

Electrical Arc Fault AFCI Advice for Homeowners & Home Inspectors

This material was originally prepared for the American Society of Home Inspectors New England Chapter, (ASHI -NE) Educational Seminar, Sept 22-23, 2008. Portions of this text are quoted from the Arc Fault Circuit Interrupter (AFCI) FACT SHEET provided by the US CPSC . Additional notes and details have been added, drawing on a variety of sources listed at the end of this article.

What is an Arc Fault Circuit Interrupter or AFCI?

The “AFCI” is an arc fault circuit interrupter. AFCIs are newly-developed electrical devices designed to protect against fires caused by arcing faults in the home electrical wiring.

Note: **Arcing faults:** a [series arc](#) occurs in electrical wiring when there is a small gap or break in a conductor. a [parallel arc](#) occurs when a small gap or break which permits current to flow to ground (a ground fault) or between the hot and neutral wires (a short circuit). Arcing faults, especially parallel arcing faults, lead to overheating and a fire hazard even if no shock hazard is present.

AFCIs are an important safety addition to homes in part because they address an additional type of electrical fault that can cause a fire and one which may not be detected and interrupted by a conventional circuit breaker, nor by a ground-fault circuit interrupter (GFCI's).

We've seen that arcing of any type can result in burned debris on wire surfaces which causes an increase in electrical resistance and thus overheating at that point. Arcing was examined earlier in detailed studies of the [aluminum electrical wiring fire hazard](#) at connections in the wire. Arcing of any type, whether it is the micro-fretting type of arcing that occurs with aluminum wire or possibly larger arcing across a gap or short in a copper wire.

The Fire Problem [addressed by AFCIs]

Annually, over 40,000 fires are attributed to home electrical wiring. These fires result in over 350 deaths and over 1,400 injuries each year. Arcing faults are one of the major causes of these fires.

When unwanted arcing occurs, it generates high temperatures that can ignite nearby combustibles such as wood, paper, and carpets.

Note: According to [Mike Holt](#), "*Studies have shown that over 60 percent of fires are from causes in the fixed wiring, switches, receptacle outlets and lighting fixtures that are part of the fixed electrical system of a residence.*" In other words, AFCI's are focused on detecting arcing and preventing fires in an area where the risk is significant.

Arcing faults often occur in damaged or deteriorated wires and cords. Some causes of damaged and deteriorated wiring include:

- puncturing of wire insulation from picture hanging or cable staples,
- poorly installed outlets or switches,
- cords caught in doors or under furniture,



- furniture pushed against plugs in an outlet,
- natural aging, and cord exposure to heat vents and sunlight.

Note: What Types of AFCIs are Available?

UL in January 2002 described various types of AFCIs which we summarize here. The first three types of AFCI's, Branch Feeder AFCIs, Outlet Circuit AFCIs, and Combination AFCIs are the three most basic types of arc fault detectors and are important definitions for the home owner or home inspector to understand:

1. **Branch Feeder AFCIs** - basically a special circuit breaker to be installed in the electrical panel and which will protect all of the devices on an individual electrical branch circuit. (15A or 20A 125V single phase wiring.)
2. **Outlet circuit AFCIs** - a device installed right in the branch circuit receptacle box. As with GFCIs this device may also protect wiring which is connected "downstream" electrically from the device itself.
3. **Combination AFCIs** - this device combines the function of Branch Feeder AFCIs and Outlet Circuit AFCIs and will protect power cords plugged into receptacles protected by the AFCI.

The following are additional types of AFCI's described by Underwriters Laboratories.

4. **Outlet Branch Circuit AFCIs** - this device, which sounds to us just like #2 above, is installed as the first outlet in a string of electrical receptacles on a single circuit; it protects the downstream receptacles.
5. **Portable AFCIs** - these devices can be plugged into a conventional electrical receptacle and provide one or more outlets into which additional devices can be connected. This device would be used by contractors working on a building to obtain additional electrical safety when using power tools.
6. **Cord-AFCIs** - this device is like the portable AFCI #5 above, but may be incorporated into the permanent power cord of a device or appliance so that when it is plugged into an electrical receptacle the appliance is protected from arc faults.
7. **Leakage Current Detection and Interruption LDCIs** - these devices are built into a device or appliance and detect current leakage from the device's electrical cord. If a hand held hair dryer contained this device and its damaged cord was dangled in a sink filled with water, the LDCI would detect the current leakage and would shut off the device.

How does an Arc Fault Circuit Interrupter (AFCI) Work?

Conventional circuit breakers only respond to overloads and short circuits; so they do not protect against arcing conditions that produce erratic current flow. An AFCI is selective so that normal arcs do not cause it to trip.

The AFCI circuitry continuously monitors current flow through the AFCI. AFCIs use unique current sensing circuitry to discriminate between normal and unwanted arcing conditions. Once an unwanted arcing condition is detected, the control circuitry in the AFCI trips the internal contacts, thus de-energizing the circuit and reducing the potential for a fire to occur.

An AFCI should not trip during normal arcing conditions, which can occur when a switch is opened or a plug is pulled from a receptacle.

Presently, AFCIs are designed into conventional circuit breakers combining traditional overload and short-circuit protection with arc fault protection. AFCI circuit breakers (AFCIs) have a test button and look similar to ground fault circuit interrupter (GFCI) circuit breakers.

Some designs combine GFCI and AFCI protection. Additional AFCI design configurations are anticipated in the near future.

It is important to note that AFCIs are designed to mitigate the effects of arcing faults but cannot eliminate them completely. In some cases, the initial arc may cause ignition prior to detection and circuit interruption by the AFCI.

The AFCI circuit breaker serves a dual purpose – not only will it shut off electricity in the event of an “arcing fault”, but it will also trip when a short circuit or an overload occurs. The AFCI circuit breaker provides protection for the branch circuit wiring and limited protection for power cords and extension cords. Single-pole, 15- and 20- ampere AFCI circuit breakers are presently available.

Where should Arc Fault Circuit Interrupters (AFCIs) be used?

The 1999 edition of the National Electrical Code, the model code for electrical wiring adopted by many local jurisdictions, requires AFCIs for receptacle outlets in bedrooms, effective January 1, 2002. Although the requirement is limited to only certain circuits in new residential construction, AFCIs should be considered for added protection in other circuits and for existing homes as well.

Older homes with aging and deteriorating wiring systems can especially benefit from the added protection of AFCIs. AFCIs should also be considered whenever adding or upgrading a panel box while using existing branch circuit conductors.

Notes: What are the code requirements for AFCIs?

AFCI Requirements under the US National Electrical Code NEC:

AFCI requirements have not been adopted uniformly in all jurisdictions, but the requirement is being increasingly accepted, and we certainly recommend the use of AFCIs as described by the US CPSC and the NEC. The US National Electrical Code, the NEC, specifies the following requirements for AFCIs (quoted indirectly from the U.S. State of Vermont office of the state fire marshal, January 2007. Vermont has required AFCIs to the NEC 2008 standard since 2000.)

History of AFCI Requirements in Homes

The 1999 NEC rules, effective in 2002, in NEC Sec. 210.12. introduced AFCI's and called for their installation on bedroom receptacle circuits powered by single phase 125V(nominal) 15A and 20A circuits.

The 2002 NEC expanded the use of AFCI's to include all bedroom circuits (such as lighting and hard-wired smoke alarms), kitchens.

The 2005 NEC code expanded the section to include combination AFCIs combined with GFCIs, basically an update to reflect improvements in the technology. The technology of AFCIs was improved to add the detection of series arcing to the previously available parallel arcing. By removing the word "receptacle" from the code in 2002, and by leaving the word "outlet" in the code, the 2005 code indicated that all outlets, including receptacles, light fixtures, smoke alarms, etc. must be protected.

- **Series arcing** occurs in an electrical circuit when there is a small **gap in a conductor** in a home. Series arcs are less dangerous than parallel arcs because they do not usually get hot enough to start a fire.
- **Parallel arcs** in an electrical circuit occur when there is a **current leak** from the "line" or hot wire (fault) to the neutral wire (ground or earth side of the circuit), or when there is a **short circuit** (a direct connection between the hot wire and the neutral wire, such as a wire being cut or damaged and its conductors brought into contact).

The 2008 NEC expanded the use of AFCI's to include all habitable rooms in new homes such as living rooms and dining rooms. The 2008 requirements mean that only [Combination AFCI's](#) will meet all of the requirements of the code. GFCI's (Ground Fault Circuit Interrupters) continue to be required to protect areas of high shock risk: bathrooms, kitchens, garages, un-finished basements. NOTE: All electricians licensed by the State of Texas are required to perform work to the 2008 NEC standards, Licensed Inspectors in Texas are required by TREC to report to 2008 NEC for AFCI and GFCI requirements.

Combination devices required after 1 Jan 2008: Simplifying a bit, after January 1, 2008, AFCI protection must be provided by a "[Combination AFCI's](#)". That's because these are an improved arc fault interrupter product that offer much more sensitive arc fault detection (5 A arc peaks as opposed to 75 A arc peak detection).