COZEN O'CONNOR
ATTORNEYS

Arc Fault Circuit Interrupters
The Next Generation of Fire Prevention - The Next Generation of Recovery Opportunities

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Manufacturers of electrical equipment have developed a new product that they claim is at the forefront of circuit protection technology. This new product is called the Arc Fault Circuit Interrupter (AFCI). AFCIs provide protection against arcing in fixed wiring, appliance cords and extension cords. The United States Consumer Product Safety Commission ("CPSC") and National Association of State Fire Marshals ("NASFM") have called AFCIs the "most promising fire protection technology since the advent of the smoke detector."[i]

This paper explores arcing, AFCI technology and recovery opportunities that may arise from this new technology.

1. The Fire Problem

During the five-year period between 1994 and 1998, there was an average of 73,500 electrical fires per year.[ii] Annually, electrical fires cause an average of 591 deaths, 2,247 injuries and $1,047,900,000 in property damage.[iii] Of the 73,500 electrical fires per year, 60,900 (82%) were caused by arcs.[iv] The CPSC estimates that AFCI technology can prevent 50-75% of residential electrical fires.[v] Similarly, NASFM predicts that AFCI technology could prevent 55,125 fires annually, thereby saving 440 lives, 1,685 injuries and $785,925,000 in property damage, if AFCIs are installed to protect all branch wiring in residences.[vi]

Residences are divided into four electrical zones. The electrical zones are designated Zone 0 – from the utility service to the distribution panel; Zone 1 – from the panel to the branch outlet; Zone 2 – from the outlet to the lighting or appliance fixture; and Zone 3 – the lighting fixture or appliance. 2% of electrically caused fires occur in Zone 0, 36% in Zone 1, 12% in Zone 2 and 50% in Zone 3.[vii]

2. Arcing Fault Causes Of Fire

Arcs are caused by:

- Pinched or pierced insulation on branch wiring, such as from staples or other fasteners;
- Cracked insulation on wire or cords from age, heat, chemical erosion or bending stress;
- Loose or improper connections;
- Frayed or ruptured extension or appliance cords;
- Damaged appliances;
- Wire or cords touching vibrating metal;
- Moisture or contaminates between conductors; and
- Cord exposure to heating vents and sunlight.

3. How The AFCI Works

Conventional circuit breakers respond to overloads and short circuits – they do not protect against arcing conditions that produce erratic current. Like circuit breakers, AFCIs protect against short circuits and overloads, but also protect against arcs by electronically identifying the unique current and voltage characteristics of arc faults and de-energizing the circuits when arc faults occur.[viii]

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, de-energizes the circuit and reduces the potential for a fire. AFCIs have been designed not to trip during normal arcing conditions that occur when a switch is opened or a plug is pulled from a receptacle.

AFCIs are designed into conventional circuit breakers, combining traditional overload and short circuit protection with arc fault protection. Currently, AFCIs are available for 15 and 20-ampere breakers for 125-volt circuits. There is no reason that AFCI technology will be limited to these ratings and, as commercial demand for other ratings emerge, additional products will be provided.[ix]

Since AFCIs are designed into conventional circuit breakers, AFCIs can be connected to a standard electrical panel. AFCIs have test buttons on the circuit breaker similar to the test buttons typically seen on ground fault interruption outlets. Currently, General Electric, Cutler-Hammer, Square D and Siemens offer AFCI circuit breakers.

4. Types of AFCIs

There are six different categories of arc fault circuit interrupters. Each of these devices is intended for different applications and/or protection of different aspects of branch circuit and extension wiring. The types of AFCIs as defined by Underwriters Laboratories ("UL") are:

- **Branch/Feeder AFCI** – This device is installed at the origin of a branch circuit or feeder, such as at a panelboard, to provide protection of the branch circuit wiring, feeder wiring, or both, against unwanted effects of arcing. This device also provides limited protection to branch circuit extension wiring (e.g. cord sets and power supply cords). These may be circuit-breaker type devices or a device in its own enclosure mounted at or near a panelboard.

- **Combination AFCI** – This is an AFCI which complies with the requirements for both branch/feeder and outlet circuit AFCIs. It is intended to protect downstream branch circuit wiring, cord sets and power-supply cords.

- **Cord AFCI** – This is a plug-in device for connection to a receptacle outlet to provide arc protection to the power-supply cord connected to it.[x]

- **Leakage Current Detection And Interruption** – This is a device provided in a power supply cord or cord set that senses leakage current flowing between or from the cord conductors and interrupts the circuit at a predetermined level of leakage current.

- **Outlet Branch Circuit AFCI** – This device is intended to be installed as the first outlet in a branch circuit. It is intended to provide protection to downstream branch circuit wiring, cord sets and power-supply cords against the unwanted effects of arcing. These devices also provide protection to upstream branch circuit wiring.

- **Outlet Circuit AFCI** – This device is installed at a branch circuit outlet, such as at an outlet box to provide protection of downstream cord sets and power-supply cords against the unwanted effects of arcing. This device may provide feed-through protection of the cord sets and power-supply cords connected to downstream receptacles.

- **Portable AFCI** – This is a plug-in device for connection to a receptacle outlet. It is intended to provide protection to connected cord sets and power-supply cords against the unwanted effects of arcing.

While this paper concentrates on the Branch/Feeder AFCI, manufacturers of appliances and appliance cords are starting to incorporate AFCI technology into their products. For example, Black & Decker and Fire Shield have developed a line of toasters and a line of heaters that use AFCI technology in the cord sets to protect against appliance cord fires. Fire Shield claims to manufacture the cords with the intelligence to sense damage to cords and disconnect power before a fire and currently offers extension cords and appliance cords that "sense pre-arc conditions to prevent cord fires and shock hazards."[xi]

5. A Basic Understanding of Arcing

Circuit breakers are designed to detect overcurrent conditioning and short circuits. In order to understand the differences between arc fault protection and traditional overcurrent protection, a basic knowledge of the terms used with distributing electricity and overcurrent protection is necessary.

- **Amp** - An amp is the unit of measurement of electric current.

- **Ampacity** - The current that a conductor can continuously carry under the conditions of use without exceeding its temperature.

- **Arc** - A luminous discharge of electricity across an insulating medium that exists at temperatures between 5000°F and 15,000°F at its center.

- **Overcurrent** - Any current in excess of the rated current of equipment or the ampacity of the conductor, resulting from an overload, short, or ground fault.

- **Overload** - Operation of equipment in excess of normal, full-load rating or of a conductor in excess of rated ampacity, which, when continuing for a sufficient period of time, causes damage or dangerous overheating.

- **Short circuit** - An abnormal connection of low resistance between circuit conductors; this is an overcurrent situation, but it is not an overload.

To better understand the conditions under which an AFCI will operate, a basic understanding of the different types of arcs is necessary:

TYPE OF ARCING	DESCRIPTION	EXAMPLES
• Parallel Arcing Fault	An arc fault between the line and neutral conductors in parallel with the loads in the circuit.	Damaged insulation.
• Series Arcing Fault	An arc fault in series with the load resulting from loose connections, severed wires, damaged switches and similar situations.	A nail that severs a wire.
• Arcing to Ground	An unintentional arcing fault between a part operating normally at some potential to ground and ground.	Wall plug or switch not installed properly.

The following table developed by UL identifies the different types of arc fault scenarios, the type of arc fault circuit interrupter and whether the type of arc fault circuit interrupter is designed to prevent an arc in a given arc fault scenario.

Arc Fault Scenario	Branch Feeder	Com-bination	Outlet Circuit	Outlet Branch Circuit	Cord, Portable or LCDI
Branch Circuit Wiring-First Leg					
Parallel Arcing Detection	Y	Y	n/a	N	n/a
Series Arcing Detection (With Ground)	Y	Y	n/a	Y	n/a
Series Arcing Detection Without Ground (#)	N	Y	n/a	Y	n/a
Branch Circuit Wiring–Beyond First Leg					
Parallel Arcing Detection	Y	Y	n/a	Y	n/a
Series Arcing Detection (With Ground)	Y	Y	n/a	Y	n/a
Series Arcing Detection Without Ground (#)	N	Y	n/a	Y	n/a
Cord Sets (Extension Cords), Power Supply Cords					
Parallel Arcing Detection	Y	Y	Y	Y	Y
Series Arcing Detection	N	Y	Y	Y	Y

Y – Arc fault protection provided
N – Arc fault protection not provided
n/a – Not applicable
(#) – Branch circuit wiring systems without ground were permitted prior to the 1962 NEC.
Parallel arcing detection includes arcing line-to-line and line-to-ground.
Cord and Portable AFCIs, and LCDIs are only intended to protect the cords connected to them.
Combination AFCIs located at other than the origin of the branch circuit do not protect upstream branch circuit wiring, cord sets, or power supply cords.
First Leg - Runs from the panelboard to the first outlet.

6. The Legal Standards Applicable to AFCIs

UL 1699 "Standard for Arc Fault Interrupters" was first published in February of 1999. UL 1699 provides the design and operational criteria for AFCIs. UL 1699.1 provides:

> 1.1 The requirements of this Standard cover arc-fault circuit-interrupters (AFCIs) of the branch/feeder, outlet circuit, portable, and cord type intended for use in dwelling units. These devices are intended to mitigate the effects of arcing faults that may pose a risk of fire ignition under certain conditions if the arcing persists.
>
> 1.3 These devices are not intended to detect glowing connections.
>
> 1.5 An AFCI that is also intended to perform other functions, such as overcurrent protection, ground-fault circuit-interruption, surge suppression, any other similar functions, or any combination thereof, shall comply additionally with the requirements of the applicable Standard or Standards that cover devices that provide those functions.

AFCIs must pass three tests to meet UL 1699:

> 56.2 Carbonized Path Arc Ignition Test – AFCI shall interrupt the electric circuit to the load before ignition of a cotton fire indicator.
>
> 56.3 Carbonized Path Arc Interruption Test – AFCI shall clear the arcing fault if 8 half-cycles of arcing occur within a period 0.5 seconds.
>
> 56.5 Point Contact Arc Test – AFCI shall clear the arcing fault if 8 half cycles of arcing occur within a period of 0.5 seconds.

While UL 1699 provides the design and operational criteria for AFCIs, the National Electric Code (NEC) provides the guidelines for the <u>minimum</u> required use of AFCIs. In 1999, NEC 210-12 was amended to require AFCIs to protect all branch circuits providing power to outlets in dwelling unit bedrooms (new construction) effective January 1, 2002.

The NEC is a model code for electrical wiring. Individual states and authorities having jurisdiction have adopted their own initiatives and schedules for the required installation of AFCIs. For example, Vermont has adopted an electric code that requires AFCIs to protect all branch circuits for all living spaces for all new construction starting January 1, 2001. Thus, Vermont's code requires greater AFCI protection (all circuits in living areas as opposed to just bedrooms) a full year earlier than the NEC's required protection for bedrooms.

The NEC had enacted a provision requiring AFCI cord protection for all room air conditioners manufactured for use in the United States starting December 19, 2003. Due to the difficulty in implementing the program, UL and the NEC moved the compliance date to August of 2004.

The next edition of the NEC will be published in 2005. Several proposals have been submitted seeking to amend the NEC to require AFCIs for mobile homes and for all living spaces in new construction. In addition, the CPSC has submitted a proposal that would require AFCIs to be installed in existing homes when the electrical service for existing homes is replaced or up-dated.

It is unclear what additional AFCI requirements will be adopted between now and the 2005 edition of the NEC. However, several jurisdictions have already taken steps to increase the requirements for AFCI protection beyond the requirements contained in the NEC. For example, the 2002 Massachusetts Electrical Code requires AFCI protection for dwelling unit bedrooms for existing structures where panel boards are replaced (effective January 1, 2005).[xii] Similarly, the City of St. Paul, Minnesota, interprets the NEC to require AFCI protection for bedroom additions to existing structures and when new outlets are installed in existing bedrooms.[xiii]

7. Potential Recovery Theories

At first, the development of AFCI technology appears to limit recovery opportunities by preventing fires. However, the development of arc fault circuit interrupters may actually increase recovery opportunities, despite the potential for reducing the number of fires. Many residential electrical fires have unspecified origins due to the extensive electrical damage to the house wiring, appliance cords and appliances in the area of origin. As subrogation professionals, we have all closed cases after the cause and origin and/or electrical engineer determined the fire to be "unspecified electric". Furthermore, we have all closed files due to faults in older branch wiring where the cause and origin and/or electric engineer could not determine the reason for the fault in the branch wiring. Cases against the entities involved in manufacturing, selling, installing and servicing AFCIs may have provide recovery opportunities in many of these cases that would have been closed before the development of AFCIs.

A. Recovery Against Manufacturers of Branch Circuit AFCIs

The most obvious, but potentially most difficult, avenue of recovery is against the manufacturers of AFCIs. Recovery against manufacturers will be difficult due to the recognition by UL, AFCI manufacturers and other professionals that AFCIs mitigate against arcs and cannot completely eliminate arcs under every circumstance. Despite the potential difficulty in pursuing a case against the manufacturer of an AFCI, a thorough investigation by an electrical engineer may assist in developing a viable recovery theory.

The first step in determining whether there is a potential recovery against the manufacturer of an AFCI is to determine if the wiring that exhibits arcing was protected by an AFCI. With all new technology, there will be a lag before persons in the field become fully educated concerning this new technology. Thus, cause and origin investigators and electrical engineers hired to investigate electrically caused fires should be educated or reminded to look for AFCIs to determine whether the arcing occurred on a circuit that was AFCI protected.

By using UL's arc failure scenario chart, you and your experts can determine if the specific type of AFCI was designed to protect against the arc failure scenario at the fire scene. Once you have determined that the AFCI was designed to protect against the particular arc failure scenario, several theories of recovery may arise.

i) Manufacturing Defect

The AFCI can be non-destructively and destructively examined to determine if there was a failure in the AFCI. By using X-rays and disassembling the breaker, it can be determined whether the breaker failed to operate as it was designed to operate.

Special care should be taken when conducting a forensic examination of an AFCI. AFCI circuitry can be damaged by electrical surges. This damage can cause the AFCI not to trip in response to an arc fault. Thus, in order to establish a manufacturing defect case, your forensic investigation will most likely have to eliminate damage to the AFCI computer chip as a possible cause of the failure of the AFCI to respond to an arc fault

ii) Failure to Warn

The warning and instructions provided by the manufactures of AFCIs may create potential recovery opportunities. The packaging, installation instructions and warnings do not mention that surges can damage AFCI circuitry. Rather, manufacturers rely on an insert card to instruct the user to conduct a monthly test of the AFCI to determine if it is operational. The warnings and instructions do not warn the consumer or instruct the licensed electrician to instruct the consumer to conduct the monthly test of the AFCI. Therefore, one of the first battlegrounds between victims of fires and AFCI manufacturers will be over the sufficiency of the manufacturers' warnings and instructions. Thus, the warnings and instructions provided by the manufacturer of the AFCI should be consulted where an AFCI has failed to detect an arc fault and the insured had not been conducting the monthly testing of the AFCI.

iii) Malfunction Theory

Most states permit plaintiffs to prove a products liability claim through a legal doctrine know as the malfunction theory. The malfunction theory permits a plaintiff to prove a product defect by eliminating the reasonable sources for an accident or for a fire. Proving a malfunction case against an AFCI manufacturer will be extremely difficult, if not impossible, because of the difficulty in eliminating other potential sources for the failure of an AFCI to respond to an arc fault. Without a specific product defect, AFCI manufacturers will be able to argue that the arc started the fire before the AFCI could sense the arc and/or that the circuitry was damaged by an electrical surge.

B. Contractors

i) Failing To Follow The Code

One theory of recovery is against builders and contractors who do not incorporate AFCIs in panel boxes for new construction after January 1, 2002 in violation of the NEC. Local codes and standards should be consulted to determine if AFCIs were required to protect the circuit that caused a particular fire. Depending on the individual jurisdictional requirements, you may find that the builder or contractor violated the code by failing to install AFCIs.

One unresolved issue under the code is whether the National Electric Code requires AFCIs in newly constructed hotels, motels and similar structures where there are bedrooms/sleeping areas. In such cases, a strong argument exists that the overall intention of the life safety aim of the code is not satisfied unless the design professional or contractor installed (or at least recommended the installation) of AFCIs for newly constructed hotels, motels and similar structures.

ii) Failing To Properly Install And Test The AFCI

Another possible theory against contractors is the failure to properly install the AFCI and to test it after its installation. The AFCI must be installed in accordance with the manufacturer's instructions and tested in compliance with those instructions. Companies have already started developing UL certified testers that test each circuit protected by the AFCI to make sure that the AFCI is operating properly. It should be determined whether the AFCI was installed in compliance with the manufacturer's recommendations and tested to make sure that it was operating properly at the time of its installation.

iii) Failing To Install Or Recommend The Installation Of AFCIs

In addition to cases arising out of the failure to install code-required AFCIs, theories may be formulated resulting out of a contractor's failure to warn and recommend that additional AFCIs be placed into living spaces. For example, in new construction, the issue is whether the design professional, general contractor or electrical subcontractor should have recommended to the purchaser of the residence that AFCIs be installed to protect branch circuits in all living areas.

Another potential theory arises out of renovations to homes and/or updating of electrical service. The 2002 edition of the NEC does not require that AFCIs be installed in panel boxes when a new panel box is installed in existing construction. Nevertheless, an argument can be made that when an electrician replaces a panel in an existing residence that the electrician should install AFCIs because the risk of arcing is greater in older construction than in new construction as evident from of the greater frequency of fixed wiring fires in construction that is over ten years of age. The Massachusetts Electrical Code provides a perfect example of a situation where an electrician's compliance with the code may not discharge the electrician's duty of due care. The 2002 Massachusetts Electrical Code requires AFCI protection for existing homes that undergo panel board replacement starting January 1, 2005. This code requirement can be used to establish that electricians in Massachusetts have knowledge of the safety benefits of AFCIs in existing construction and should be installing AFCIs in new panel boards for existing dwellings, starting in 2002.

If a potential case exists against a design professional, general contractor or electrical subcontractor for failing to install AFCIs, there is a significant body of information available to the subrogation practitioner to use in establishing that the code is the <u>minimum</u> standard of care and that a reasonably prudent design professional or contractor should have installed AFCIs. For example, the CPSC recommends AFCI protection for both new and existing homes and recommends that older homes especially may benefit from the added protection against arcing faults that can occur in aging wiring systems.[xiv] Furthermore, electrical equipment manufacturers are starting to develop and market AFCI protection for commercial uses. For example, General Electric is now marketing AFCIs for office buildings and hotels.

C. Appliance/Cord Manufacturers

Fire Shield has developed AFCI/LCDI technology for cord sets and extension cords. Black & Decker has incorporated this technology in its new heaters and toasters. Fire Shield and Black & Decker may have set the design benchmark for all manufacturers of cords and appliances. When faced with a fire caused by a power-strip, extension cord or appliance cord, the insured should be interviewed as to the date of the purchase and possible theories that exist against the appliance/cord manufacturer for failing to include the AFCI technology in recently manufactured products. In cases involving cords that have the AFCI technology, and arcing there may be failure to warn or manufacturing defect theories.

8. Conclusion

The widespread use of AFCIs may or may not result in a decrease in subrogation cases due to the expected decrease in fires caused by arcing. It is too early to tell whether arc fault technology will prevent fires. Furthermore, it is too early to determine whether recovery possibilities exist in situations where arc fault technology has been employed, but failed to detect an arc. However, as subrogation professionals, we should be aware of this new technology so that we can better serve our clients by investigating potential cases against AFCI manufacturers and the construction professionals charged with the duty of designing and installing electrical distribution systems.

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[i] George E. Miller, President NASFM, May 30, 2002 report to Donald A. Bliss, Consumer Product Fire Safety Task Force.

[ii] George E. Miller, President NASFM, May 30, 2002 report to Donald A. Bliss, Consumer Product Fire Safety Task Force.

[iii] George E. Miller, President NASFM, May 30, 2002 report to Donald A. Bliss, Consumer Product Fire Safety Task Force.

[iv] George E. Miller, President NASFM, May 30, 2002 report to Donald A. Bliss, Consumer Product Fire Safety Task Force.

[v] King William H. Jr., Chief Engineer for Electrical Fire & Safety, Division of Electrical Engineering, U.S. Consumer Product Safety Commission, in discussion with the N.A.S.F.M. Science Advisory Committee, July 14, 2002.

[vi] George E. Miller, President NASFM, May 30, 2002 report to Donald A. Bliss, Consumer Product Fire Safety Task Force.

[vii] Illinois Electric Counsel Fact Sheet, Number 28. www.iecounsel.org/educational/fs28.html.

[viii] Divid Dini, UL Senior Research Engineer, Arc Fault Circuit Interrupters, IAEINEWS, September 2001.

[ix] George Gregory, Square D Company, A Brief On The Arc-Fault Circuit Interrupter. www.hq.usae.army.mil/cemp/e/et/arcpoult.pdf

[x] Arc Fault Testing and Arc Fault Scenarios, January 28, 2002- Underwriters Laboratories.

[xi] Fire Shield Product Literature www.fireshield.com.

[xii] 527 CMR 12.210.12(C).

[xiii] City of St. Paul, Office of License, Inspections and Environmental Protection, Bulletin 01-1, and Bulletin 02-1. www.ci.stpaul.mn.us/depts/liep/pdf/building/electric/bulletin01-1.pdf

[xiv] Consumer Product Safety Commission Pamphlet – Preventing Home Fires: Arc Fault Circuit Interrupters (AFCIs). www.cpsc.gov/cpscpup/pubs/afci.html.