



# Arc Fault Circuit Interrupter (AFCI)



## Arc Faults and Potential Causes

- Arc faults usually occur across carbonized paths. These carbonized paths can develop over a wide time range, from instantly to years. In order to understand more, we will begin with some definitions:
  - ◆ UL 1699 Definitions:
    - Arcing – A luminous discharge of electricity across an insulating medium, usually accompanied by the partial volatilization of the electrodes
    - Arc fault – An unintentional arcing condition in a circuit
    - Carbonized Path – A conductive carbon path formed through or over the surface of a normally insulating material.
- Arc faults may occur anywhere in the home's electrical system as a result of:
  - ◆ Worn electrical insulation or damaged wire
  - ◆ Misapplied or damaged plug-in appliance cords and equipment
  - ◆ Loose electrical connections
  - ◆ Accidentally piercing electrical cable behind drywalls with drill bit, nail, or screw
  - ◆ Hammering electrical cable too tightly against studs during installation
  - ◆ Pushing furniture against cords plugged into outlets

**AFCI's can address these hidden dangers.**

# What is an AFCI (Arc-Fault Circuit Interrupter)?

## ■ ARC-FAULT CIRCUIT-INTERRUPTER (AFCI)

- ◆ UL 1699 definition: A device intended to mitigate the effects of arcing faults by functioning to de-energize the circuit when an arc-fault is detected.

## ■ There are 2 basic types of circuit breaker AFCI's

### ◆ Branch/Feeder type

- UL 1699 definition: A device intended to be installed at the origin of a branch circuit or feeder, such as at a panelboard. It is intended 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. It may be a circuit-breaker type device or a device in its own enclosure mounted at or near a panelboard.

### ◆ Combination type

- UL 1699 definition: An AFCI which complies with the requirements for both branch/feeder and outlet circuit AFCIs. It is intended to protect downstream branch circuit wiring and cord sets and power-supply cords.
- UL 1699 definition for outlet circuit AFCI: A device intended to be installed at a branch circuit outlet, such as at an outlet box. It is intended to provide protection of cord sets and power-supply cords connected to it (when provided with receptacle outlets) 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.
  - **Important Note:** Outlet circuit AFCIs cannot protect upstream of the device for all types of arcing, leaving the "homerun" wiring unprotected.

## ■ 2005 NEC<sup>®</sup> requires Combination type AFCI's beginning Jan 1, 2008

## Why do you need an AFCI?

- AFCIs provide an increased level of safety to the electrical wiring system.
  - ◆ U.S. Fire Administration estimates:
    - Statistics based on home wiring issues
      - 67,800 fires each year<sup>1</sup>
      - 485 deaths annually<sup>1</sup>
      - ~2,300 injuries annually<sup>1</sup>
      - \$868 million in property losses<sup>1</sup>
    - “AFCI devices currently on the market may address 50% or more of these fires”<sup>2</sup>
  - ◆ The 1999 through 2005 versions of the National Electrical Code® (NFPA 70 Section 210.12) require the use of AFCI protection for bedroom circuits in new residential construction.
    - States and local governments may adopt or amend the NEC
    - Check local codes for specific requirements
  - ◆ The U.S. Consumer Product Safety Commission and the National Association of State Fire Marshals (NASFM) are two of the leading groups pushing for use of AFCI protection in other circuits in both new and existing homes.

1 *On the Safety Circuit: A Fact Sheet on Home Electrical Fire Prevention*. United States Fire Administration (2006)

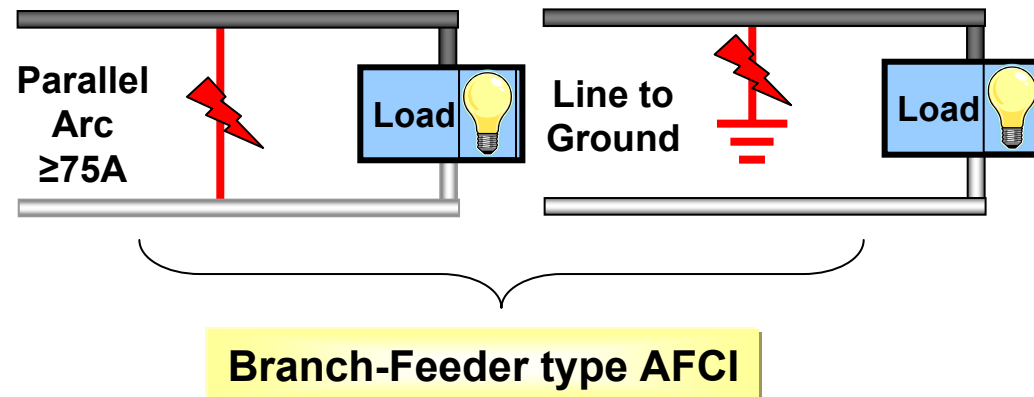
2 Oct 1, 2002 CPSC – NFPA Technical Committee Document Proposal Form

## Details of an AFCI: Arc Fault vs. Conventional Circuit Protection

- Conventional circuit breakers have 2 tripping mechanisms
  - ◆ Short circuit or Magnetic trip (Electromagnetic element)
    - occurs when two current-carrying conductors touch and a low resistance path for current between the conductors is created
    - results in a surge current that will quickly trip a standard circuit breaker
  - ◆ Overload or Thermal trip (Bimetal element)
    - occurs when the rated capacity of circuit breaker is exceeded because additional devices are added to a circuit or existing devices require additional current
    - overload current will also trip a standard circuit breaker
- AFCI's have the same tripping mechanisms above **PLUS**:
  - ◆ Arcing fault trip (Electronic)
    - results from brief, intermittent current flow between current-carrying conductors
    - sporadic and high resistance in nature
    - results in low-level current surges that are unlikely to trip a conventional circuit breaker due to the sporadic characteristics

## Details of an AFCI: Branch/Feeder type Arc-Fault Circuit-Interrupter

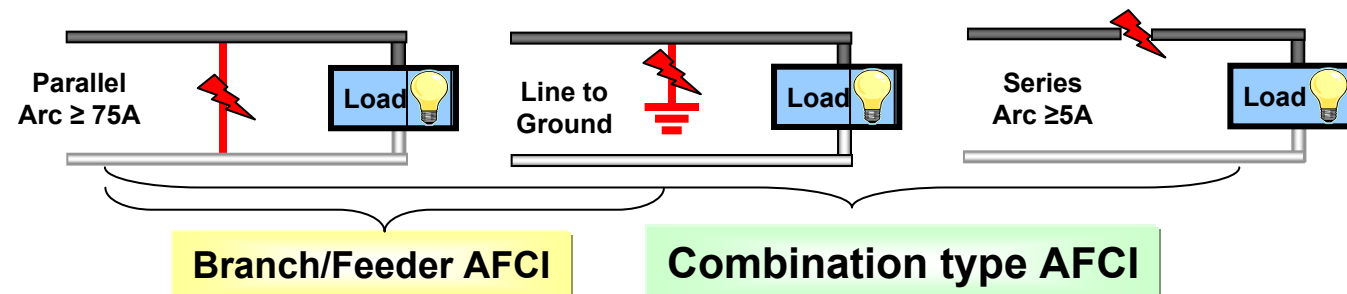
- Siemens Branch/Feeder type AFCI's consist of two sides
  - ◆ Mechanical
    - Functions as a normal thermal magnetic circuit breaker
  - ◆ Electronic
    - Detects the arc and activates a solenoid to trip the mechanical side
    - Detects line-to-neutral arcs  $\geq 75A$  and line-to-ground arcs



- It is NOT a replacement for a GFCI (Ground Fault Circuit Interrupter)
  - ◆ AFCI's are not intended for personnel protection

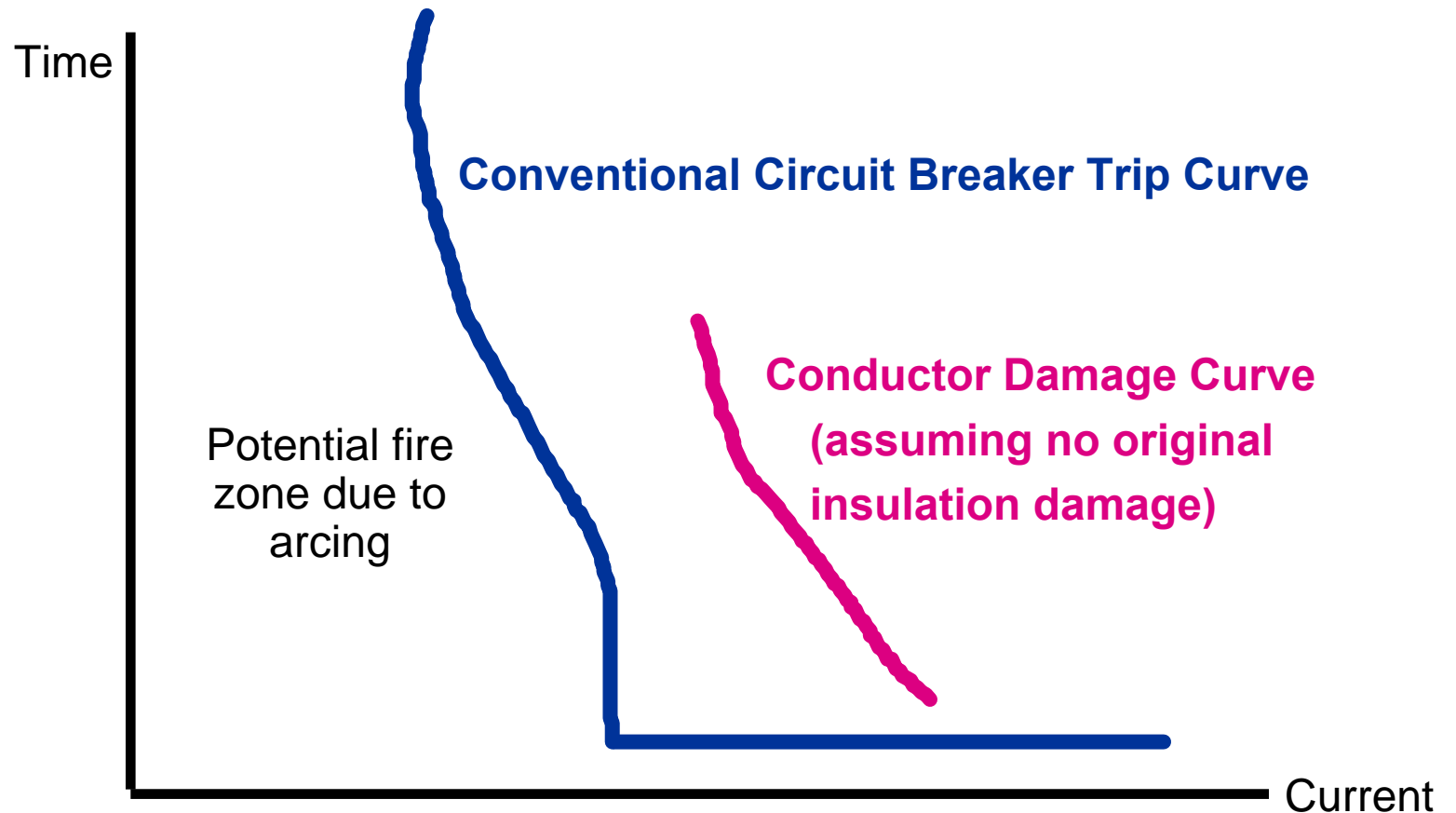
# Details of an AFCI: Combination type Arc-Fault Circuit-Interrupter

- Complies with the UL requirements for both branch/feeder type and outlet circuit type AFCIs.
- “Combination” does **NOT** mean an AFCI + GFCI
- Provides protection against the high-energy parallel (line-to-neutral and line-to-ground) arcing and low-energy series arcing.
  - **Combination** = parallel + series arcing

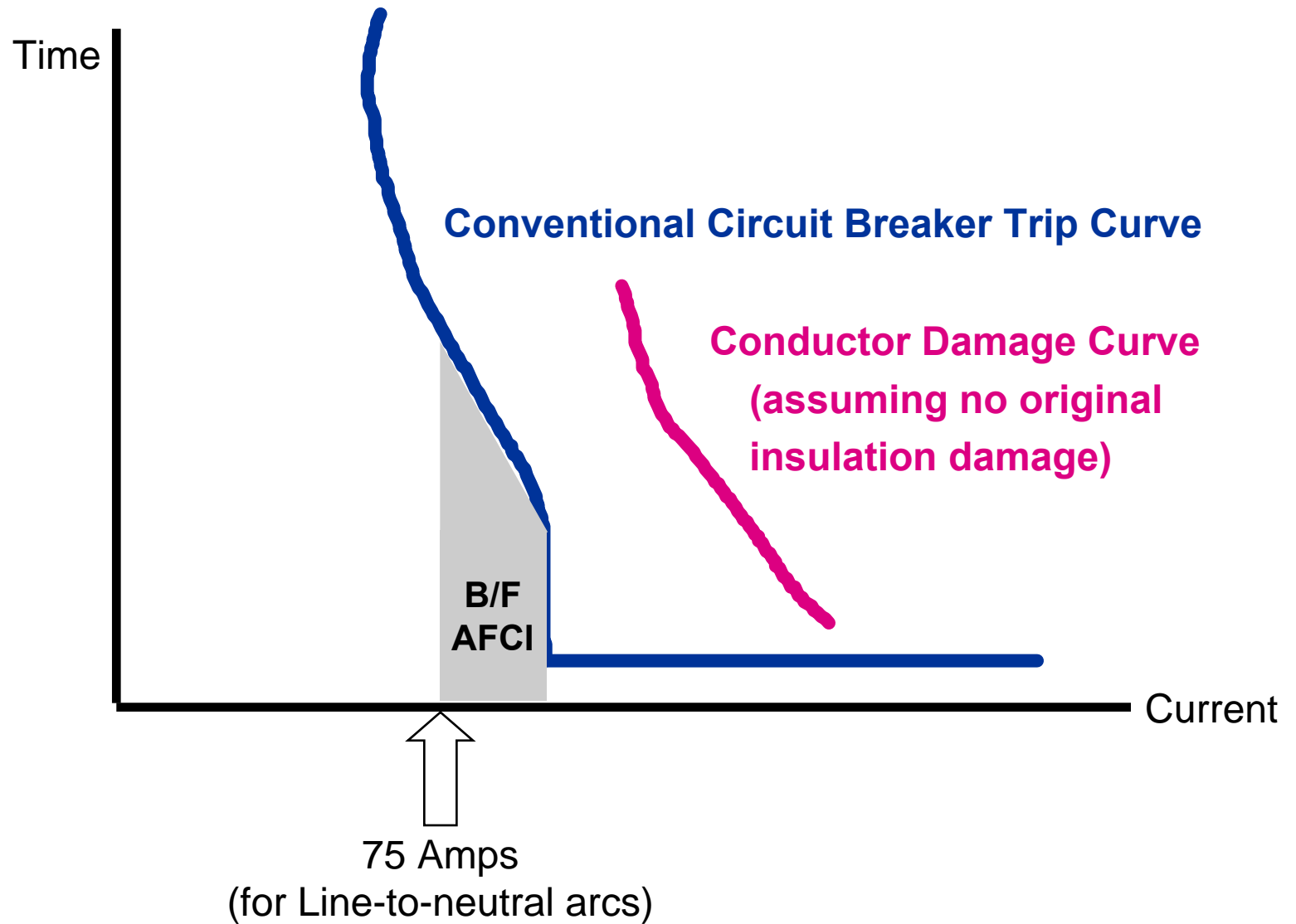


- Protects downstream branch circuit wiring, cord sets and power-supply cords.

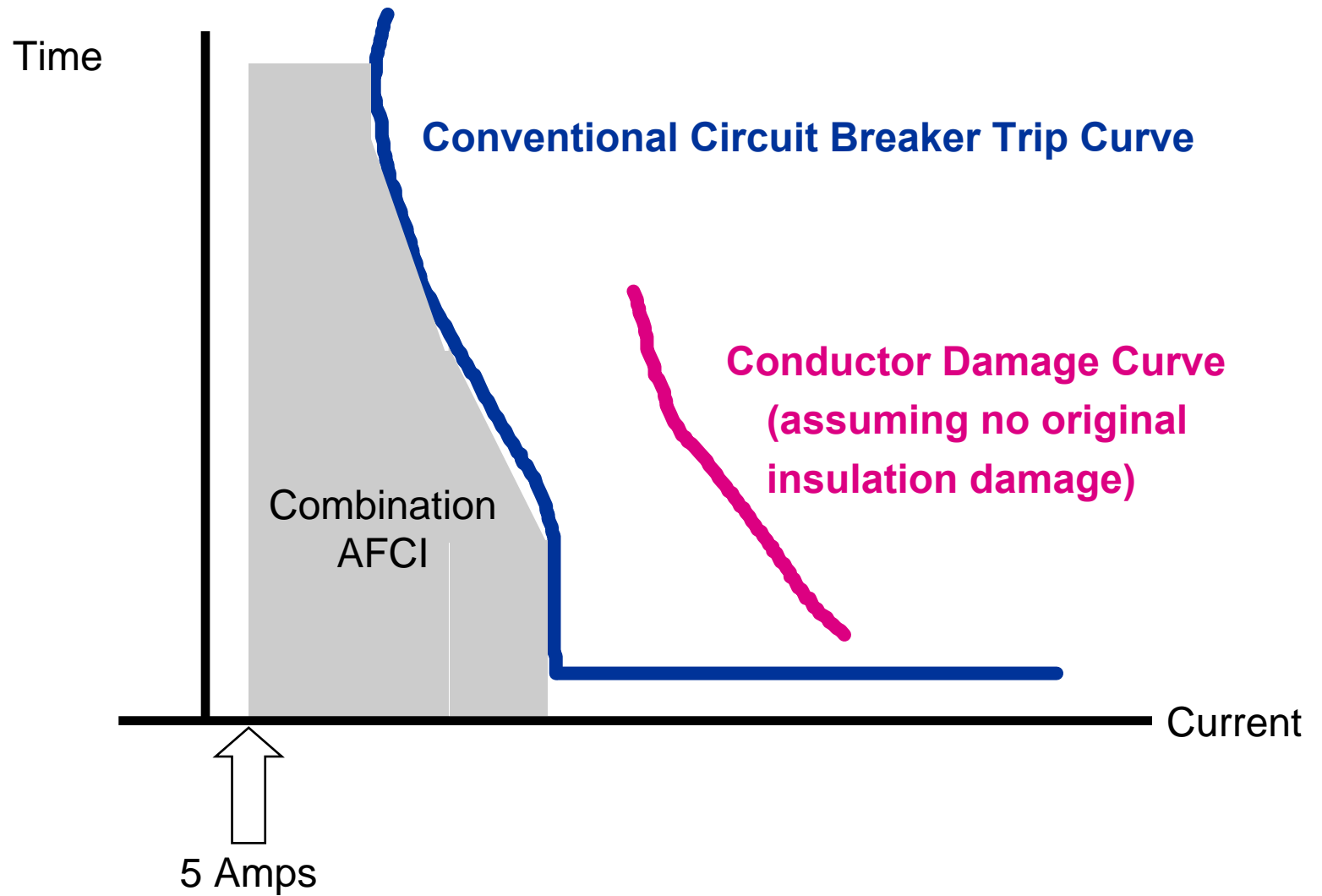
## Details of an AFCI: Conventional Circuit Protection



## Details of an AFCI: Branch/Feeder type AFCI Circuit Protection



## Details of an AFCI: Combination type AFCI Circuit Protection





## Code Requirement details regarding AFCI



- **1999 National Electrical Code® Section 210-12**
  - **Dwelling Unit Bedrooms.** All branch circuits that supply 125-volt, single-phase, 15- and 20-ampere **receptacle outlets** installed in dwelling unit bedrooms shall be protected by an arc-fault circuit-interrupter(s).



- **2002 National Electrical Code® Section 210.12**
  - **Dwelling Unit Bedrooms.** All branch circuits that supply 125-volt, single-phase, 15- and 20-ampere **outlets** installed in dwelling unit bedrooms shall be protected by an arc-fault circuit interrupter listed to provide protection of the entire branch circuit.



- **2005 National Electrical Code® Section 210.12**
  - All 120-volt, single phase, 15- and 20-ampere branch circuits supplying **outlets** installed in **dwelling unit bedrooms** shall be protected by a listed arc-fault circuit interrupter, **combination type** installed to provide protection of the branch circuit. Branch/feeder AFCIs shall be permitted to be used to meet the requirements of 210.12(B) until **January 1, 2008**.
  - **Exception:** The location of the arc-fault circuit interrupter shall be permitted to be at other than the origination of the branch circuit in compliance with (a) and (b):
    - (a) The arc-fault circuit interrupter installed within 1.8 m (6 ft) of the branch circuit overcurrent device as measured along the branch circuit conductors.
    - (b) The circuit conductors between the branch circuit overcurrent device and the arc-fault circuit interrupter shall be installed in a metal raceway or a cable with a metallic sheath.

**Dwelling Unit:** A single unit, providing complete and independent living facilities for one or more persons, including permanent provisions for living, sleeping, cooking, and sanitation



## Expectations for 2008 NEC® AFCI Requirements

### Current Status of 2008 NEC Section 210.12

- ◆ All 120-volt, single phase, 15- and 20-ampere branch circuits supplying outlets installed in dwelling unit bedrooms, family rooms, living rooms, parlors, libraries, dens, sun rooms, recreation rooms or other similar rooms shall be protected by a listed arc-fault circuit interrupter, combination type installed to provide protection of the branch circuit.
  - **Exception:** The location of the arc-fault circuit interrupter shall be permitted to be at the location of the first outlet from the origination of the branch circuit when the wire to that outlet is protected in EMT or Type AC cable, steel type.

## Example applications

- Detached homes
- Extended stay hotels
- Military barracks
- Dormitories
- Assisted Living facilities



## National Electrical Code® Progression

1999 NEC

- Listed AFCI future requirement
  - Allows Branch/Feeder AFCI
- Jan 1, 2002: Bedroom [receptacles](#)

2002 NEC

- Listed AFCI in All Bedroom [circuits](#)
  - Allows Branch/Feeder AFCI

2005 NEC

- [Combination Type](#) AFCI in bedroom circuits
- Branch/Feeder AFCI permitted until Jan 1, 2008

2008 NEC

Current

Status

- Requires Combination type AFCI
- [Expand](#) to 1 pole, 15-20A circuits installed in bedrooms, family rooms, living rooms, parlors, libraries, dens, sun rooms, recreation rooms or similar rooms
- For receptacle Combination type AFCI use – Steel conduit required for “home run” wiring