

COMBINATION AFCIs:

WHAT THEY WILL AND WILL NOT DO

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*The Complete Works of William Shakespeare
(abridged)*

All 37 Plays in 97 Minutes!

By the Reduced Shakespeare Company

**My task is harder, I have only 30 minutes to describe
the 20+ year history of the Combination AFCI.**

Notes are not required, see

<http://www.CombinationAFCI.com>

Combination AFCIs:

What they Will and Will Not Do



Abstract

The primary goal of this web site is to describe what a Combination AFCI circuit breaker can do, while also clarifying what it can't do. The features of the Combination AFCI, and the earlier Branch/feeder AFCI, are explained. The site's IEEE paper explains that neither provides series arc protection. Also the available Branch/feeder provides the extra important feature of 30mA ground fault protection.

The paper outlines, but does not justify, how the Combination AFCI came to be mandated, while the Branch/feeder that provides more protection at less cost is disallowed. The key drivers behind this were the AFCI manufacturers, their NEMA organization, and UL.

Finally, the author, having participating actively during the AFCI development, would encourage the IEEE engineering communities of these great institutions to become more engaged to insure their codes and standards representatives fully understand the technical issues. These are their products; they have a responsibility to insure their products are not inadvertently misrepresented.

Document Library

[Combination AFCI: What they Will and Will not Do](#) (899kb pdf)

[UL Study of Glowing Contact](#) (731kb pdf)

CPSC database:

Keyword Search

Damaged and Overloaded Cords:

[Search results for \["cord" AND "fire"\]](#) (852kb pdf)

Glowing Contacts:

[Search results for \[\("outlet" OR "receptacle"\) AND "fire"\]](#) (941kb pdf)

Proposed NEC2014 Revisions to Paragraph 210.12

[Remove words "combination type"](#) (138kb pdf)

[Remove references to "first receptacle outlet"](#) (190kb pdf)

[Add "30mA" requirement](#) (280kb pdf)

- Today there are two types of AFCIs; the Branch/feeder and the Combination.
- Their technical performance differences will be described to allow manufacturers, UL, and others to evaluate their support for the Combination AFCI.
- The author hopes to get industry backing for a proposed revision of NEC 2014 that will remove the mandate that a Combination AFCI be used.

COMBINATION AFCIs:

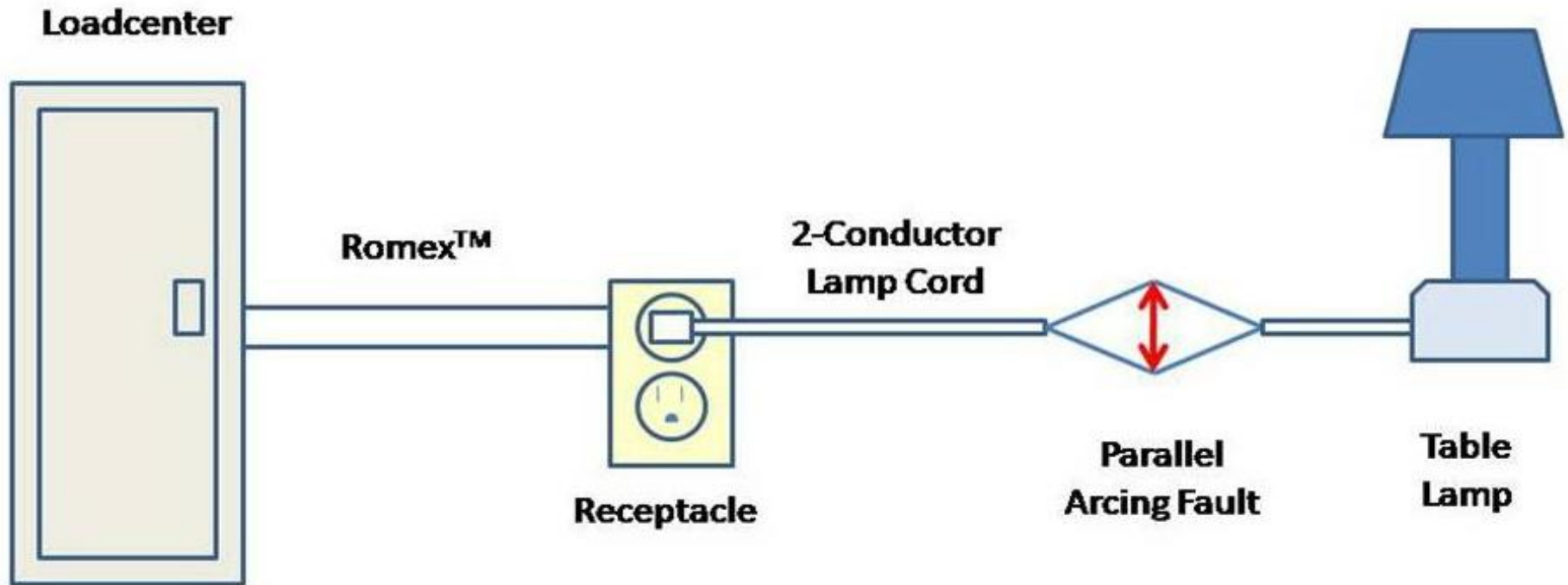
WHAT THEY WILL AND WILL NOT DO

(short answer)

types of protection	Branch/feeder AFCI	Combination AFCI
overcurrent	yes	yes
overload	yes	yes
ground fault (30mA) <i>Glowing Contact Protection</i>	yes	no*
parallel arcing	yes	yes
series arcing	no	no

“The” Parallel Arcing Problem

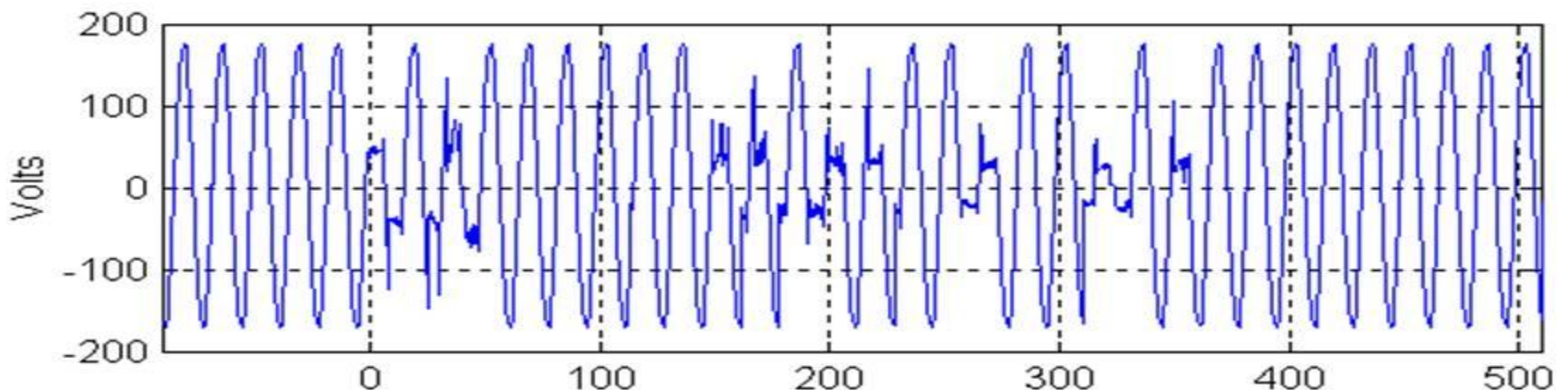
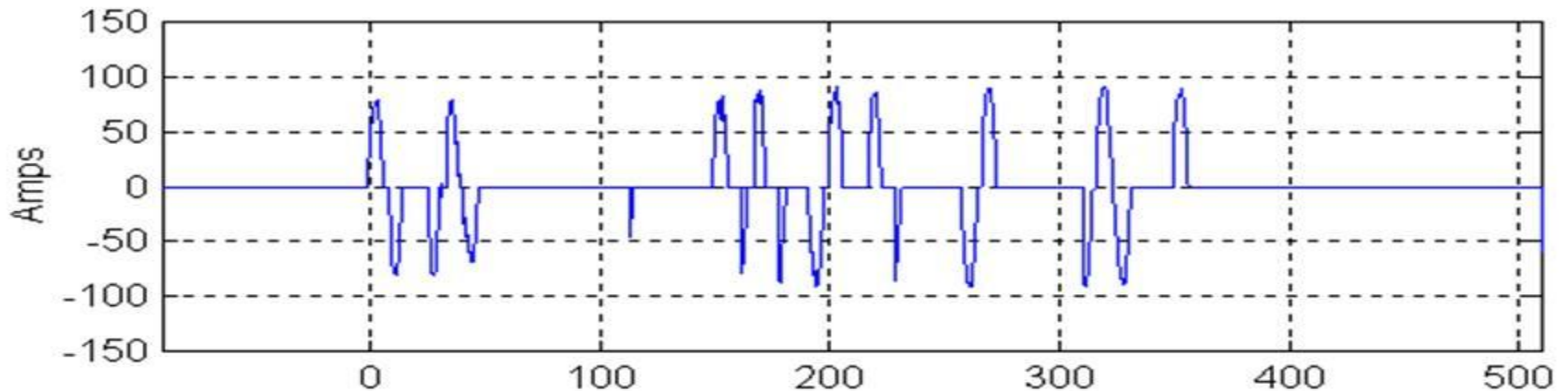
- During the early 1990s appliance manufacturers became concerned over home fires attributed to damaged power cords.



- CPSC funded UL to investigate problem
- UL found the problem to be parallel arcing faults caused by overheated and damaged cord insulation
- They also found that associated fault currents are often too low to trip a standard residential circuit breaker

• Why doesn't the circuit breaker trip?

- Peak current too low
- RMS current too low



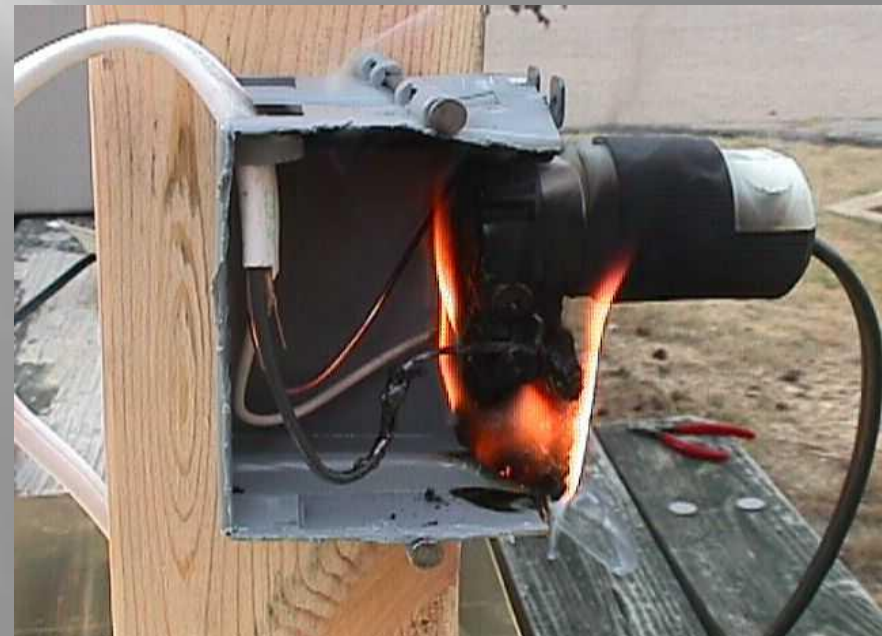
New CB Technology Needed

Birth of the AFCI?

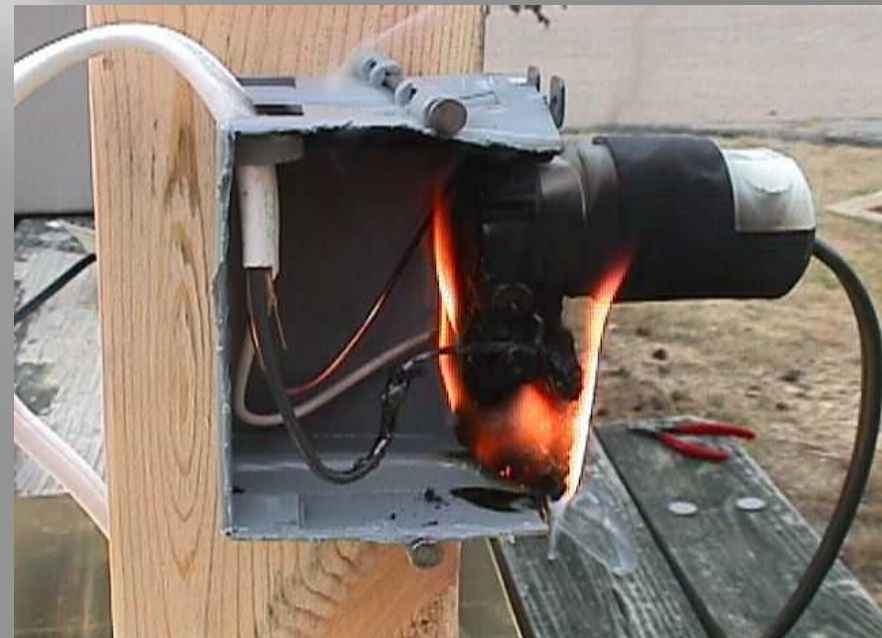
AFCI History

- Landmark UL report published in 1995
- Study included tests for:
 - parallel arcing
 - series arcing
 - glowing contacts
- This was the first time that UL publically acknowledged the fire hazard associated with glowing contacts.

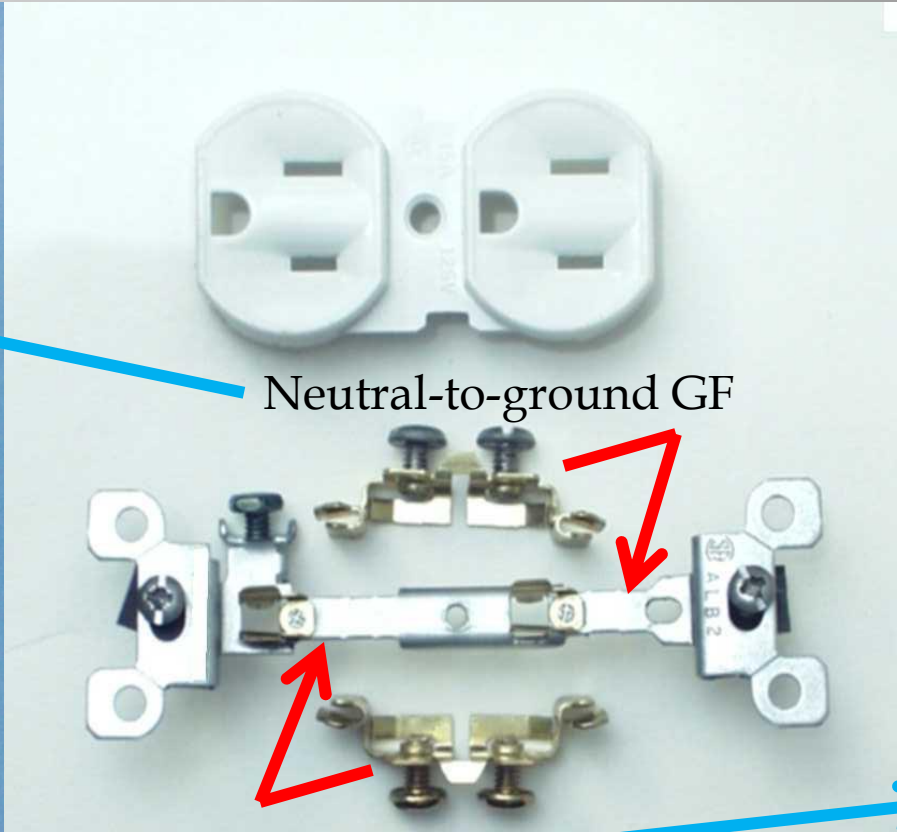
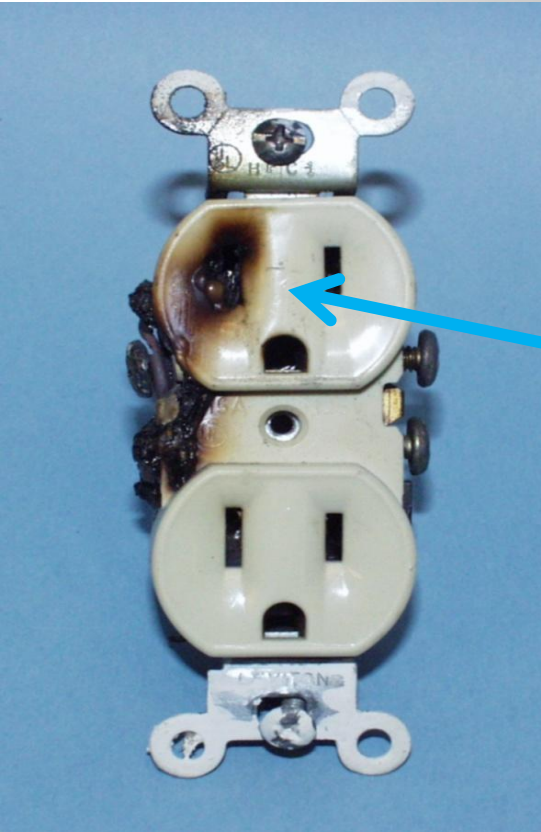
- UL taught how easy it is to create a glowing contact by jiggling a loose connection
- Plastics allowed by UL for receptacles and wire insulation melt and can burn in the presence of a 600C glowing contact



- UL published a report describing the ability of an AFCI, with 30mA GF protection, to mitigate the effect of a glowing contact.
- Today's available but NEC disallowed Branch/feeder AFCI includes the UL recommended AF plus GF protection.



How does AF + GF mitigate the effect of a glowing contact?



Neutral-to-ground GF

Line-to-ground AF



COMBINATION AFCIs:

WHAT THEY WILL AND WILL NOT DO

(short answer)

types of protection	Branch/feeder AFCI	Combination AFCI
overcurrent	yes	yes
overload	yes	yes
ground fault (30mA) <i>Glowing Contact Protection</i>	yes	no*
parallel arcing	yes	yes
series arcing	no	no

- The value of providing both arc and ground fault protection has been discussed
- The Branch/feeder AFCI provides both, the Combination AFCI doesn't
- NEMA and UL claim that the Combination AFCI will respond to a “series arcing” events
- They further claim that this is a fire hazard.

Let's talk about series arcing. A few facts:

1. The UL 1699 AFCI standard has no test for series arcing at a loose connection or across a cord's broken conductor
2. Attempts to demonstrate that a Combination AFCI will respond to such arcing events have failed

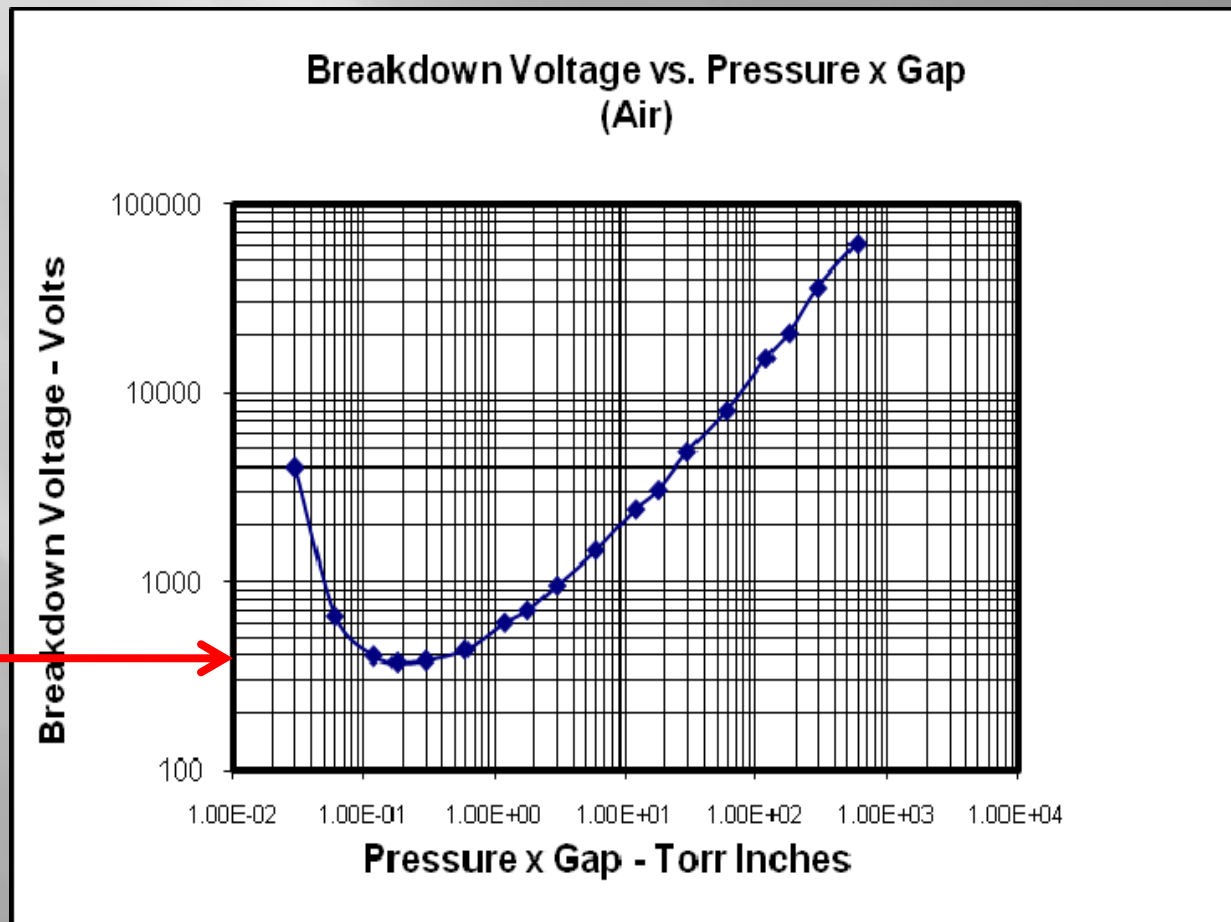
Trust, But Verify

- Why doesn't a Combination AFCI respond and trip in response to series arcing at a loose connection or across a cord's broken conductor?
- It's all about a 100 hundred year old Law of Physics

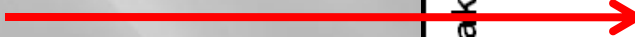
Paschen's Law

Trust, But Verify

A person named F. Paschen in 1889 published a law which sets out what has become known as Paschen's Law.



Minimum voltage is 327V.
The peak of a 120VAC
sine wave is only 170V.



Trust, But Verify

- I will have a simple Combination AFCI series arc demonstration available after this presentation.

- **The test will attempt to validate a Combination AFCI's manufacturers' claim.**

- “A series arc is an arcing incident across a break in a conductor. A common example is a cut across one of the two wires in a lamp cord, with a dangerous arc forming in the gap. Combination AFCI circuit breakers detect the arcing condition and turn off the circuit, thus providing the enhanced protection.”

From Square D web site <http://products.schneider-electric.us/products-services/products/circuit-breakers/miniature-circuit-breakers/combination-arcfault-circuit-interrupters/>

Trust, But Verify

So if there is no UL test for series arcing across a break in a cord's conductor, and if available Combination AFCIs do not respond as claimed, three important questions may need to be answered.

- 1. Were false claims knowingly made?*
- 2. Was there financial damage?*
- 3. Was information withheld which would make a true claim worthless?*

Trust, But Verify

1. Were false claims knowingly made?

Only the manufacturers and UL can answer this important question. The key word is “knowingly.”

I believe this paper and the web site should encourage manufacturers and UL to reexamine their claims, it will be hard for them to claim, I didn't know!

Trust, But Verify

2. Was there financial damage?

This can be calculated knowing three things:

- a. The cost differential between a Combination AFCI and Branch Feeder AFCI*
- b. Number of AFCIs per new home*
- c. New home starts 2008 through 2014*

a. The cost differential between a Combination AFCl and Branch Feeder AFCl

The average retail cost of a Combination AFCl, from Home Depot's web site, is \$37.07.

There are two ways to calculate the projected cost of a Branch/feeder AFCl provided in the paper. Both yield a cost of ~\$17.

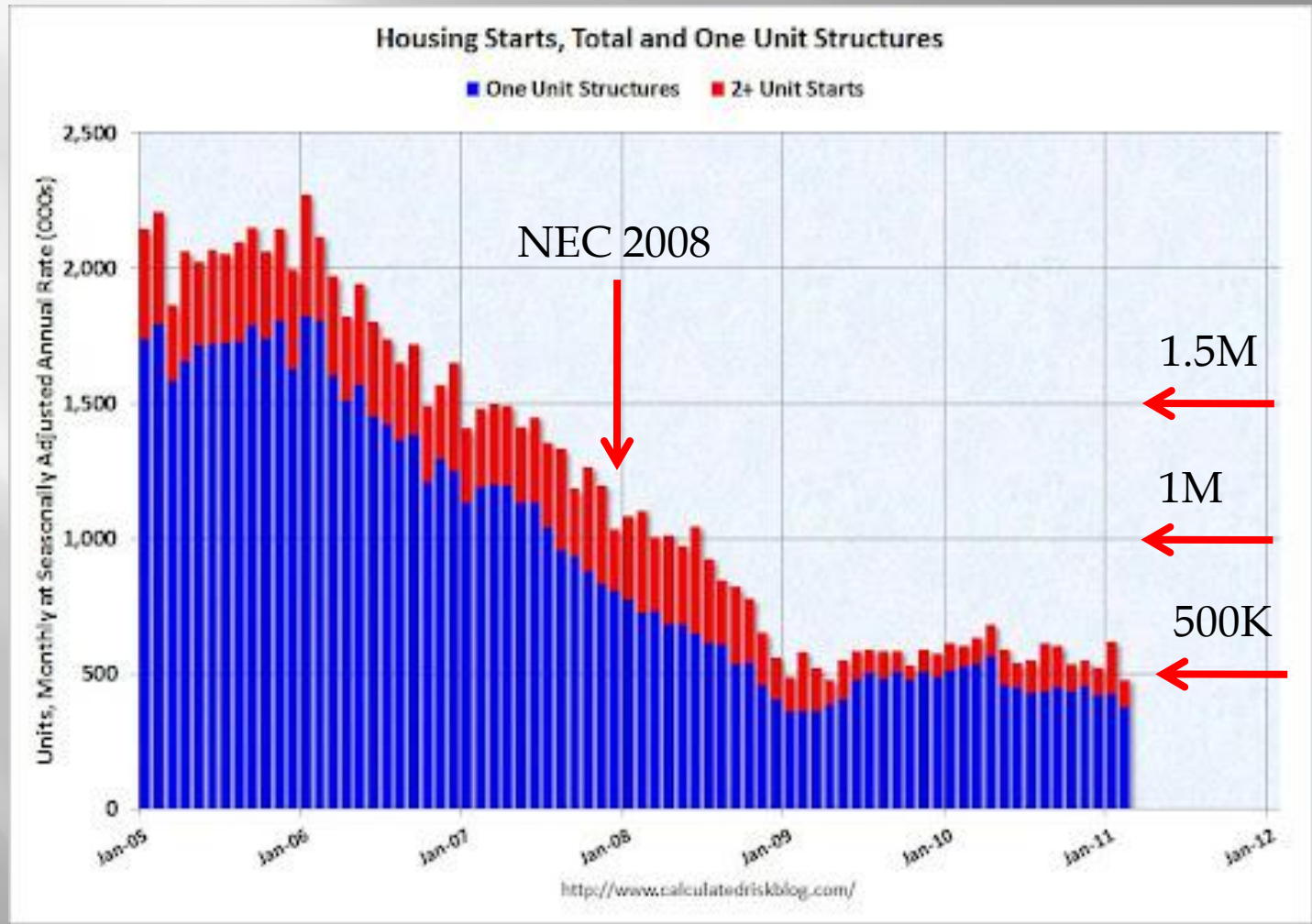
The cost differential is thus \$20.

b. Number of AFCIs per new home

I don't know the exact average value;

20 is probably a good estimate.

c. *New home starts 2008 through 2014*



2. Was there financial damage?

The calculation yields:

*damages = cost differential x AFCIs/home
x homes/year x years*

The years are 2014 – 2008 = 6

So damages = \$20 x 20 x 500K x 6

damages of ~ \$1B

This for the mandated purchase of a device that provides less fire protection than the disallowed Branch/feeder AFCI.

Trust, But Verify

3. Was information withheld which would make a true claim worthless?

This issue addresses an engineer's response to an NEC 2008 Code Panel's question asking if his Combination AFCI would respond to arcing at a loose connection. His answer was

Yes, if arcing was continuous.

COMBINATION AFCIs:

WHAT THEY WILL AND WILL NOT DO

Three NEC 2014 paragraph 210.12 Proposals:

1. Eliminate wording “~~combination type~~”
2. Add wording “which includes earth leakage protection (30mA trip sensitivity)”
3. Eliminate wording “~~AFCI located at the first receptacle outlet~~”

CMP 2 Initial Action on Proposals

1. Eliminate wording “~~combination type~~”

Panel Meeting Action: Reject

Panel Statement:

“Replication of the experiments shown in the video shows that there is minimal actual arcing occurring. When arcing does occur, causing the sparking seen in the video, its duration is very short and the energy is three orders of magnitude below what is required to ignite the NM cable or surrounding materials. The waveform looks the same as when a wall switch is switched on and off. If the AFCI responded to this waveform it would increase the incidence of unwanted tripping while not contributing significantly to mitigating fire hazards.”

http://www.nfpa.org/Assets/files/AboutTheCodes/70/70_A2013_NEC-P02_ROPballot.pdf

COMBINATION AFCIs:

WHAT THEY WILL AND WILL NOT DO

- The author hopefully has answered the questions. Despite NEMA and UL claims, they don't respond to series arcing in cords.
- History of ACFI was outlined in hope that the standard and code processes can be improved.
- There is an important ethical role IEEE engineers need to play, to avoid false claims.

COMBINATION AFCIs:

WHAT WILL HAPPEN NEXT?

1. **Nothing**, the NEC will continue to require the Combination AFCI, while disallowing the lower cost better performing Branch/feeder AFCI.

This is unlikely. The early responses to my web site indicates that people are angry. They want action.

COMBINATION AFCIs:

WHAT WILL HAPPEN NEXT?

- 2. NEC 2014 remove requirement for a Combination AFCI and UL and NEMA will correct their AFCI claims**

This is preferred action.

I believe people should be judged not by the mistakes they make, but how they respond when they learn they've made them!

COMBINATION AFCIs:

WHAT WILL HAPPEN NEXT?

3. The Federal Trade Commission becomes involved.

*“Diet-Pill Makers Fined for False Advertising
Morning Edition, January 5, 2007 – The Federal Trade
Commission slaps four leading makers of diet pills with a
\$25-million fine for falsely claiming that their product
promotes weight loss.”*

<http://www.npr.org/templates/story/story.php?storyId=6727752>

Trust, But Verify

Questions?