

WHITE PAPER:

**THE IMPORTANCE OF ARC FAULT  
CIRCUIT INTERRUPTER TECHNOLOGY**

## **Introduction**

Thousands of deaths and billions of dollars in property loss occur every year due to residential structure fires. These data are collected through the National Fire Incident Reporting System (NFIRS). The National Fire Protection Association (NFPA) states that in 2009, home electrical fires were the cause of 44,800 home structure fires, 472 civilian deaths, 1,500 civilian injuries, and \$1.6 billion in direct property damage.<sup>1</sup> According to the U.S. Fire Administration (USFA), electrical failures and malfunctions contributed to 24 percent of non-confined one- and two-family fires.<sup>2</sup> These statistics may be startling to some. Technology exists to help mitigate the effects of arcing and sparking. The Arc-Fault Circuit-Interrupter (AFCI) is designed to detect the arcing and sparking that can cause electrical fires. This is a technology that has a goal of stopping the fire before it begins and can be leveraged in new and existing homes to mitigate the effects of the arcs and sparks that can cause electrical fires.

## **Background**

Article 100 in the National Electrical Code<sup>®</sup> (NEC<sup>®</sup>) defines AFCIs as devices intended to provide protection from the effects of arc faults by recognizing characteristics unique to arcing and by functioning to de-energize the circuit when an arc fault is detected.<sup>4</sup> The AFCI should not be confused with a ground fault circuit interrupter (GFCI) whose purpose is to protect personnel from electrical shock.

Electrical arcing can be either intentional or unintentional. Intentional arcing occurs safely in many appliances and other types of equipment. Unintentional arcing, on the other hand, may cause dangerous situations. These arcs can result in temperatures in excess of several thousand degrees Celcius; more than enough to ignite surrounding materials. Arcing and sparking can be intermittent yet persistent, occurring in hidden areas such as behind drywall or in attics. Unlike smoke alarms and fire extinguishers, AFCIs can stop the fire before it occurs. AFCIs have proven to be effective in both testing laboratories and in real-life applications. Success stories, where AFCIs have located damaged conductors and appliances, can be found on the AFCI Safety web site, [www.afcisafety.org](http://www.afcisafety.org).

As reported in a conference by the Fire Protection Research Foundation, a panel of industry leaders commented on AFCIs, saying, “What we see in residential occupancies is a slow transition, and there will need to be recognition of incentives or benefits.”<sup>5</sup> This slow transition mainly arises from lack of awareness of the technology, special interest group opposition, and slow building code adoption.

National Electrical Code® (NEC): The NEC addresses the installation of electrical conductors, equipment, and raceways; signaling and communications conductors, equipment and raceways; and more. It is updated on a three year cycle. Each new version of the NEC is then adopted at a state or local jurisdiction level with jurisdictions adopting with or without amendments if adopted at all.

AFCIs first entered the NEC® in 1999 based on a substantiation built from electrical fire statistics. The products were first required on bedroom circuits as the statistics showed many fires occurring in this room while occupants slept. NEC 1999 required, effective January 1, 2002, all bedroom receptacle outlets to be protected by a branch/feeder type AFCI. NEC 2002 expanded AFCIs to protect all bedroom outlets; not just receptacle outlets. NEC 2005 subsequently permitted the use of the branch/feeder type AFCI until January 1, 2008 after which time the combination-type AFCI was required. The combination-type AFCI extends low current arc detection to connected cords. NEC 2008 expanded AFCI protection to the following dwelling rooms: family rooms, dining rooms, living rooms, parlors, libraries, dens, bedrooms, sunrooms, recreation rooms, closets, hallways, or similar rooms or areas. NEC2011 expanded the AFCI requirement to existing homes. Figure 3 displays the NEC® progression and Figure 4 provides the specific version of the NEC® each state or local jurisdiction within a state has adopted.

The NEC® currently requires AFCIs in new homes and in existing homes where branch-circuit wiring is modified, replaced, or extended. According to the U.S. Department of Housing and Urban Development (HUD) and the U.S. Census Bureau, the median year of construction of American homes is 1974.<sup>6</sup> The Electrical Safety Foundation International (ESFi) stated that many electrical fires have occurred in aging homes<sup>7</sup>. Today, our dependency on electricity is increasing calling upon the electrical distribution systems of older homes to support the ever growing use of appliances and

other electronic types of loads. AFCIs continuously monitor installed wires and connected cords for wear and tear and other types of damage that could cause a dangerous, unintentional arc fault. The Consumer Product Safety Commission (CPSC) found that fires in residential electrical systems were disproportionately higher for homes that were older than 40 years<sup>8</sup>. According to HUD, this equates to around 61 million homes. Thus, there is a large number of homes that may be susceptible to dangerous arcing conditions and could benefit from the installation of AFCI technology.

Fire Statistics: The USFA methodology includes a three-level structure hierarchy for fire causes. Many references will be made to electrical distribution and electrical malfunction. In the hierarchy, electrical distribution is a part of the total electrical malfunction. Figure 1 represents a graphical representation of the hierarchy.

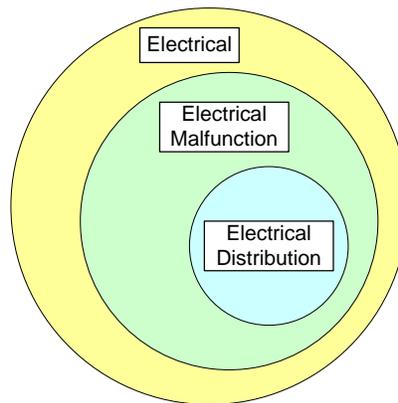


Figure 1. USFA Electrical Fire Hierarchy

Electrical distribution is defined as only lighting equipment fires.<sup>1</sup> The USFA defines electrical malfunction, or basically an electrical failure, to include the following reason for a source of fire outlined in Figure 2.<sup>3</sup>

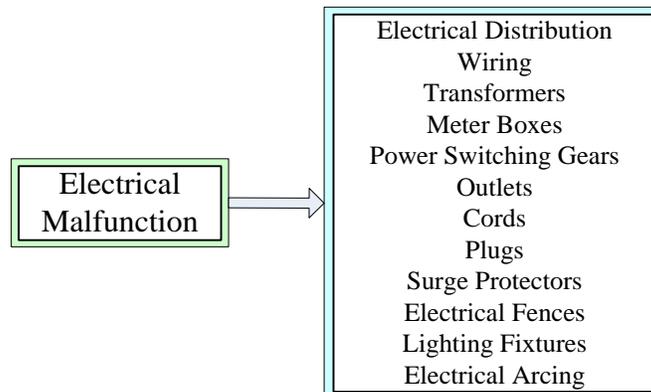


Figure 2. Electrical Malfunction Definition

Therefore, while statistics that only include “electrical distribution” might give insight to the trends, they do not give the entire picture in terms of the devastation of electrical fires on homes.

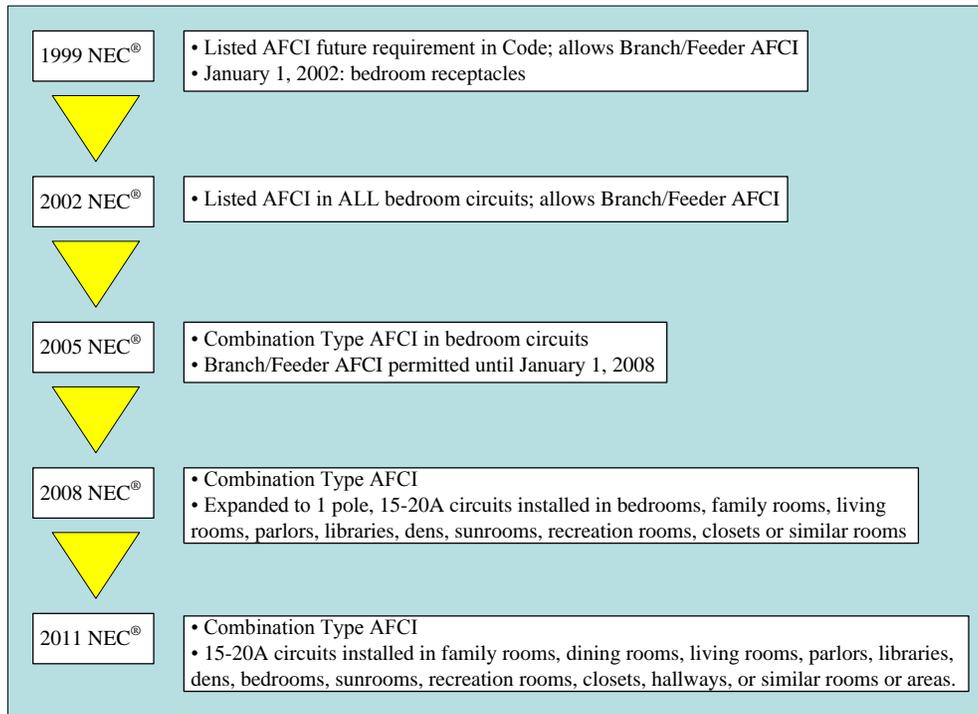


Figure 3. NEC® Progression by Year

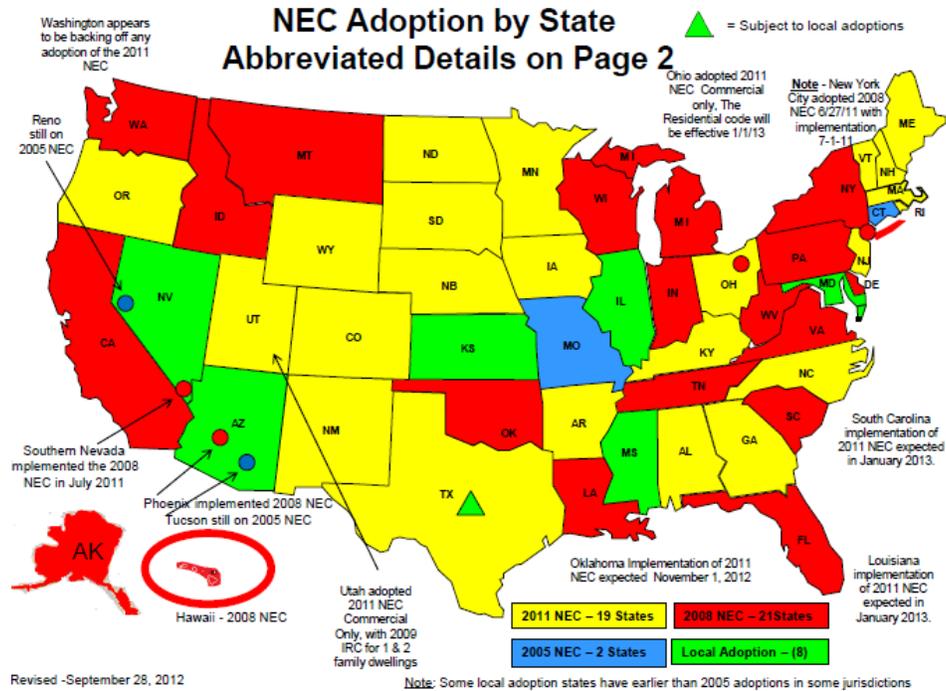


Figure 4. NEC® Adoption Years by State as of September 28, 2012

### Data Analysis and Findings

As shown previously, the AFCI technology has seen a slow progression from bedroom circuits to expanded areas of the home since 2002. In addition, adoption rates by state vary, slowing the protection coverage for a structure that these devices provide. There is limited data available to show the impact of AFCIs on residential fires. What statistics can't show are those electrical fires that were prevented. It is difficult to prove that a found electrical problem would have started a fire. Having said this, it is beneficial to look at available data to obtain an understanding of electrical fire trends in residential homes knowing that this technology plays a role in impacting these numbers. The following data sources are those that are currently available and pertinent to the discussion of electrical fires and arc-fault protection needs.

NFPA: A report on home electrical fires was published by the NFPA.<sup>1</sup> Figures 5 and 6 below show the number of fires that occurred each year and the property damage that resulted.

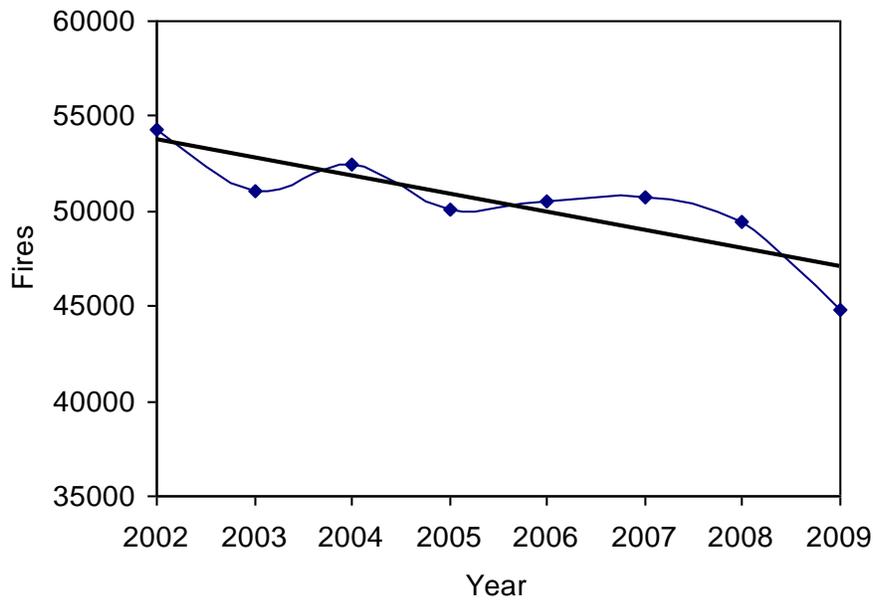


Figure 5. NFPA Electrical Malfunction Fires per Year

As the graph in Figure 5 shows, the number of fires caused by electrical malfunction has been decreasing over the past decade.

The NFPA also has statistics involving home fires from electrical distribution and lighting equipment. Figure 6 displays one finding on the number of fires.

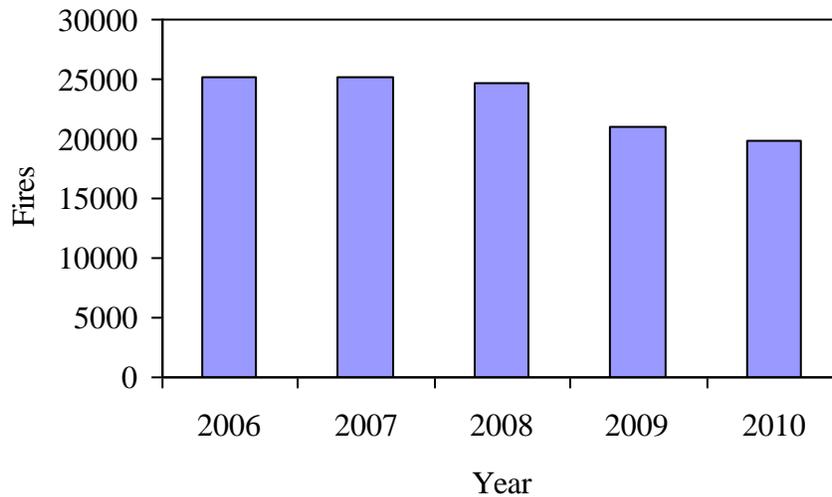


Figure 6. Home Electrical Distribution and Lighting Fires by Year.

The same report states that home electrical fires represented 13% of the total home structure fires from 2005 to 2009, 17% of associated civilian deaths, 11% of

associated civilian injuries, and 21% of associated direct property. Fires caused by electrical malfunctions are costly. From 2008-2010, the 3-year average cost was \$18,900 for each confined fire and \$31,170 for each non-confined fire in one- and two-family residential building fires.<sup>2</sup> The only way to ensure a reduction in fire damage is to reduce the number of fires occurring, and AFCIs help contribute toward diminishing electrical fires.

Since 2008, the year that AFCIs were expanded to more living areas in the home, the number of electrical distribution and lighting equipment fires has steadily decreased. Key findings in this study showed that wiring or related equipment was the highest cause of home fires, followed by lamps, light fixtures, cords, and plugs.<sup>9</sup> The NFPA recommends keeping the house updated with current codes. Building codes work together to help positively impact instances of fires. AFCIs are one of many system of requirements that help contribute to this steady decline in electrical fires.

USFA: The United States Fire Administration found that over a five year period from 2006 to 2010, there was an 18% decrease in fires, a 4% decrease in deaths, and a 3% decrease in dollar loss (all converted to the equivalent 2010 value) related to residential building electrical malfunctions.<sup>10</sup>

CPSC: A recall of ceiling mounted light fixtures occurred on June 19, 2012. The concern was fire and shock hazard because the fixture's socket wire insulation could easily degrade, which in turn could cause electrical current to pass through the exposed, charged wires. The manufacturer, received 11 reports on arc fault circuit interrupters tripping from defective fixtures.

A study was conducted by the CPSC to find the economic considerations of switching standard thermal magnetic circuit breakers to AFCIs. The first finding was that 85% of the electrical distribution fires investigated occurred in homes older than 20 years old.<sup>12</sup> These homes would most likely not be protected by AFCIs because the NEC® only requires new and renovated homes to have AFCI technology present. It also stated that the inclusion of AFCI protection in circuit breakers may have prevented 50% or more of these fires.

UL: Underwriters Laboratories performed a study on electrical components in 30 homes across the country that ranged in age from 30 to 110 years old. The purpose of the

investigation was to further understand the reasoning behind electrical fires to provide more information to code writers, manufacturers, homeowners, electricians, and insurers. It was found that the top three factors that contribute to electrical fires are the effects of natural aging of wiring and equipment, misuse or abuse of the electrical system by the homeowners, and NEC® requirements not being followed in installations, upgrades, or repairs.<sup>13</sup>

Although some homes have updated electrical systems, a larger number of homes have their original electrical wiring which may or may not have been modified over time. The electrical distribution system in a home is subject to natural aging, do-it-yourself unqualified homeowners, hungry rodents, incorrect use of circuit extensions and more. Because damage and degradation may be hidden from view, it may be difficult to detect. The AFCI device can help mitigate the effects of an aging electrical distribution system.

### **Endorsements of AFCIs**

Many public and private organizations have endorsed the proven AFCI technology. The following is a list of several examples of comments made.

- U.S. Consumer Safety Commission, “You may want to consider adding AFCI protection for both new and existing homes. Older homes with ordinary circuit breakers especially may benefit from the added protection against the arcing faults that can occur in aging wiring systems.”
- John C. Bean, President of the National Association of State Fire Marshals said, “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.”
- Mallory Anderson, Executive Directors of the National Association of Home Inspectors stated, “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.”

- The U.S. Fire Administration stated, “CPSC has identified arc fault circuit interrupter (AFCI) technology as an effective means of preventing fires caused by electrical wiring faults in homes.”
- Brett Brenner, President of the Electrical Safety Foundation International said, “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.” He also said, “Preventing a fire before it starts is the best way to protect your family. Arc fault circuit interrupters are one of the most important advancements in electrical fire protection for the home.”
- John Marcario of the National Electrical Manufacturers Association said, “Arc-fault circuit interrupters (AFCIs) – the next generation in circuit breaker technology – are one such life-saving tool that should be considered by home owners and home builders alike.”
- AFCIs were included as an important home safety technology in ESFi’s National Safety Electrical Month Report in May 2012.

### **Success Stories**

NEMA AFCI Manufacturers have and continue to collect success stories of where AFCIs have found damaged wire, damaged appliances and other similar problems. The following success stories and more are also available at [www.afcisafety.org](http://www.afcisafety.org):

- In South Carolina, a homeowner wanted to sell a home that was built in 2005. According to the code at the time, it was mandatory to have AFCIs installed in the bedroom circuits. Since the circuit breaker tripped often, the homeowner called an electrician who recommended changing back to regular thermal magnetic circuit breakers. After refusing, the homeowner found another electrician who found arcing in the home run circuit because of shredded wiring. During the troubleshooting, a gas leak was found in the vicinity of the damaged conductors. The AFCI circuit breaker helped avert a disaster.
- A homeowner in Pennsylvania wanted to perform a significant renovation to the house, which was built in 1979. After the upgrade to include AFCIs, the kitchen

circuit breaker would trip. Troubleshooting revealed a damaged conductor in the kitchen wall.

- An AFCI feeding the master bedroom receptacle outlets started tripping three years after renovation in a New Mexico house. A 12/2 cable was stapled to the floor, and after taking off the cable sheath, it was found that the hot and neutral wires were shorted and charred inside the outer sheath. The AFCI tripped instantaneously each time protecting the house and the people inside.
- A 73 year old home was upgraded to include AFCIs on every circuit. Once the installation was complete, one of the AFCIs started and continued to trip. The contractor came back, and instead of diagnosing the problem, the contractor switched the AFCI back to a regular circuit breaker. The homeowner found that a ceiling light in the bedroom was out, and when a new bulb was put in, it immediately blew out. The homeowner discovered a threaded porcelain socket had loosened over time. This allowed the socket to rotate and the hot and neutral wire to twist causing an arcing condition. The AFCI was doing its job by informing the homeowner of the potential hazard.

## **Conclusion**

AFCI technology has been proven in laboratories and real-life situations to be effective in mitigating the effects of arcing and sparking that can cause residential fires. The NEC® requires AFCIs to be installed in newer and remodeled homes, but the number of homes affected by this Code requirement is very small compared to the total number of dwelling units in America. AFCIs can benefit homeowners and their homes for all of the reasons given above.

## **Reference:**

<sup>1</sup> J. Hall. "Home Electrical Fires." *National Fire Protection Association Fire Analysis and Research Division*, Jan. 2012.

<sup>2</sup> "One- and Two-Family Residential Building Fires (2008-2010)." *Topical Fire Report Series*, vol. 13, issue 4, May 2012.

<sup>3</sup> "USFA Structure Fire Cause Methodology." Internet:  
[http://www.usfa.fema.gov/fireservice/nfirs/tools/fire\\_cause\\_category\\_matrix.shtm](http://www.usfa.fema.gov/fireservice/nfirs/tools/fire_cause_category_matrix.shtm), Feb. 15, 2012.

- <sup>4</sup> A. Manche. "GFCI and AFCI Basics." *International Association of Electrical Inspectors Magazine* May-June 2012.
- <sup>5</sup> "Fire Protection and Safety: The Next 25 Years." *Fire Protection Research Foundation*, Dec. 2008.
- <sup>6</sup> "American Housing Survey for the United States: 2009." *U.S. Department of Housing and Urban Development*, March 2011.
- <sup>7</sup> "Know the Dangers in Your Older Home." *The Electrical Safety Foundation International*.
- <sup>8</sup> "What Causes Wiring Fires in Residents?" *U.S. Consumer Product Safety Commission Fire Journal*, Jan.-Feb.1990.
- <sup>9</sup> "Home Fires Involving Electrical Distribution and Lighting Equipment – 2010." *National Fire Protection Association*, Jan. 2012.
- <sup>10</sup> "2010 Residential Building Electrical Malfunction Fire Trends" *USFA Fire Estimate Summary*, Dec. 2011.
- <sup>11</sup> T. Karels. "Economic Considerations --- AFCI Replacements." *U.S. Consumer Product Safety Commission*, March 10, 2003.
- <sup>13</sup> D. Dini. "Residential Electrical System Aging Research Project." *The Fire Protection Research Foundation*, July 1, 2008.
- <sup>14</sup> J. Jones. "One Out of Four Homeowners Never Check for Electrical Hazards." *International Association of Electrical Inspectors Magazine*, July 21, 2004.