce an erratic current flow. According to the National Electrical Manufacturers Association, arcs naturally occur in the operation of electrical devices such as motors and switches. An arc fault occurs when wiring insulation damages the arc. These can produce extreme heat and lead to fires.

"Arc faults can occur in two ways: a series arc would be a broken current-carrying path in a single conductor, while a parallel arc would be an arc between two conductors or between a conductor and ground. Parallel arcs generally involve more energy," says Gerard Winstanley, program manager for NEMA. "An AFCI utilizes advanced electronic technol-





ABOVE: Some examples of typical AFCI units from several manufacturers. Right: Arc faults can occur in improperly sheathed or worn wiring. PHOTOS COURTESY OF NEMA

ABOVE: An example of a how a typical arc-fault occurs in appliances and other household electrical equipment. PHOTOS COURTESY OF NEMA

THE PRICE OF SAFETY

Electrical Wholesaling Magazine breaks down the cost of using AFCIs using a 2,500-square-foot home costing $192,846. As per the Consumer Product Safety Commission, the average professionally installed cost differential between an AFCI and a standard circuit breaker is between $15 and $20. With the average number of circuits requiring AFCIs being 12, this equates to an approximate cost increase of $180 to the builder.

ogy to monitor the circuit for the presence of normal and dangerous arcing conditions. It will analyze ... an arcing event and determine if it is hazardous, in which case it will interrupt power to the line."

According to NEMA, the 2008 National Electrical Code is expanding requirements for AFCIs. NEMA estimates AFCI protection in circuit breakers could prevent 50 percent or more of the fires caused by problems in the electrical system. The 2008 edition of the code also takes safety a step further by requiring that all new home construction builders install combination AFCIs to all 15-amp and 20-amp branch circuits not only in bedrooms, but in additional living areas in new dwellings and in the lighting system.

It is important to note that AFCIs are not a panacea; it is possible for a high-voltage surge to damage the arc-detecting circuits of an AFCI. "This is a very rare occurrence, and in this case, the device may still function as a circuit breaker. The test button on the AFCI will confirm whether the arc detecting circuitry is still functioning," says Winstanley. "We recommend that the operation of all AFCIs is checked on a monthly basis."

AFCIs may also be tripped inadvertently, though this too is rare. According to NEMA, the majority of the "nuisance trip" issues are related to installation problems. Specific examples include reversing neutral to ground wires, shared neutral wiring on single pole circuits, and ground wires touching neutral wires. These are arcs that a standard circuit breaker would not detect, but an AFCI would and then shut the circuit down immediately. "As contractors become more familiar with the installation and operation of AFCIs, these wiring errors, reports of nuisance tripping will decline," says Winstanley.

"AFCIs are a relatively new technology and manufacturers are investing great effort in their development. It is very likely we will see further developments in these products. The key issue is safety. There are many home safety options, but AFCIs are a technological leap forward that provides immediate preventative protection to the home's electrical system," says Winstanley.

He believes the expanded NEC requirement will have a significant impact on home safety and decrease the number of lives lost and injuries that occur in residential fires. "Homeowners deserve the safest home possible. This is especially important with new home construction, where safety needs to be the number one priority in the home building processes." **PB**

LOG ON Read 'What arc-fault circuit Interrupters mean to homebuilders' online at **www.ProBuilder.com/innovations**

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Codes Standards

AFCI circuit breakers: valuable safeguard against electrical fires

BY MICHAEL SHIELDS, PE, *Senior Electrical Engineer, SEi Companies, Boston*

How many times have you seen or heard of a home destroyed by fire due to faulty wiring? Oftentimes, it is not recently installed wiring, but wiring that had been in the walls for years.

Building occupants would hope that because considerable time has elapsed since installation, they could rest easy knowing that the wiring is safe and free of fault.

Well, not necessarily. Wires still cause fires, even years after installation. The phenomenon most likely responsible for these faulty wiring fires is something called an arc fault. Arc faults may start as a result of a small defect or damage to a cable, and grow over time into something far more significant. To protect against arc faults, a type of circuit breaker called an arc fault circuit interrupter (AFCI) was developed in the 1990s. The first official requirement for AFCIs is in the 2002 National Electric Code (NEC) and applied to bedroom circuits only.

Now, the 2008 NEC, published in September, expands this requirement to include nearly all receptacle circuits in dwelling units. Anyone involved in residential construction can expect to hear more about these devices in the not-too-distant future.

To fully understand an arc fault, we must first understand the difference between an arc fault and a bolted fault. Figure 1 illustrates the difference between a regular, or bolted fault and an arc fault. We can follow this figure to discuss how AFCI circuit breakers work.

Fault and arc fault

I will explain why an arc fault may exist undetected and in fact be harmless for long periods of time before sparking disaster—literally. But first, look at 1a in Figure 1, which shows that conductors come with a color-coded plastic coating designed to keep them from touching one another. Note that the overall sheath encasing these conductors is not shown for simplicity's sake. When the insulation becomes damaged to an extent that conductors either come in direct contact with one another or are connected by a metal object such as in 1b in Figure 1—where the metal object is a nail—one gets what's known as a bolted fault. The resistance in the conductors and through the nail is low.

Bolted fault and arc fault in a typical receptacle

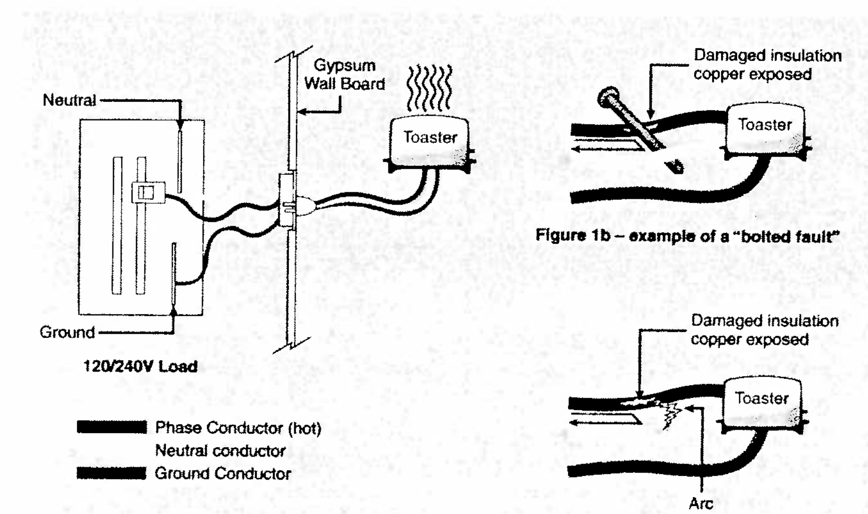

Figure 1a – typical household receptacle

Figure 1b – example of a "bolted fault"

Figure 1c – example of an arc fault

Figure 1 *When insulation is damaged to an extent that conductors either come in direct contact with one another or are connected by a metal object such as in Figure 1b, there is a bolted fault. The resistance in the conductors and through the nail is low.*

Current waveform showing arc fault

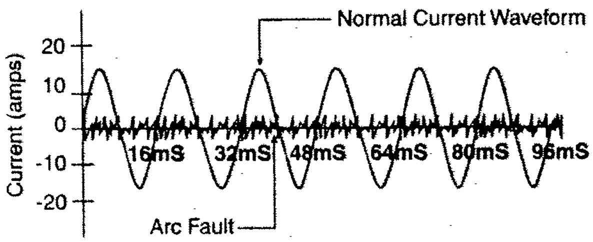

***Figure 2** AFCIs monitor wave form. When they detect a pattern similar to the blue one, AFCIs recognize this signature as being an arc fault.*

As a consequence, currents as high as 10,000 amps—sometimes more—can occur. This sounds serious, and it is. However, conventional circuit breakers effectively protect against this scenario. Upon sensing this high current, conventional circuits open in less than 1/10th of a second.

An arc fault is similar inasmuch as conductor insulation damage is involved. However, with an arc fault, the conductors are not in direct contact with one another, nor are they connected by a metal object.

Instead, because there are exposed conductors relatively close to each other, an arc forms between the two. The current in this case literally has to jump an air gap to get from one conductor to the next. Because air is a poor conductor, the resultant current is relatively small, often much too small to trip a conventional breaker.

In this case, the arc is outside the cable and continues indefinitely. When protected by a conventional breaker, the resultant heat may start a fire.

How AFCIs work

AFCI is yet another example of an advance in solid state technology. These breakers actually monitor the waveform pattern—or signature—rather than just the magnitude of the circuit that they are feeding. When AFCIs detect a pattern similar to the blue one in Figure 2, they recognize this signature as being an arc fault. As can be seen in the figure, an arc fault is characterized by a steady, relatively low-level, high-frequency current waveform.

However, one growing pain problem that this technology encountered when it first came into use involved normal, controlled, and acceptable arcing in electrical circuits. Examples of a normal arc include the arc that is seen when pulling out an electrical cord or the arc a light switch makes when it is operated. Power tools are another example, as power tools generate a sustained arc while being operated.

How does the AFCI breaker know when to trip and when not to? As it turns out, all of these types of electrical arcs have subtle differences in their signatures. As AFCI technology has evolved, it has reached a point where it can effectively filter out normal and safe arcing and only trip on the occurrence of a true arc fault.

Arc faults take time

An arc fault can begin with the smallest of damage to conductor insulation. At first, an imperceptible current flows through that weak link from one conductor to another. Over time, further damage develops as the insulation is heated by the arc beyond its tolerance. Eventually, the damage becomes significant enough to allow a more intense arc and to ultimately cause a fire.

The intent of this article is not to scare anyone. The fact of the matter is electrical wiring, when installed correctly, results in relatively few fires—let alone fatalities. The fact remains that AFCI circuit breakers can make projects safer ones. They are about 10 times more expensive than a regular breaker ($35 vs. $3.50), but the labor to install them is the same. It strikes me as a small price to pay. Regardless, as it looks right now, if you're building residential construction in 2008 and beyond, you will not have a choice.

And occupants of the building where you design electrical systems can rest easy that new wiring will be free of arc fault. **cse**

NEMA launches AFCI safety Web site

The Natl. Electrical Manufacturers Assn. has set up a Web site at www.AFCISafety.org as a one-stop information resource for residential arc fault breaker safety information.

AFCISafety.org states its goals:

1. Increase the level of awareness of arc fault circuit interrupters (AFCIs) and their uses in residential applications.
2. Inform engineers about the differences between branch/feeder AFCIs, combination AFCIs, and ground fault circuit interrupter (GFCI) devices.
3. Provide information related to AFCIs' preventative aspects of arcing faults and their links to fire safety.
4. Highlight proper installation and operation of AFCI devices.

Research in arc fault began in the late 1980s and early 1990s when the Consumer Product Safety Commission (CPSC) identified a concern with the residential fires of electrical origin. A large number of these fires were estimated to be in branch circuit wiring systems.

NEC Code-Making Panel 2 (CMP2) reviewed many proposals, and after much data analysis and discussion, CMP2 concluded that AFCI protection should be required for branch circuits that supply receptacle outlets in bedrooms. Subsequent editions of the NEC further upgraded the requirements to include protection on all outlets (lighting, receptacle, smoke alarm, etc.) In bedrooms along with other some other enhancements.

U.S. CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, DC 20207

Andrew M. Trotta, Director
Division of Electrical Engineering
Directorate for Engineering Sciences

Tel: (301) 504-7578
Fax: (301) 504-0533
Email: ATrotta@cpsc.gov

May 29, 2008

To: Code Making Authorities Considering the Adoption of the 2008 *National Electrical Code*

The U.S. Consumer Product Safety Commission (CPSC) staff[1] understands that you and your Committee are considering adoption of the 2008 *National Electrical Code* (*NEC*) but have been lobbied to reject select revisions of the 2005 *NEC* that were approved during the latest code revision cycle. It is our understanding that particular objections have been raised regarding the expansion of arc fault circuit interrupters (AFCIs) to all 120-volt, single-phase, 15- and 20-ampere branch circuits in living areas, the removal of exceptions for receptacle locations requiring ground-fault circuit-interrupter (GFCI) protection in 210.8 (A)(2) and 210.8 (A)(5) of the 2005 *NEC*, and the addition of a new requirement for tamper-resistant receptacles in dwellings.

<u>AFCIs:</u> The CPSC staff is a strong proponent of the implementation of AFCIs as a powerful tool in mitigating fires that originate in the electrical distribution system. AFCIs are a significant upgrade in electrical fire safety over conventional circuit breaker and fuse technology. The CPSC staff supports the implementation of AFCI technology as a means to reduce these electrical fires based on a thorough analysis of electrical wiring fire incidents, a complete engineering assessment of arc fault detection technology, and a comprehensive laboratory evaluation of AFCI products. The expansion of AFCIs to all 120-volt, single-phase, 15- and 20-ampere branch circuits supplying outlets installed in dwelling unit family rooms, dining rooms, living rooms, parlors, libraries, dens, bedrooms, sun rooms, recreation rooms, closets, hallways, or similar rooms will provide an improvement in fire safety in these living areas.

<u>GFCIs:</u> The CPSC staff advocates the implementation of GFCIs as a highly effective means of reducing incidents of electric shock, electrocutions and thermal burns. Evidence of improved electric shock safety is discussed in the report, *An Evaluation of the U.S. Consumer Product Safety Commission's Electrocution Reduction Program* (Garrett, Robert and Kyle, Susan; U.S. CPSC Office of Planning and Evaluation; November 2002).

<u>Tamper-resistant Receptacles:</u> The new requirements in 406.11 for tamper-resistant receptacles will help to reduce the incidence of thermal burn and electric shock incidents that occur to small children and toddlers.

[1] These comments are those of the CPSC staff and have not been reviewed or approved by, and may not necessarily reflect the views of, the Commission.

The CPSC staff urges that the authorities having jurisdiction adopt the 2008 edition of the *NEC* in its entirety as approved by the NFPA Standards Council on July 26, 2007.

Additional information regarding AFCIs, GFCIs, and the *NEC* is available on the CPSC website under voluntary standards and electrical/fire and electrocution safety (http:www.cpsc.gov/volstd/standards.html). Please let me know if we can provide any additional information that might be of assistance to you. We appreciate this opportunity to comment.

Sincerely,

Andrew M. Trotta

"Let the Code Decide"

OHIO CHAPTER

International Association of Electrical Inspectors

Understanding the Cost Impact of the 2008 NEC

The impact of additional Arc-Fault Circuit Interrupters and the new Tamper Resistant Receptacles in the 2008 NEC has prompted controversy driven by the misunderstood cost impact of moving from the 2005 NEC to the 2008 NEC. The NEC provides for the safe use of electricity from fire and shock. Technology over the years has enhanced that protection with minimal cost impact. Circuit breakers protect the home from overloaded circuits to prevent fires and GFCIs are well recognized in the safe use of electricity to protect us and our children from shock hazards. The GFCI entered the home in the 1970s, AFCIs became part of the NEC in the 1999 NEC and the tamper resistant receptacle in the 2008 NEC.

We will show that the impact of adding AFCI protection and Tamper Resistant Receptacles will have minimal impact on affordable housing. Keep in mind the NEC establishes the requirements for the safe electrical operation of a home. Additional circuits that include extra lighting, specific known loads, or a desire to separate circuits for isolation purposes is an additional cost that may be incurred that is once again not driven by the NEC. The additional lighting loads or appliances are not code driven, they are upgrades similar to windows, roofing configuration, or brick vs siding.

This report has been prepared by the following Ohio Chapter Board of Director Members; Oran P. Post, Electrical Inspector for the City of Tallmadge, Ohio and Thomas E. Moore, Electrical Inspector for the City of Beachwood, Ohio and Tim McClintock, Building Official/Electrical Inspector for Wayne County, Ohio. All three Board Members have extensive experience with the code development process.

This report provides an impact statement based entirely on the 2008 NEC requirements for three different homes. The first is a 900 sq ft home to help understand the impact to affordable housing. The other two homes are typical size homes and will include a 1700 sq ft home and a 2100 sq ft home.

The findings are based on prices obtained at a local electrical distributor and other verifiable resources as follows:

Combination AFCI	$36.34
Standard Receptacle	$.50
Tamper Resistant Receptacle	$1.25
Standards GFCI Receptacle	$8.00
Tamper Resistant Receptacle with GFCI	$14.85

Results

900 sqft Home	$160.18 for 900 sq. ft. dwelling unit or $.18/sq. ft.
1700 sqft Home	$205.27 for 1700 sq. ft. dwelling unit or $.12/sq. ft.
2100 sqft Home	$241.36 for 2100 sq. ft. dwelling unit or $.11 /sq. ft

The 2008 NEC impact is minimal at less than a 20 cents per sq ft.

Respectfully,

Jack Jamison, President

*Cost Analysis for a new dwelling based on the minimum 2008 NEC requirements (900 Sq ft)

2008 NEC Code Section	Description of Code Requirement	Total Required Branch Circuit/Devices	Cost per 2005 NEC	Cost per 2008 NEC	Cost Difference
	GENERAL LIGHTING LOADS				
220.12, Table 220.12 & 220.14(J)	900 sq. ft. X 3VA = 2700 VA/120 Volts = 22.5 Amps = 1.5 or 2 circuits. 2 general purpose 15 Ampere circuits which includes family rooms, dining rooms, living rooms, parlors, libraries, dens, bedrooms, sunrooms, recreation rooms, closets, hallways, or similar rooms or areas is required.	2	$3.25	$36.34	$33.09
			$25.00[1]	$36.34	$11.34
	DINING ROOM				
210.52(A), 220.12, 220.14(J)	210.12(B) requires the dining room outlets to be protected by an arc fault circuit interrupter. 210.52(B)(1) requires this circuit to be on a 20 ampere circuit.	1	$3.25	$36.34	$33.09
	KITCHEN				
210.52(C), 210.11(C)(1), 220.14(J), & 406.11	2 Kitchen small appliance branch circuits supplying 2 Tamper Resistant GFCI Receptacles serving the kitchen countertop.	2	$8.00	$14.85	$13.70
210.52(C), 210.11(C)(1), 220.14(J), & 406.11	2 Kitchen small appliance branch circuits supplying 6 Tamper Resistant receptacles located as required by 210.52(B)(1)	6	$.50	$1.25	$4.50
	BATHROOM				
210.52(D), 210.11(C)(3), 220.14(J), & 406.11	1 Tamper Resistant GFCI recptacle required for bathroom	1	$8.00	$14.85	$6.85
	GARAGES				
210.52(G), 220.14(J), & 406.11	1 Tamper Resistant GFCI receptacles required for attached garages & unattached garages with power.	1	$8.00	$14.85	$6.85
	OUTDOOR & BASEMENT RECEPTACLES				
210.52(E), 220.14(J), & 406.11	2 Tamper Resistant/Weather Resistant receptacles (front & rear of Dwelling)	2	$.50	$7.03	$13.06[2]
210.52(G), 220.14(J), & 406.11	1 Tamper Resistant GFCI required for unfinished basements	1	$8.00	$14.85	$6.85
	LAUNDRY				
210.52(F), 210.11(C)(2), 220.14(J), & 406.11	1 Tamper Resistant GFCI Installed for the Laundry within 6 feet of laundry sink	1	$8.00	$14.85	$6.85
	GENERAL PROVISION RECEPTACLE OUTLETS				
210.52(A), 220.12, 220.14(J), & 406.11	which includes family rooms, dining rooms, living rooms, parlors, libraries, dens, bedrooms, sunrooms, recreation rooms, closets, hallways, or similar rooms or areas	32	$.50	$1.25	$24.00
				TOTAL	**$160.18**

Footnotes

1. Standard AFCI breakers as required by the 2005 NEC
2. Alternative method protecting outdoor receptacles fed from basement GFCI receptacle

This analysis is based on 2-wire home runs for branch circuits. The following consists of alternative wiring methods and their respective prices;
250ft NM-B-14/2/2-CU-WG............$114.66
250ft NM-B-14/3-CU-WG...............$75.87
250ft NM-B-14/2-CU-WG.................$54.13

$160.18 for 900 sq. ft. dwelling unit is a cost of $.18/sq. ft.
Not a whole lot to pay for safety!
Any extra wiring or devices above and beyond this is the choice of the builder and not mandated by the NEC.
***Prices obtained from Leff Electric Supply (see attached quote), Lowes, & Home Depot**

*Cost Analysis for a new dwelling based on the minimum 2008 NEC requirements (1700 Sq ft)

2008 NEC Code Section	Description of Code Requirement	Total Required Branch Circuit/Devices	Cost per 2005 NEC	Cost per 2008 NEC	Cost Difference
	GENERAL LIGHTING LOADS				
220.12, Table 220.12 & 220.14(J)	1700 sq. ft. X 3VA = 5100 VA/120 Volts = 42.5/15 Amps = 2.8 or 3 circuits. 2 general purpose 15 Ampere circuits which includes family rooms, dining rooms, living rooms, parlors, libraries, dens, bedrooms, sunrooms, recreation rooms, closets, hallways, or similar rooms or areas is required.	3	$3.25	$36.34	$66.18
			$25.00[1]	$36.34	$11.34
	DINING ROOM				
210.52(A), 220.12, 220.14(J)	210.12(B) requires the dining room outlets to be protected by an arc fault circuit interrupter. 210.52(B)(1) requires this circuit to be on a 20 ampere circuit.	1	$3.25	$36.34	$33.09
	KITCHEN				
210.52(C), 210.11(C)(1), 220.14(J), & 406.11	2 Kitchen small appliance branch circuits supplying 2 Tamper Resistant GFCI Receptacles serving the kitchen countertop.	2	$8.00	$14.85	$13.70
210.52(C), 210.11(C)(1), 220.14(J), & 406.11	2 Kitchen small appliance branch circuits supplying 8 Tamper Resistant receptacles located as required by 210.52(B)(1)	6	$.50	$1.25	$6.00
	BATHROOM				
210.52(D), 210.11(C)(3), 220.14(J), & 406.11	1 Tamper Resistant GFCI recptacle required for bathroom	1	$8.00	$14.85	$6.85
	GARAGES				
210.52(G), 220.14(J), & 406.11	1 Tamper Resistant GFCI receptacles required for attached garages & unattached garages with power.	1	$8.00	$14.85	$6.85
	OUTDOOR & BASEMENT RECEPTACLES				
210.52(E), 220.14(J), & 406.11	2 Tamper Resistant/Weather Resistant receptacles (front & rear of Dwelling)	2	$.50	$7.03	$13.06[2]
210.52(G), 220.14(J), & 406.11	1 Tamper Resistant GFCI required for unfinished basements	1	$8.00	$14.85	$6.85
	LAUNDRY				
210.52(F), 210.11(C)(2), 220.14(J), & 406.11	1 Tamper Resistant GFCI Installed for the Laundry within 6 feet of laundry sink	1	$8.00	$14.85	$6.85
	GENERAL PROVISION RECEPTACLE OUTLETS				
210.52(A), 220.12, 220.14(J), & 406.11	which includes family rooms, dining rooms, living rooms, parlors, libraries, dens, bedrooms, sunrooms, recreation rooms, closets, hallways, or similar rooms or areas	46	$.50	$1.25	$34.50
				TOTAL	**$205.27**

Footnotes

1. Standard AFCI breakers as required by the 2005 NEC
2. Alternative method protecting outdoor receptacles fed from basement GFCI receptacle

This analysis is based on 2-wire home runs for branch circuits. The following consists of alternative wiring methods and their respective prices;
250ft NM-B-14/2/2-CU-WG............$114.66
250ft NM-B-14/3-CU-WG...............$75.87
250ft NM-B-14/2-CU-WG.................$54.13

$205.27 for 1700 sq. ft. dwelling unit is a cost of $.12/sq. ft.
Not a whole lot to pay for safety!
Any extra wiring or devices above and beyond this is the choice of the builder and not mandated by the NEC.
***Prices obtained from Leff Electric Supply (see attached quote), Lowes, & Home Depot**

*Cost Analysis for a new dwelling based on the minimum 2008 NEC requirements (2100 Sq ft)

2008 NEC Code Section	Description of Code Requirement	Total Required Branch Circuit/Devices	Cost per 2005 NEC	Cost per 2008 NEC	Cost Difference
	GENERAL LIGHTING LOADS				
220.12, Table 220.12 & 220.14(J)	2100 sq. ft. X 3VA = 6300 VA/120 Volts = 52.5/15 Amps = 3.5 or 4 circuits. 2 general purpose 15 Ampere circuits which includes family rooms, dining rooms, living rooms, parlors, libraries, dens, bedrooms, sunrooms, recreation rooms, closets, hallways, or similar rooms or areas is required.	4	$3.25	$36.34	$99.27
			$25.00[1]	$36.34	$11.34
	DINING ROOM				
210.52(A), 220.12, 220.14(J)	210.12(B) requires the dining room outlets to be protected by an arc fault circuit interrupter. 210.52(B)(1) requires this circuit to be on a 20 ampere circuit.	1	$3.25	$36.34	$33.09
	KITCHEN				
210.52(C), 210.11(C)(1), 220.14(J), & 406.11	2 Kitchen small appliance branch circuits supplying 2 Tamper Resistant GFCI Receptacles serving the kitchen countertop.	2	$8.00	$14.85	$13.70
210.52(C), 210.11(C)(1), 220.14(J), & 406.11	2 Kitchen small appliance branch circuits supplying 8 Tamper Resistant receptacles located as required by 210.52(B)(1)	6	$.50	$1.25	$6.00
	BATHROOM				
210.52(D), 210.11(C)(3), 220.14(J), & 406.11	1 Tamper Resistant GFCI recptacle required for bathrooms	2	$8.00	$14.85	$6.85
	GARAGES				
210.52(G), 220.14(J), & 406.11	1 Tamper Resistant GFCI receptacles required for attached garages & unattached garages with power.	1	$8.00	$14.85	$6.85
	OUTDOOR & BASEMENT RECEPTACLES				
210.52(E), 220.14(J), & 406.11	2 Tamper Resistant/Weather Resistant receptacles (front & rear of Dwelling)	2	$.50	$7.03	$13.06[2]
210.52(G), 220.14(J), & 406.11	1 Tamper Resistant GFCI required for unfinished basements	1	$8.00	$14.85	$6.85
	LAUNDRY				
210.52(F), 210.11(C)(2), 220.14(J), & 406.11	1 Tamper Resistant GFCI Installed for the Laundry within 6 feet of laundry sink	1	$8.00	$14.85	$6.85
	GENERAL PROVISION RECEPTACLE OUTLETS				
210.52(A), 220.12, 220.14(J), & 406.11	which includes family rooms, dining rooms, living rooms, parlors, libraries, dens, bedrooms, sunrooms, recreation rooms, closets, hallways, or similar rooms or areas	50	$.50	$1.25	$37.50
				TOTAL	**$241.36**

Footnotes

1. Standard AFCI breakers as required by the 2005 NEC
2. Alternative method protecting outdoor receptacles fed from basement GFCI receptacle

This analysis is based on 2-wire home runs for branch circuits. The following consists of alternative wiring methods and their respective prices;
250ft NM-B-14/2/2-CU-WG...........$114.66
250ft NM-B-14/3-CU-WG..............$75.87
250ft NM-B-14/2-CU-WG..............$54.13

$241.36 for 2100 sq. ft. dwelling unit is a cost of $.11/sq. ft.
Not a whole lot to pay for safety!
Any extra wiring or devices above and beyond this is the choice of the builder and not mandated by the NEC.
***Prices obtained from Leff Electric Supply (see attached quote), Lowes, & Home Depot**

Residential Building Electrical Fires

These short topical reports are designed to explore facets of the U.S. fire problem as depicted through data collected in USFA's National Fire Incident Reporting System (NFIRS). Each topical report briefly addresses the nature of the specific fire or fire-related topic, highlights important findings from the data, and may suggest other resources to consider for further information. Also included are recent examples of fire incidents that demonstrate some of the issues addressed in the report or that put the report topic in context.

Findings

- **Annually, an estimated 28,300 residential building electrical fires cause 360 deaths, 1,000 injuries, and $995 million in direct loss.**
- **Fifteen percent of residential building electrical fires start in bedrooms.**
- **Nearly half (47%) of the residential building electrical fires where equipment was involved were caused by the building's wiring.**
- **Twenty-two percent of residential building electrical fires occur during December and January.**

Electricity is a basic part of residential life in the United States. It provides the energy for most powered items in a contemporary home, from lights to heating systems to televisions. Today it is hard to imagine a residence without electricity. It is a part of our homes and our activities that most of us take for granted. We rarely think how powerful electricity is.

Yet, using electricity can have dangerous consequences. Electrical fires are pervasive throughout the United States, causing injury, claiming lives, and resulting in large losses of property. Faulty electrical systems cause many fires. Even more electrical fires result from inappropriate wiring installations, overloaded circuits, and extension cords. Based on the latest available data for 2003 to 2005, an estimated 28,300 residential building electrical fires occur annually and cause 360 deaths, 1,000 injuries, and losses of $995 million.[1,2,3] Electrical fires accounted for 7% of all residential building fires in this 3-year period.

Fire Rates Attributed to Residential Electrical Building Fires

Electrical fires in residential buildings result in more damage and higher death rates per 1,000 fires on average than nonelectrical residential fires (Table 1). Dollar loss per fire for residential building electrical fires is more than double that for nonelectrical residential building fires; deaths per 1,000 fires is about 70% higher for residential building electrical fires. The injury rates resulting from residential building electrical and nonelectrical fires, however, are roughly the same, at 28 to 29 injuries per 1,000 fires.

Table 1. Loss Measures for Residential Building Electrical Fires (3-year average, 2003-2005).

Loss Measure	Residential Building Electrical Fires	All Nonelectrical Residential Building Fire Causes
Loss per fire	$25,126	$10,635
Injuries per 1,000 fires	28.5	28.2
Deaths per 1,000 fires	6.3	3.7

Source: NFIRS 5.0

Note: Loss per fire is computed only for those fires where loss and cause information was available.

The Electrical Fire Problem

Despite their prevalence, electrical fires are not always noted as such. When fire is severe, it can be difficult, for example, to discern whether an electric appliance started the fire or if a poorly wired plug was the cause. Heat-producing electrical equipment (e.g., hair dryers, portable heaters, cooking

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appliances, and the like) tend to use more power than other electrical equipment. Devices like these may overload a circuit, especially one that is already reaching its maximum amperage allowance. Coupled with a faulty circuit breaker, this overload can cause the products to overheat and possibly to catch fire. Moreover, electrical fires that start in walls can smolder for some time. By the time the fire is detected, most likely it already has spread within the walls, unseen. There are over three times more residential building electrical fires than nonresidential building electrical fires, so the problem is particularly important for each of us in our homes.

Electrical fires can be particularly tricky to put out. Since they involve electricity, and water conducts electricity, using water to put out the fire can cause electrocution. Chemical powders can cause the fire to smolder rather than extinguish, setting the stage to reignite. Turning power off to the residence is an important step, if it is possible to do so.

While new construction is not immune from electrical fires caused by faulty wiring, there are many older homes with outdated wiring that is deteriorating, inappropriately amended, or insufficient for the electrical loads of a typical household in the 21st Century.

According to Underwriters Laboratories (UL), over 30 million homes—more than one-third of all U.S. housing—are more than 50 years old.[4] Consider the expansion in the number of appliances used by residents in the past half-century, and it is quickly obvious that overloaded wiring and circuitry is likely in these structures. Overloading will heat up wiring that already could be deteriorating, crumbling, and no longer a good insulator.

Just how big this problem is remains to be seen. The Residential Electrical System Aging Research project was launched by the Fire Protection Research Foundation to study how the age of wiring, outlets, junctions, and other connectors affects the pattern of electrical fires in homes.[5,6] One objective of the study is to make improvements to the National Electrical Code® (NEC) (National Fire Protection Association (NFPA) 70) and through the building codes adopted by local and State jurisdictions around the country. Already, changes in wiring practices dictated by better electrical codes and the required use of smoke alarms have made new construction safer.[7]

Residents demand higher levels of electrical energy to power their homes and appliances than they did in the past, and new homes are built to meet this demand for multiple televisions, phones, hairdryers, microwaves, washers and dryers, etc. As the consumers' electrical demands increase, so does their expectation that their homes will supply adequate power to meet these. They meet their needs by adding more circuitry (and circuit breakers in blank spots on the breaker panel, or even another circuit breaker box) and outlets to accommodate their purchases. If an outlet is added to an existing circuit, then the load easily can be more than the wiring originally was designed to conduct—perhaps decades ago.[8]

What these consumers really do is create unseen hazards in their homes. Inside the walls, wiring is heating and damaging its own insulation, wood frames are being charred by high-wattage light bulbs too close to ceilings, and fixture wattage ratings are being exceeded. But as long as the lights come on and the appliances start, the consumer remains unaware of the danger—until a fire starts.[9]

Where Residential Building Electrical Fires Occur

The functional and structural areas of the home are the most likely to experience electrical fires (Figure 1). Included in the functional category are bedrooms, dining rooms, kitchens, bathrooms, laundry areas, and the like. Fifteen percent of residential building electrical fires start in a bedroom (Table 2). The bedroom also is the leading area of fire origin for fires with injuries and dollar loss—bedrooms account for 30% of residential building electrical fires that result in injuries and 16% of residential building electrical fires that result in dollar loss. Structural areas of the home include areas such as crawl spaces, attics, walls, porches, and roofs. Attics, the second leading area of fire origin, account for 11% of residential building electrical fires. Over a quarter of all residential electrical fires start in these two areas. While fewer residential electrical fires start in lounge areas (family rooms, living rooms, and the like), these fires result in nearly a third of the deaths (31%).

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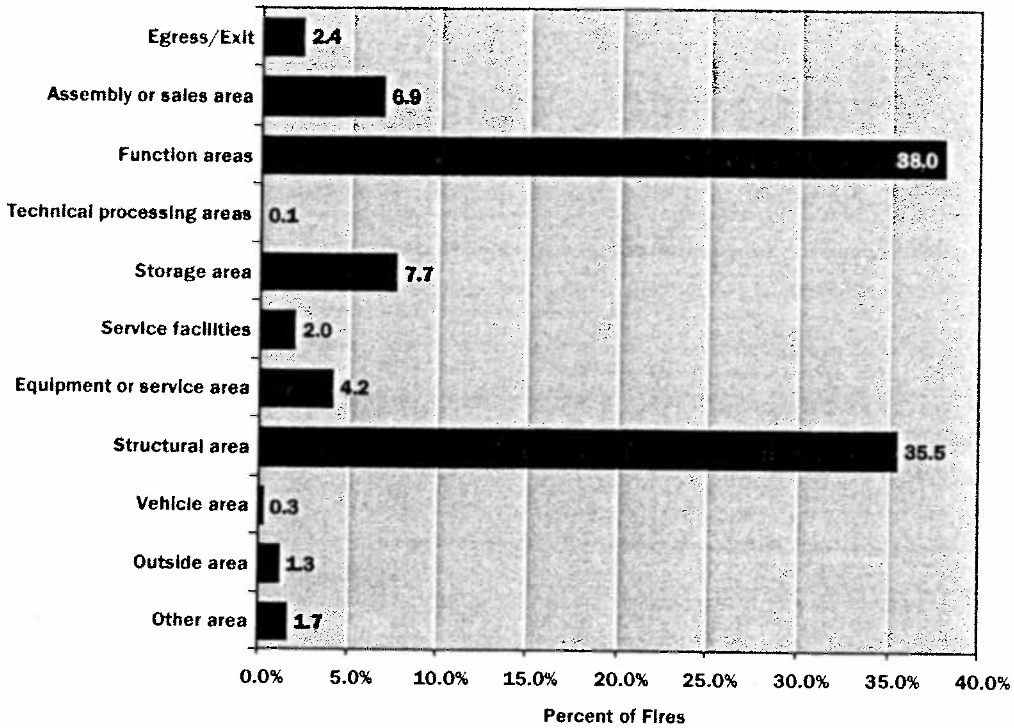
Figure 1. General Area of Fire Origin in Residential Building Electrical Fires, 2003–2005.



Source: NFIRS 5.0
Note: Percentages may not equal 100 due to rounding.

Table 2. Leading Area of Fire Origin in Residential Building Electrical Fires, 2003–2005 (fire-based).

Area of Fire Origin	Fires	Fires with... Deaths	Injuries	Dollar Loss
Bedroom for fewer than 5 people	15.1%	16.6%	29.6%	16.0%
Attic: vacant, crawl space above top story	11.3%	—	—	11.6%
Cooking area, kitchen	9.4%	6.4%	6.2%	9.0%
Wall assembly, concealed wall space	8.4%	5.7%	5.9%	8.2%
Common room, den, family room, living room, lounge	6.8%	31.2%	13.9%	7.1%
Function areas, other	—	8.3%	6.6%	—

Source: NFIRS 5.0

What Ignites

By far, building structural components is the largest category of items first ignited in residential building electrical fires (Figure 2). Structural components include structural member or framing, insulation, trim, wall coverings, flooring, and the like. Of these components, structural framing (usually wood) accounts for 17% of residential electrical fires (Table 3). Insulation and interior and exterior wall coverings (e.g., paneling, wallpaper, siding) account for an additional 18% of residential electrical fires. However, the leading item first ignited in residential electrical fires is the insulation around electrical wires and cables. At 30% of residential electrical fires, it accounts for nearly the entire general materials category.

Together, insulation around electrical wires and structural member/framing account for 38% of all deaths from fires in residential buildings.

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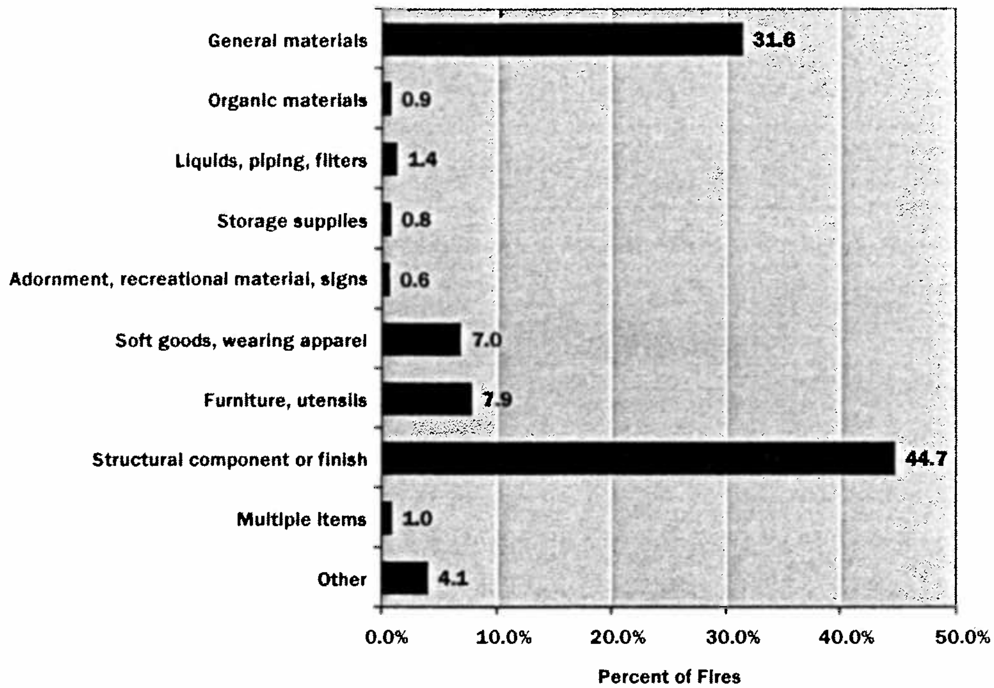
Figure 2. General Items First Ignited in Residential Building Electrical Fires, 2003–2005.



Source: NFIRS 5.0
Note: Percentages may not equal 100 due to rounding.

Table 3. Leading Items First Ignited, Electrical Fires, 2003–2005.

Item First Ignited	Percent of Fires
Electrical wire, cable insulation	30.2%
Structural member or framing	17.1%
Thermal, acoustical insulation within wall, partition, or floor/ceiling space	7.0%
Interior wall covering excluding drapes, etc.	6.5%
Exterior sidewall covering, surface, finish	4.7%

Source: NFIRS 5.0

When Residential Building Electrical Fires Occur

Heating, lighting, and cooking activities are highest in winter and so, too, are the occurrence of indoor fires stemming from electrical problems. Throughout most of the year, the pattern of residential electrical fires is consistent, but occurrences peak in December and January, accounting for 22% of all such fires (Figure 3). In the winter months, the relative humidity within the walls of a typical home can be very, very low and can turn wood wall framing into kindling, easily ignited by an arcing current. Fire deaths also are high in these months, but March and October, still dry months, both have similar peaks. Summertime has the lowest incidence of deaths resulting from electrical fires in the home. Figure 4 shows that late afternoon and evening are the most likely time for electrical fires to occur in residences. But it is the hours before dawn, between 3 and 6 in the morning, when deaths are most frequent.

Equipment Involved in Residential Building Electrical Fires

Wiring and electrical components have a life expectancy that does not always equal the life cycle of the building. As the electrical equipment wear out, fires are more probable. Electrical wiring with its various components is by far the major culprit in residential building electrical fires. Lamps and other lighting and cords and plugs also present severe problems (Figure 5).

Fire Spread

Most residential building fires are confined to the object of origin (62%) with 38% of fires spreading through the residence and beyond (Figure 6). Fire spread from residential building electrical fires, however, has nearly the opposite

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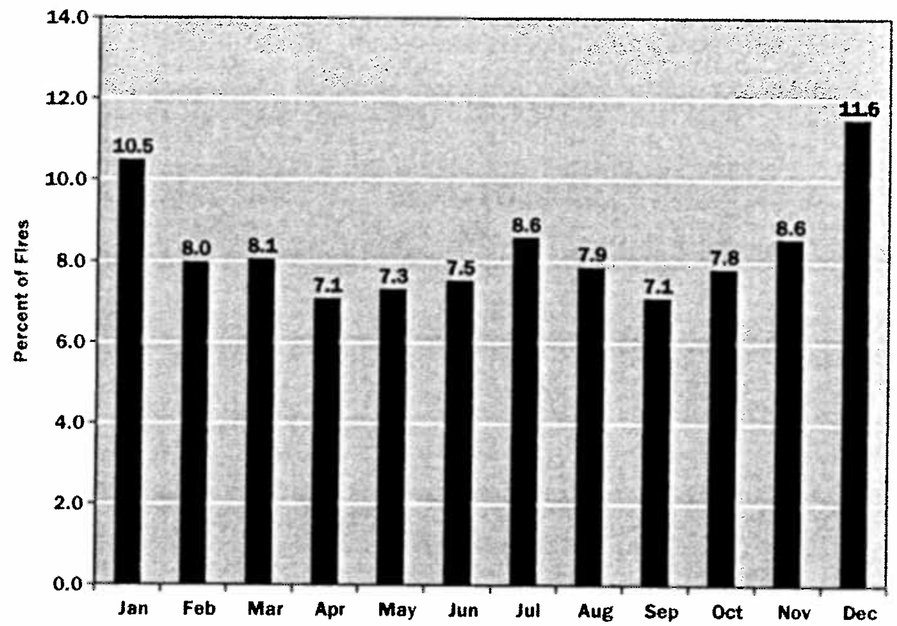
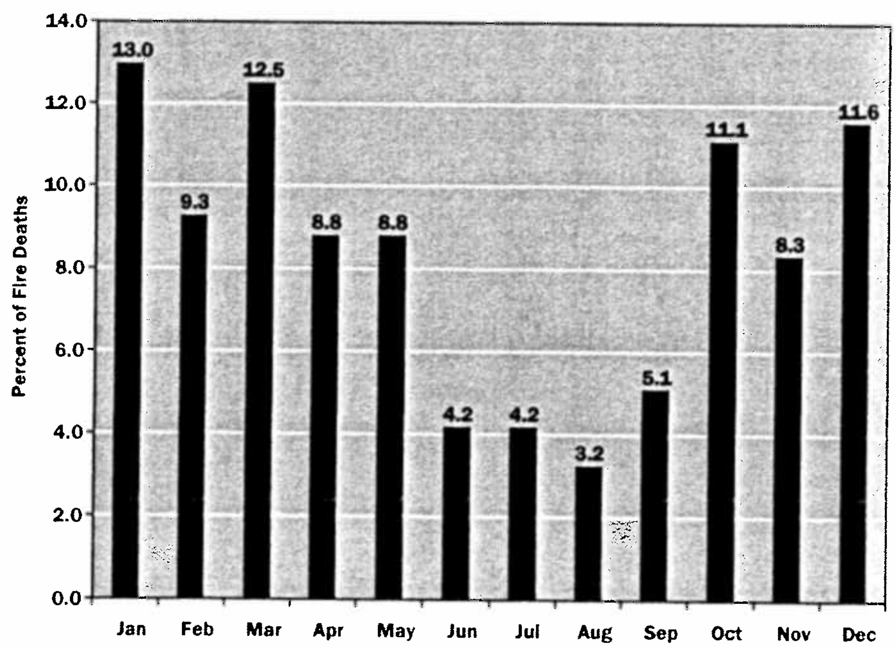
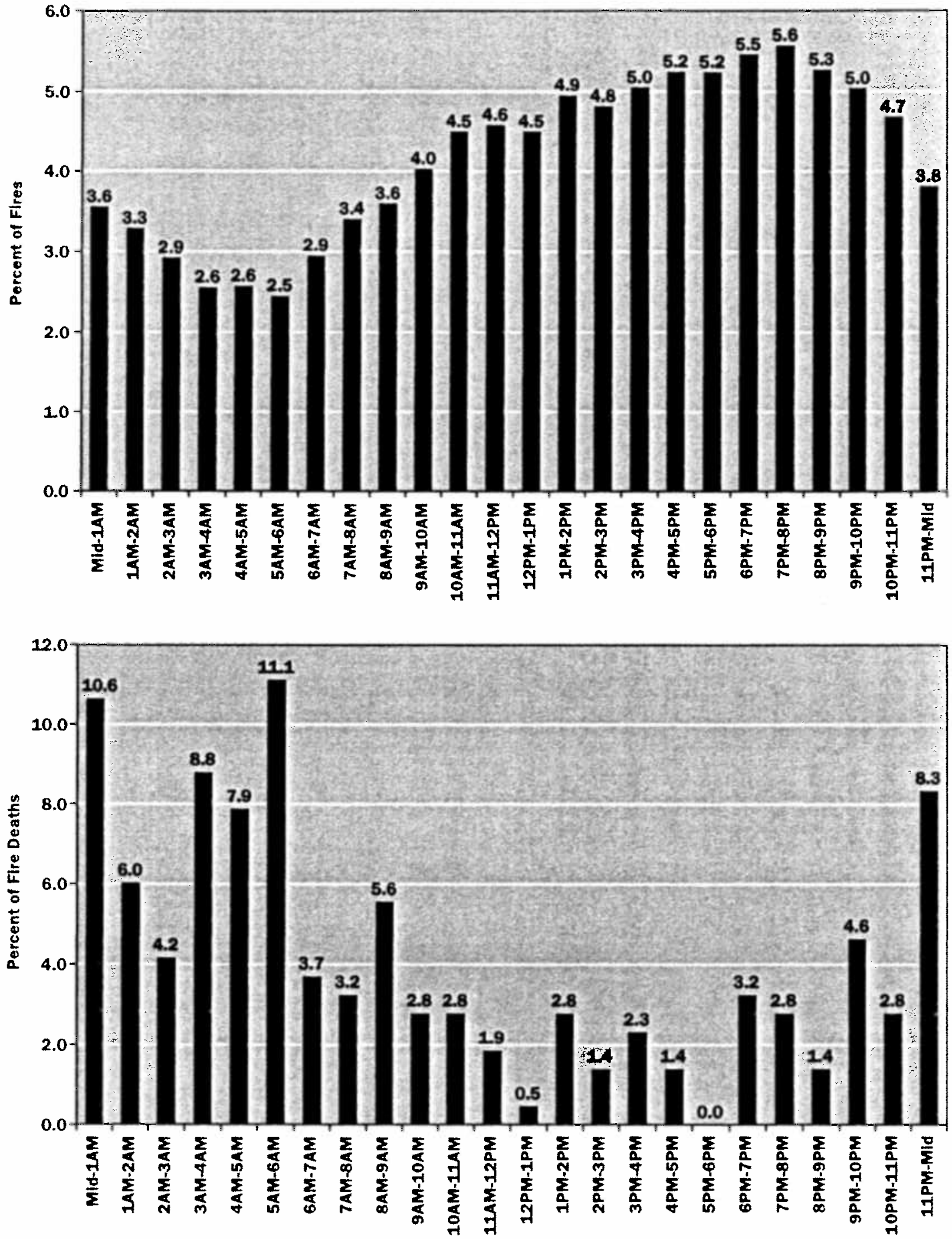
Figure 3. Month of Occurrence for Residential Building Electrical Fires and Fire Deaths, 2003–2005.





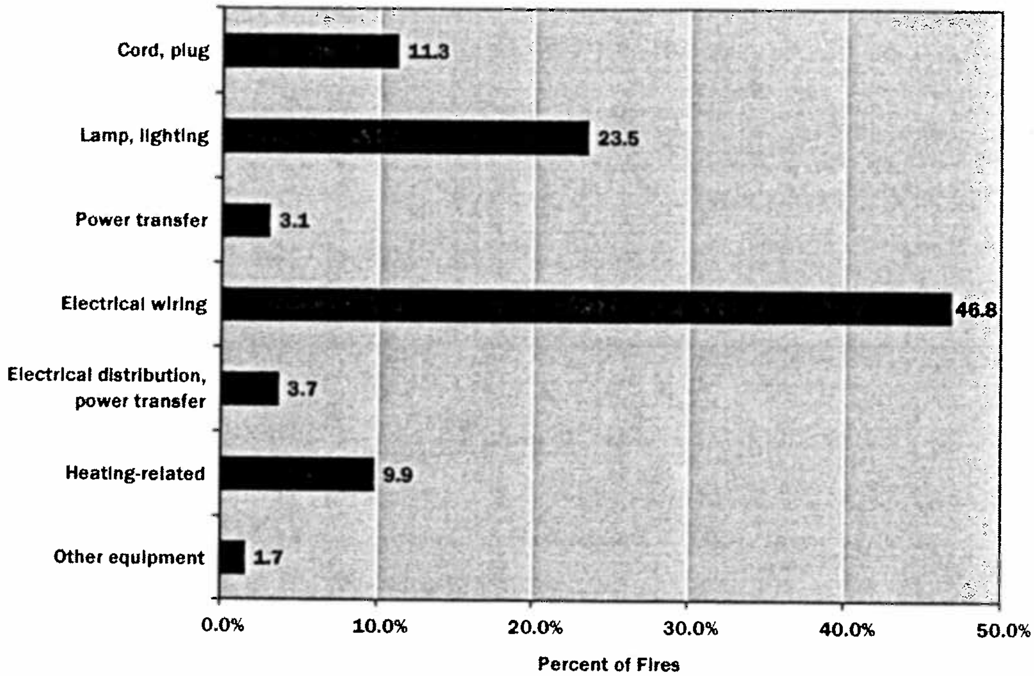
Source: NFIRS 5.0
Note: Percentages may not equal 100 due to rounding

Figure 4. Alarm Time for Residential Building Electrical Fires and Fire Deaths, 2003–2005.



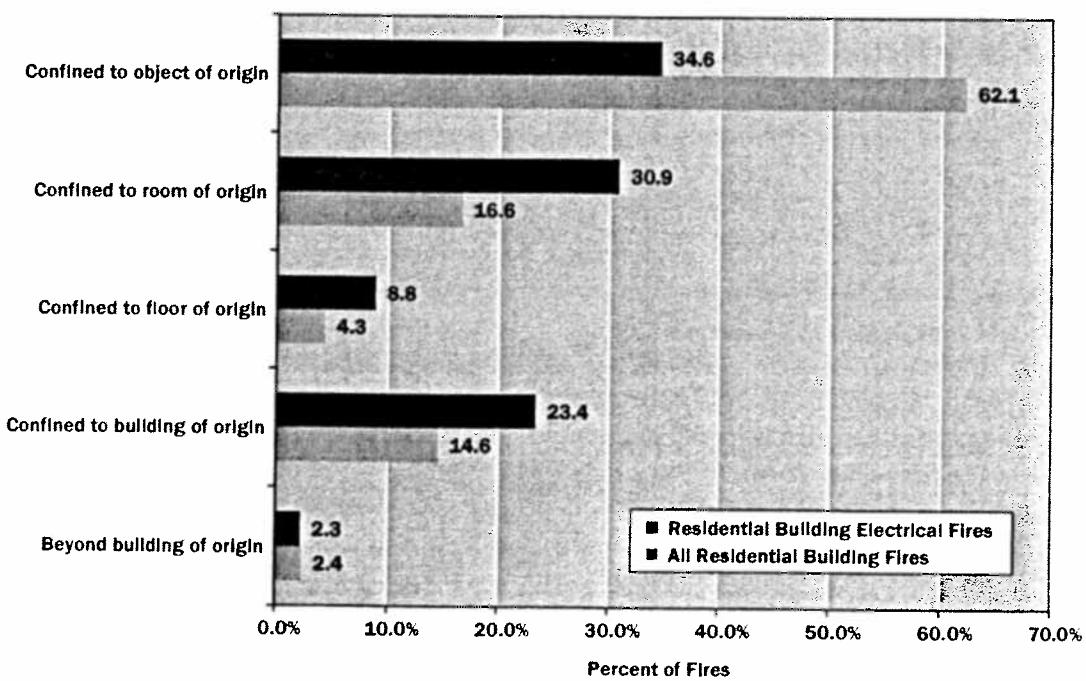
Source: NFIRS 5.0
Note: Percentages may not equal 100 due to rounding.

Figure 5. General Equipment Involved in Ignition in Residential Building Electrical Fires, 2003–2005.



Source: NFIRS 5.0

Figure 6. Fire Spread in Residential Building Electrical Fires, 2003–2005.



Source: NFIRS 5.0

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profile—these electrical fires are more likely to spread throughout the home. Sixty-five percent of residential building electrical fires spread beyond the initial object that started the fire. Structural members and framing contribute most to flame spread (27%).

Leading Factors Contributing to Residential Building Electrical Fires

Not surprisingly, when a factor was noted as contributing to ignition, some type of electrical failure accounted for 89% of electrical fires in residential buildings. The four leading specific factors, all electrical issues, account for 81% of these electrical failures (Table 4).

Table 4. Leading Factors Contributing to Ignition, Electrical Fires, 2003–2005.

Factor Contributing to Ignition	Percent of Fires
Electrical failure, malfunction, other	35.4%
Unspecified short-circuit arc	26.0%
Short-circuit arc from defective, worn insulation	15.1%
Arc from faulty contact, broken conductor	4.4%
Mechanical failure, malfunction, other	3.8%

Source: NFIRS 5.0

Electrical Safety Devices

Arc Fault Circuit Interrupters (AFCI) or Arc Fault Interrupters (AFI) and Ground Fault Circuit Interrupters (GFCI) or Ground Fault Interrupters (GFI) perform different jobs.[10] A GFCI protects you from electrical shock. An AFCI breaker protects you and your house from a fire caused by electrical arcs.[11,12]

GFCIs traditionally meet the standard for protecting against electric shock. GFCIs were first implemented as an electrical code requirement in the early 1970s for bathroom outlets. Over time, GFCIs have become required in other areas likely to pose a risk for shock, especially those in potentially wet locations such as kitchens, unfinished basements, garages, outdoors, Jacuzzis, and hot tubs. Although GFCIs are designed to protect people from electrocution, they are not designed to protect against house fires.

AFCIs identify arcing at cords, outlets, and lights and trip breakers before the arcing can start a fire. AFCIs recently became a requirement for bedrooms in new construction by the NEC in use in many local and State jurisdictions. This technology is better suited for new homes with updated wiring rather than older homes where the grounding for wiring is questionable.

Examples

The following recent examples illustrate typical residential building electrical fire scenarios:

> July 2007, Havre, MT: A family lost all of their personal belongings in an electrical fire. The fire, which officials said originated in one of the wall outlets, consumed an 8' x 14' bedroom and its contents. Fire or smoke was not seen although a family member smelled something burning. Bedrooms were checked and, in the corner of one, was a fire. "At first it started small but it went up fast," the young woman observed.[13]

> November 2007, Newton, KS: A malfunction in the electric distribution system was determined to be the cause of an apartment complex fire that sent three people to the hospital. The fire originated in an electric box on the outside of the building near the stairwell.[14]

> December 2007, Salem, OR: Fire blamed on a worn extension cord extensively damaged a house in Salem, OR. Fire investigators noted the fire was caused by an extension cord that had been pinched under the corner of a couch. The investigators expected the house to be a total loss.[15]

Conclusion

While the source of an electrical fire can be hard to determine, some known culprits—overloading circuits with heat producing equipment, for example—can lead to items such as the insulation around electrical wires and cables catching fire, either slowly or immediately. With over three times more residential building electrical fires than nonresidential building electrical fires, it is important to ensure that the electrical panels, outlets, switches, and junction boxes in your home are correctly installed and not damaged or modified by unlicensed electricians. Do not use extension cords and multiple plug-in devices as a replacement for new circuits. Since 15% of residential building electrical fires start in a bedroom, upgrade bedrooms with AFIs where possible.

Never use water on suspected electrical fires, and inform your local fire department when you call 9-1-1 that you presume the fire to be electrical.

Notes:

[1] NFIRS 5.0 contains both converted NFIRS 4.1 data and native NFIRS 5.0 data. This topical report includes only native 5.0 data and excludes incident type '110', since it is a 4.1 conversion code.

[2] National estimates are based on 2003 to 2005 native version 5.0 data from the National Fire Incident Reporting System (NFIRS) and residential structure fire loss estimates from the National Fire Protection Association's (NFPA) annual survey of fire loss. Fires are rounded to the nearest 100, deaths to the nearest 5, injuries to the nearest 25, and loss to nearest $M.

[3] In NFIRS 5.0, a structure is a constructed item of which a building is one type. The term "residential structure" commonly refers to buildings where people live. The definition of a residential structure fire has, therefore, changed to include only those fires where the NFIRS 5.0 structure type is 1 or 2 (enclosed building and fixed portable or mobile structure) with a residential property use. Such fires are referred to as "residential buildings" to distinguish these buildings from other structures on residential properties that may include fences, sheds, and other uninhabitable structures. In addition, incidents that have a residential property use, but do not have a structure type specified are presumed to be buildings.

[4] "Drawing Wisdom from the Wall," http://www.ul.com/newsroom/wiring/index.html

[5] Ibid.

[6] Rasdall, Joyce, "Aging Residential Wiring Issues: Concerns for Fatalities, Personal Injuries, and Loss of Property," Education Presentation, Annual Household Equipment Technical Conference, Louisville, KY, Oct. 26-28, 2005, http://www.esfi.org/educators/documents/AheeAgingResidentialWiringIssues5-05.pdf

[7] Ibid.

[8] Ibid.

[9] "Drawing Wisdom from the Wall," http://www.ul.com/newsroom/wiring/index.html

[10] AFCIs also are known as Arc Fault Interrupters (AFI). GFCIs also are known as Ground Fault Interrupters (GFI).

[11] Consumer Product Safety Commission, GFCI Fact Sheet, http://www.cpsc.gov/cpscpub/pubs/99.html

[12] Consumer Product Safety Commission, AFCI Fact Sheet, http://www.cpsc.gov/CPSCPUB/PUBS/afcifac8.PDF

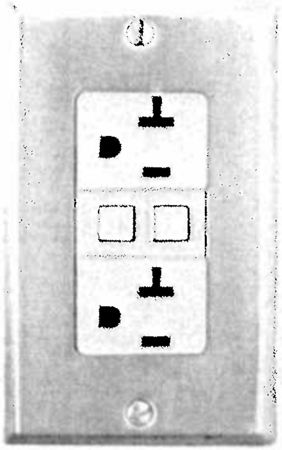
[13] "Electrical fire consumes family belongings," Elizabeth Doney, *Havre Daily News*, (Havre, MT), http://www.havredailynews.com/articles/2007/08/07/local_headlines/local.txt

[14] "Accident ruled cause of Nov. 18 blaze," The Kansan.com, http://www.thekansan.com/stories/112707/topstories_112707008.shtml

[15] "Extension cord blamed for fire," Statesman Journal (Salem, OR), http://www.statesmanjournal.com/apps/pbcs.dll/article?AID=/20071213/NEWS/712130324

WHAT IS THE DIFFERENCE BETWEEN A GROUND FAULT AND AN ARC FAULT?

There is a major difference between the functioning of an AFCI as compared to a GFCI (Ground Fault Circuit Interrupter). The function of the GFCI is to protect people from the deadly effect of electric shock that could occur if parts of an electrical appliance or tool become energized due to a ground fault. The function of the AFCI is to protect the branch circuit wiring from dangerous arcing faults that could initiate an electrical fire.



AFCI and GFCI technologies can co-exist with each other and are a great complement for the most complete protection that can be provided on a circuit.

IT'S ALL ABOUT SAFETY

Smoke alarms, fire extinguishers and escape ladders are all examples of emergency equipment used in homes to take action when a fire occurs. AFCIs are products designed to detect a wide range of arcing electrical faults to help reduce the electrical system from being an ignition source of a fire. Conventional overcurrent protective devices do not detect low level hazardous arcing currents that have the potential to initiate electrical fires.

AFCIs are the next generation product in electrical circuit protection. As you evaluate your new home's construction or consider upgrading or remodeling your current electrical system, consider enhancing the protection of your electrical system with AFCI.

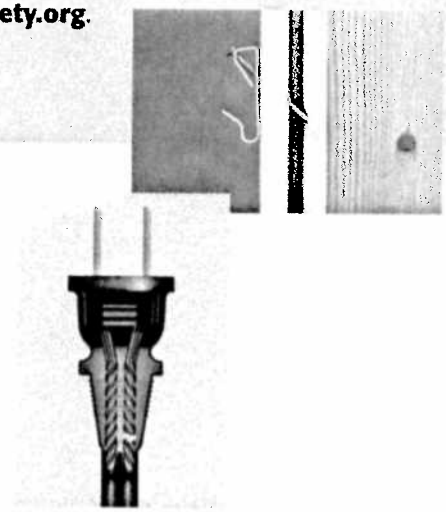
NEMA AND ELECTRICAL SAFETY

For more than 80 years, manufacturers of low voltage distribution equipment have been working to ensure public safety by standards writing efforts and the dissemination of important industry information through the National Electrical Manufacturers Association (NEMA), one of the most respected standards development organizations in the world.

Headquartered in Rosslyn, Virginia, NEMA has approximately 400 electroindustry companies, including large, medium and small businesses.

To learn more about NEMA visit **www.nema.org**.

To learn more about AFCIs, visit our AFCI web site at **www.afcisafety.org**.

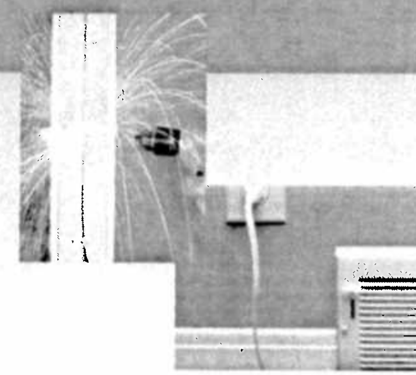


NEMA

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION
Low Voltage Distribution Equipment Section

1300 North 17th Street, Suite 1752 • Rosslyn, Virginia 22209
(703) 841-3200 Fax: (703) 841-5900
www.nema.org

arc faults and electrical safety



PROTECTING HOMES & FAMILIES FROM ELECTRICAL FIRES WITH ADVANCED TECHNOLOGY

NEMA

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION
Low Voltage Distribution Equipment Section

ELECTRICAL FIRES KILL THOUSANDS EVERY YEAR

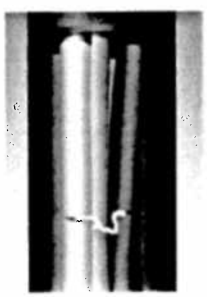
According to the U.S. Fire Administration,[*] home electrical problems accounted for an estimated 67,800 fires and $868 million in property losses in 2003. Electrical fires also cause an estimated 485 deaths annually and injure almost 2,300 more individuals.

Electrical fires can be caused by a number of failures. Appliance defects or misuse, incorrectly installed wiring, or misapplied extension cords can lead to electrical hazards.

In 1992, the Consumer Product Safety Commission (CPSC) contracted with Underwriters Laboratories (UL) to provide research and evaluation of products and technology that could reduce the likelihood of residential fires. A result of the research, UL identified an electrical hazard called "arcing faults" that could eventually lead to the ignition of a fire as one possible cause of residential fires.

WHAT IS AN ARC FAULT?

Most people are familiar with the term arcing. Arcing may be intended, such as with an arc welder or unintended, such as when a tree falls on a power line during a storm creating a current discharge between conductors or to ground.



An arc fault is an unintended arc created by current flowing through an unplanned path. Arcing creates high intensity heating at the point of the arc resulting in burning particles that may easily ignite surrounding material, such as wood framing or insulation. The temperatures of these arcs can exceed 10,000 degrees Fahrenheit.

[*]USFA. 2006. "On the Safety Circuit: A Factsheet on Home Electrical Fire Prevention." U.S. Fire Administration.

HOW ARE ARCING FAULTS DETECTED?

Traditional overcurrent protective devices cannot detect these types of arcs. The capability now exists to detect many of these arcing conditions and disconnect the problem circuit through the use of Arc Fault Circuit Interrupters (AFCIs).

HOW DOES AN ARC FAULT CIRCUIT INTERRUPTER (AFCI) WORK?

In essence, the detection is accomplished by the use of advanced electronic technology to monitor the circuit for the presence of "normal" and "dangerous" arcing conditions. Some equipment in the home, such as a motor driven vacuum cleaner or furnace motor, naturally create arcs. This is considered to be a normal arcing condition. Another normal arcing condition that can sometimes be seen is when a light switch is turned off and the opening of the contacts creates an arc.

WHY IS IT IMPORTANT TO HAVE AN AFCI BREAKER INSTALLED IN MY HOME?

AFCIs were developed in response to an identified electrical problem causing fires in the home as noted by the CPSC and other prominent organizations.

An AFCI provides a higher level of protection than a standard circuit breaker by detecting and removing the hazardous arcing condition before it becomes a fire hazard.

HOW MUCH DO AFCIS COST?

There is an added expense associated with equipping a home with AFCIs over standard circuit breakers. But from a safety standpoint, the cost is insignificant when compared to the number of lives and amount of property the device helps to protect.

WHERE ARE THEY REQUIRED TO BE INSTALLED BY THE NATIONAL ELECTRICAL CODE?

The 2005 National Electrical Code states that AFCIs must be placed on bedroom power and lighting circuits. The 2008 NEC may expand this requirement to other areas in the home. As with all property protection and life saving devices, the ultimate use, beyond the Code, rests with the homeowner. Whether new construction or retrofit, NEMA supports that you utilize the maximum electrical protection level available to reduce the chance of an electrical fire.

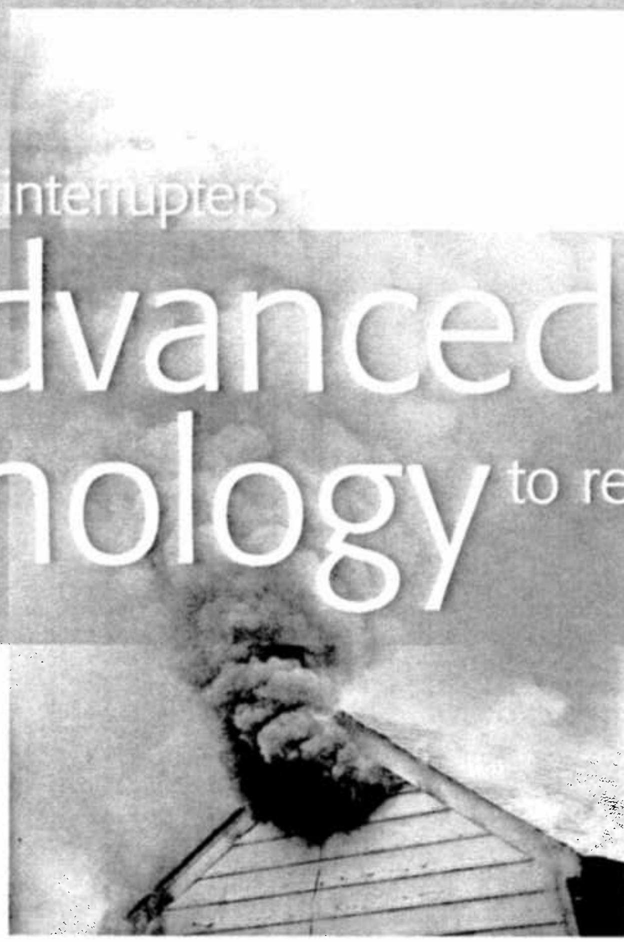
CAN I HAVE AFCIs INSTALLED EVEN IF MY STATE OR MUNICIPALITY DOESN'T REQUIRE THEM?

Absolutely, do you only place locks on the front door of the house? Just like placing locks on all external doors and windows for security reason, it is logical to request AFCI protection on all 15 and 20A branch circuits, not just those in the bedroom, to protect the entire home from an electrical arcing ignition hazard.

AFCIs are available through electrical distributors and in many home centers and hardware stores nationally. The only major physical requirement is that the AFCI requires directly wired hot and neutral wires on the circuit you're going to protect.

arc fault circuit interrupters

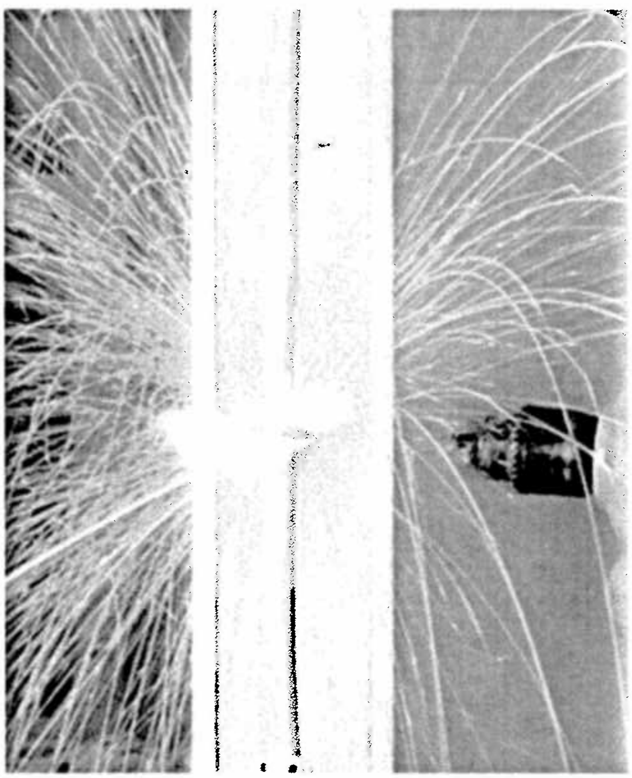
using advanced technology to reduce electrical fires



NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION
Low Voltage Distribution Equipment Section

INTRODUCTION

Arc Fault Circuit Interrupters (AFCIs) are required by he National Electrical Code for certain electrical circuits in the home. Questions have been raised regarding their application and even the need for them. Various technical "opinions", organizational "marketing pitches", and misinformation is being distributed about AFCIs that further mislead the public about the purpose of the device as a part of overall electrical safety for the public.



This brochure is intended to address the various aspects of AFCIs and clear up the misinformation circulating in the industry.

WHY DO WE REALLY NEED AFCIs?

Smoke alarms, fire extinguishers and escape ladders are all examples of emergency equipment used in homes to take action when a fire occurs. An AFCI is a product that is designed to detect a wide range of arcing electrical faults to help reduce the electrical system from being an ignition source of a fire. Conventional overcurrent protective devices do not detect low level hazardous arcing currents that have the potential to initiate electrical fires. It is well known that electrical fires do exist and take many lives and damage or destroy significant amounts of property. Electrical fires can be a silent killer occurring in areas of the home that are hidden from view and early detection. The objective is to protect the circuit in a manner that will reduce its chances of being a source of an electrical fire.

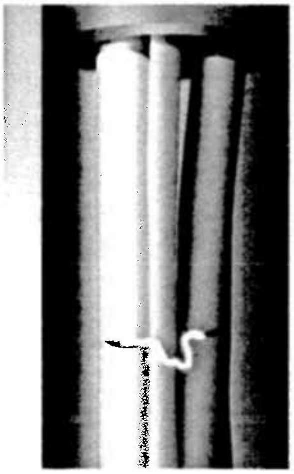
THE JOURNEY TO DEVELOP DETECTION TECHNOLOGY

Research in the arc fault area began in the late 1980's and early 1990's when the Consumer Product Safety Commission (CPSC) identified a concern with the residential fires of electrical origin. A large number of these fires were estimated to be in branch circuit wiring systems.

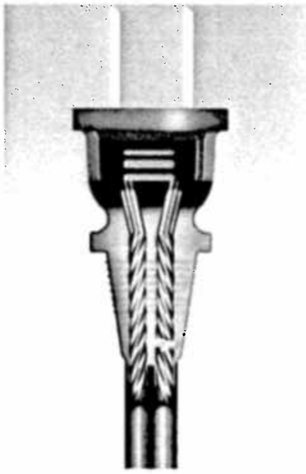
The concept of AFCIs gained more momentum when code proposals were made to the 1993 NEC® to change the instantaneous trip levels of 15A and 20A circuit breakers. The Electronic Industries Association (EIA) had studied the issue of electrical fires and determined that additional protection against arcing faults were an area that needed to be addressed by electrical protection. This proposal first attempted to do this by requiring that instantaneous trip levels of a circuit breaker be reduced from a range of 120 to 150 amperes down to 85 amperes. However, it became clear that the lowering of those levels below some of the minimums already available on the market would result in significant unwanted tripping due to normal inrush currents.

It was these early studies and code efforts that led to the first proposals requiring AFCIs, which were made during the development of the 1999 NEC. NEC Code-Making Panel 2 (CMP2) reviewed many proposals ranging from protecting the entire residence to the protection of living and sleeping areas. In addition, the panel heard numerous presentations on both sides of the issue. After much data analysis and discussion, the CMP2 concluded that AFCI protection should be required for branch circuits that supply receptacle outlets in bedrooms.

Subsequent editions of the NEC further upgraded the requirements to include protection on all outlets (lighting, receptacle, smoke alarm, etc.) in bedrooms along with other enhancements.

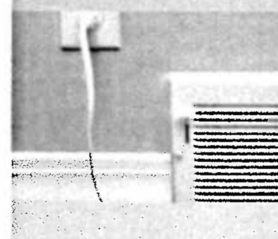


Parallel Arc

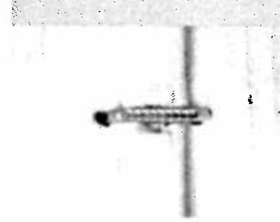


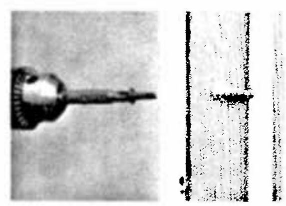
Series Arc

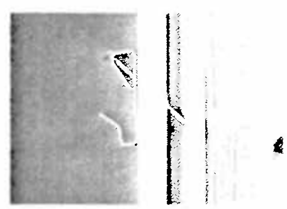
Cord insulation can be deteriorated by heat generated by hot air ducts or sunlight.

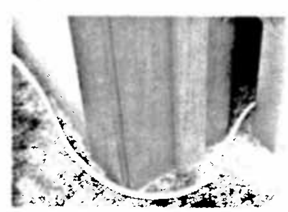


Cables that are improperly nailed or stapled too tightly against a wall stud can sever insulation and cause arcing.









WHAT ARE ARC FAULTS?

The UL Standard for AFCIs (UL 1699) defines an arcingfault as an unintentional arcing condition in a circuit. Arcing creates high intensity heating at the point of the arc resulting in burning particles that may over time ignite surrounding material, such as wood framing or insulation.

The temperatures of these arcs can exceed 10,000 degrees Fahrenheit. Repeated arcing can create carbonpaths that are the foundation for continued arcing, generating even higher temperatures.

typical causes
of arc faults

Example conditions where arc faults may start include:

- Damaged Wires
- Worn electrical insulation
- Wires or cords in contact with vibrating metal
- Overheated or stressed electrical cords and wires
- Misapplied or damaged electrical appliances

FIRE DATA ANALYSIS

The National Fire Protection Association, the insurance industry and others track the incidence of electrical fires across the United States and categorize those fires based on their causes. In reviewing statistics dating back to 1999, fires in the home electrical system exceed 31,000 annually.*

Updated figures from a March 2006 report of the U.S. Department of Housing and Urban Development (HUD) – ("Healthy Home Issues: Injury Hazards") – provides additional support for the need to protect residences and their occupants:

"Electrical problems spark an estimated 67,800 home fires on an annual basis, according to the most recent data from the United States Fire Administration (USFA). The USFA is an agency of the federal government and is committed to reducing the number of deaths and economic losses due to fire and related emergencies. The USFA also reports that electrical fires kill 485 innocent victims and injure approximately 2,300 others, while causing $868 million in residential property damage each year." (USFA. 2006. *On the Safety Circuit: A Factsheet on Home Electrical Fire Prevention.* U.S. Fire Administration)

The HUD recommendation was to promote AFCIs as one of the many devices that can be used to prevent burns and fire related injuries. In addition, it cites a 1999 CPSC Report recommending the use of AFCIs to "prohibit or reduce potential electrical fires from happening".**

As you can see from the data above, fires of electrical origin are a significant issue that must be addressed. Frequently, it is argued that fires only occur in older homes. However, it should be recognized that new homes become older homes. It is critical to install the AFCIs in the beginning so that they can perform their protection function from the start. Seldom are devices such as AFCIs added to homes after they are constructed and occupied.

*Ref: 1999 Revised - 2002 Residential Fire Loss Estimates. U.S. National Estimates of Fires, Deaths, Injuries, and Property Losses from Unintentional Fires. U.S. Consumer Product Safety Commission, November 2005

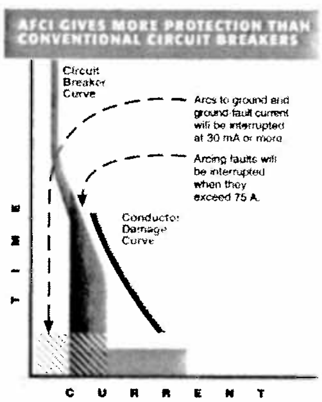
**Healthy Homes Issues: Injury Hazards. U.S. Department of Housing and Urban Development, Version 3, March 2006

HOW IS AN ARC FAULT DETECTED?

Unlike a standard circuit breaker detecting overloads and short circuits, an AFCI utilizes advanced electronic technology to "sense" the different arcing conditions. While there are different technologies employed to measure arcs by the various AFCI manufacturers, the end result is the same, detecting parallel arcs (line to line, line to neutral and line to ground) and/or series arcs (arcing in series with one of the conductors).

How does arc fault detection work? In essence, the detection is accomplished by the use of advanced electronic technology to monitor the circuit for the presence of "normal" and "dangerous" arcing conditions. Some equipment in the home, such as a motor driven vacuum cleaner or furnace motor, naturally create arcs. This is considered to be a normal arcing condition. Another normal arcing condition that can sometimes be seen is when a light switch is turned off and the opening of the contacts creates an arc.

A dangerous arc, as mentioned earlier, occurs for many reasons including damage of the electrical conductor insulation. When arcing occurs, the AFCI analyzes the characteristics of the event and determines if it is a hazardous event. AFCI manufacturers test for the hundreds of possible operating conditions and then program their devices to monitor constantly for the normal and dangerous arcing conditions.



THE NEC® AND UL® STANDARD

National Electrical Code®

The National Electrical Code® specifically defines and mandates the installation of AFCIs. In the 1999 edition of the NEC, Section 210.12 required that dwelling unit bedrooms have AFCIs installed to protect all branch circuits that supply 125-volt, single-phase, 15 and 20-ampere receptacle outlets installed in the dwelling unit bedrooms. This requirement became effective January 1, 2002.

In the 2002 edition, the update of section 210.12 expanded AFCI protection to all bedroom outlets (lighting, receptacle, smoke alarm, etc.).

The 2005 NEC 210.12 revised the AFCI requirement to provide for a technology upgrade. While previous generations of product detected parallel arcing, this new device – a combination AFCI – would also detect series arcing, and at lower current levels.

UL Standard

Product standards to cover AFCIs began to be developed in the mid 1990's. Underwriters Laboratories published UL 1699 – Standard for Safety for AFCIs – in 1996 to cover a wide variety of conditions to evaluate an AFCI. The standard includes requirements for the following conditions:

- Humidity Conditioning
- Leakage Current
- Voltage Surge
- Environmental Evaluation
- Dielectric Voltage
- Arc-Fault Detection
- Unwanted Tripping
- Operation Inhibition
- Resistance to Environmental Noise
- Abnormal Operation

One of the most frequent questions about AFCIs is related to resistance to unwanted tripping. There are four varieties of tests related to its ability to resist unwanted tripping.

- Inrush Current: High current draw devices such as tungsten filament lamps and capacitor start motors.
- Normal Arcing: Brush motors, thermostatic contacts, wall switch and appliance plugs.
- Non-Sinusoidal Waveforms: Examples of devices creating these electrical waveforms include electronic lamp dimmers, computer switching-mode power supplies and fluorescent lamps.
- Cross Talk: This test measures trip avoidance for an AFCI when an arc is detected in an adjacent circuit. Only the circuit with the arc should cause the breaker to trip, not another circuit.

Through the use of the National Electrical Code requirement and extensive UL testing, manufacturers' AFCI products provide superior protection against arcing faults.

CONTRASTING AFCI AND GFCI

There is a major difference between the functioning of an AFCI as compared to a GFCI (Ground Fault Circuit Interrupter). The function of the GFCI is to protect people from the deadly effects of electric shock that could occur if parts of an electrical appliance or tool become energized due to a ground fault. The function of the AFCI is to protect the branch circuit wiring from dangerous arcing faults that could initiate an electrical fire.

AFCI and GFCI technologies can co-exist with each other and are a great complement for the most complete protection that can be provided on a circuit.

WHAT ARE THE VARIOUS SAFETY AND GOVERNMENTAL AGENCIES SAYING ABOUT AFCI?

"The National Association of State Fire Marshals (NASFM) strongly supports the broad adoption of AFCI technology through national, state, and local building codes. AFCIs are the most welcome addition to fire prevention in decades. AFCIs promise to save hundreds of lives every year."
John C. Bean, President, NASFM

"The National Association of Home Inspectors (NAHI) strongly encourages its members to educate all of their clients about the life and property saving benefits of AFCI technology, especially those clients considering the purchase of a home more than 20 years old."
Mallory Anderson, Executive Director

"The National Electrical Contractors Association (NECA) submitted comments to legislative committees in Michigan and South Carolina, urging them to retain requirements for AFCI protection of bedroom receptacles in their state electrical codes. Cost cutting pressure from homebuilders' association in both states led to code proposals to delete AFCI protection required by the National Electrical Code, when constructing new homes."
NECA Contractor Code Letter

"CPSC has identified arc fault circuit interrupter (AFCI) technology as an effective means of preventing fires caused by electrical wiring faults in homes."
U.S. Fire Administration

"The Electrical Safety Foundation International (ESFI) urges that arc fault circuit interrupter (AFCI) technology be installed in all new and existing housing to protect homes and families from fires caused by electrical arcing."
Brett Brenner, President, ESFI

TYPES OF AFCI ARC FAULT CIRCUIT INTERRUPTER (AFCI)

AFCIs are intended to mitigate the effects of arcing faults by functioning to de-energize the circuit when an arc fault is detected. AFCIs are required by the NEC® to be a listed product. This means that they must be evaluated by a nationally recognized testing laboratory to the national standard for AFCIs (UL 1699). NEC 210.12 establishes the requirement to use AFCIs. Protection is required for branch circuits in locations as specified in this NEC® rule.

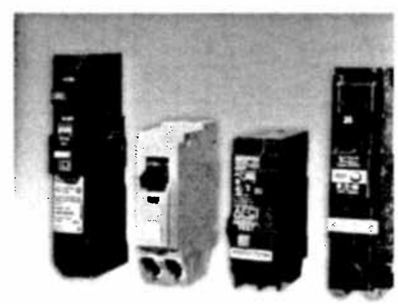
Branch/Feeder AFCI

A device intended to be installed at the origin of a branch circuit or feeder, such as at a panelboard. The branch/feeder AFCI provides for detection of arcing faults that can occur line-to-line, line-to-neutral and line-to-ground.

To be able to handle shared neutral circuits (a common application in older homes), a two-pole AFCI can be used. This will accommodate the three-wire circuit arrangement used in shared neutral applications.

Combination AFCI

In addition to the protection provided by the Branch Feeder AFCI, the Combination AFCI provides for series arc detection down to 5 amperes. This series arc detection is beneficial to detect lower level arcing in both branch circuits and power supply cords. Combination AFCI protection is required by the NEC as of January 1, 2008*.



AFCI and GFCI Protection

An AFCI can be used in conjunction with GFCI protection to provide both arcing fault protection as well as 5mA ground fault (people) protection. A common way to provide both types of protection is to use an AFCI circuit breaker and a GFCI receptacle. AFCIs can also incorporate 5mA GFCI protection into the same package. This solution for AFCI and GFCI on the same circuit can be useful where the circuit design requires both types of protection or where the installer (or user) wants to have both types of protection.

* The 2005 NEC® added the requirement for combination AFCI protection, but implemented an effective date of January 1, 2008.

WIRING AND INSTALLATION GUIDELINES

There are no special requirements of an AFCI circuit other than proper installation and wiring practices. There are various special considerations that must be given to certain circuits that vary from the norm, such as shared neutral applications, but in general the application of an AFCI is as simple as following the installation instructions that come from the manufacturer.

The basic difference between installing the AFCI versus a standard thermal magnetic circuit breaker is the requirement to connect both the hot and neutral conductor to the proper terminals of the AFCI. In a circuit wired with a conventional circuit breaker, the hot conductor is connected to the breaker and the neutral conductor is connected directly to the neutral bar of the load center.

defining the arc fault risk to people and property

As with any change in the required protection for the electrical system, there have been many discussions and deliberations both for and against arc fault protection being a part of the National Electrical Code. Some have argued that the cost of the AFCI is higher than a standard circuit breaker and, as such, it costs too much to provide the increased protection. Others have argued that since it is a relatively new type of protection, it does not have the history on which to base a decision as to whether to support or not.

These issues have been debated thoroughly and completely. It is important to keep a few critical facts in mind.

- The cost to install AFCI circuit breakers in the home is insignificant when compared to the number of lives and property the device helps protect. According to *Electrical Wholesaling Magazine* (Sept. 2006), for an average sized home of 2,500 square feet the average total cost is $192,846. A quick survey of hardware stores and "do-it-yourself" home centers found AFCIs priced between $30 and $35, not including installation. With the average number of circuits requiring AFCIs being 12, this equates to an approximate cost increase of $372-$396 to the homeowner, or one-fifth of one percent of the national average home cost.
- The Consumer Product Safety Commission staff report on *Estimated Residential Structure Fires on Selected Electrical Equipment* (October 2006) from 1999-2003 reported that 142,300 electrical distribution fires occurred on all distribution components. Installed wiring fires were estimated to have occurred in 50,200 instances.
- Using the same report, the CPSC projected that there were 910 deaths attributed to electrical distribution equipment during that five-year period. Installed wiring led to approximately 210 deaths as a part of that total.

Applying technology to improve the electrical safety of the home is a wise investment for both the homeowner and the community at large. Reducing fires of electrical origin and saving lives is an important responsibility of the entire construction and regulatory community. Taking these CPSC statistics into account, one has to ask that if a portion of the 50,200 fires could have been prevented, would the increase in cost have been worth the added protection AFCIs provide the homeowner?

what is the price of new safety technology worth?

When Ground Fault Circuit Interrupters (GFCIs) were introduced in the 1970s, similar discussions took place regarding the cost/benefit to the consumer, homebuilder and others. GFCIs have been a standard requirement in homes for over 30 years with additional locations and circuits being added over time as well. GFCI also has a statistical track record over time as to the reduction of electrocutions. On an annualized basis, in 1983, there were almost 900 electrocutions total per year with approximately 400 being consumer product related. Ten years later, the total was reduced to 650 annually and slightly over 200 consumer product electrocutions annually.

With over 20 years of history, statistically based analysis of GFCIs was built on a solid foundation of data. AFCIs are new and have only been installed in new construction on bedroom circuits for a few years. As with all products, given time, they too will be able to provide a solid statistical base of measure.

Some have argued that it should be shown how many times an AFCI has "prevented" a fire from occurring. Of course, this is not a feasible request. The AFCI disconnects the power when an arc fault occurs, therefore no incidence of fire or arc is reported to authorities. The same can be true when a smoke alarm siren alerts the homeowner and the small smoking event is extinguished without incident. Is that statistic reported to the Federal Government or local fire department? Of course not. Safety prevention is just that ... prevention. The only statistics that are reported are those that have resulted in a fire or a response of a fire department. Many safety protection actions go unreported.

If we are to offer consumers a safer home, then the appropriate technology should be put into place.

Removing AFCI as a local or state code requirement is reducing safety requirements. These rules are established by a national body of experts that have heard testimony from many sources as well as reviewed a significant amount of data to make their recommendation. Shouldn't we trust the safety experts that develop our safety procedures?

To learn more about the safety benefits of AFCIs, please visit our AFCI web site at **www.afcisafety.org**.

NEMA AND ELECTRICAL SAFETY

For more than 80 years, manufacturers of Low Voltage Distribution Equipment have been working to ensure public safety through standards writing efforts and the dissemination of important industry information through the National Electrical Manufacturers Association (NEMA), one of the most respected standards development organizations in the world. Headquartered in Rosslyn, Virginia, NEMA has approximately 400 electroindustry companies, including large, medium and small businesses. To learn more about NEMA visit **www.nema.org.**

NEMA

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION
Low Voltage Distribution Equipment Section

1300 North 17th Street, Suite 1752 • Rosslyn, Virginia 22209
(703) 841-3200 Fax: (703) 841-5900
www.nema.org