arc fault circuit interrupters

using advanced technology to reduce electrical fires

NEMA

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION

INTRODUCTION

Arc fault circuit interrupters (AFCIs) are required by the National Electrical Code® (NEC) 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 are 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 dispell 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 prevent 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.

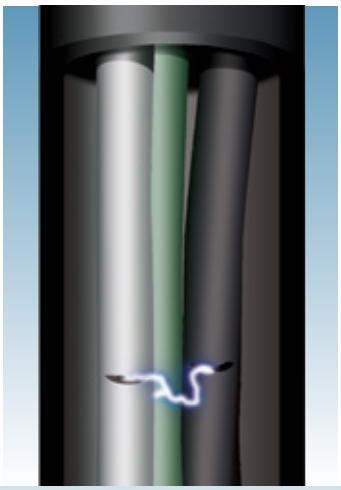
THE JOURNEY TO DEVELOP DETECTION TECHNOLOGY

Research in the arc fault area began in the late 1980s and early 1990s when the U.S. 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.

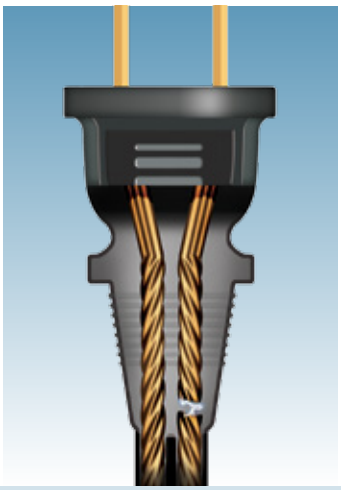
The concept of AFCIs gained more momentum when code proposals were made to the 1993 NEC to change the instantaneous trip levels of 15A and 20A circuit breakers. The Electronic Industries Association (EIA) had studied the issue of electrical fires and determined that additional protection against arcing 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 all 120-volt, single-phase, 15- and 20-ampere branch circuits supplying outlets or devices installed in dwelling unit kitchens, family rooms, dining rooms, living rooms, parlors, libraries, dens, bedrooms, sunrooms, recreation rooms, closets, hallways, laundry areas, and similar rooms or areas, along with other enhancements.



Parallel Arc



Series Arc

WHAT ARE ARC FAULTS?

The UL Standard for AFCIs (UL 1699) defines an arc fault 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 carbon paths that are the foundation for continued arcing, generating even higher temperatures.

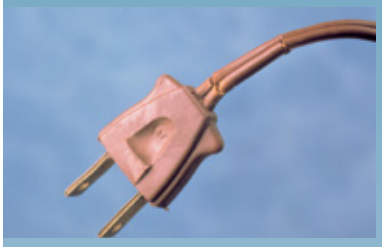
typical causes of arc faults

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

Furniture pushed against or resting on electrical cords can damage the wire insulation. Damaged cords can become a potential condition for arcing.

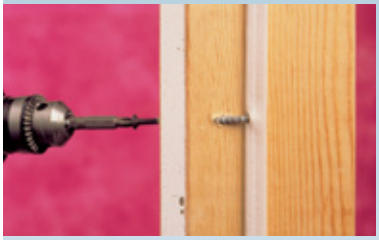
Extension or appliance cords that are damaged or have worn or cracked insulation can contribute to electrical arcing.



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.

Wires located behind walls can be accidentally punctured by a screw or drill bit damaging the insulation of the wiring.



Nails carelessly driven into walls can break wire insulation and cause arcing.

Nonmetallic sheathed cable damaged by gusset plate while being pulled through attic.

FIRE DATA ANALYSIS

The Federal Government, the National Fire Protection Association, and US fire departments track the incidence of electrical fires across the United States and categorize those fires based on their causes. In reviewing statistics from 2003 to 2014, fires in home electrical systems averaged 25,366 annually and resulted in 378 civilian deaths, 1,290 civilian injuries and $1.4 billion in direct property damage.* The NFPA Home Electrical Fires Fact Sheet indicates that wiring and related equipment were involved in 63% of these fires and half of the associated deaths in 2007-2011.

The U.S. Department of Housing and Urban Development (HUD) recommendation is 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.

*Home Electrical Fires Fact Sheet, National Fire Protection Association

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

HOW IS AN ARC FAULT DETECTED?

An AFCI device uses 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. The areas in homes where AFCI protection is required have gradually expanded, and as of the 2014 edition include kitchens, family rooms, dining rooms, living rooms, parlors, libraries, dens, bedrooms, sunrooms, recreation rooms, closets, hallways, laundry areas, and similar rooms or areas.

UL Standard

Product standards to cover AFCIs began to be developed in the mid-1990s. Underwriters Laboratories published UL 1699 Standard for Safety for AFCIs in 1999 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 NEC requirement and extensive UL testing, manufacturers' AFCI products provide superior protection against arcing faults.

CONTRASTING AFCIs AND GFCIs

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 and electrical cords connected to it 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' associations 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 ARC FAULT CIRCUIT INTERRUPTERS

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 way to provide both types of protection is to use an AFCI circuit breaker and a GFCI receptacle. Another way is to install a dual function device that provides both AFCI and GFCI protection.

defining the arc fault risk to people and property

WIRING AND INSTALLATION GUIDELINES

There are no special requirements for 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.

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 NEC. Some have argued that the cost of installing AFCIs is higher than the cost of installing standard devices 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.
- The additional cost to install AFCIs is insignificant compared to the total cost of a new home, typically less than 0.1%.
- 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, 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 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 annual 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 relatively new and have only been installed in a small fraction of the total number of circuits in U.S. homes. 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?

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 350 electroindustry member companies, including large, medium and small businesses. To learn more about NEMA visit **www.nema.org**.

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION
1300 North 17th Street, Suite 900 • Rosslyn, Virginia 22209
(703) 841-3200 Fax: (703) 841-5900
www.nema.org