BOARD OF ELECTRICAL ENGINEERING
PROFESSIONAL REGULATION COMMISSION

Common Mistakes in Electrical Grounding and Bonding

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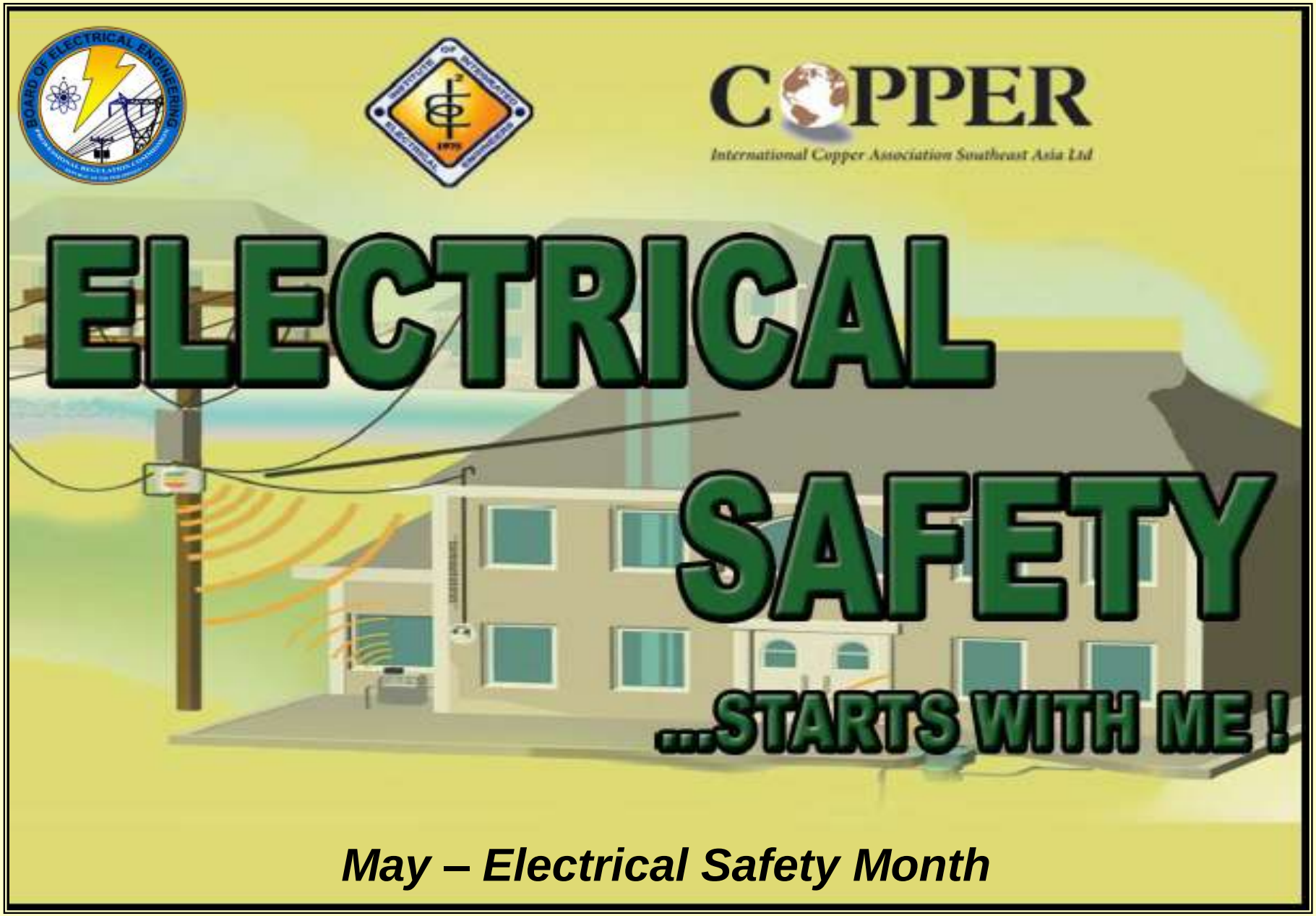
Member- Board of Electrical Engineering
member-Technical Committee, PEMCI
Chairman-Distribution Management Committee



May – Electrical Safety Month

1. **It is important to *ground* metal parts to a suitable *grounding electrode*, so that in the event of a ground fault, dangerous *ground-fault current* will be shunted into the earth away from persons, thereby protecting them against electric shock.**
2. **Electrical equipment must be *grounded* to ensure that dangerous voltage on metal parts resulting from a *ground fault* can be reduced to a safe value.**
3. **Electrical equipment must be *grounded* so that sufficient fault current will flow through the circuit protection device to quickly open and clear the *ground fault.* For example, a 20 A circuit breaker will trip and de-energize a 240 V ground fault to a metal pole that is grounded to a 25 ohm ground rod.**
4. **When electrical current is given multiple conductive paths on which to flow, current will only take the path of least resistance.**

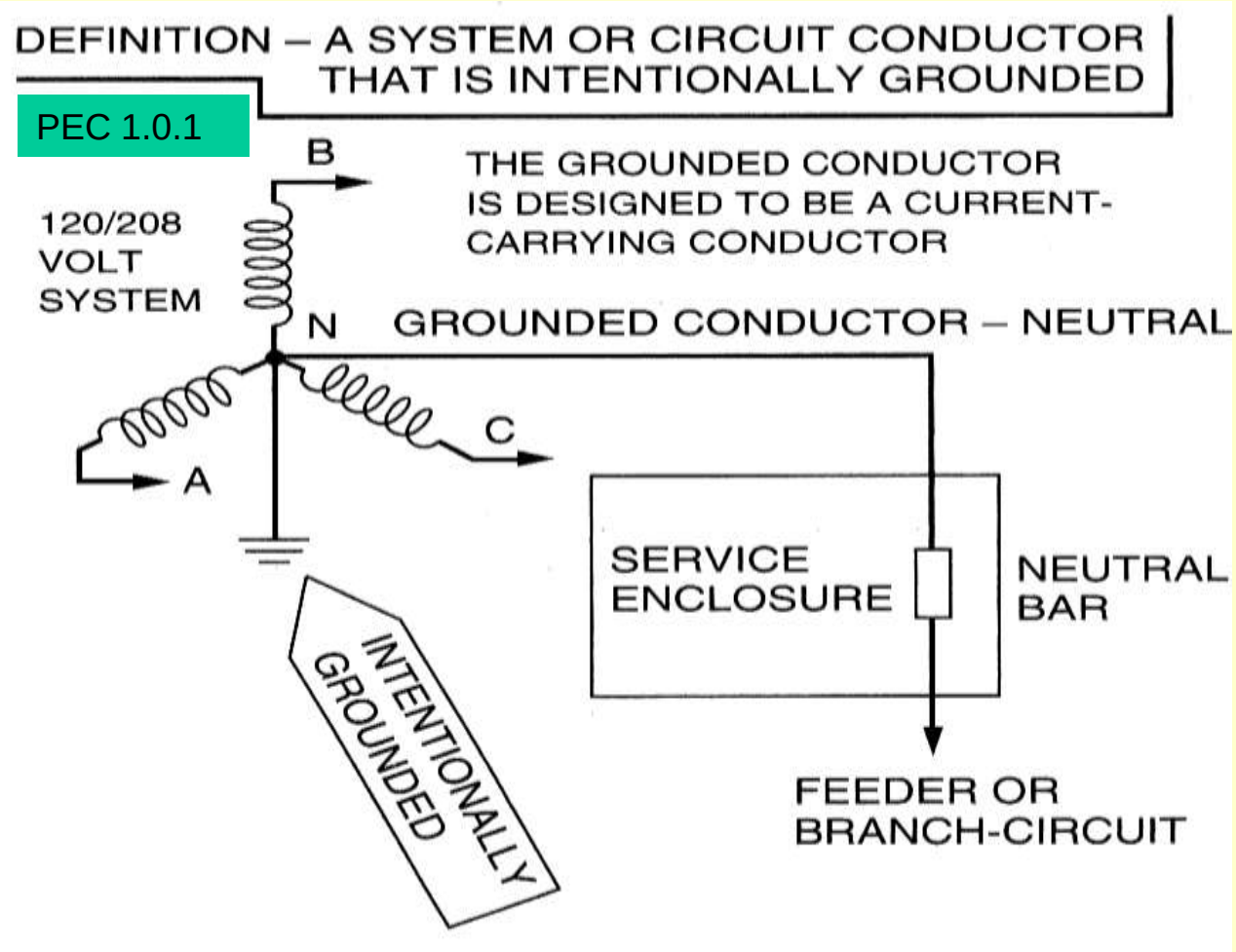
Introduction

- Why Electrical Grounding and Bonding?
  - The most controversial and misunderstood concepts in the Code.
  - The most neglected subject by electrical practitioners.
  - When improperly installed, it may results to physical injuries, costly damage to electrical facilities or even death to individual.
  - Each utility (power, telephone, cable TV) has its own grounding electrodes.
  - Electrical Grounding and Bonding circuit follows the basic laws of electricity.

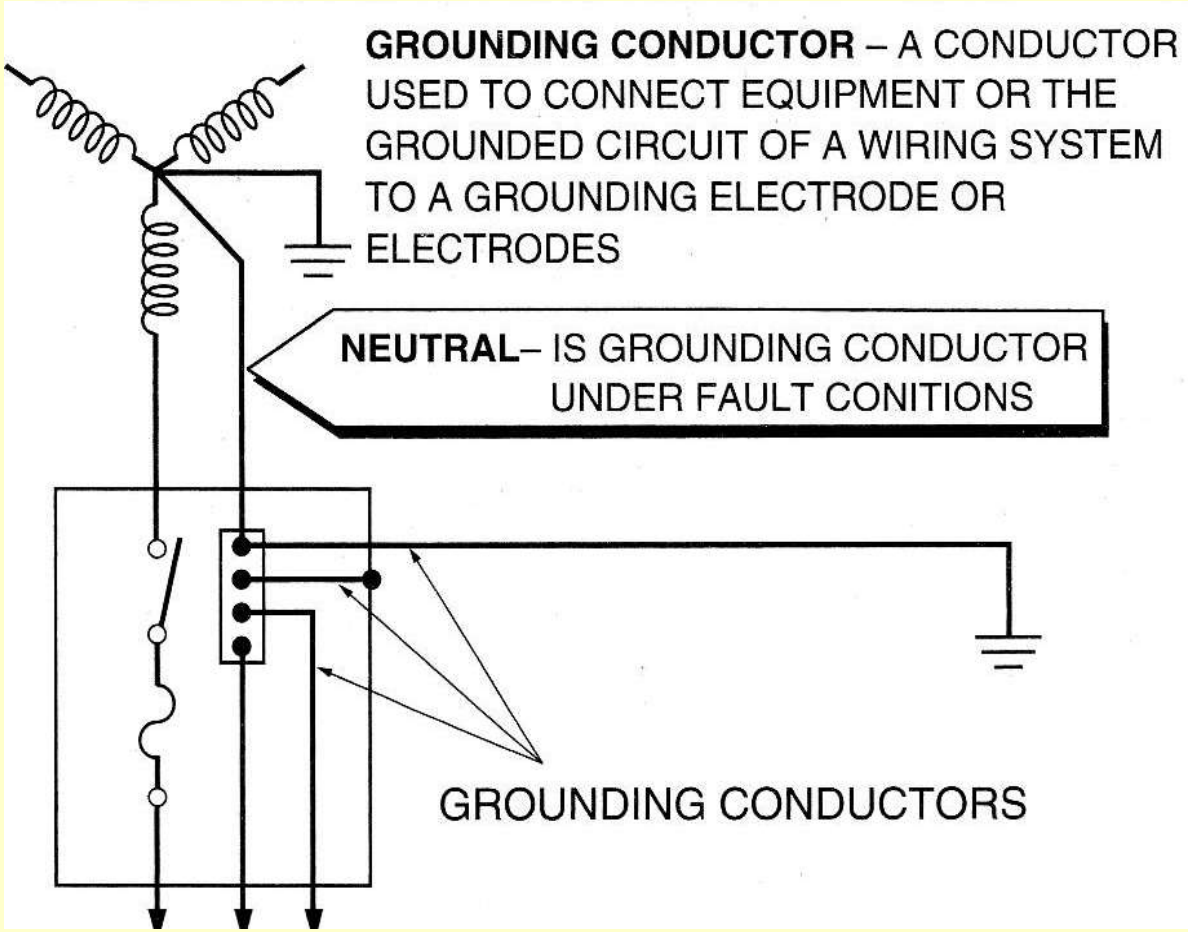
What is the difference between grounded conductor and grounding conductor???

- Grounded conductor – a system or circuit conductor that is intentionally grounded.
- Grounding Conductor – a conductor used to connect equipment or the grounded circuit of a wiring system to a grounding electrode conductor.
- From PEC 2009

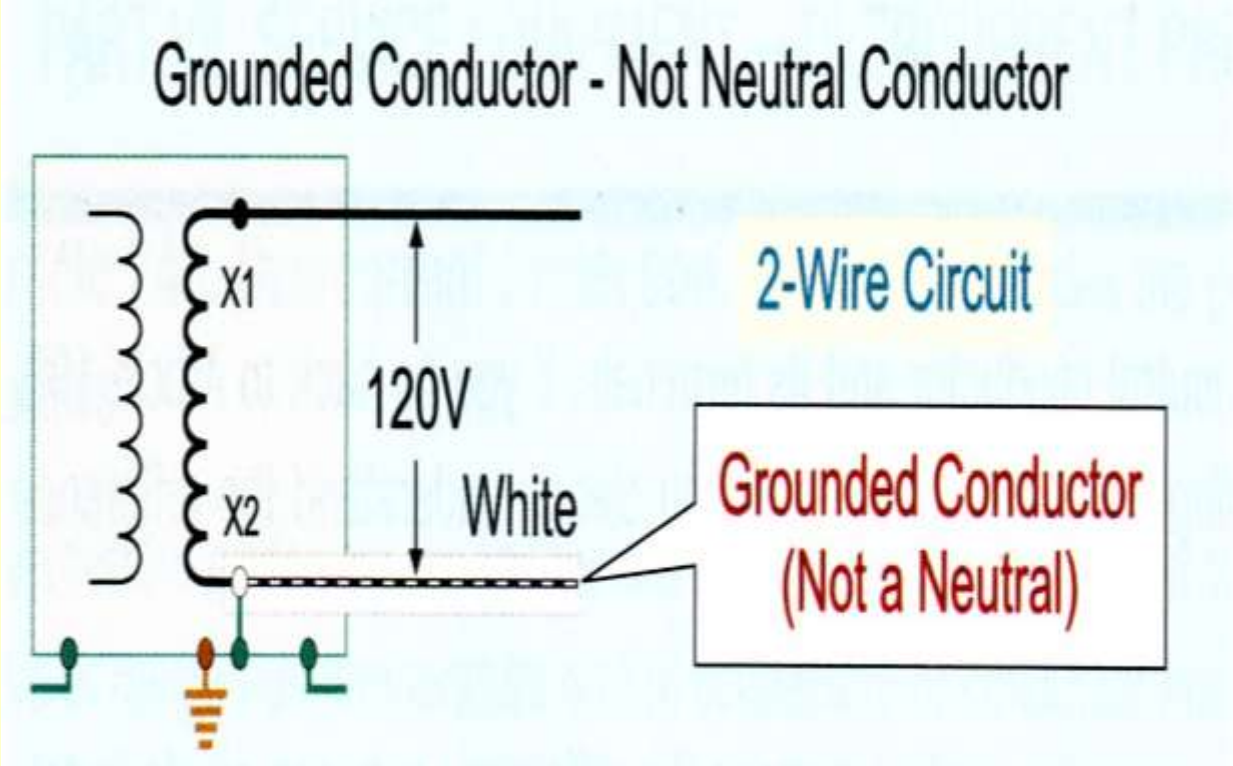
Definition of Grounded Conductor



Definition of Grounding Conductor

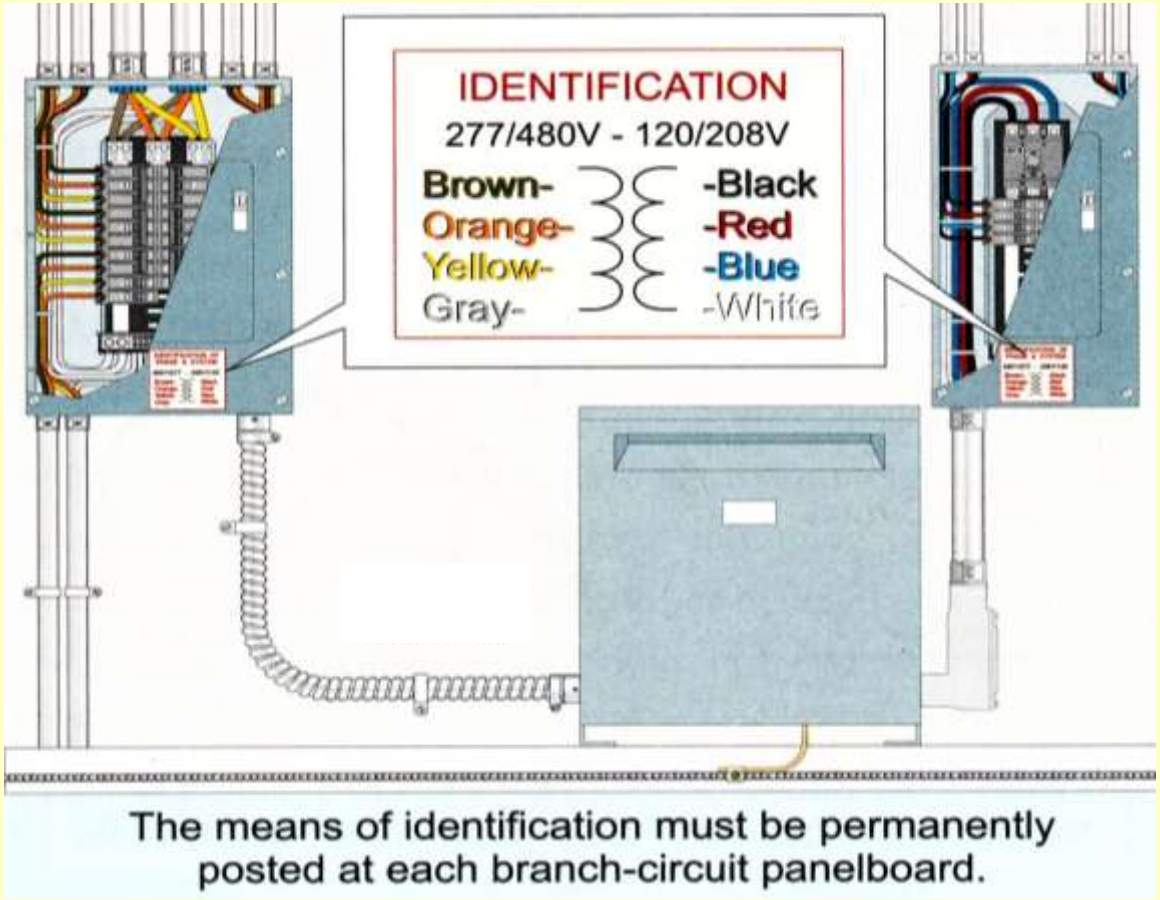


Grounded Conductor



Not a “neutral” because it is not a 3 0r 4 wire system.

Identifying Grounded Neutral Conductors of Different Systems



The means of identification must be permanently posted at each branch-circuit panelboard.

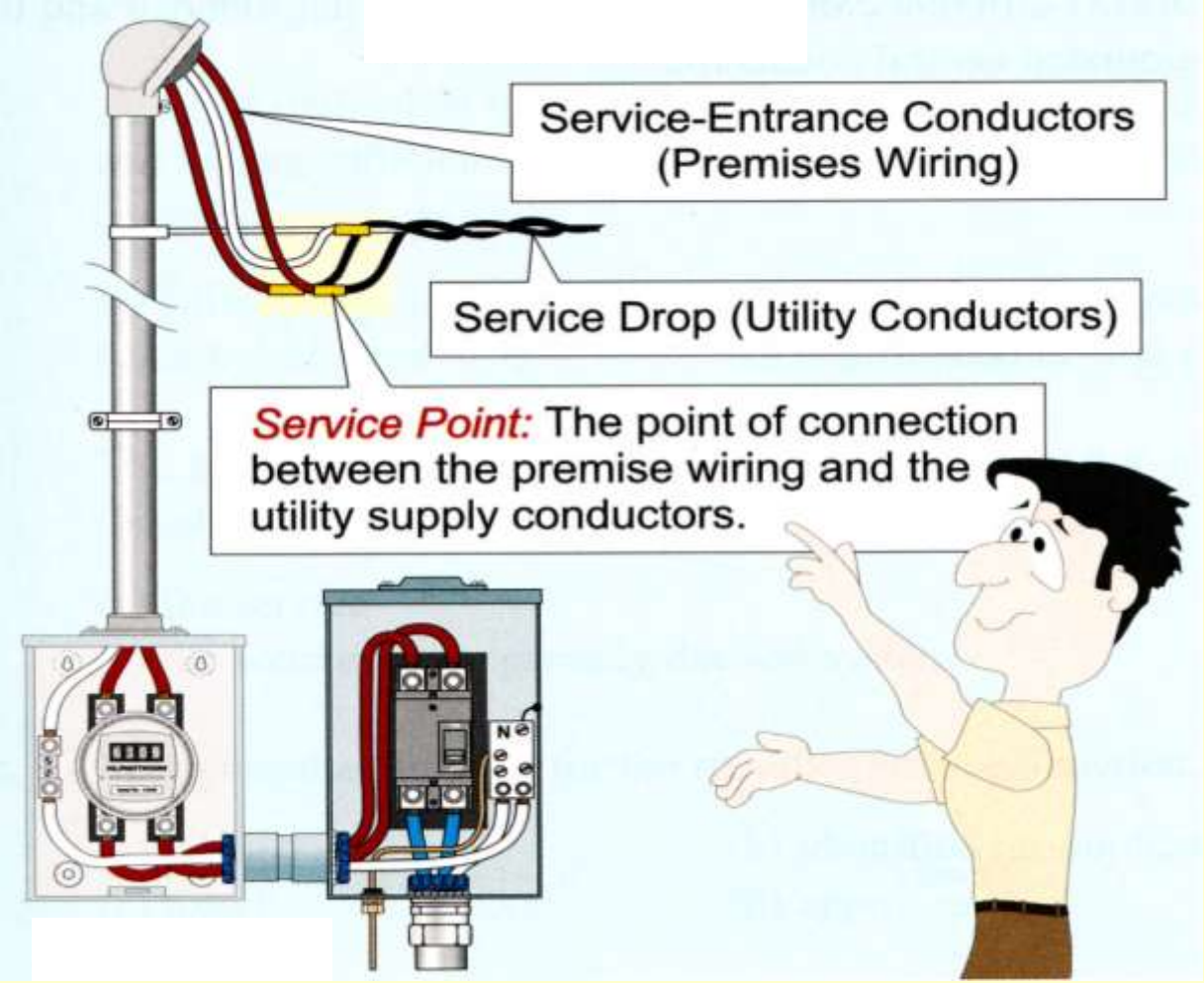
Proper Wiring Starts with the Right Color Used in Conductor Wiring

	120/240 – V, Single Phase	208Y/120 – V, Three-Phase	480Y/277-V, Three-Phase
Phase A	Black	Black	Brown
Phase B	Red	Red	Orange
Phase C		Blue	Yellow
Neutral Conductor	White	White with red Stripe	Gray
Equipment Grounding Conductor	Green	Green	Green

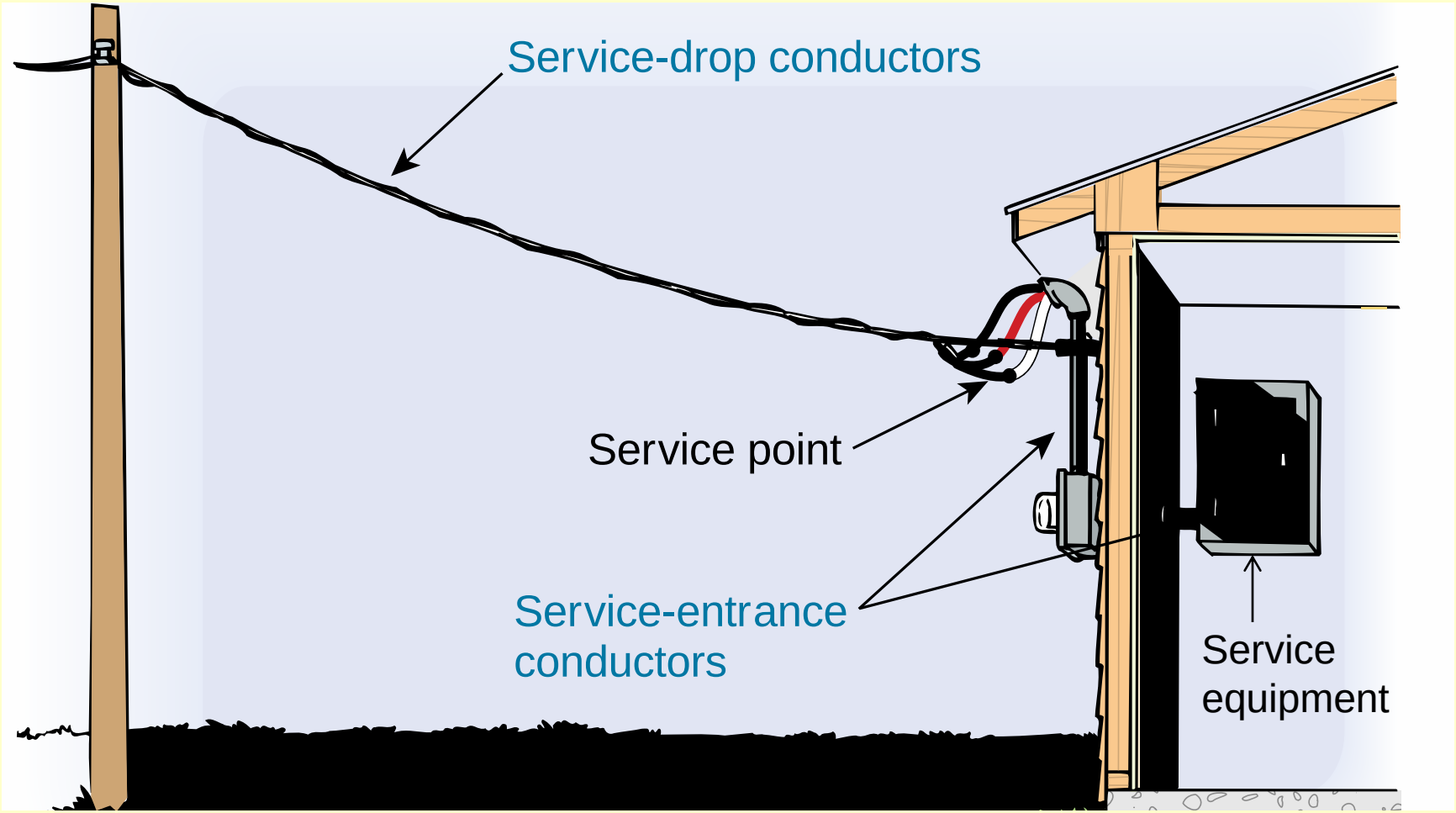
Service Equipment

- The necessary equipment, usually consisting of a circuit breaker(s) or switch(es) and fuse(s) and their accessories, connected to the load end of the of service conductors to a building or other structure, or an otherwise designated area, and intended to constitute the main control and cutoff of the supply.

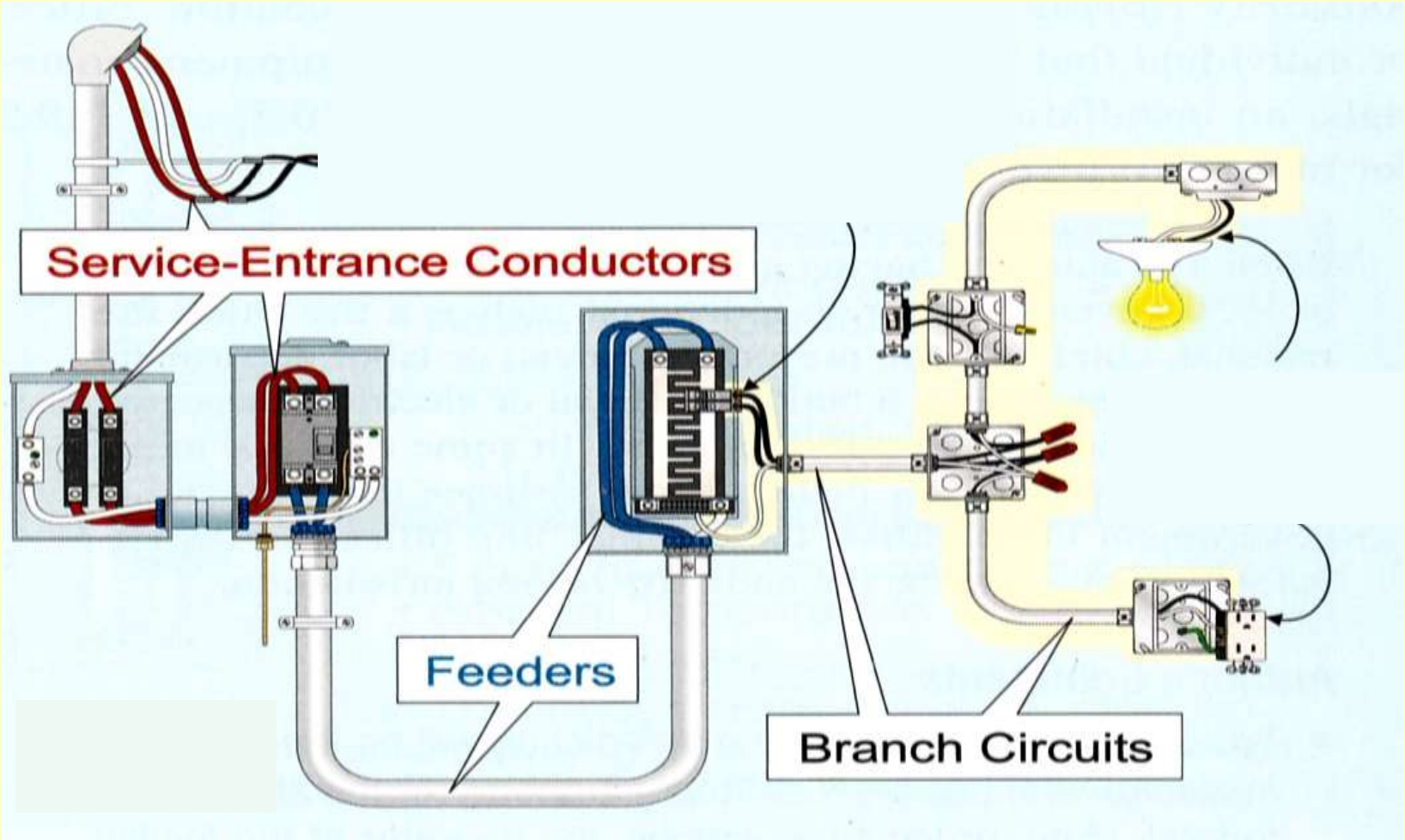
Service


Service-Entrance Conductors
(Premises Wiring)
Service Drop (Utility Conductors)
Service Point: The point of connection between the premise wiring and the utility supply conductors.

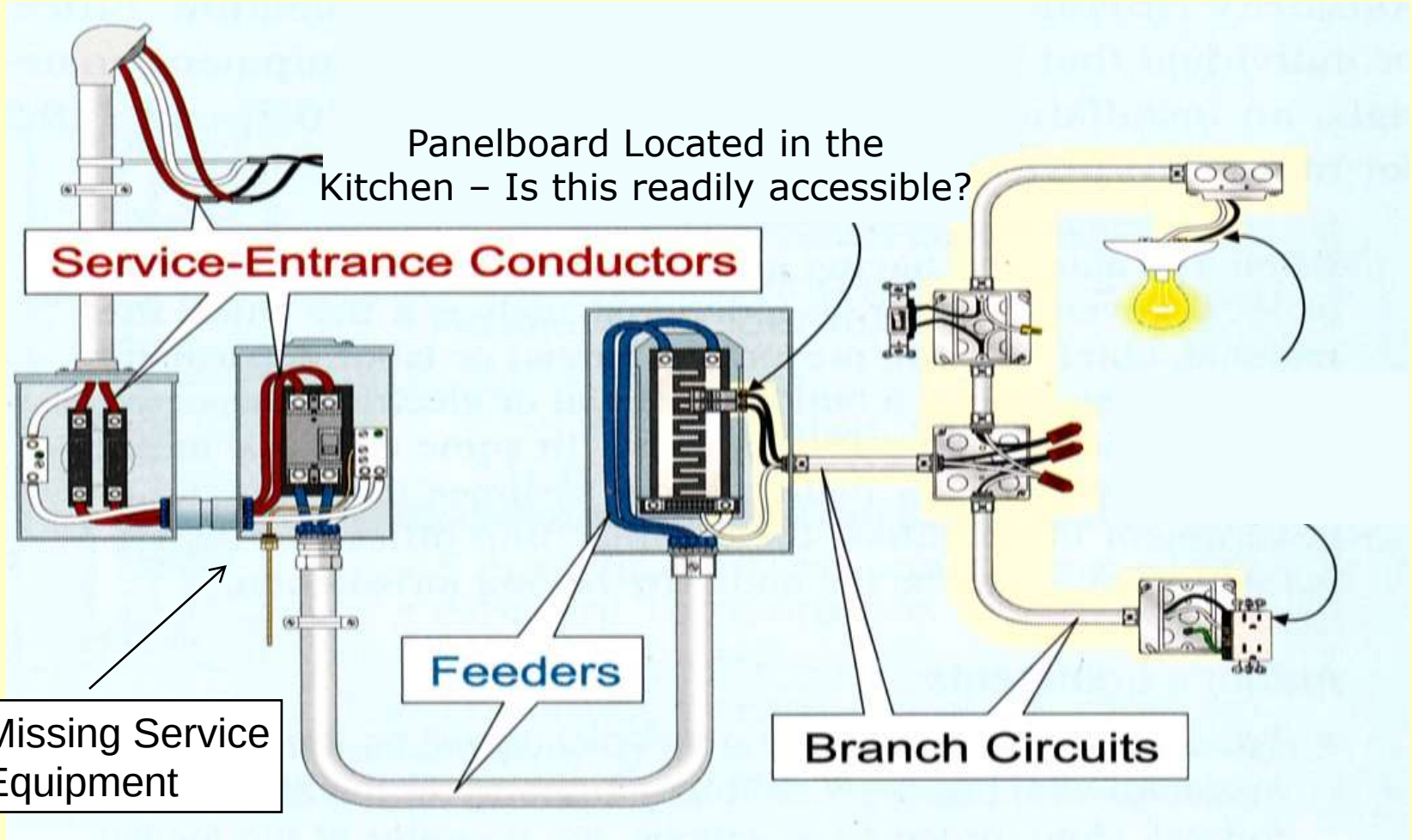
Service


Service-drop conductors
Service point
Service-entrance conductors
Service equipment

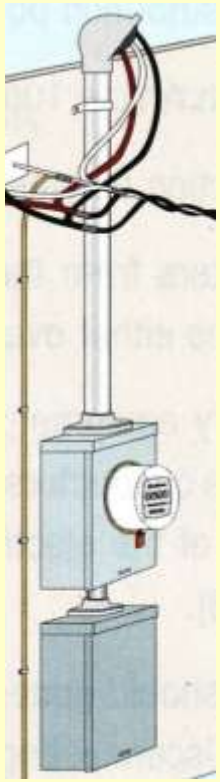
Proper Electrical Installation



Existing Practice???

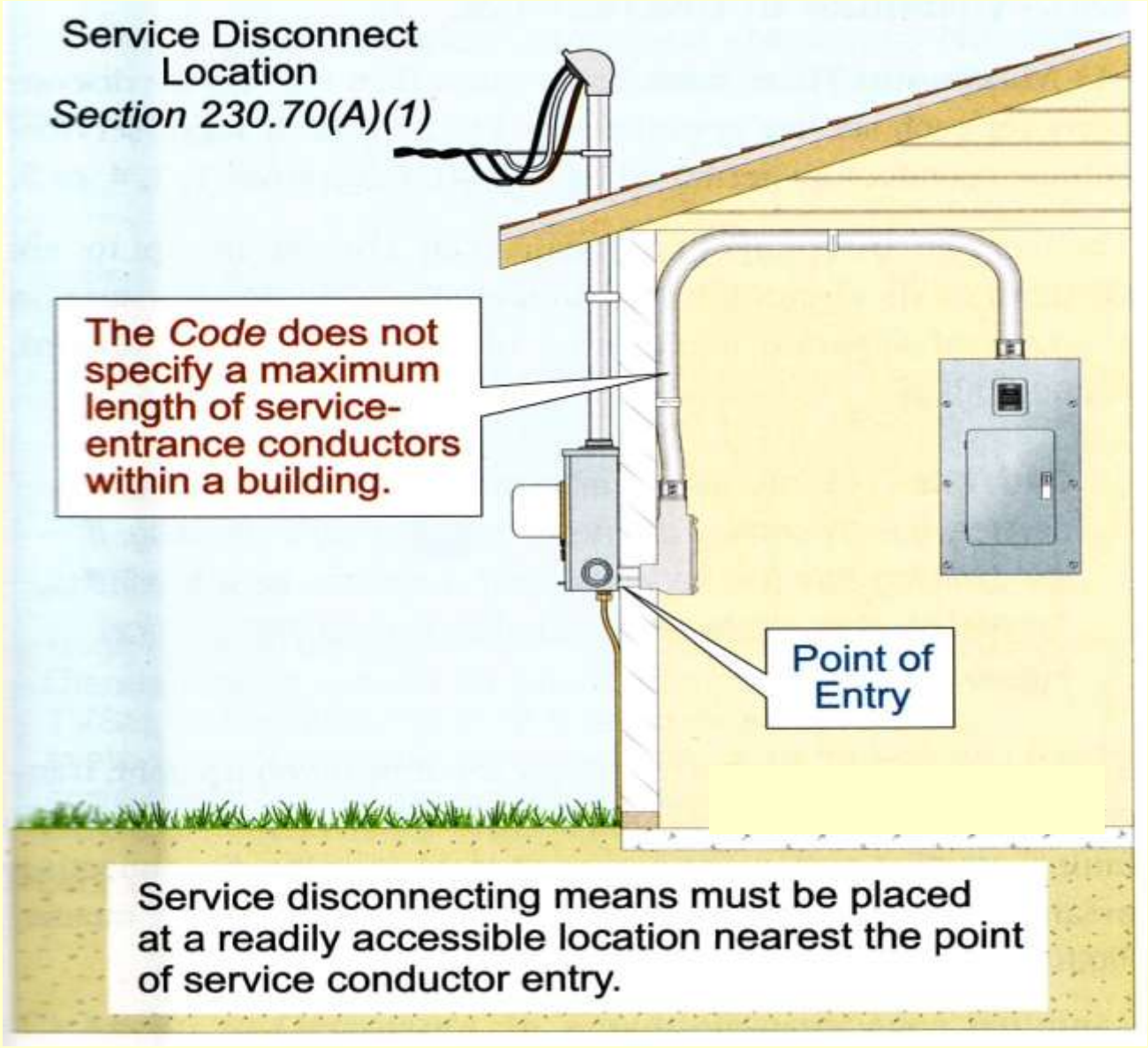


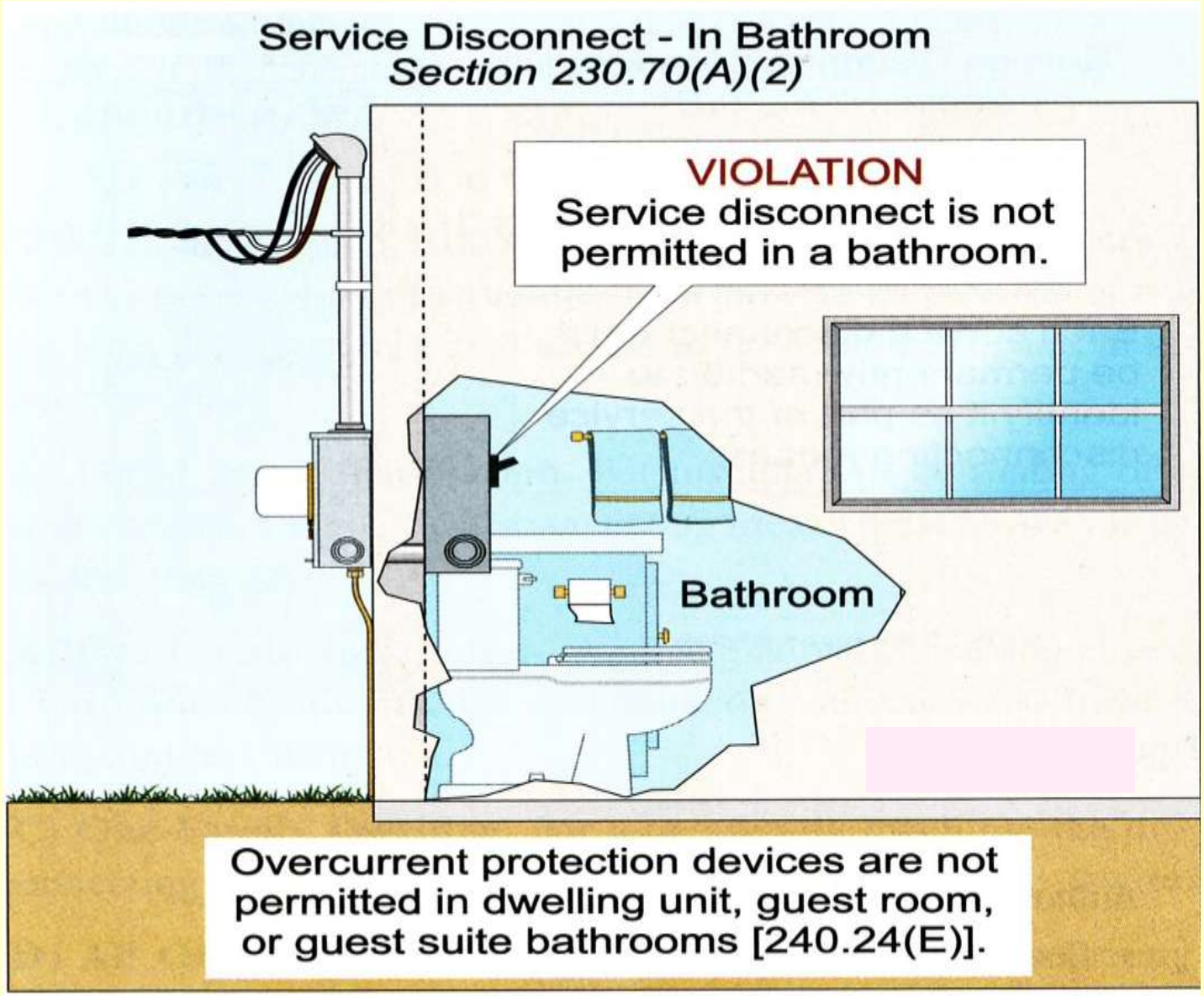
Service Equipment-Disconnecting Means



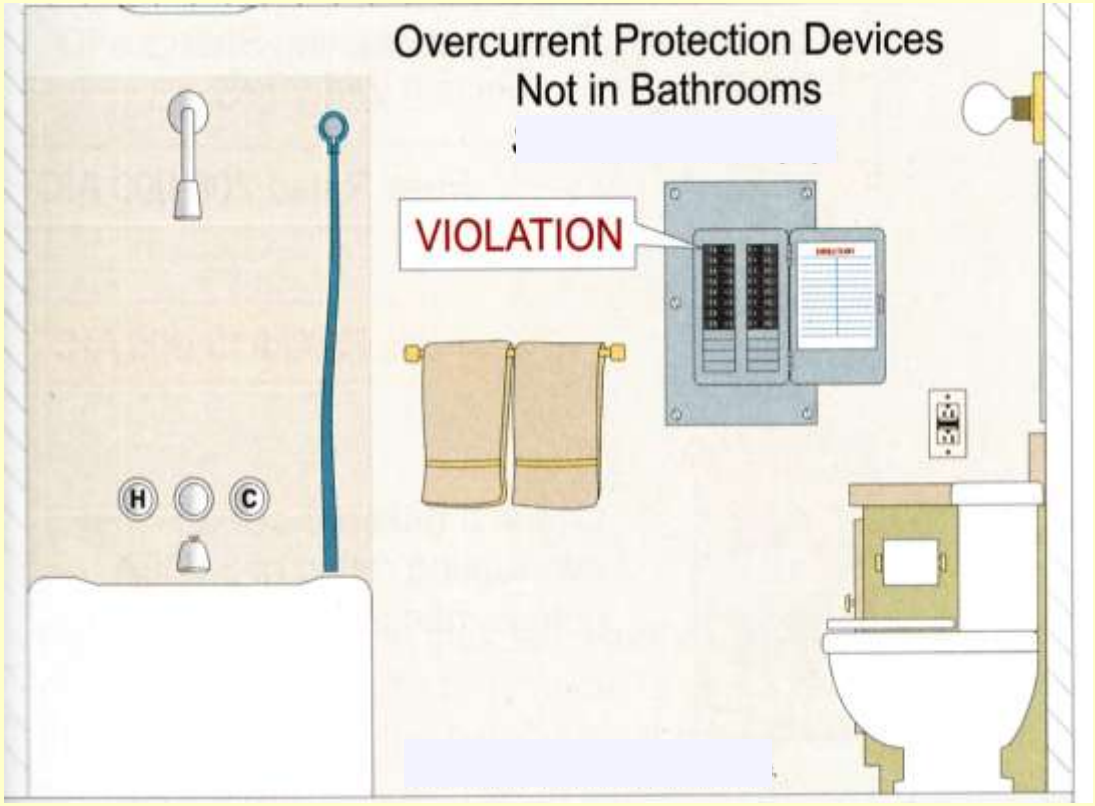
A – The service disconnecting means shall be installed at a readily accessible location of a building or a structure. 2.30.6.1(a)(1)

It may be located either outside wall or inside, nearest the point of the Service Conductors.


Service Disconnect Location
Section 230.70(A)(1)
The Code does not specify a maximum length of service-entrance conductors within a building.
Point of Entry
Service disconnecting means must be placed at a readily accessible location nearest the point of service conductor entry.

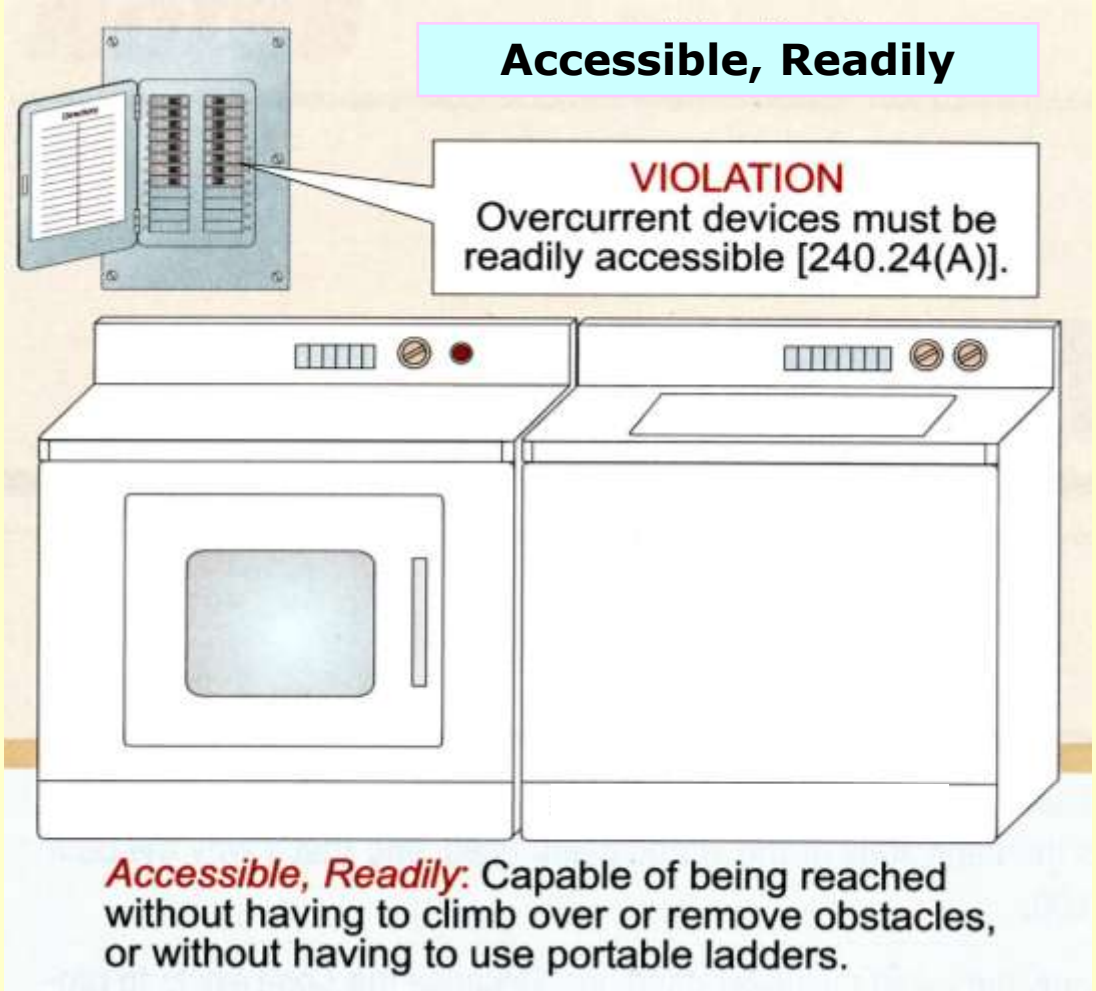

Service Disconnect - In Bathroom
Section 230.70(A)(2)
VIOLATION
Service disconnect is not permitted in a bathroom.
Bathroom
Overcurrent protection devices are not permitted in dwelling unit, guest room, or guest suite bathrooms [240.24(E)].

Not Located in Bathrooms

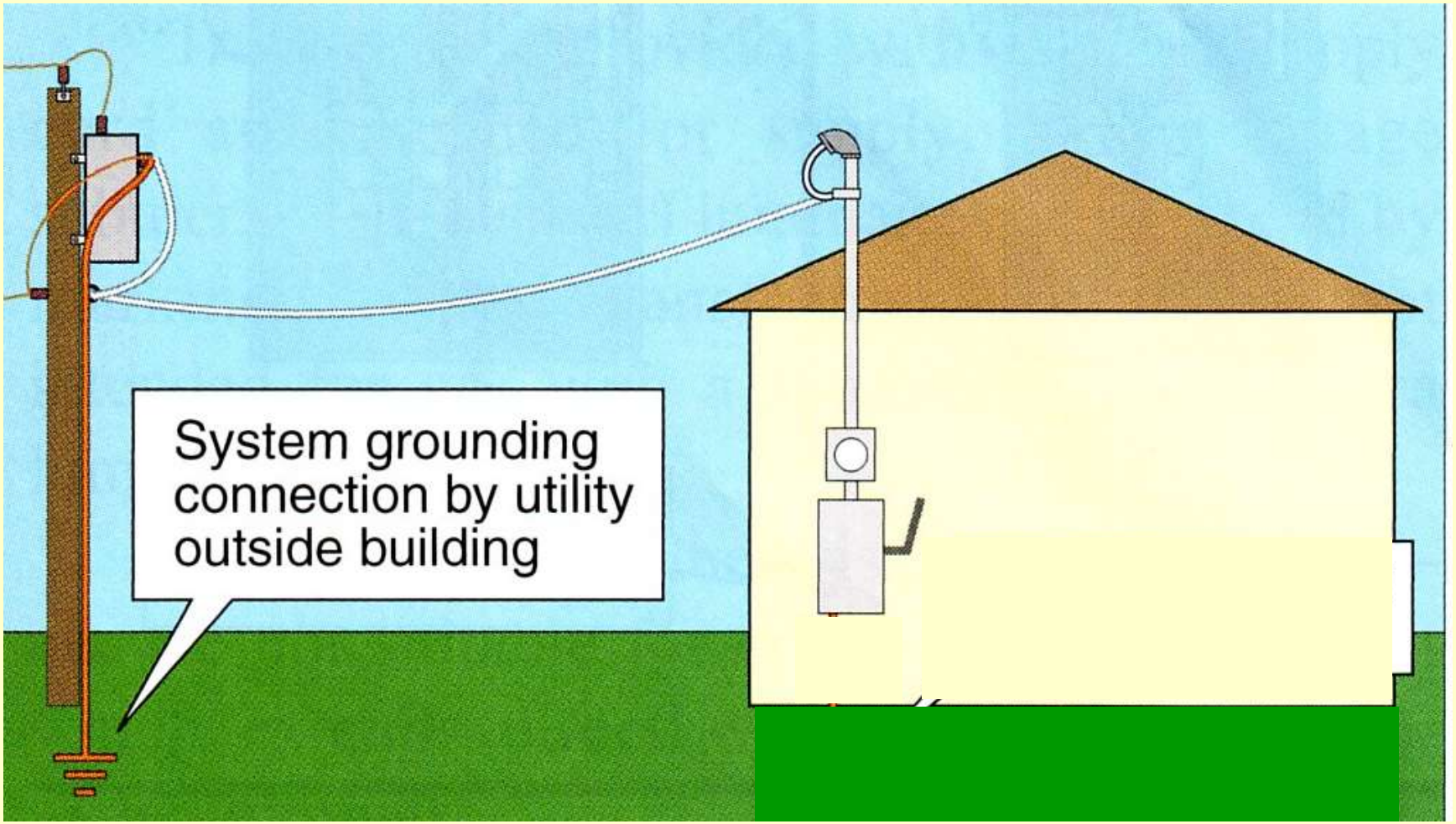


Overcurrent protection devices must not be located in the bathrooms of dwelling units, or in guest rooms or guest suites of hotels or motels.(2.40.2.5

Accessible, Readily

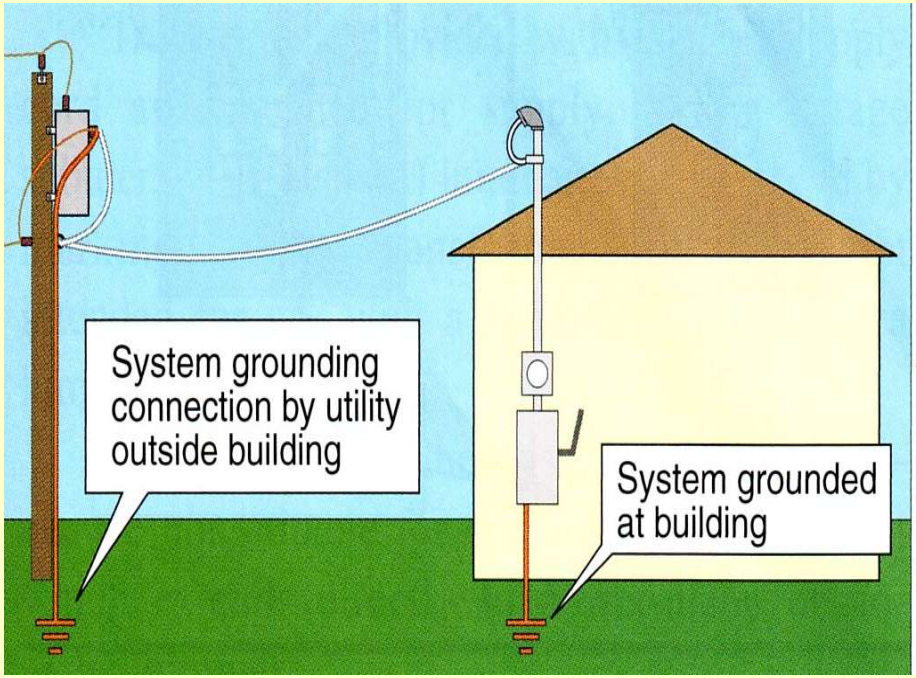


No Grounded Service at the Customer Side



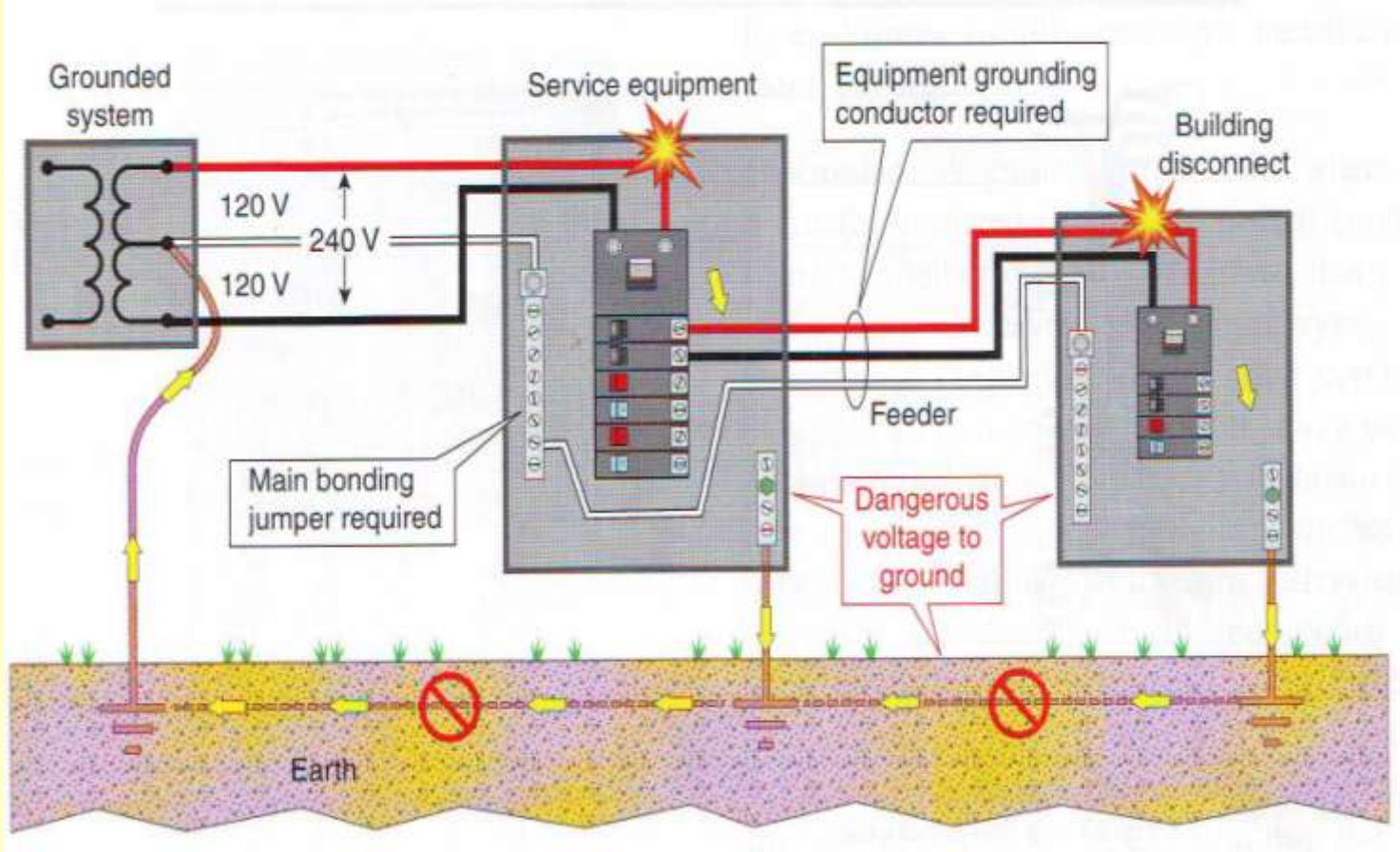
250.24 (A)(2) Outdoor Transformer

- Where the transformer supplying the service is located outside the building, at least one additional grounding connection is required to be made from the grounded service conductor to a grounding electrode, either at the transformer or elsewhere outside the building.



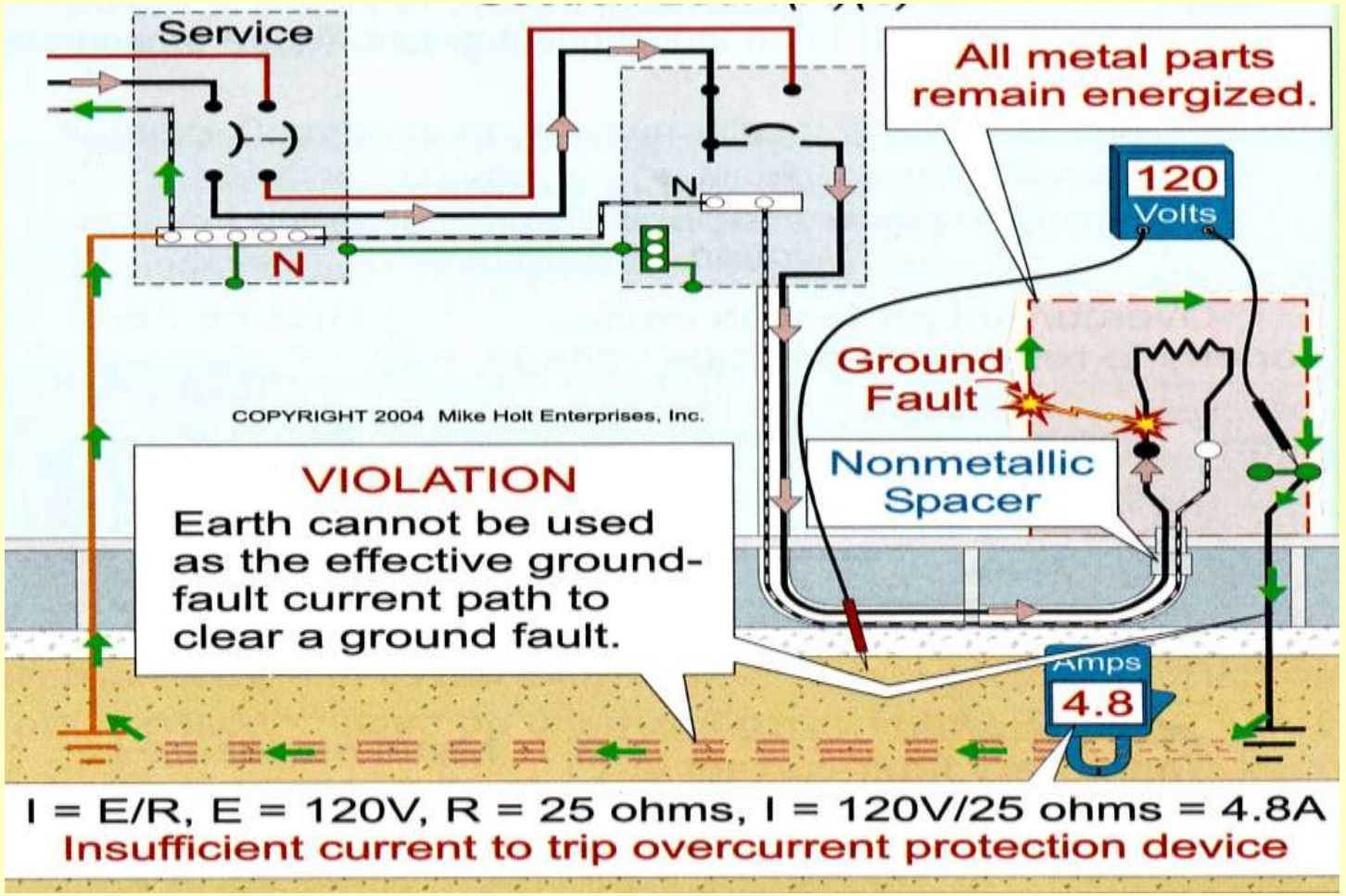
WHY?

Grounded Improperly

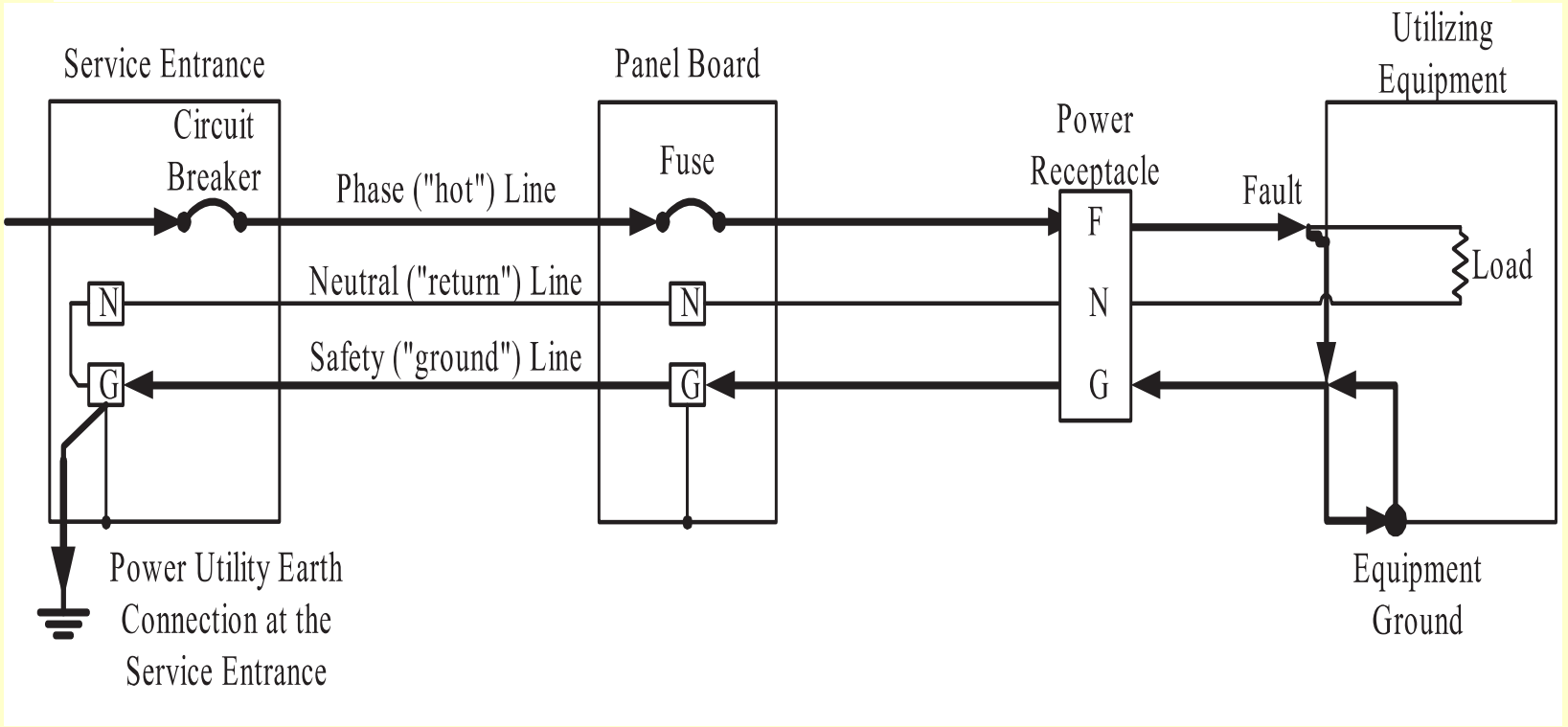


Earth Return Prohibited

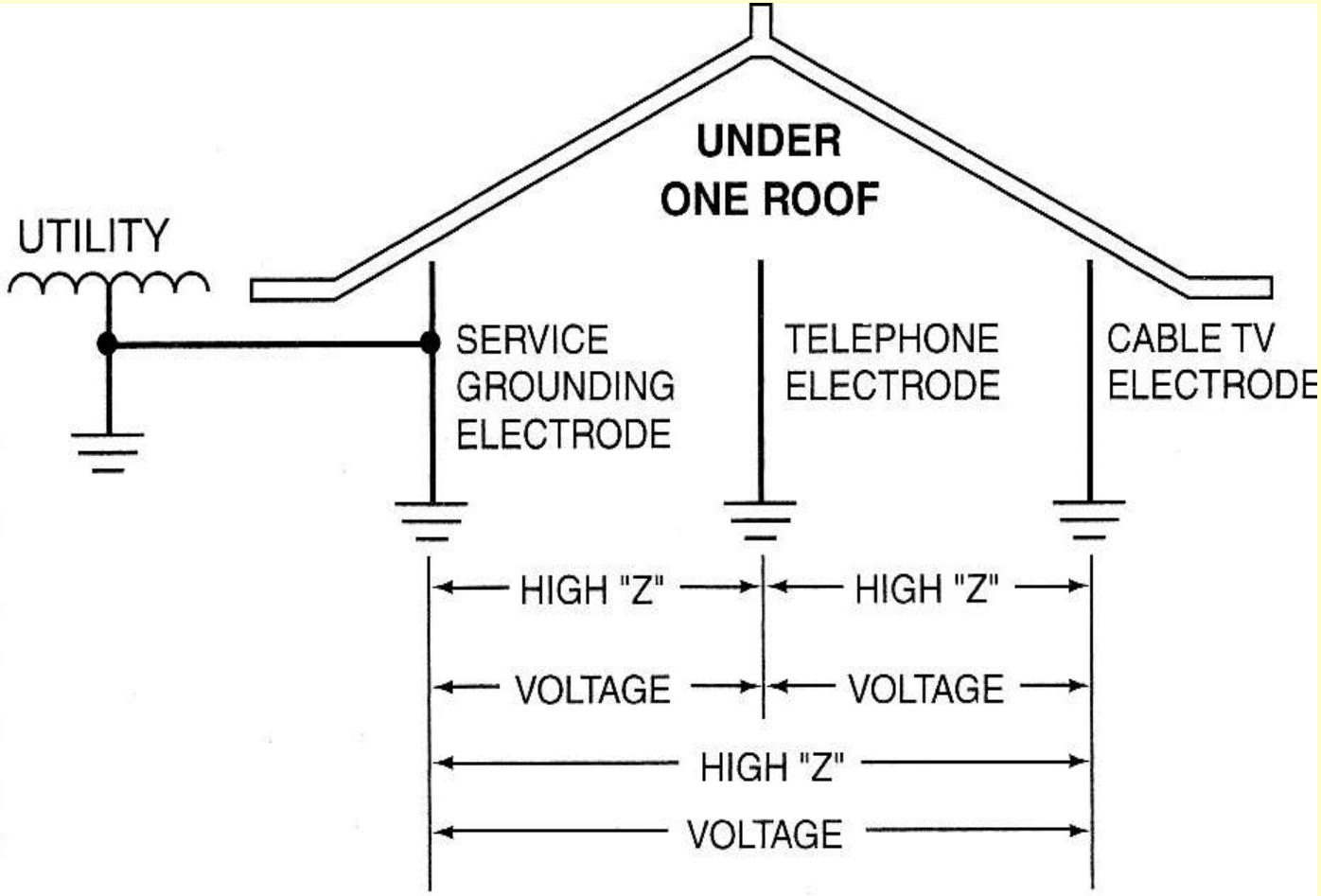
Earth is Not an Effective Ground-Fault Current Path



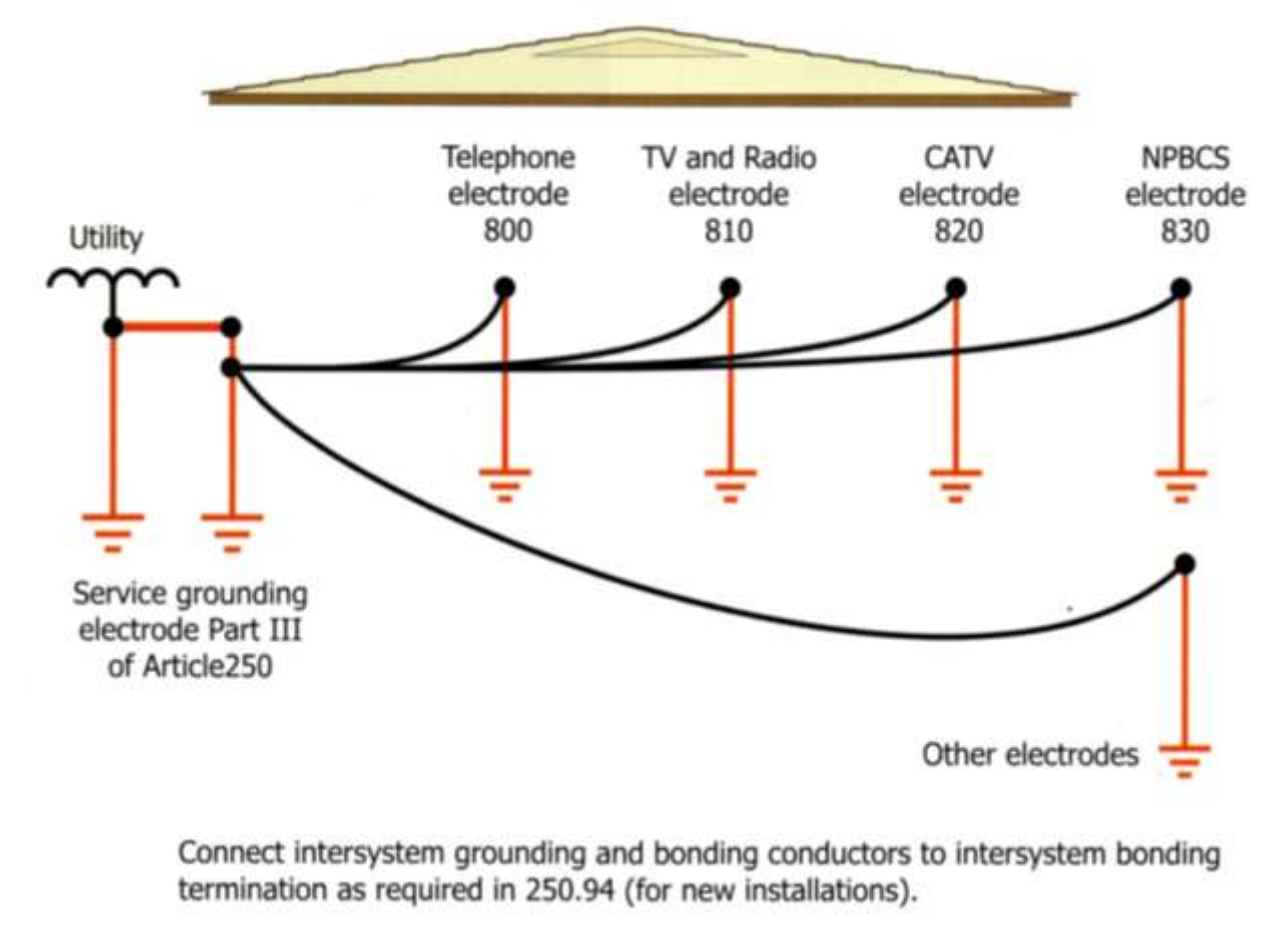
Proper Wiring Installation



Each Utilities has its Own Grounding Electrode



Low-Voltage & Intersystem Grounding and Bonding



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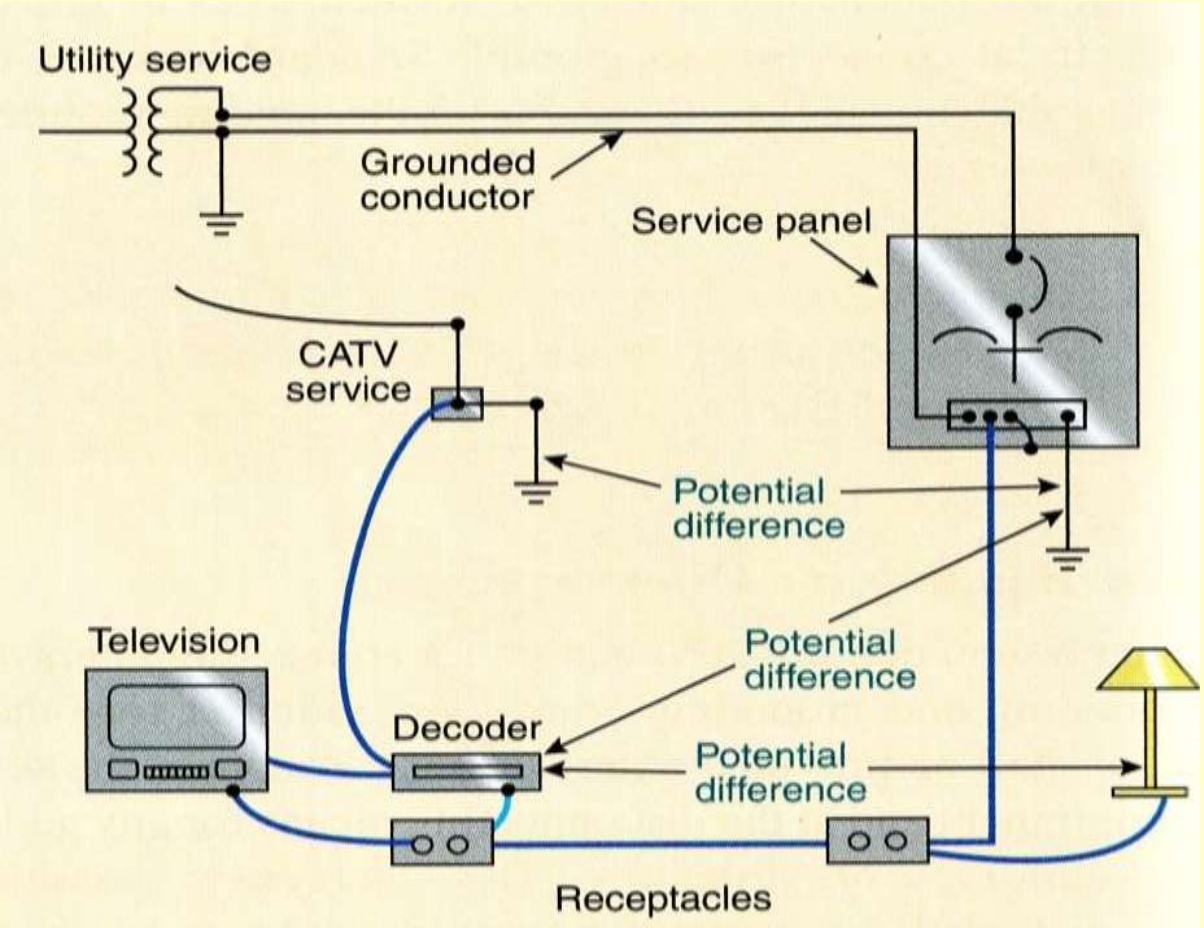
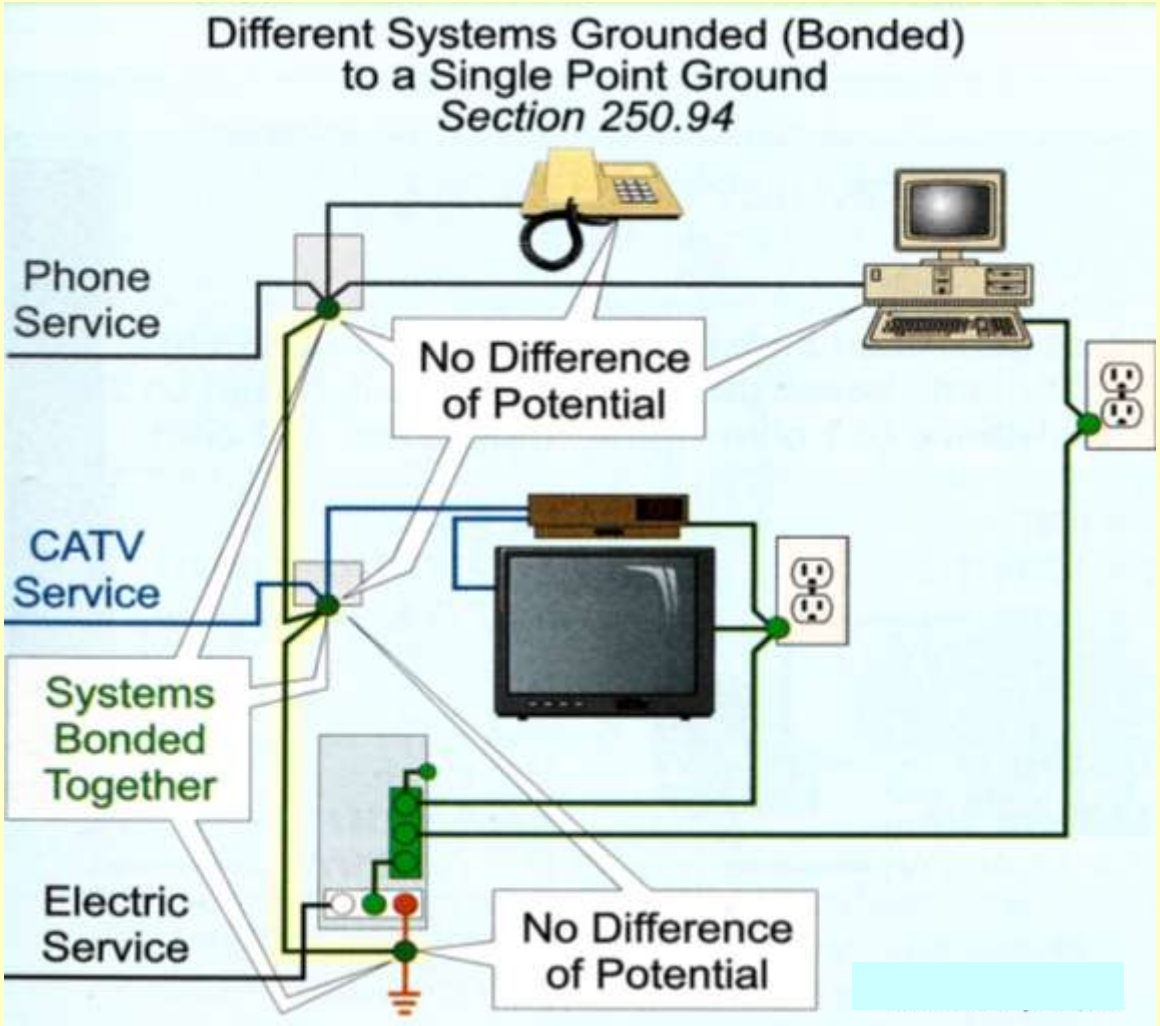
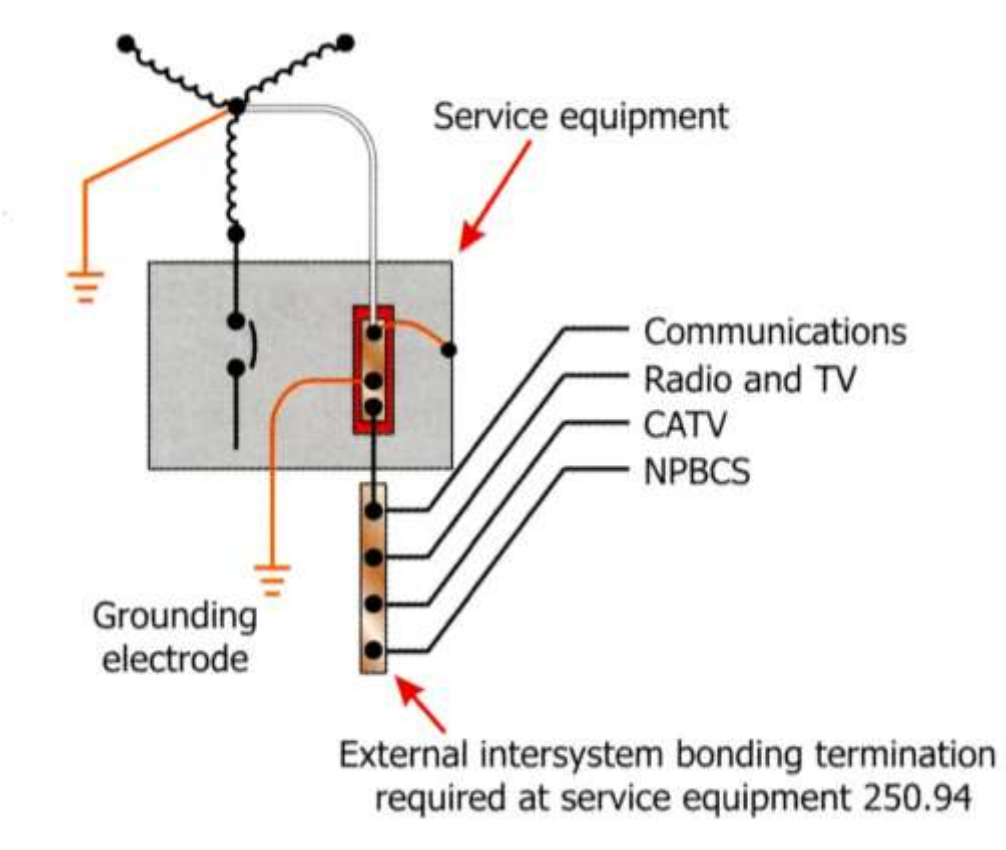


Single Point Ground

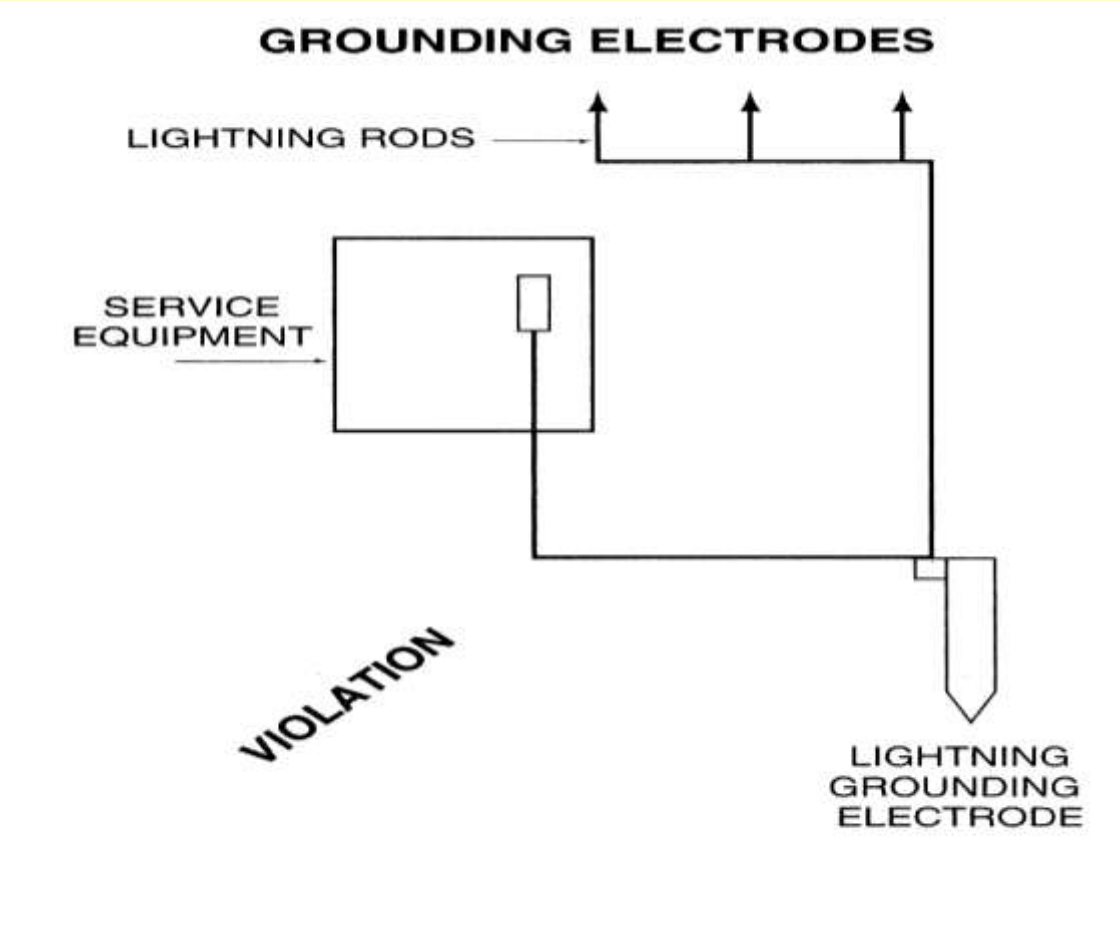


Low-Voltage & Intersystem Grounding and Bonding



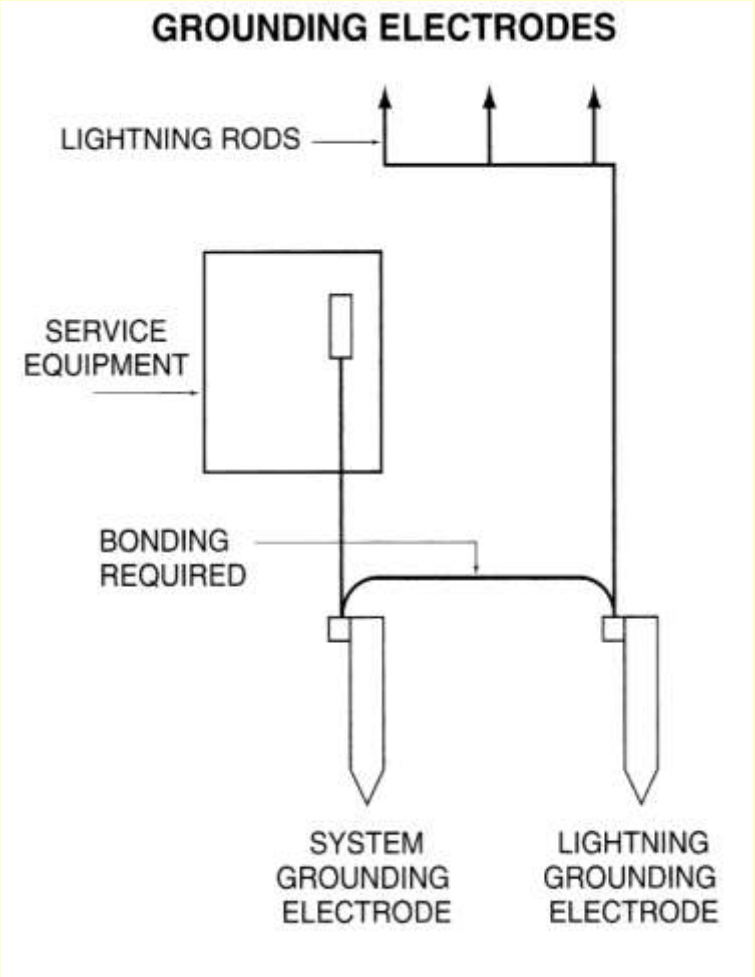
Intersystem bonding and grounding

The Same Grounding Electrode for Lightning and Power Supply

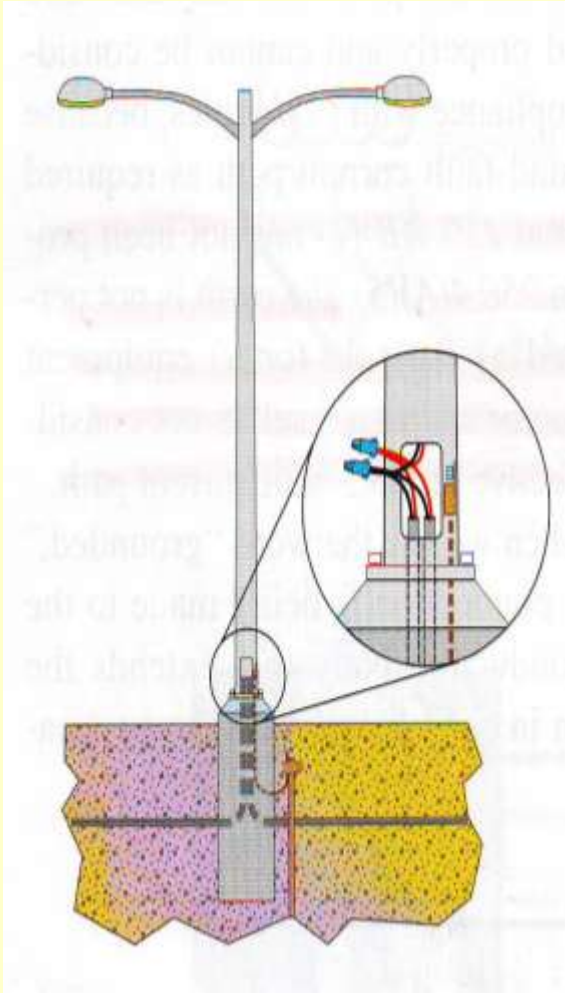


Proper Grounding

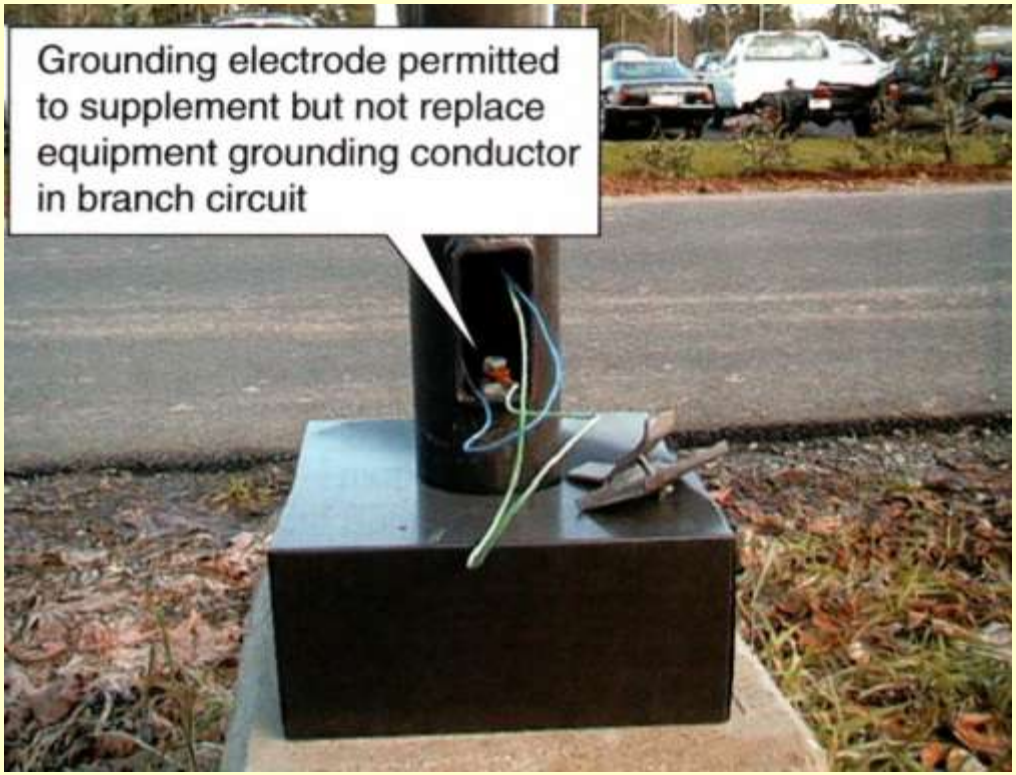
- **PEC Art. 250.5.17 Lightning Protection System. The bonding of a system grounding electrode and a lightning rod grounding electrode.**



Streetlight Grounded System to Ground Rod Only

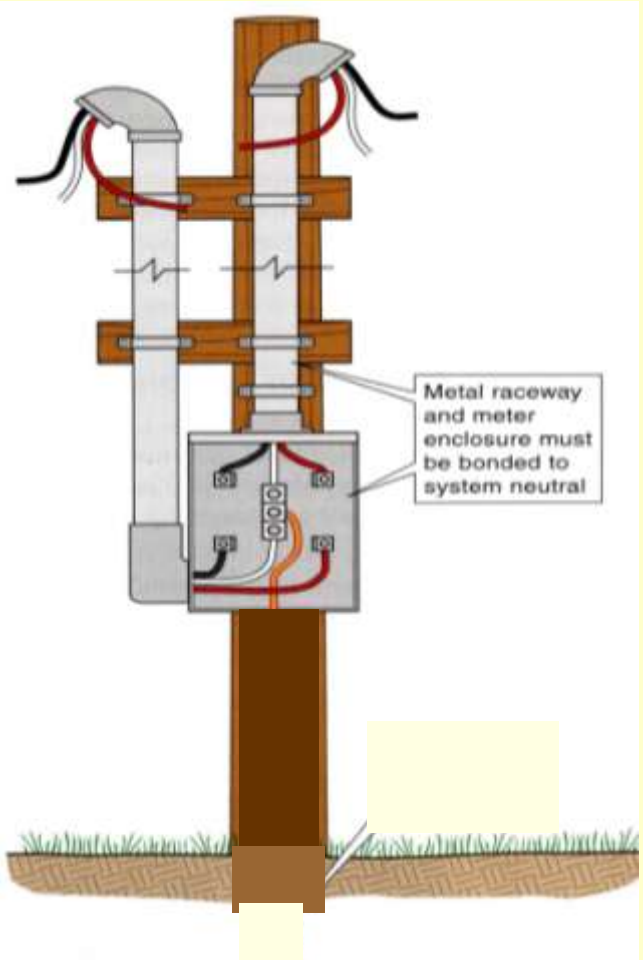


2.50.3.5 Auxiliary Grounding Electrodes

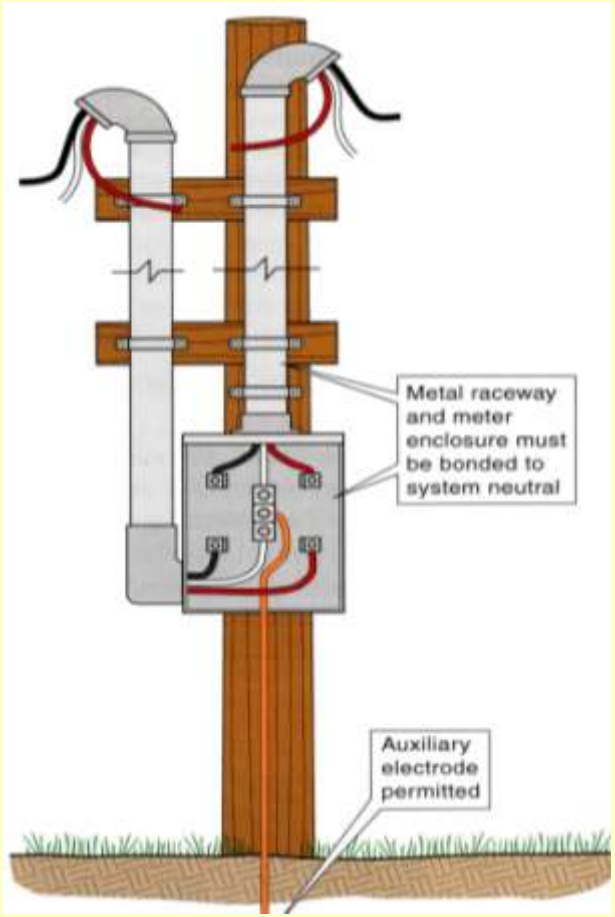


2.50.3.5 Auxiliary grounding electrodes But the earth shall NOT be used as an effective ground-fault current path

No Auxiliary Electrode for Remote Metering

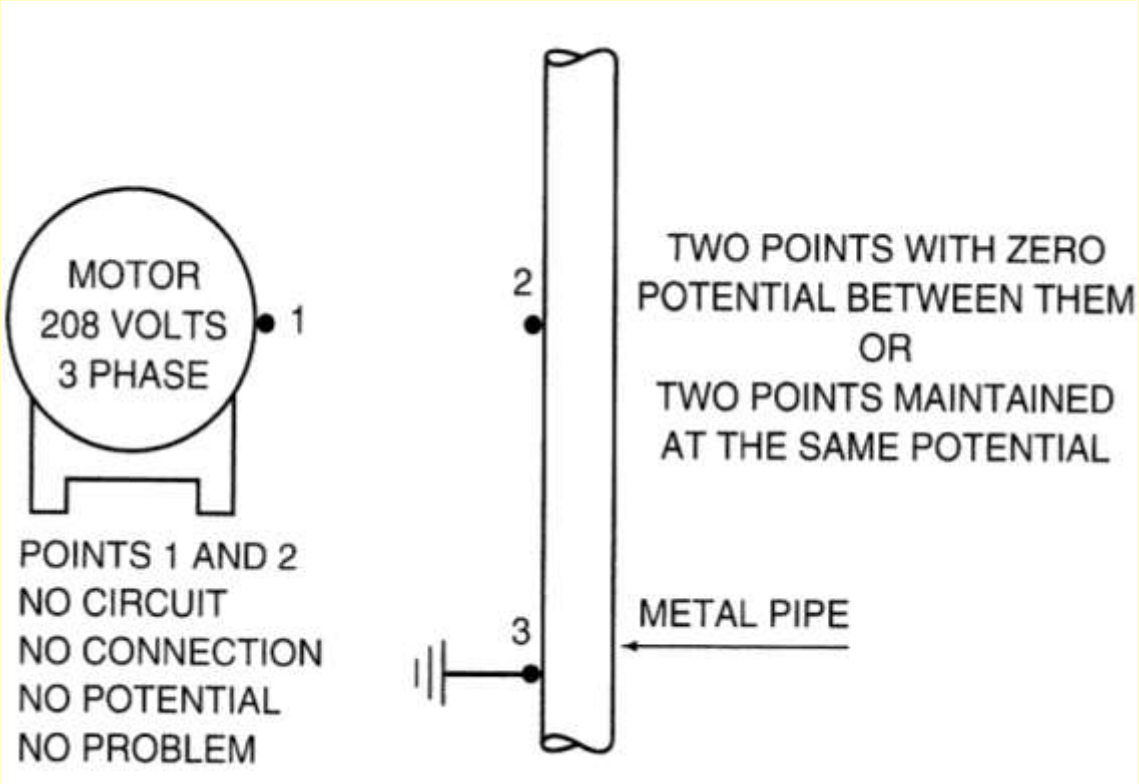


2.50.5.3(b) Method of Bonding at the Service



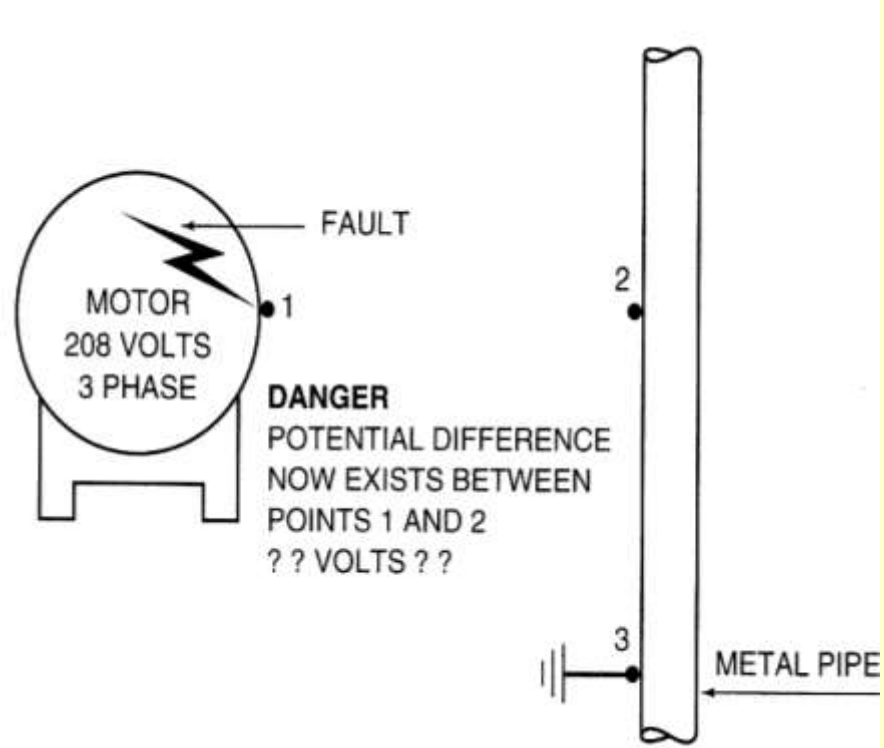
(b)(1)Bonding remote meter enclosures on on supply side of service

Potential Difference



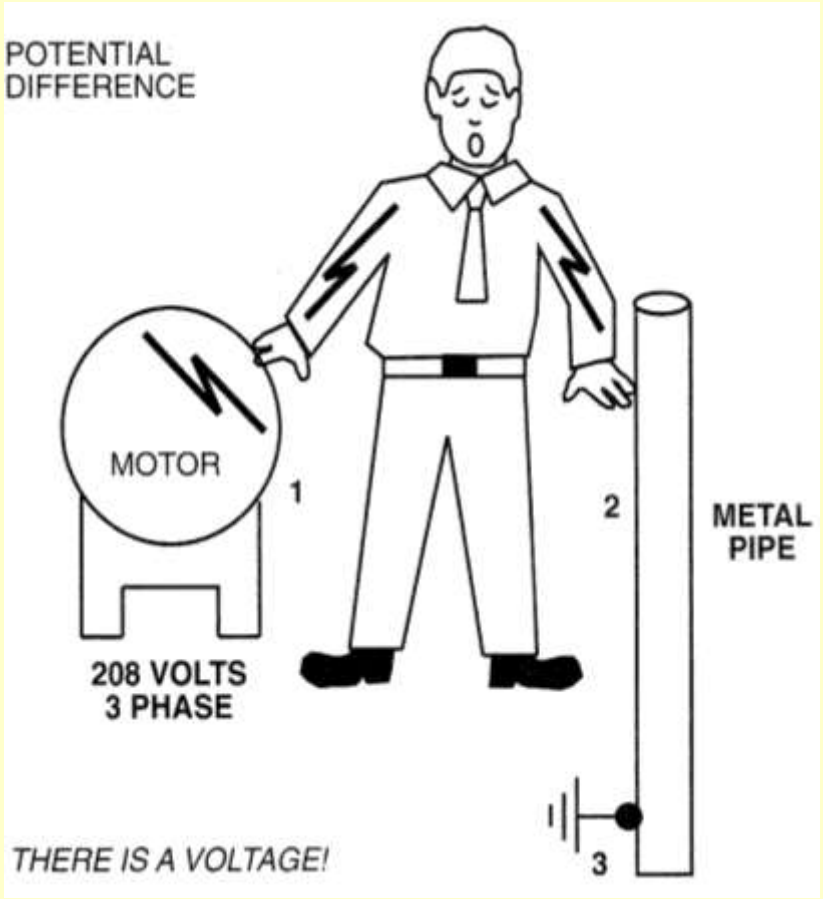
Potential difference between a grounded Water pipe and an ungrounded motor.

Potential Difference



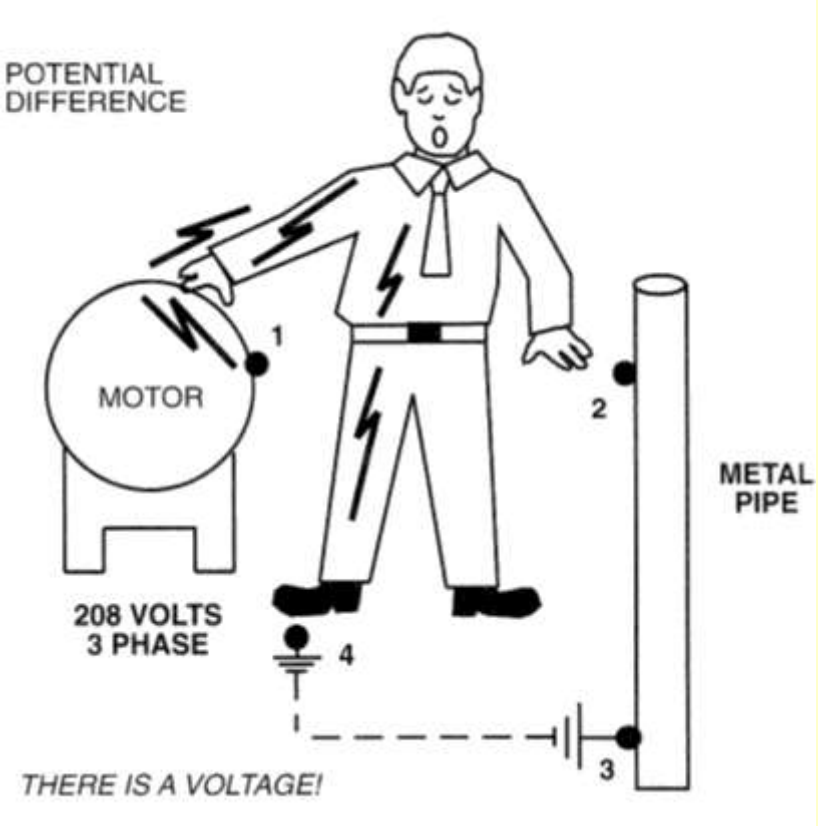
Motor ground-fault. A hazard now exists.

Potential Difference



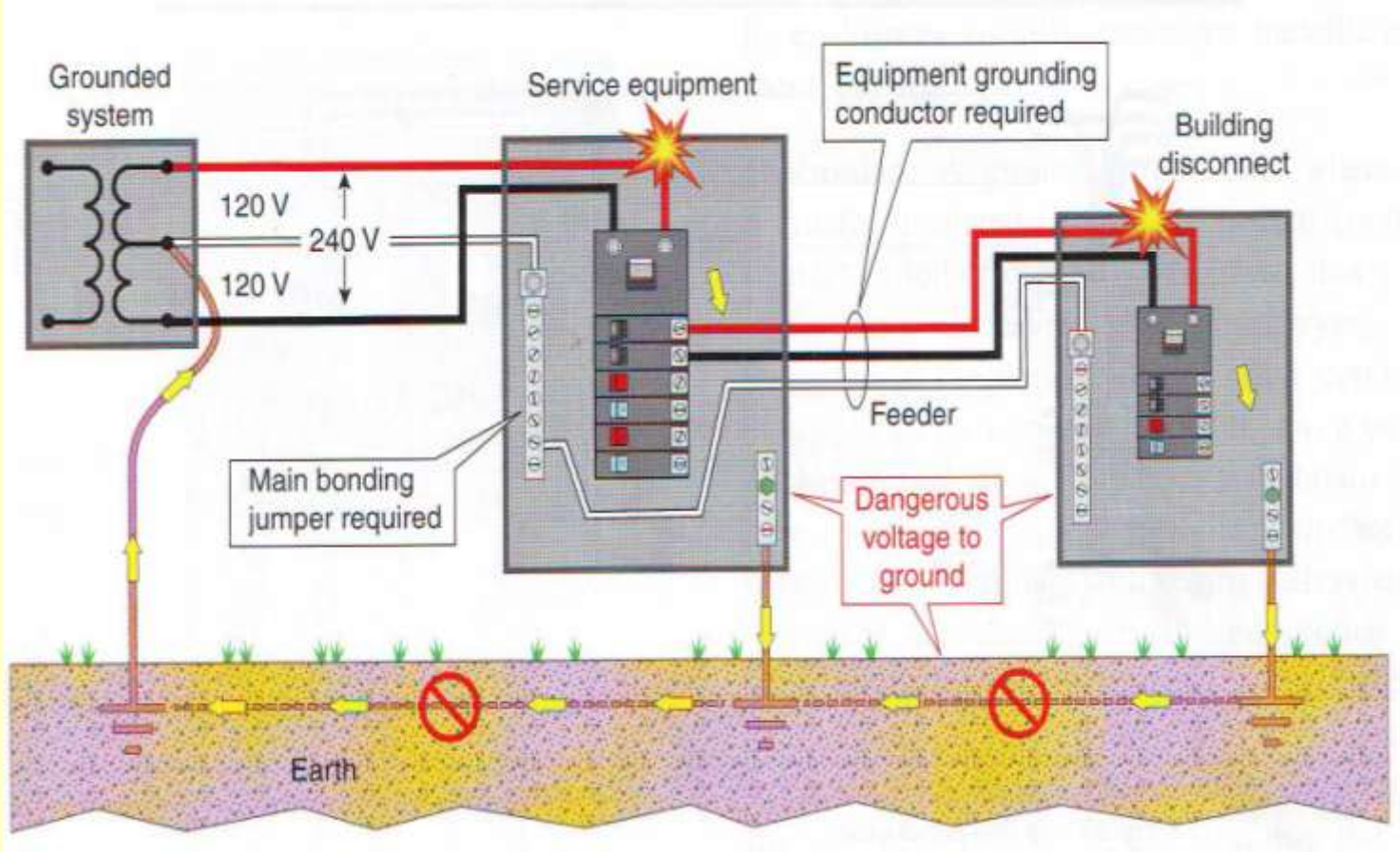
The hazard results in an electric shock.

Potential Difference



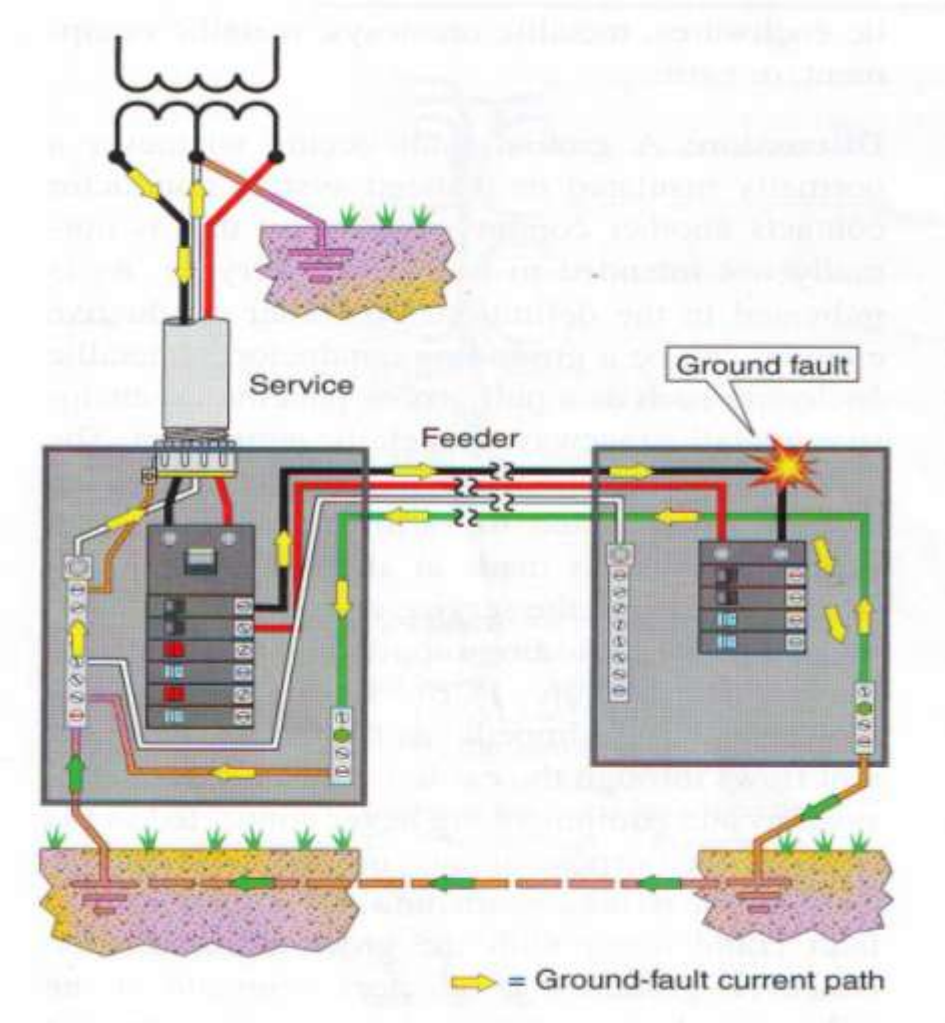
Another shock hazard exists.

Grounded Improperly

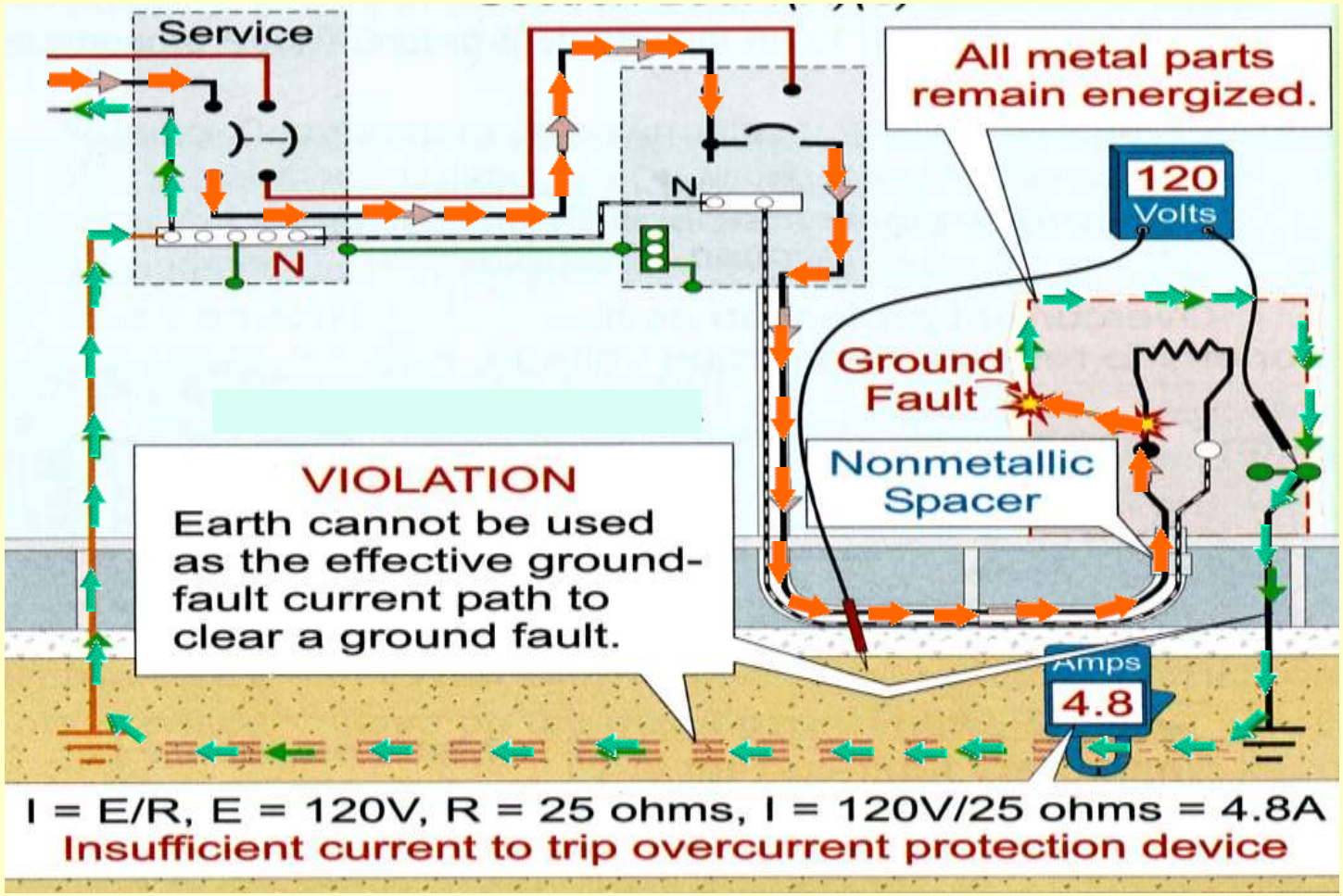


Earth Return Prohibited

Grounded Properly



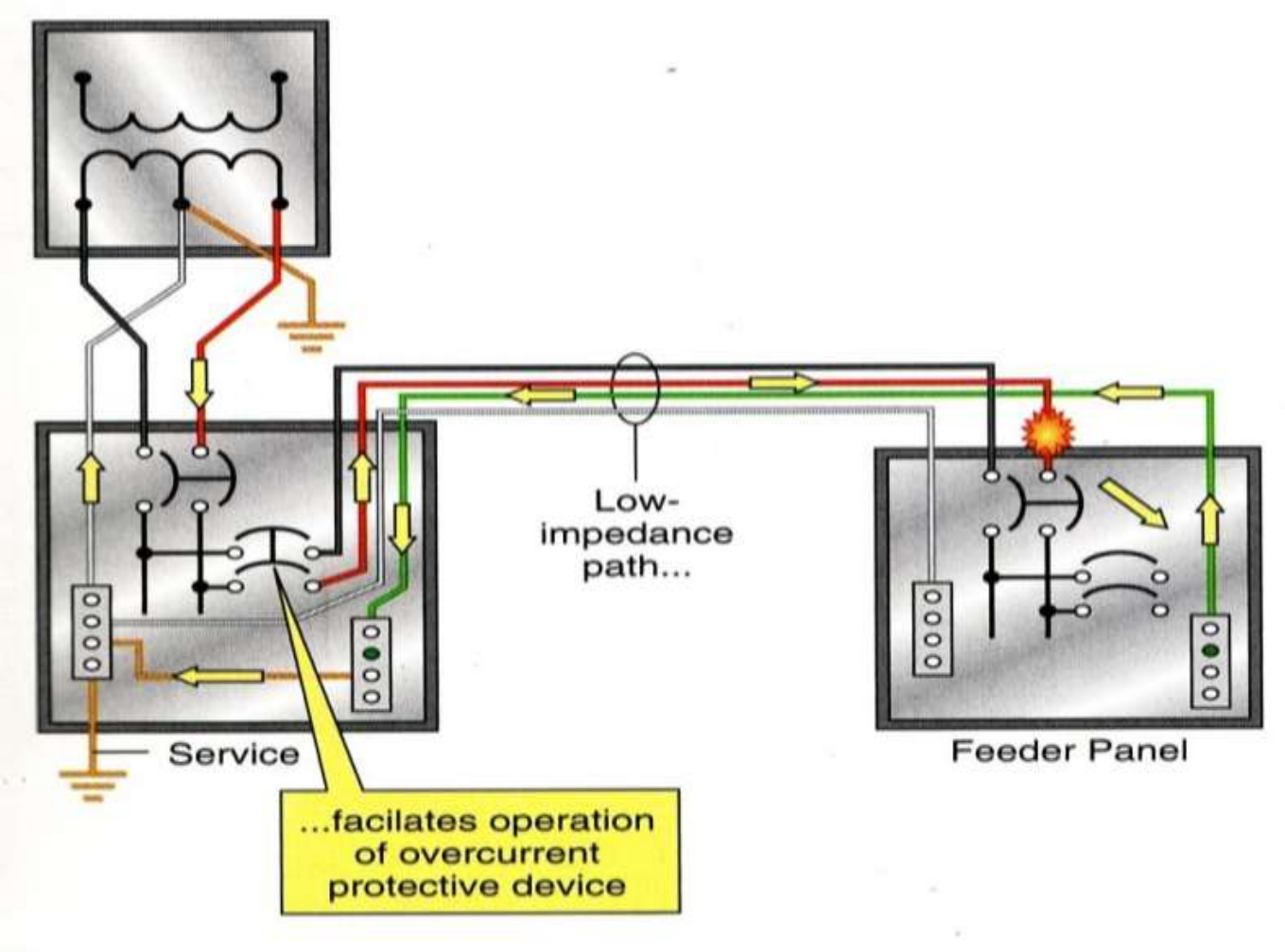
Earth is Not an Effective Ground-Fault Current Path



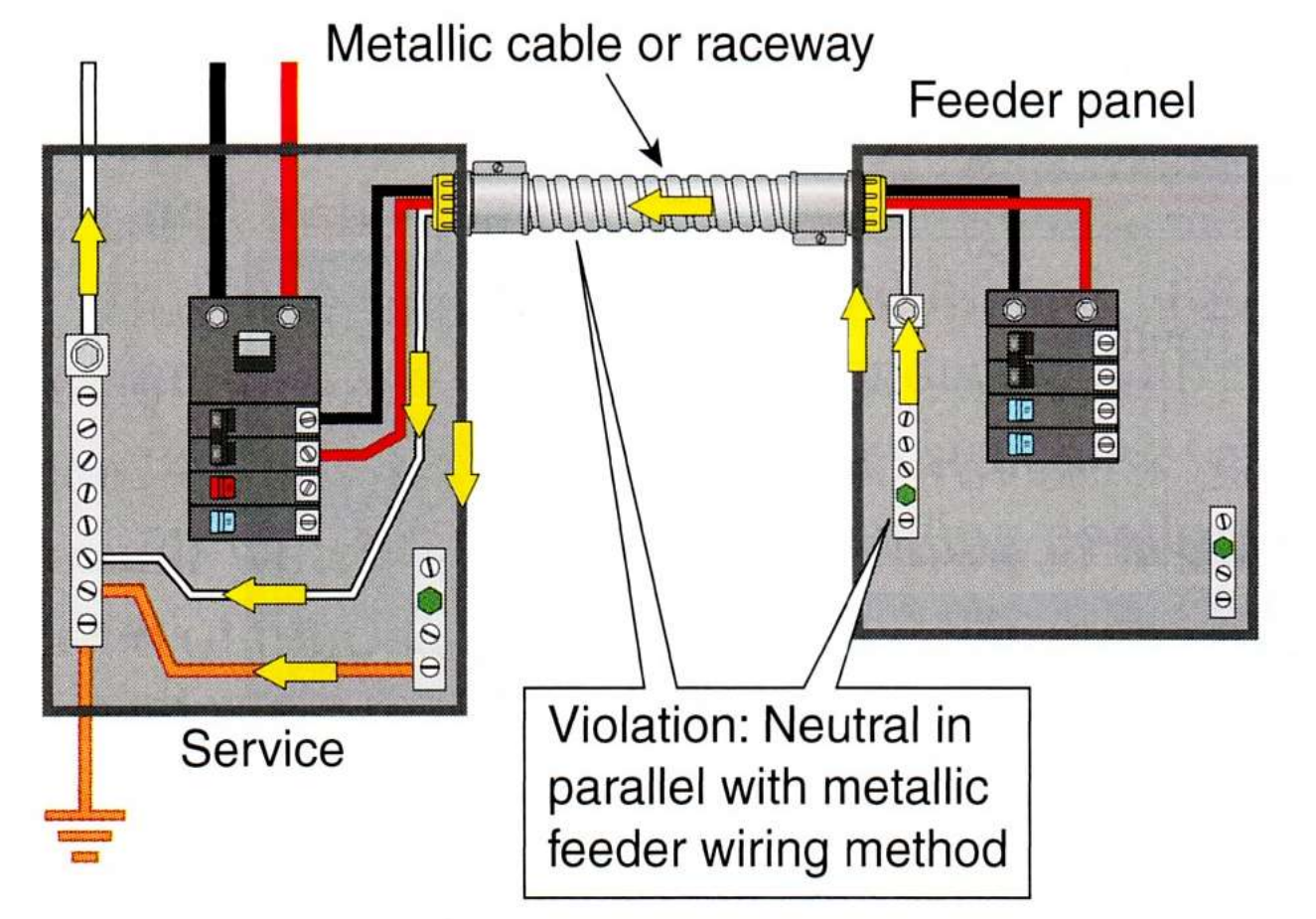
Objectionable Current

- If current is regularly flowing over equipment grounding conductors, it would be considered " objectionable current" as covered in Sec. 2.50.1.6
- It is intended that fault current will flow over equipment grounding conductors only while a ground fault exists.

Equipment Grounding Conductor



Grounded Improperly



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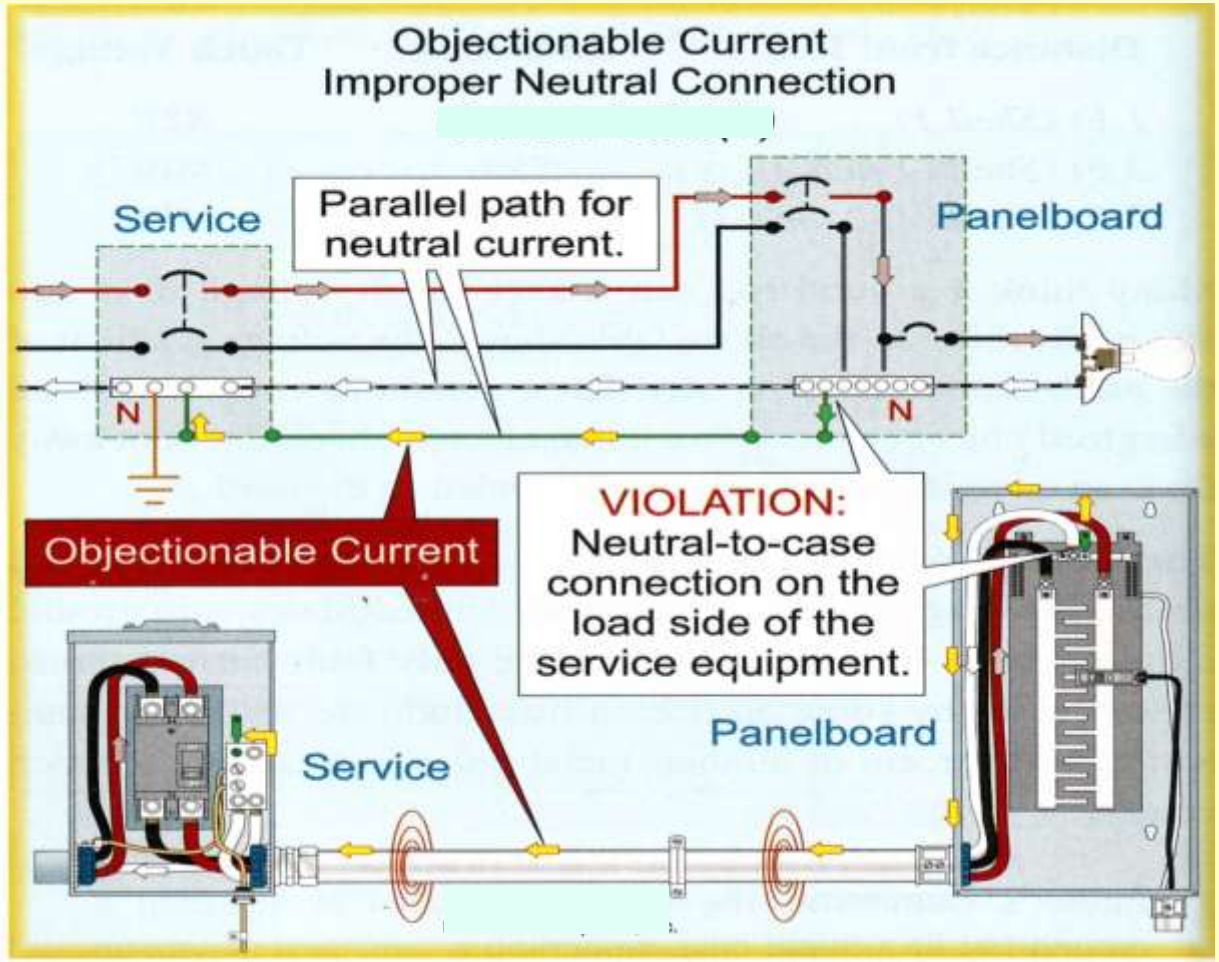

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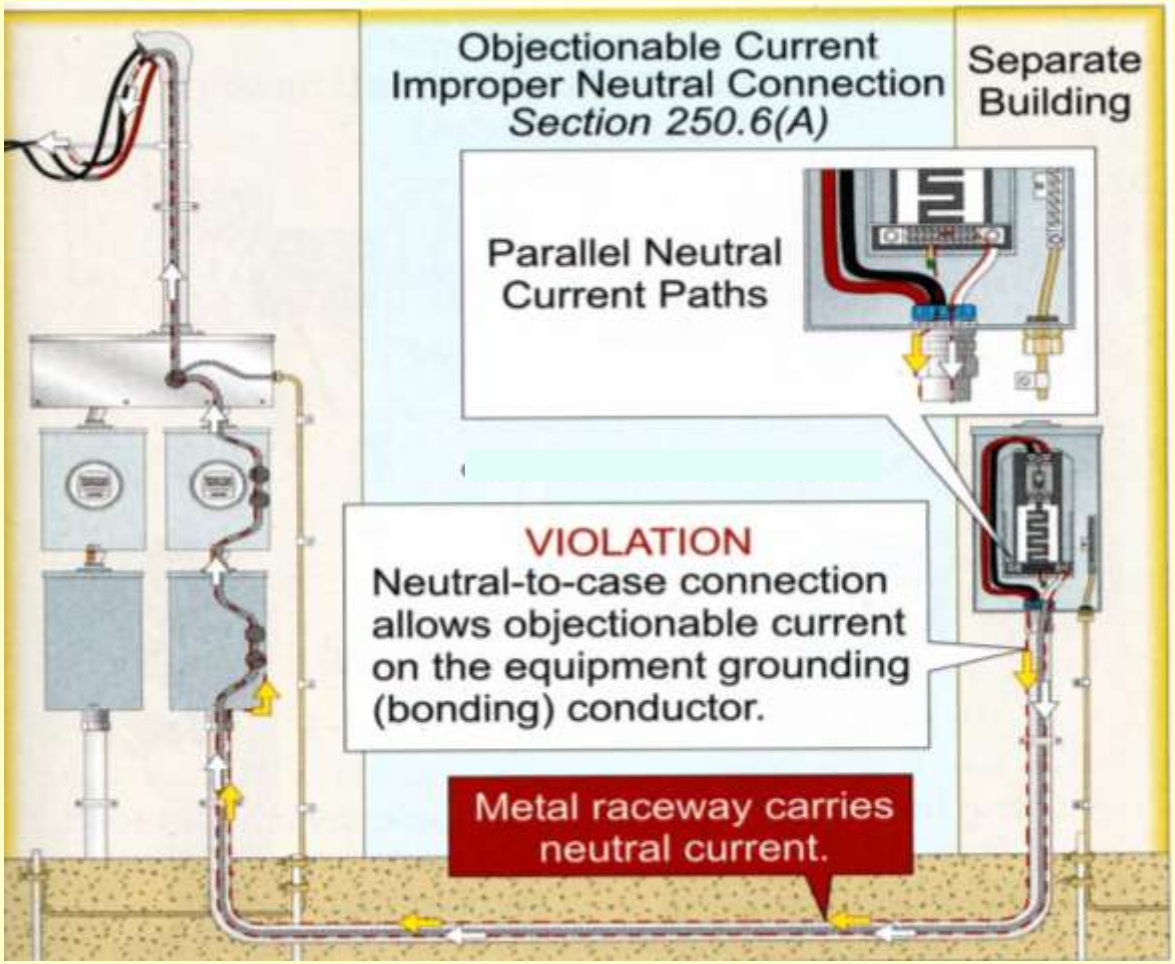

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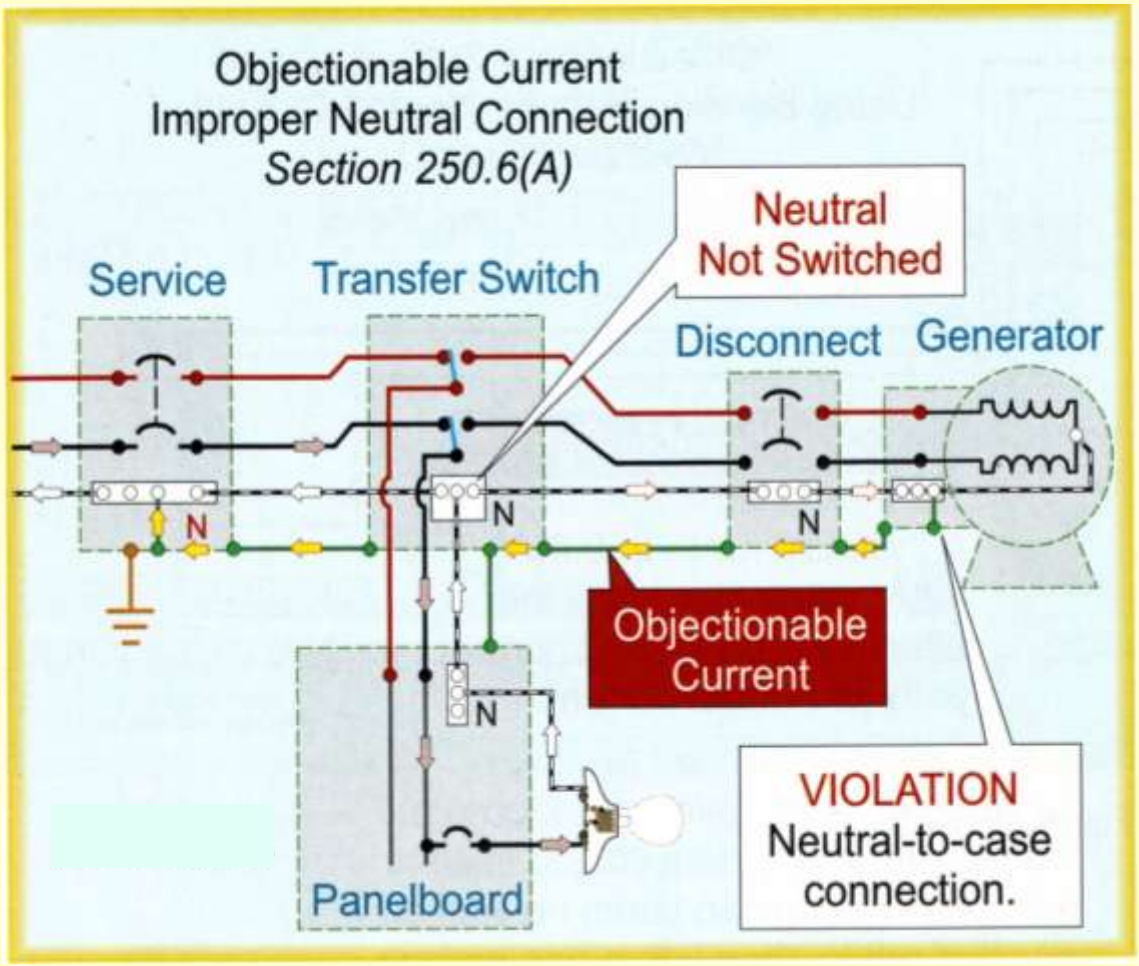

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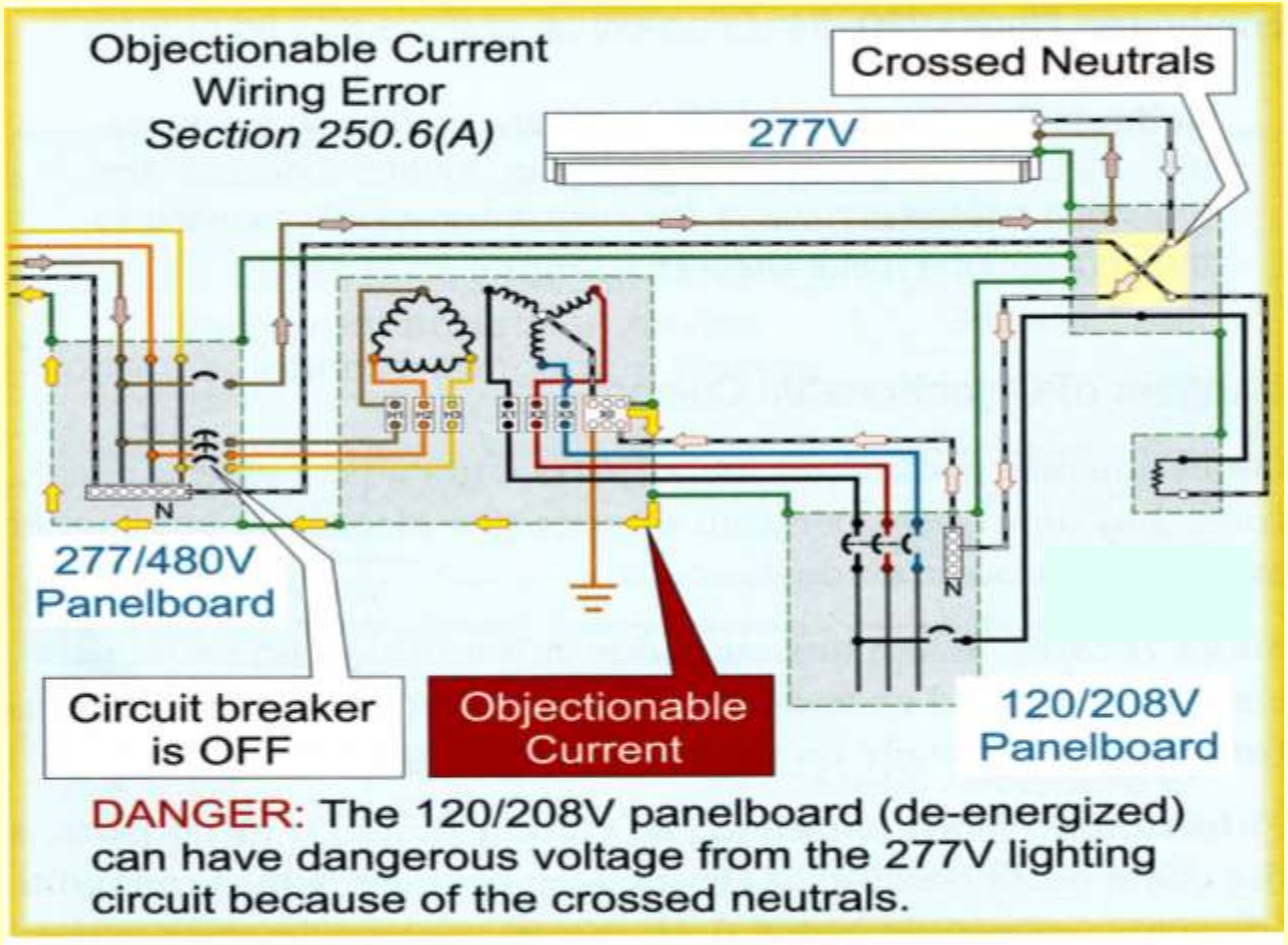

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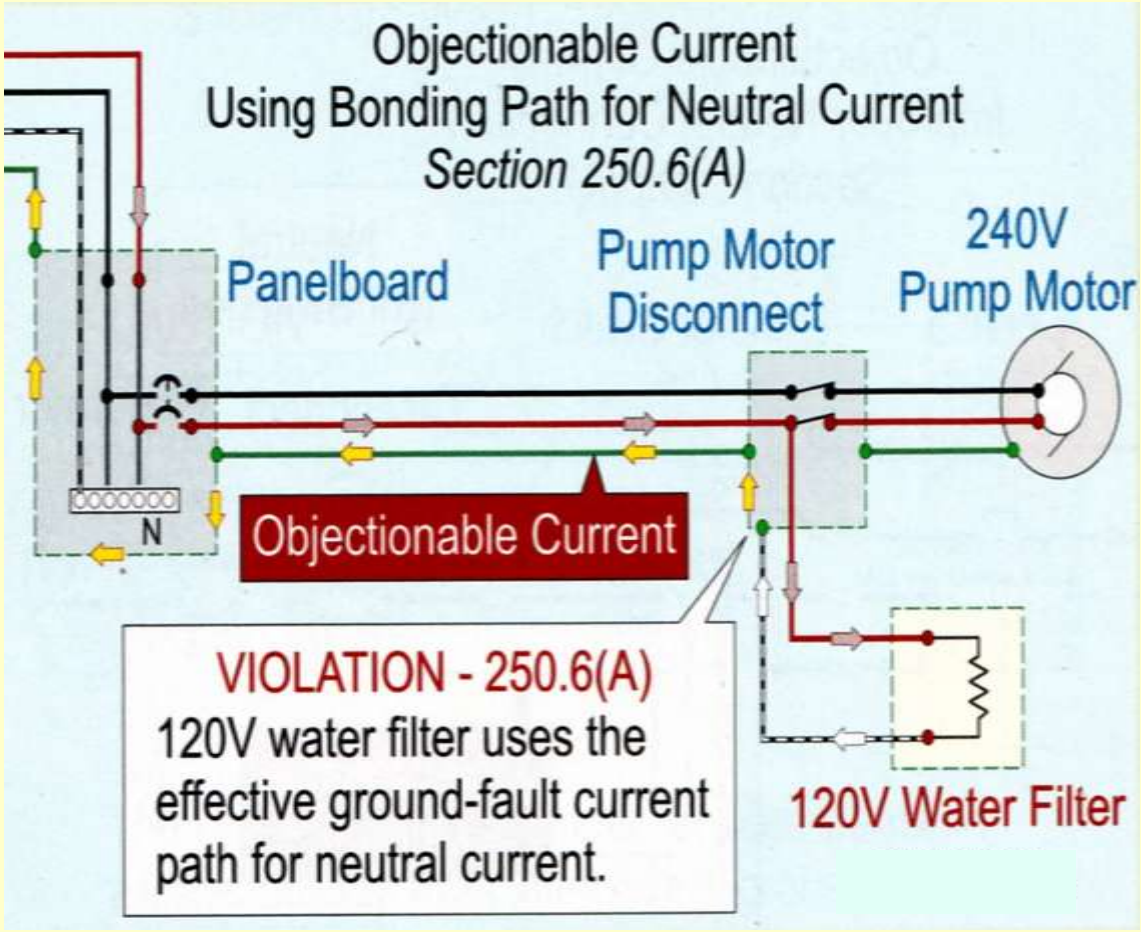

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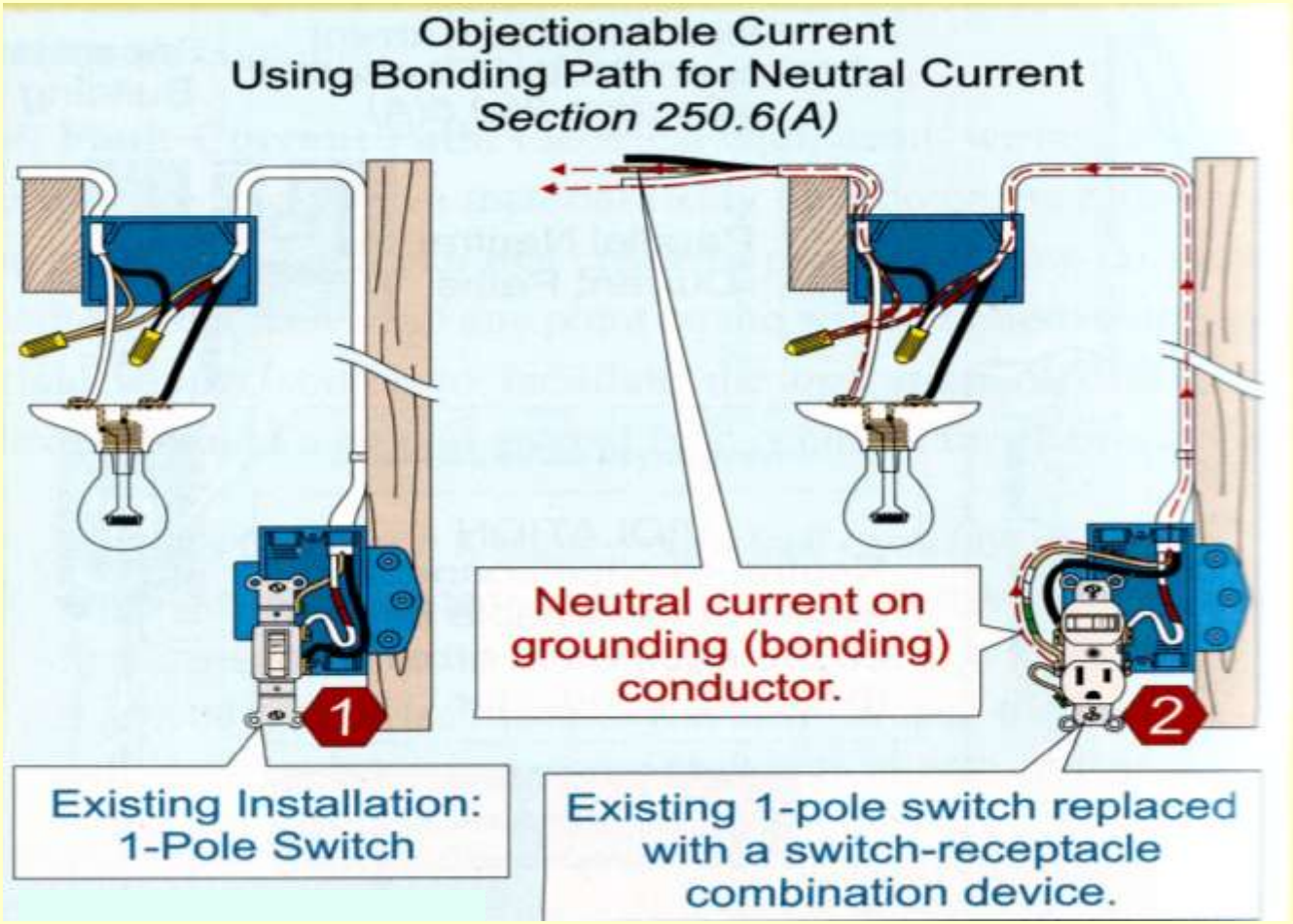

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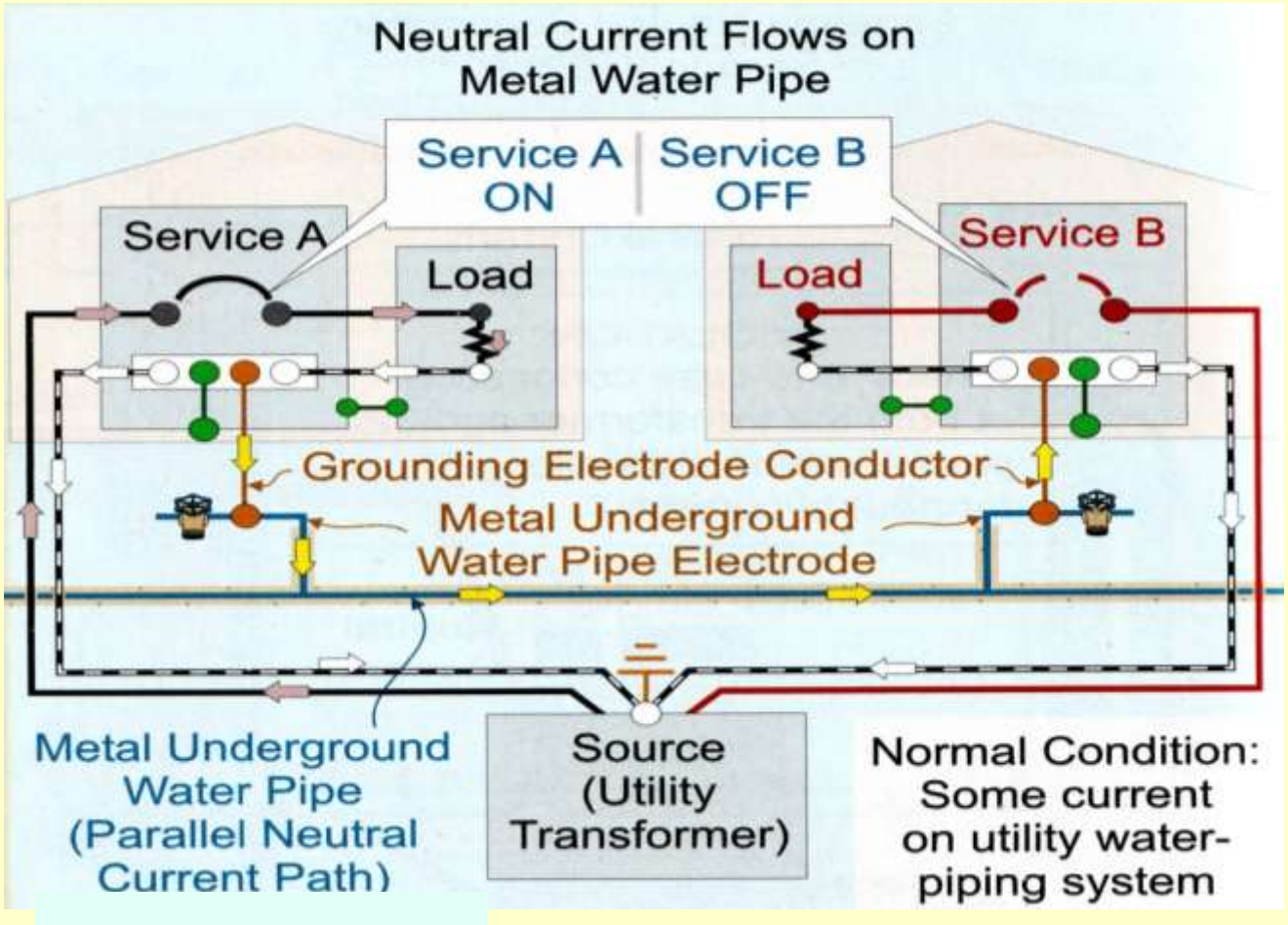

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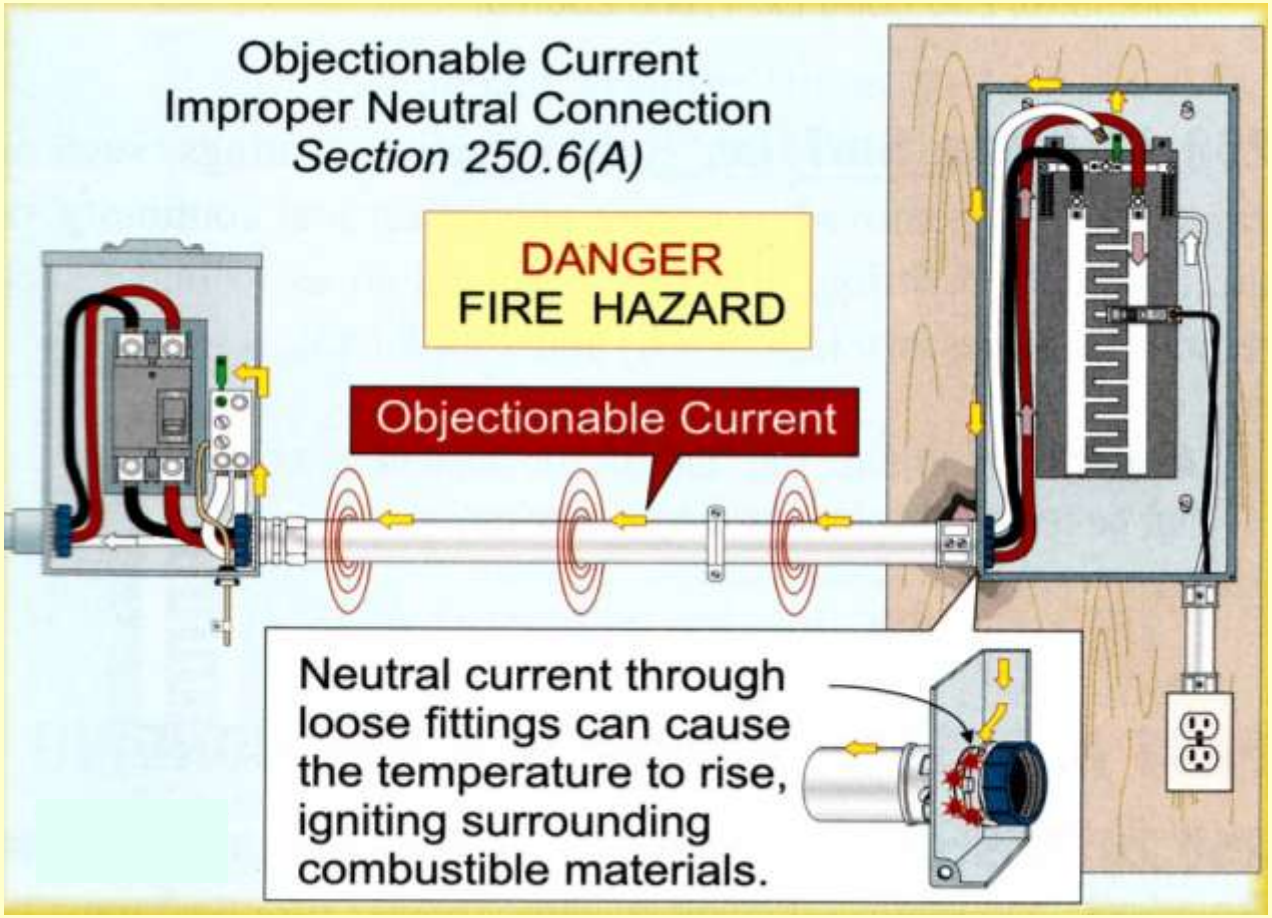
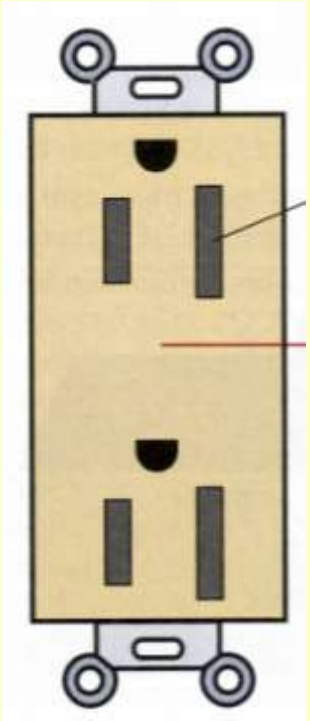


Receptacles

A. Tamper-Resistant Receptacles in Dwellings Unit (NEC 2008 - 406.11)

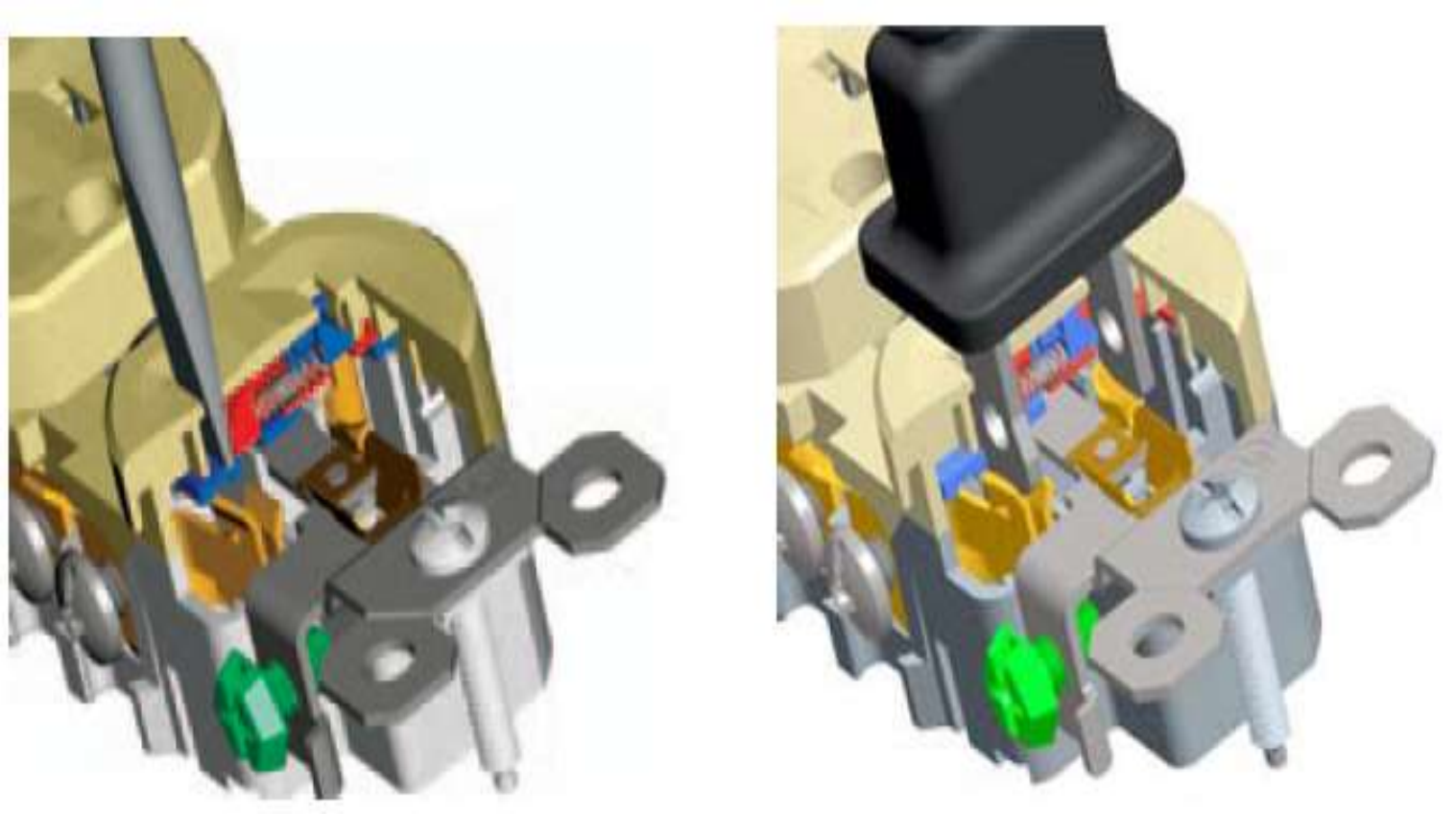


Why do you think it is a tamper-resistant receptacle?

…..To increase safety for children.

…..maybe that your son, daughter, or grandchildren that you will save…

Tamper-Resistant Receptacles



Insertion of an object in any one side does not open the shutter (left), but a two-bladed plug or grounding plug compresses the Spring and simultaneously opens both shutters (right)

Electric Shock

- Electric Shock Severity

1. Path of Current through Body
2. Length of Time Current Flows
3. Amount of Current through Body

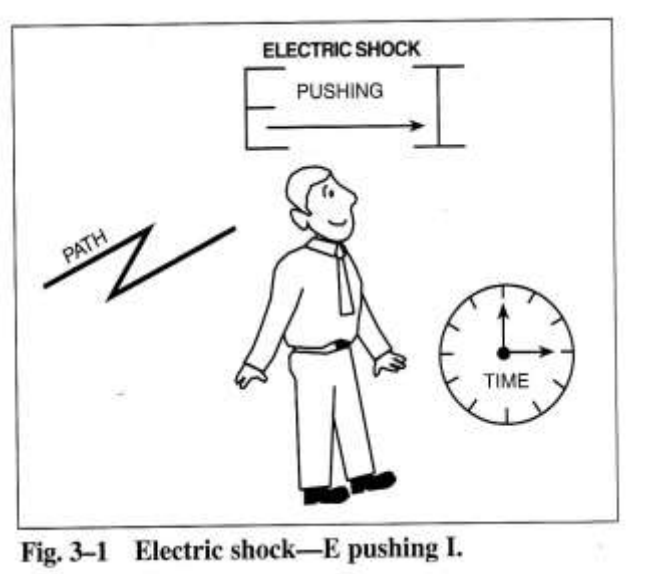


Fig. 3–1 Electric shock—E pushing I.

Electric Shock

- Current flow through body tissues delivers energy in the form of heat. The magnitude of energy may be approximated by

$$J = I^2Rt$$

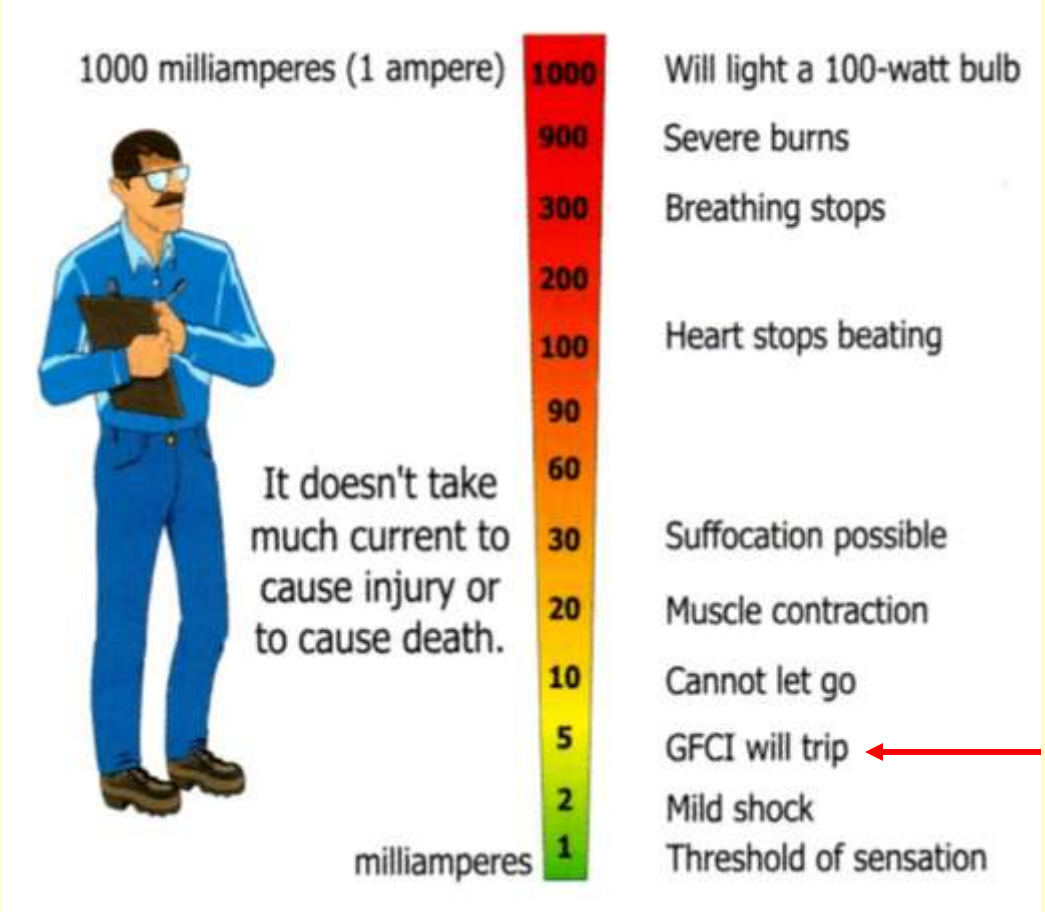
where J = energy, joules

I = current, amperes

R = resistance of the current path through the body, ohms

t = time of current flow, seconds

Effects of AC Electric Shock

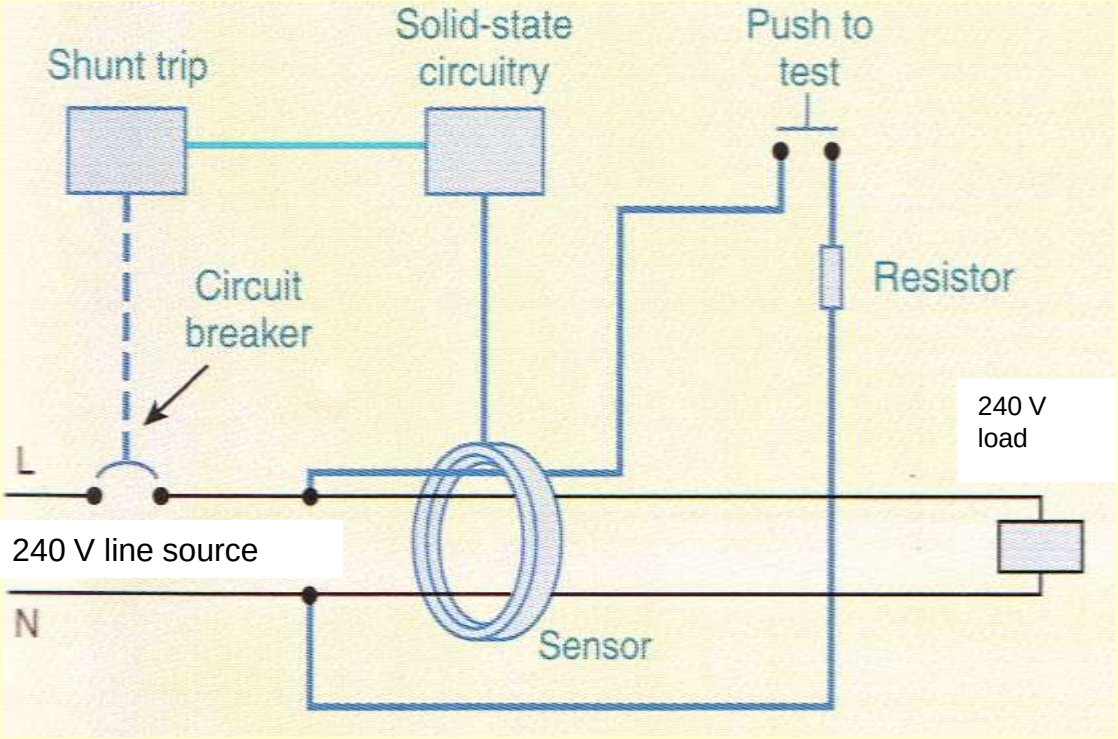


Level (in milliamperes) of current through the body

Ground Fault Circuit Interrupter

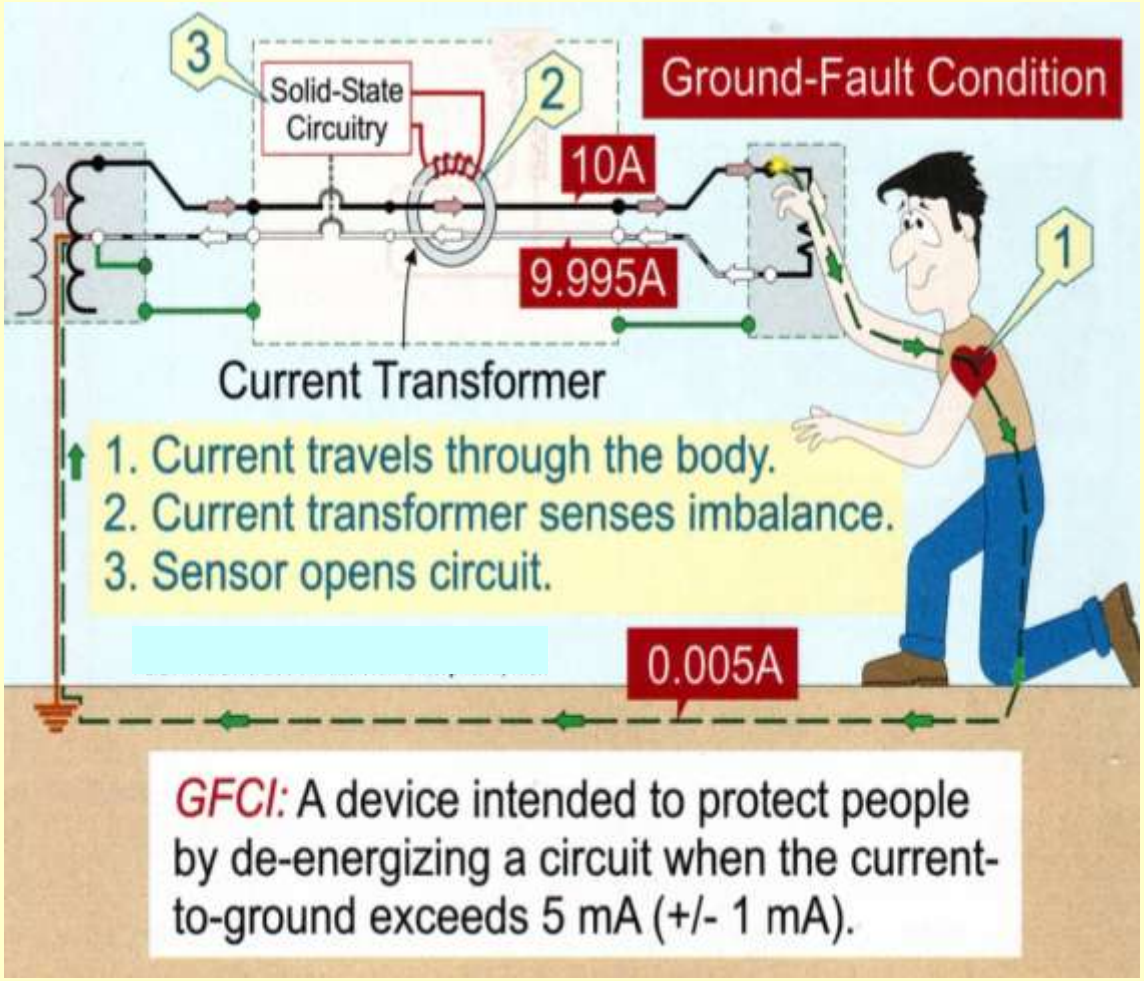
- **GFCI – A device intended for the protection of personnel that functions to deenergize a circuit or portion thereof within an established period of time when a current to ground exceeds the values established for a device.**
- **The GCFI does not protect someone against receiving a electrical shock, but it does limit the time hazards exists. Hazard exist only during period of time fault is there.**

Ground Fault Circuit Interrupter

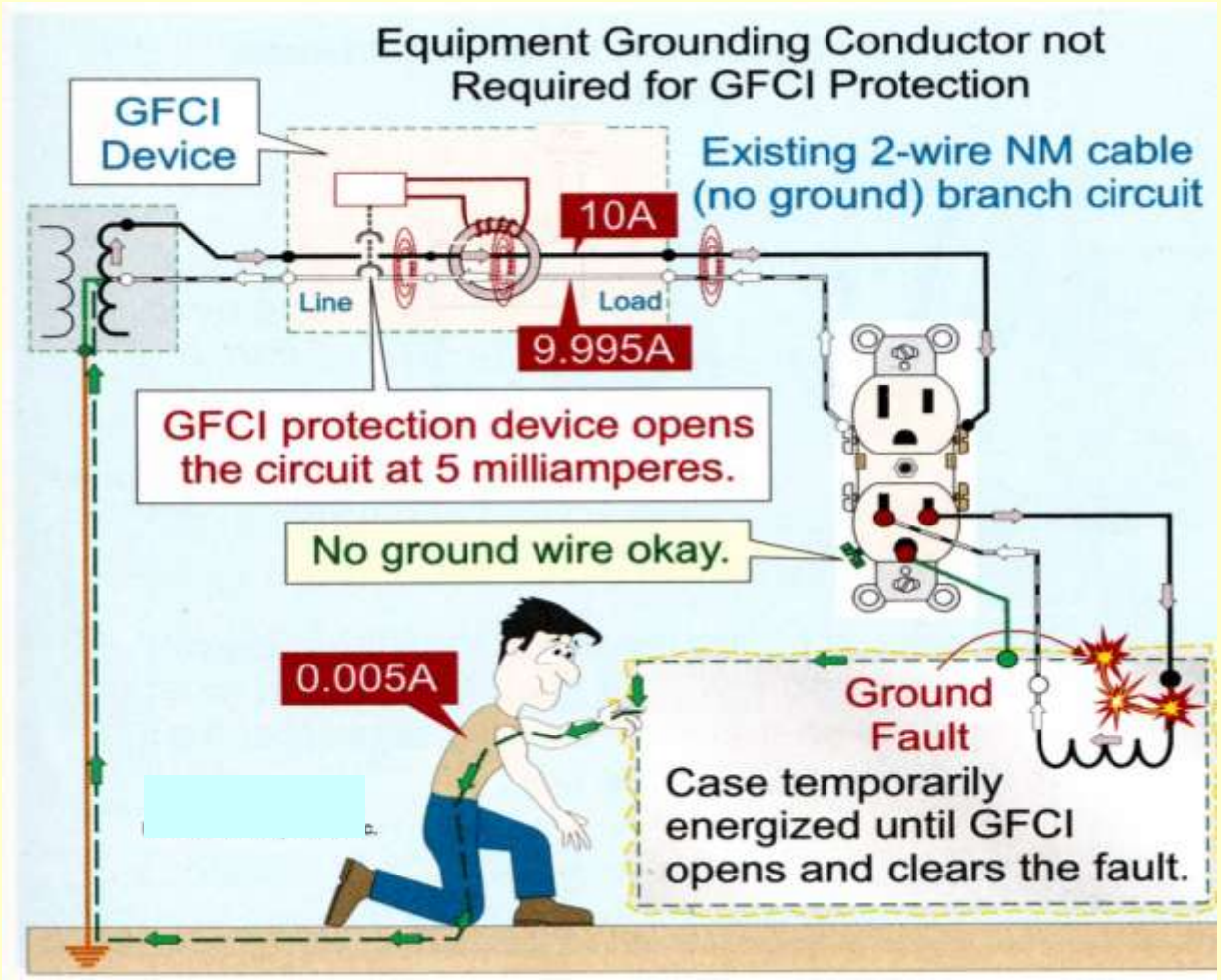


The circuitry and components of a typical GFCI

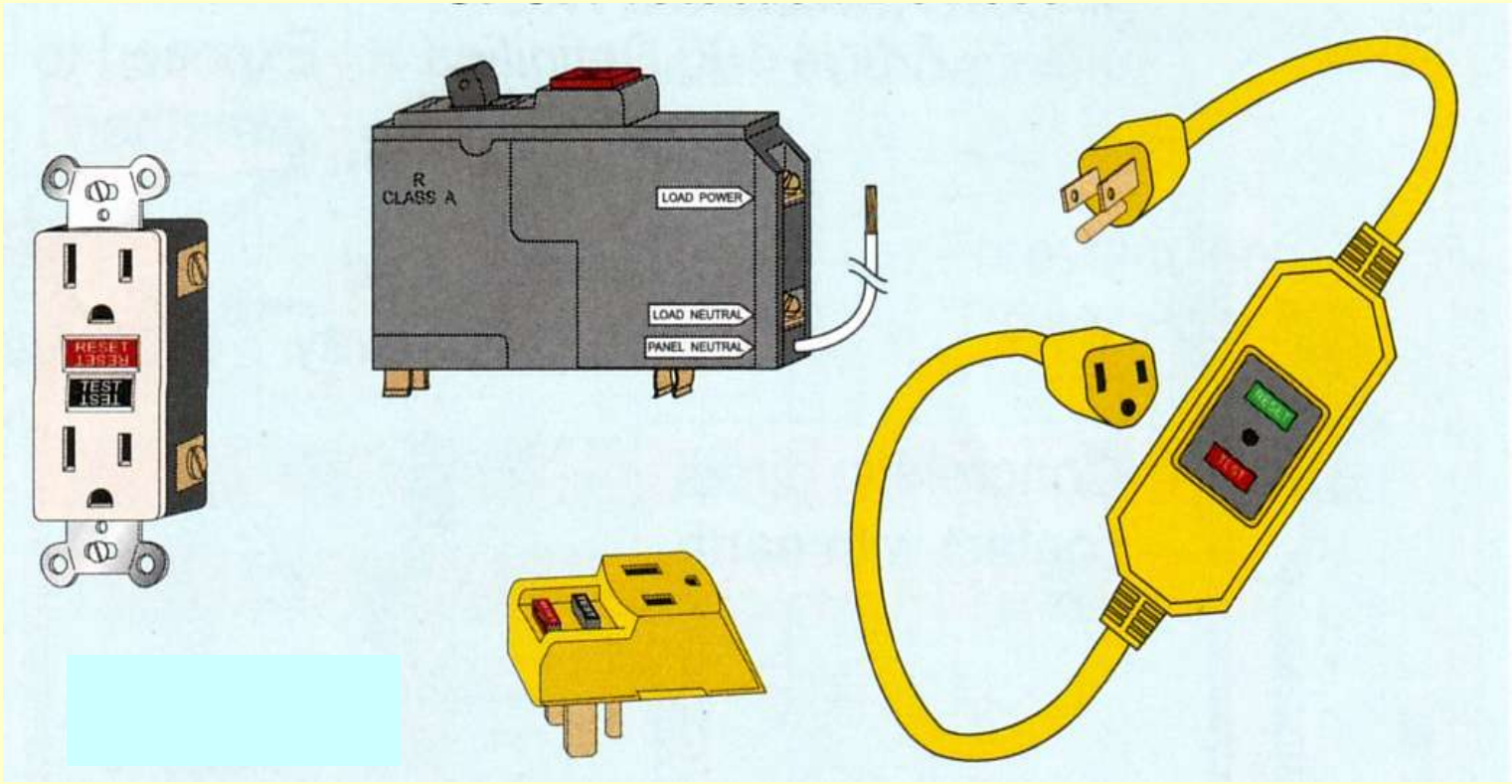
Ground Fault Circuit Interrupter



Ground Fault Circuit Interrupter



Ground Fault Circuit Interrupter



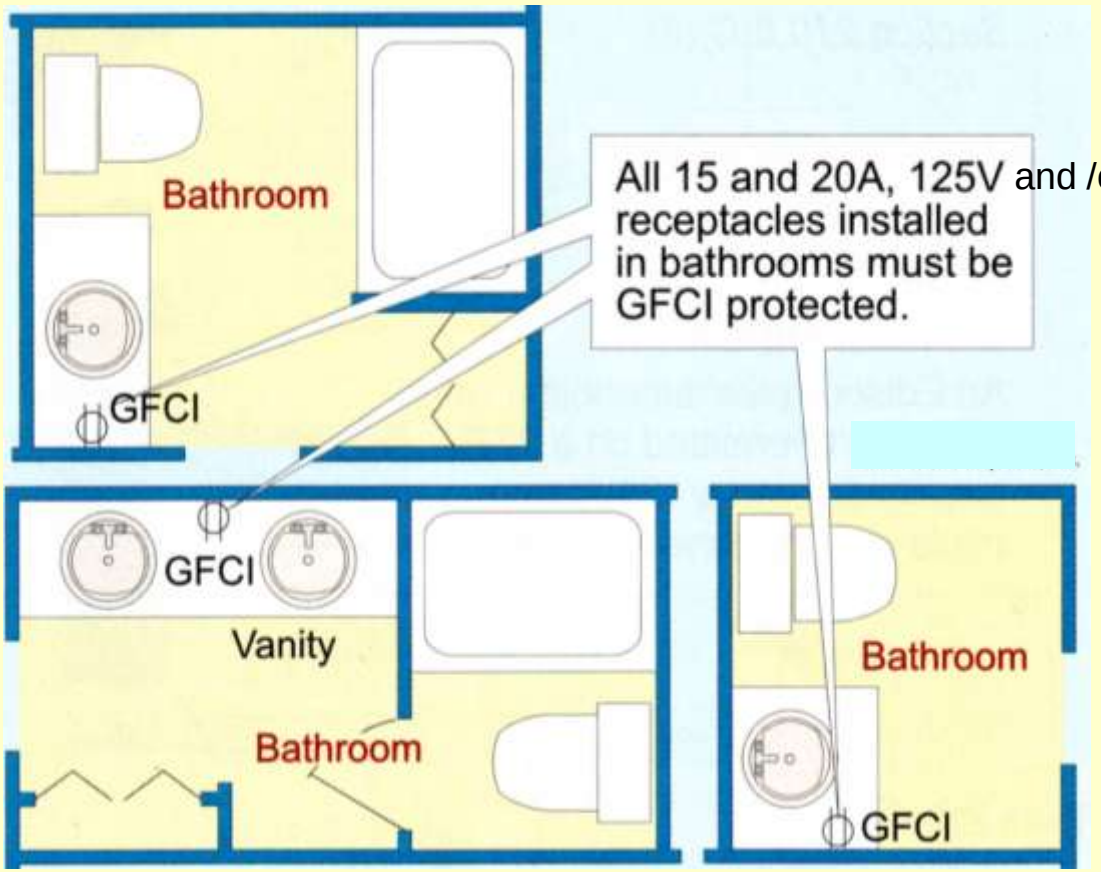
A GFCI is designed to protect persons against electric shock.
It operates on the principles of monitoring the unbalanced current
Between the ungrounded and the grounded neutral conductor.

Ground Fault Circuit Interrupter

GCFI CAN ELIMINATE THIS!

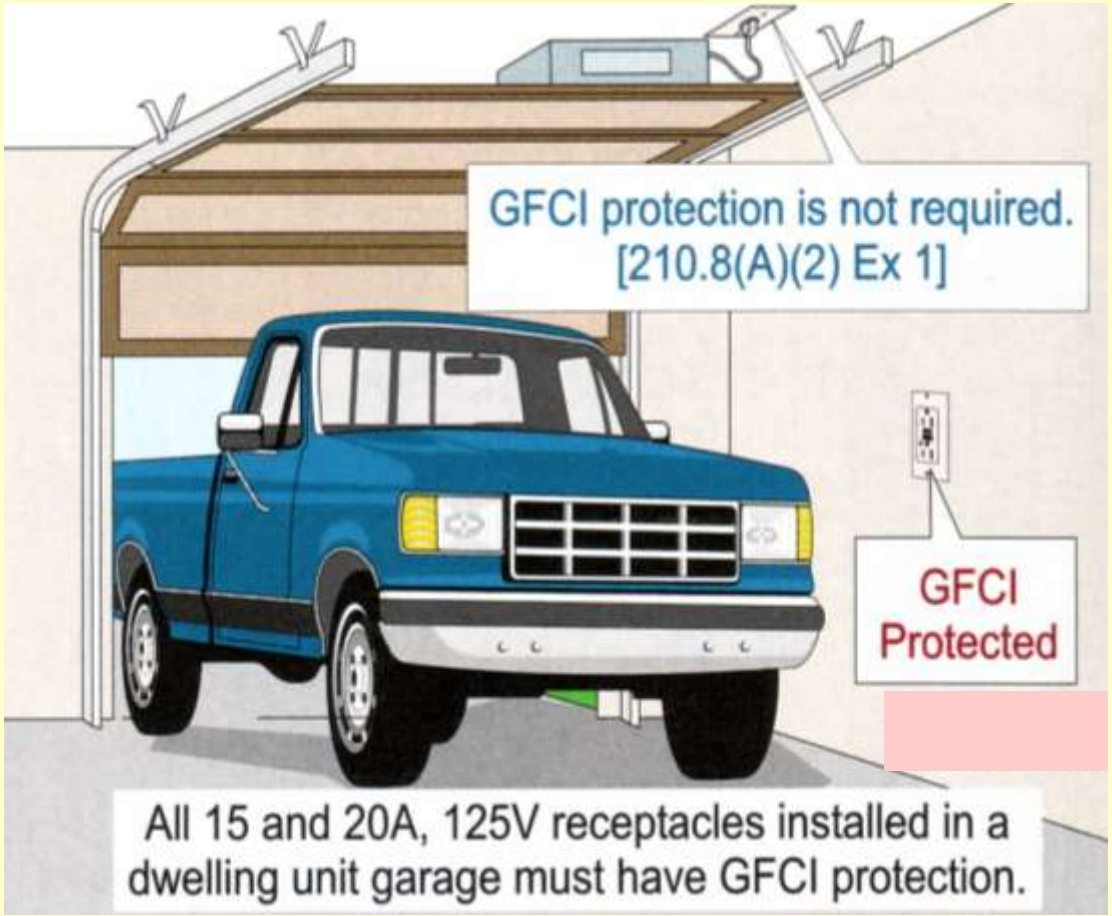
GFCI Protection for Personnel

1. Dwelling Bathroom Receptacle



GFCI Protection for Personnel

2. Dwelling Garage Receptacle



GFCI Protection for Personnel

2. Dwelling Garage Receptacle

All 15 and 20 A, 125/250 V receptacles in accessory buildings and similar work areas must be GFCI protected.

GFCI Protection for Personnel

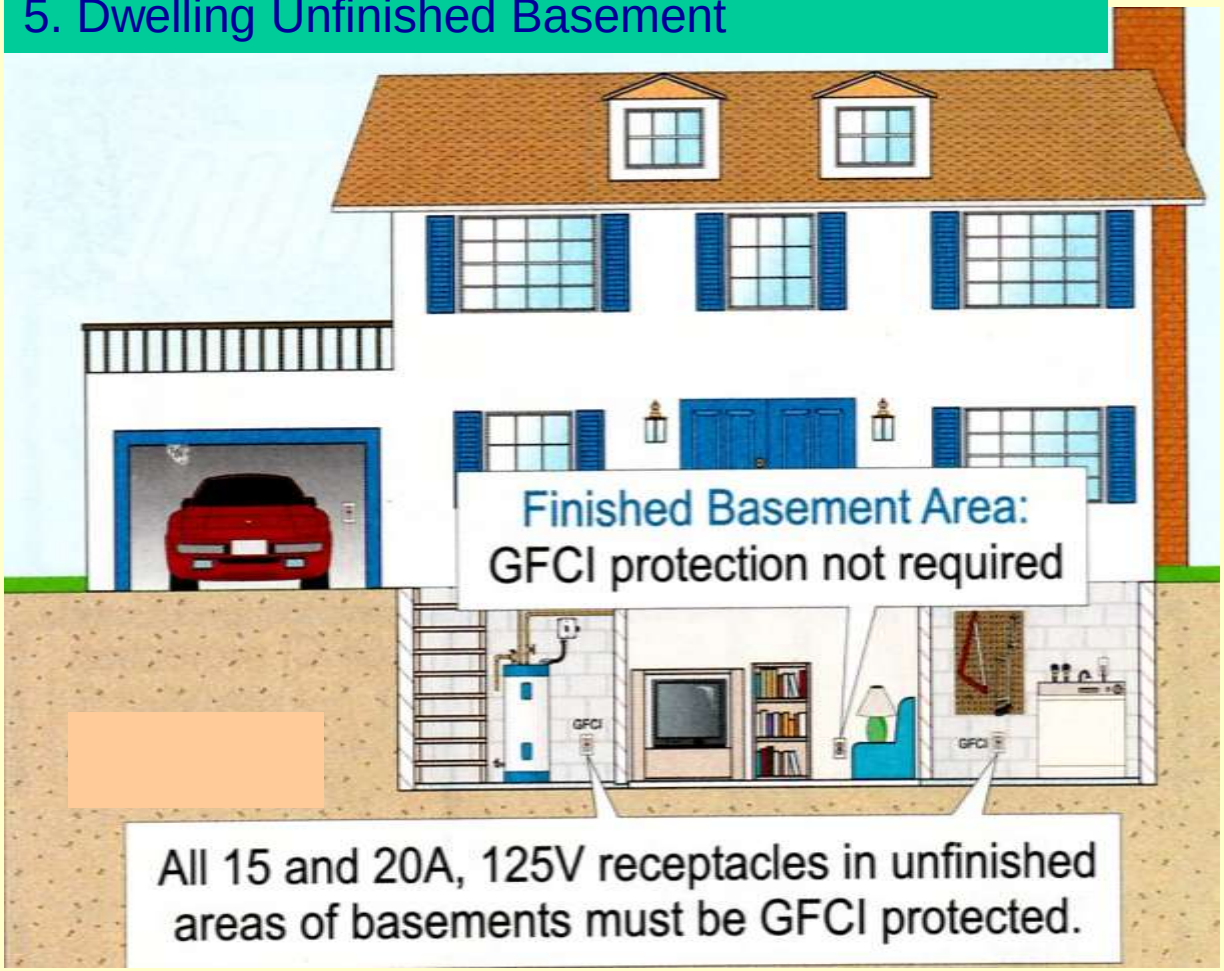
3. Dwelling Outdoor Receptacle

GFCI Protection for Personnel

4. Dwelling Basement Receptacle

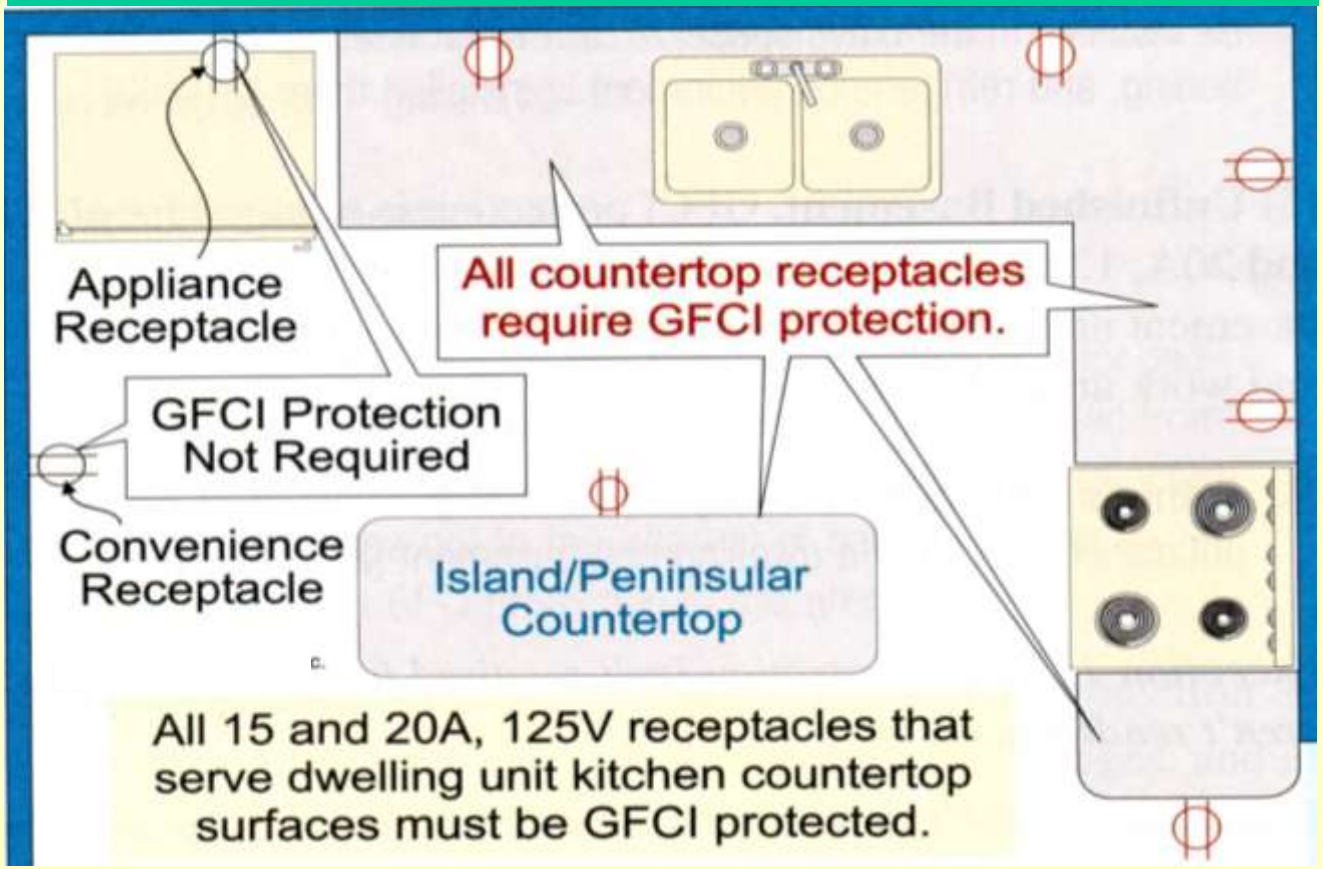
GFCI Protection for Personnel

5. Dwelling Unfinished Basement



GFCI Protection for Personnel

6. Kitchens for Countertop Appliances



GFCI Protection for Personnel

6. Dwelling Laundry or Utility Sink

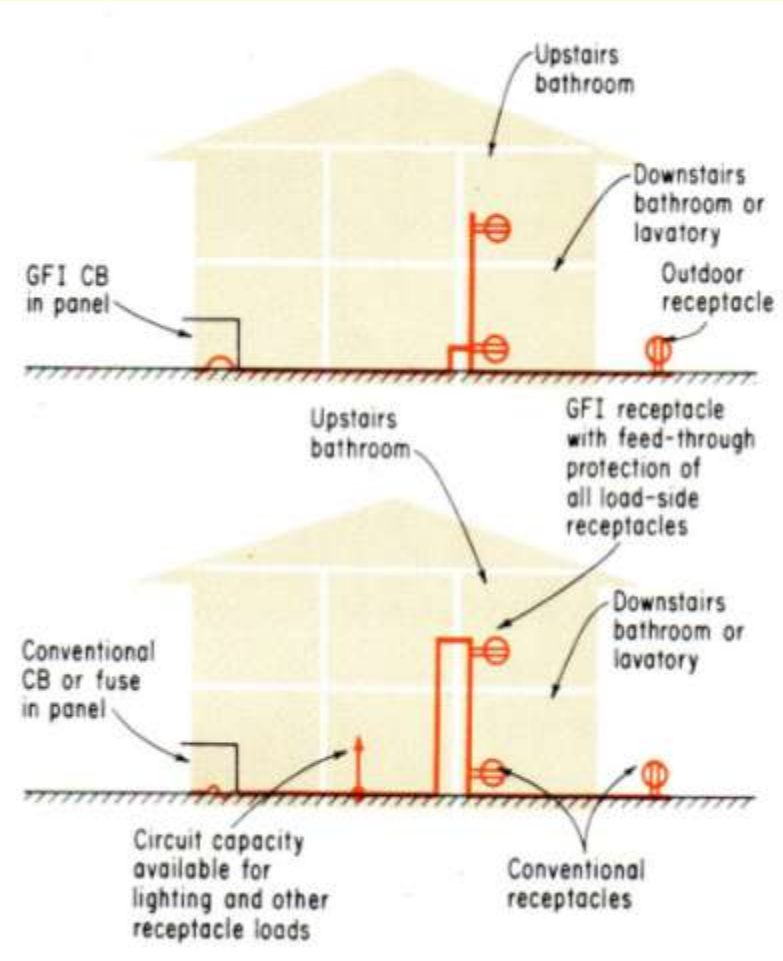
GFCI Protection for Personnel

7. Dwelling Wet Bar Sinks

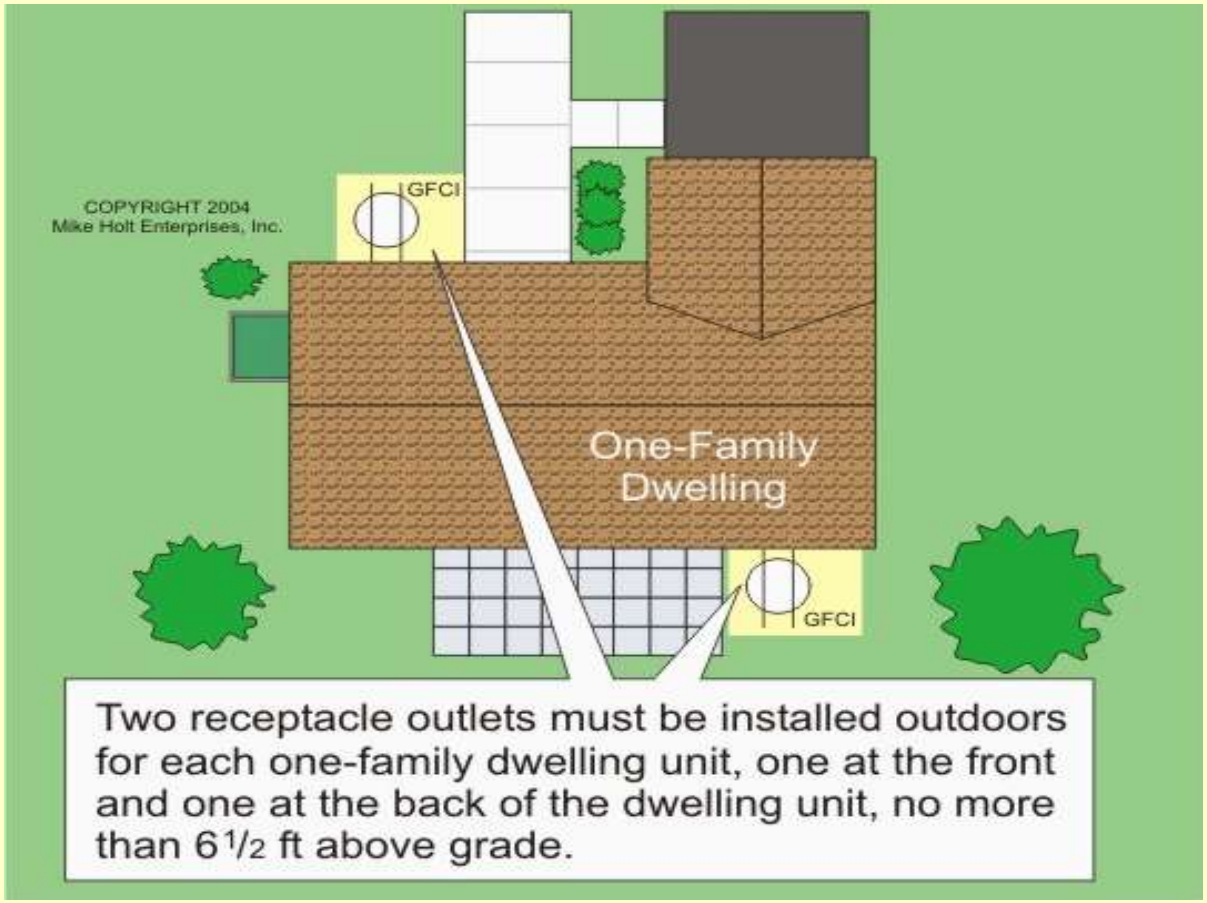
GFCI Protection for Personnel

PEC-2.10.1.8 (a)

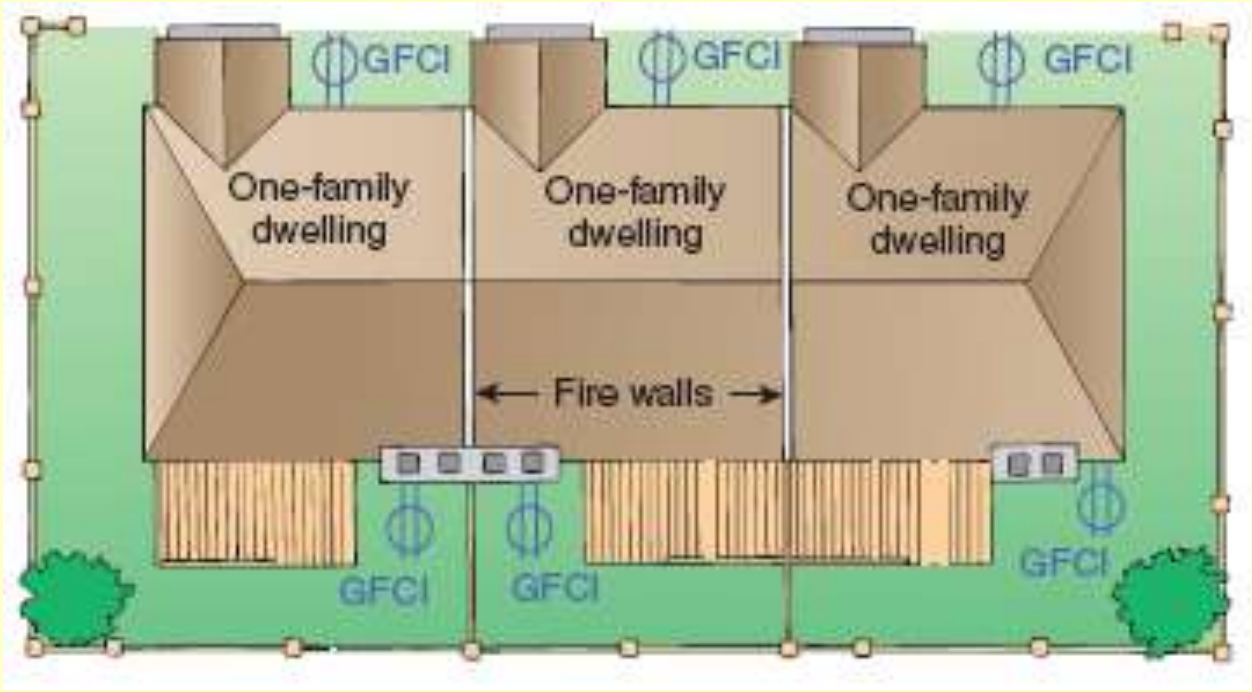
a) Dwelling Units
   1. Bathrooms
   2. Garages
   3. Outdoors
   4. Crawl spaces at or below grade level
   5. Unfinished basements
   6. Kitchens for countertop appliances
   7. Wet bar sinks



Outdoor Receptacles Outlets – One Family Dwelling



New Provision



Row Housing with GFCI-protected receptacles located at the front and the back of each one family dwelling, as required by 210.52(E)

New Provision

- 2.10.1.8(b)(2) –GFCI Protection Other than Dwelling
  - Commercial and institutional kitchens – for the purposes of this section, a kitchen is an area with a sink and permanent facilities for food preparation and cooking. (Culinary Schools)

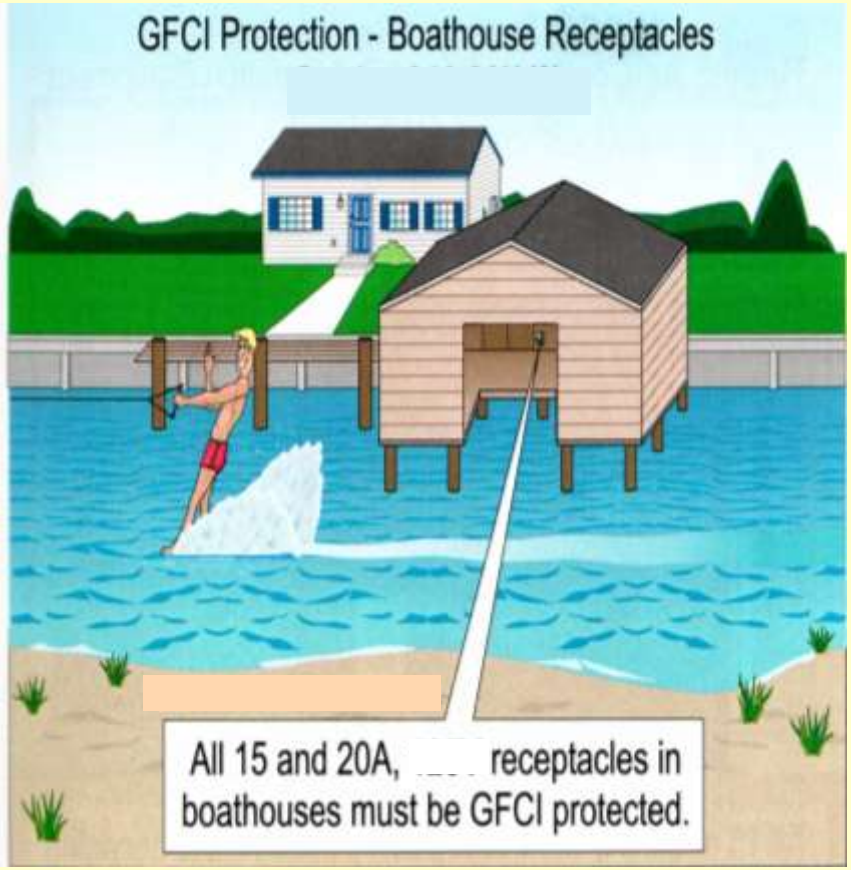
New Provision

- 2.10.1.8(b)(4) –GFCI Protection Other than Dwelling
  - Outdoor in Public Spaces – for the purpose of this section a public space is defined as any space that is for use by, or is accessible to the public.

New Provision

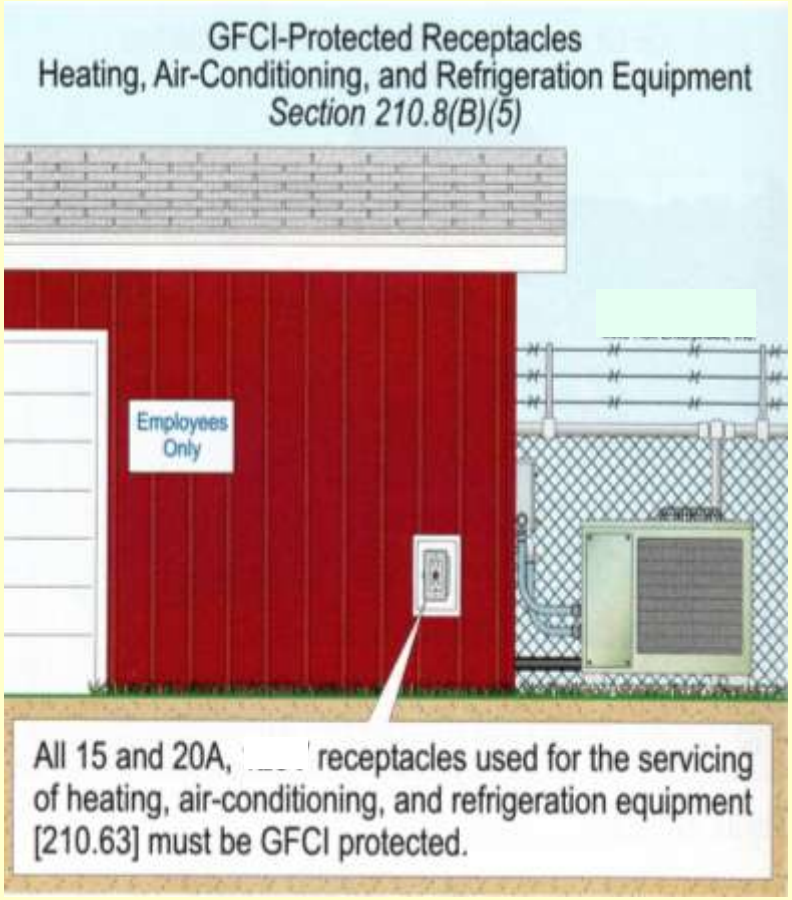
2.10.1.8(c)Boat Hoists

- GFCP for personnel shall be provided for outlets that supply boat hoists installed in dwelling unit locations



New Provision

- 2.10.1.8(b)(5) –GFCI Protection Other than Dwelling
  - (5)Outdoor , where installed to comply with 2.10.3.14 Heating, Air-conditioning, and Refrigeration Outlet



6.95 Fire Pumps

- The general philosophy behind Code articles is that circuit protection will shut down equipment before letting the supply conductors melt from overload.
- Art. 6.95 Fire Pumps depart from this philosophy.
- The idea is that the fire pump motor must run, no matter what; it supplies water to facility's fire protection piping, which in turn supplies water to the sprinkler system and fire hoses.

Introduction

- Art. 6.95 contains many requirements to keep that supply of water uninterrupted.

  For example:

  1. Locating the pump so as to minimize its exposure to fire.
  2. Ensuring that the fire pump and its jockey pump have a reliable source of power.
  3. It makes sense to keep fire pump wiring independent.

Introduction

- Other requirements seem wrong at first glance, until you remember why the fire pump is there in the first place.

  For example:

  1. The disconnect must be lockable in the closed position.
  2. Fire pumps power circuits cannot have automatic protection against overload.

Introduction

- **“ It’s better to run the fire pump until its winding melt, than to save the fire pump and lose the facility”**

- **And the intent of Article 6.95 is to save the facility.**

6.95.1.1 Scope

a) Covered

1) Electric power sources and interconnecting circuits
2) Switching and control equipment dedicated to fir pump drivers

b) Not Covered

1) The performance, maintenance, and acceptance testing of the fire pump system, and the internal wiring of the components of the system
2) Pressure maintenance (jockey or makeup) pumps

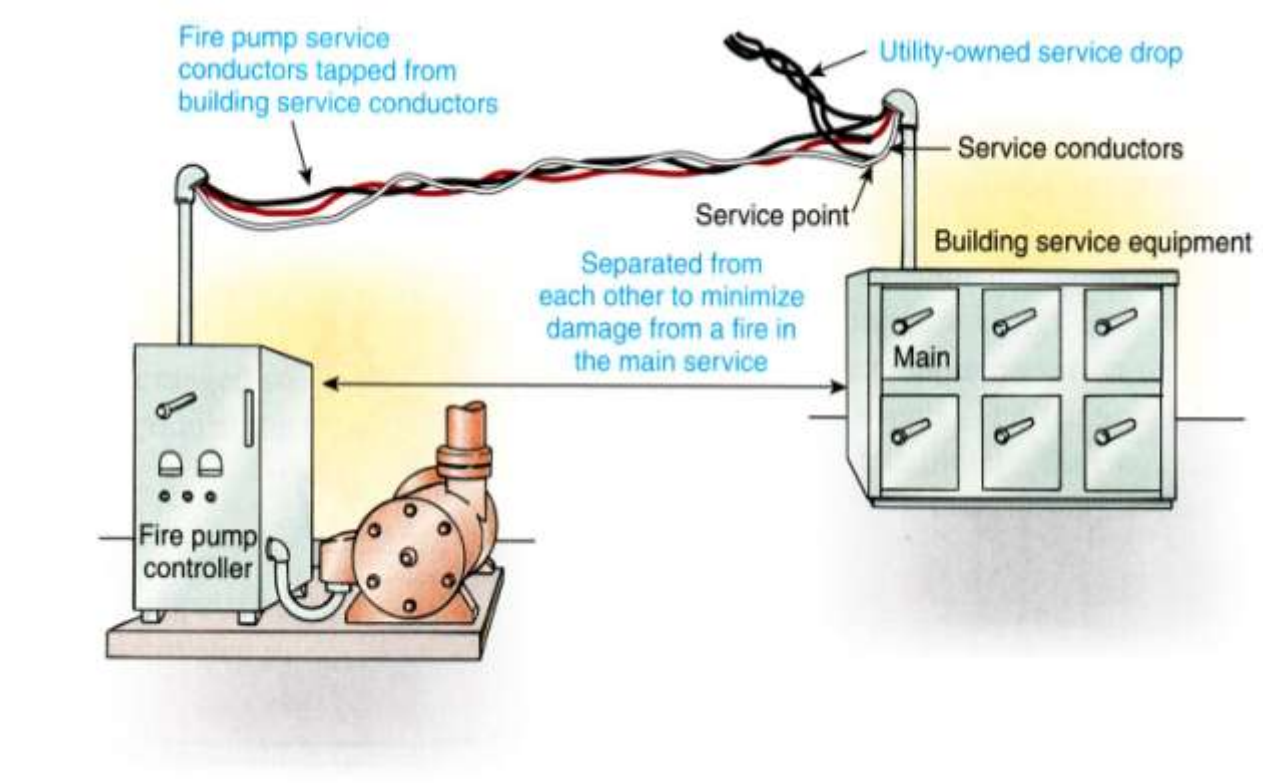
6.95.1.3 Power Sources for Electric-Motor Driven Fire Pumps

a) Individual Source

1) **Electric Utility Service.** A separate service from a connection located ahead of but not within the service disconnecting means.

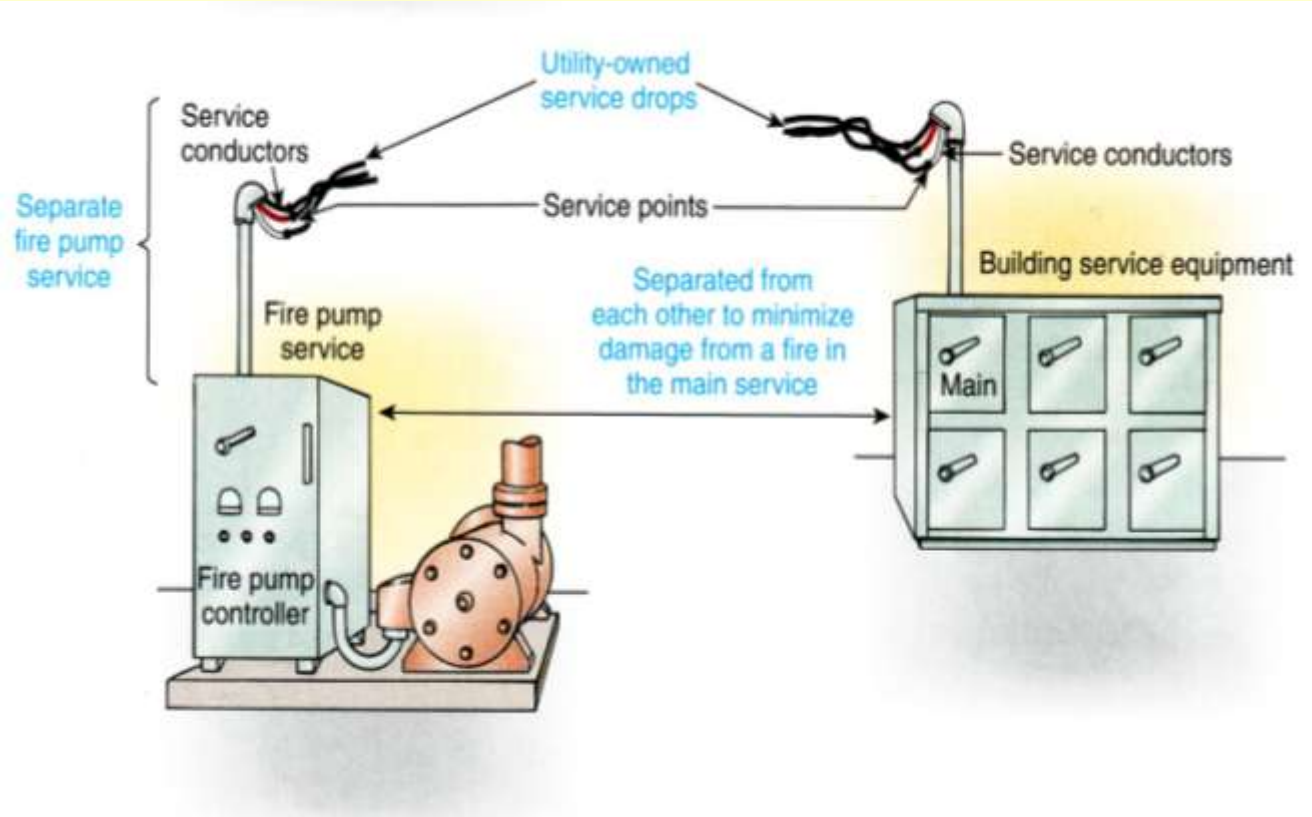
2) **On-Site Power.** An on-site power supply, such as generator, located and protected to minimize damage by fire is permitted to supply a fire pump.

6.95.1.3 Power Sources for Electric-Motor Driven Fire Pumps



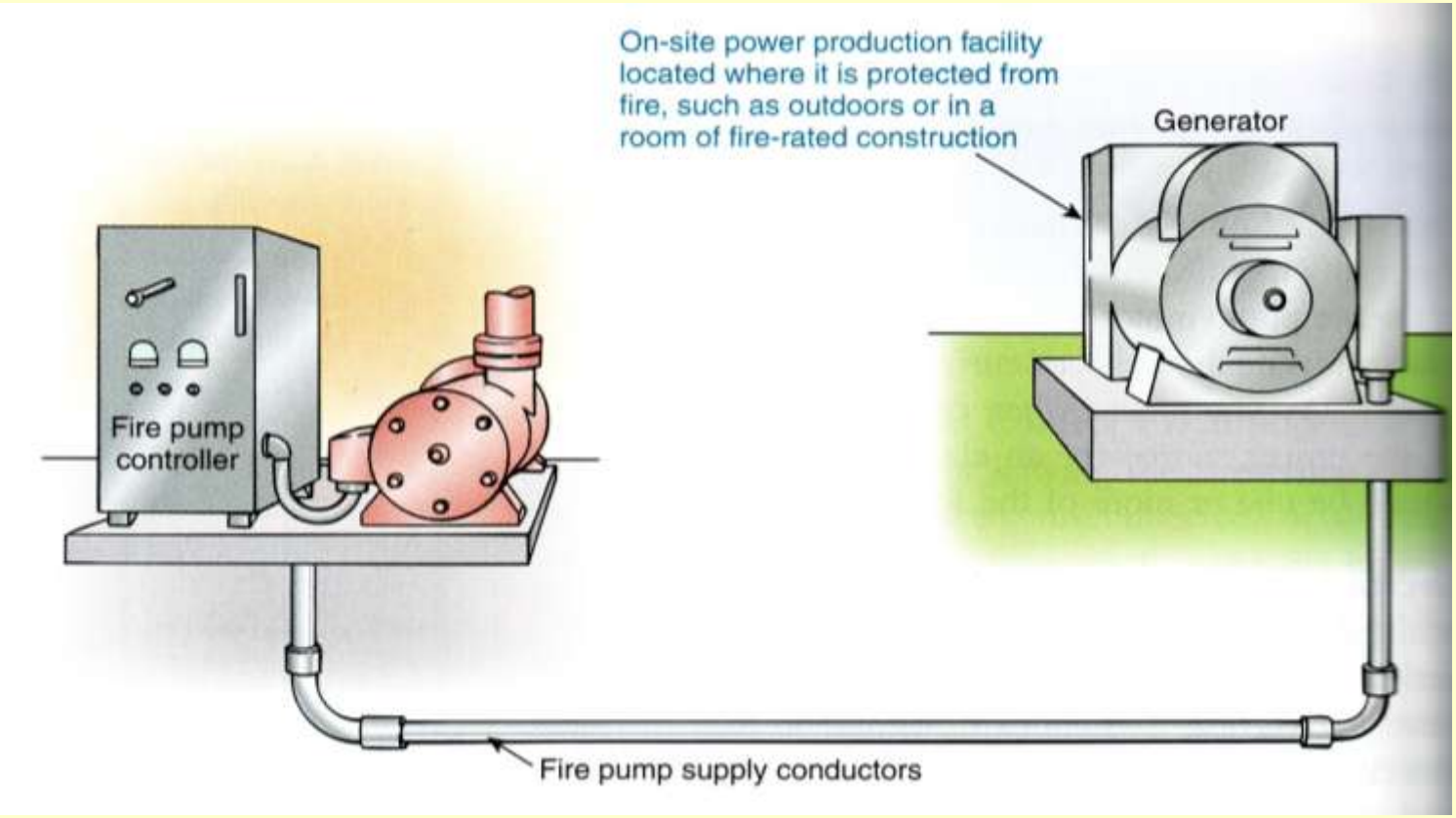
a) Electric-Utility Service Connection

6.95.1.3 Power Sources for Electric-Motor Driven Fire Pumps



a) Electric-Utility Service Connection

6.95.1.3 Power Sources for Electric-Motor Driven Fire Pumps



2) On-Site Power Production Facility

6.95.1.3 Power Sources for Electric-Motor Driven Fire Pumps

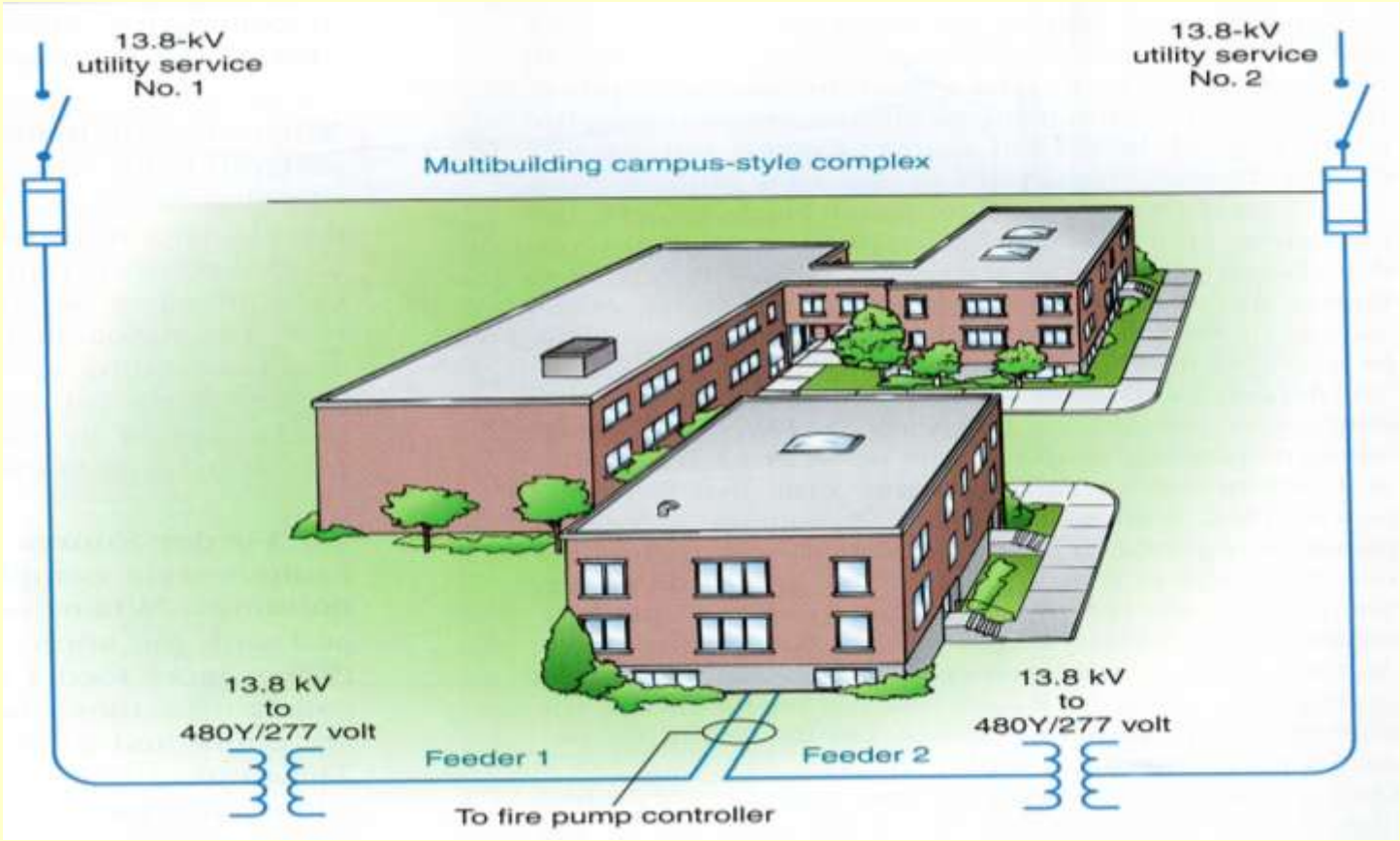
b) Multiple Sources

1) **Generator Capacity.** Shall have sufficient capacity to allow normal starting and running 0f the motor(s) driving the fire pump(s) while supplying other simultaneously operated load.

2) **Feeder Sources.**

3) **Arrangement.** The power sources shall be arranged so that a fire at one will not cause an interruption at the other source.

6.95.1.3 Power Sources for Electric-Motor Driven Fire Pumps

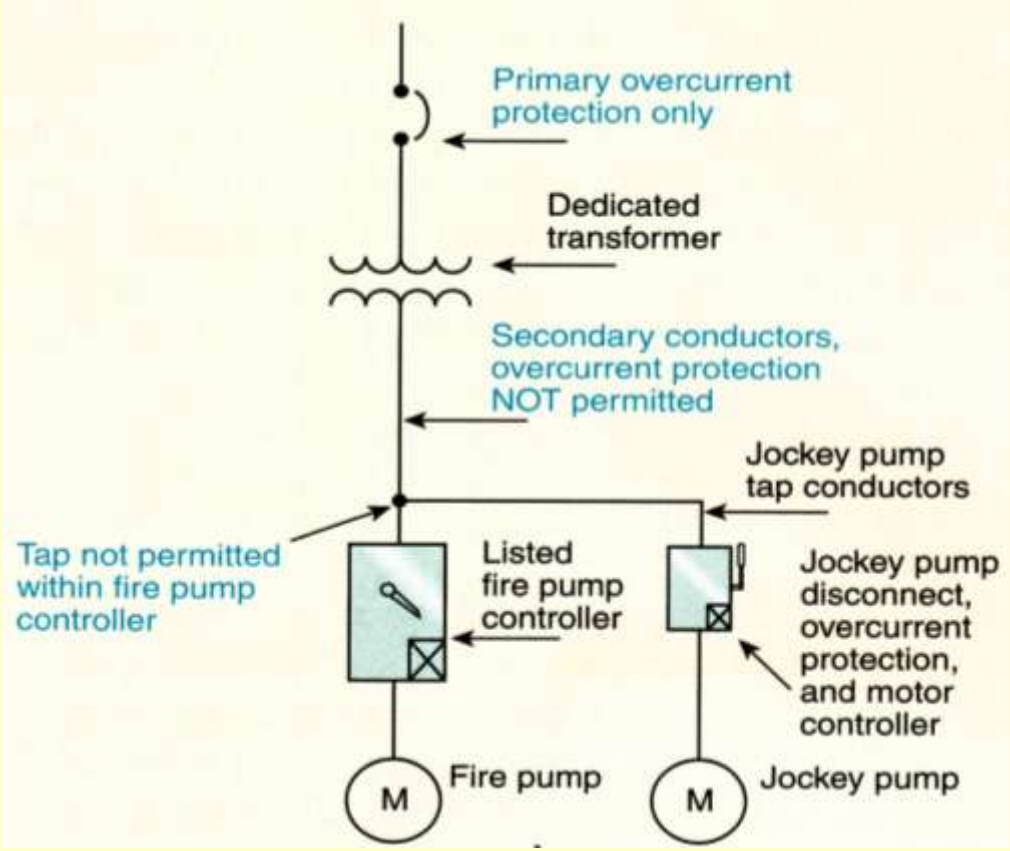


2) Feeder Sources

6.95.1.5 Transformers

- **Dedicated transformer and overcurrent protection sizing can be broken down into three requirements.**
  1. **The transformer must be size to at least 125% of the sum of the loads.**
  2. **The transformer primary overcurrent device must be at least a specified minimum size.**
  3. **The transformer secondary must not contain any overcurrent device whatsoever.**

6.95.1.5 Transformers



The overcurrent device in the primary of a transformer supplying a fire pump installation. The device is required to be sized to carry the locked-rotor current motor(s) and associated fire pump accessory equipment indefinitely.

6.95.1.6 Power Wiring

a) Service and Feeder Conductors.

Supply conductors must be physically routed outside buildings and must be installed in accordance with Article 2.30. Where supply conductors cannot be routed outside buildings, they must be encased in 2 inches or 50 mm of concrete or brick.

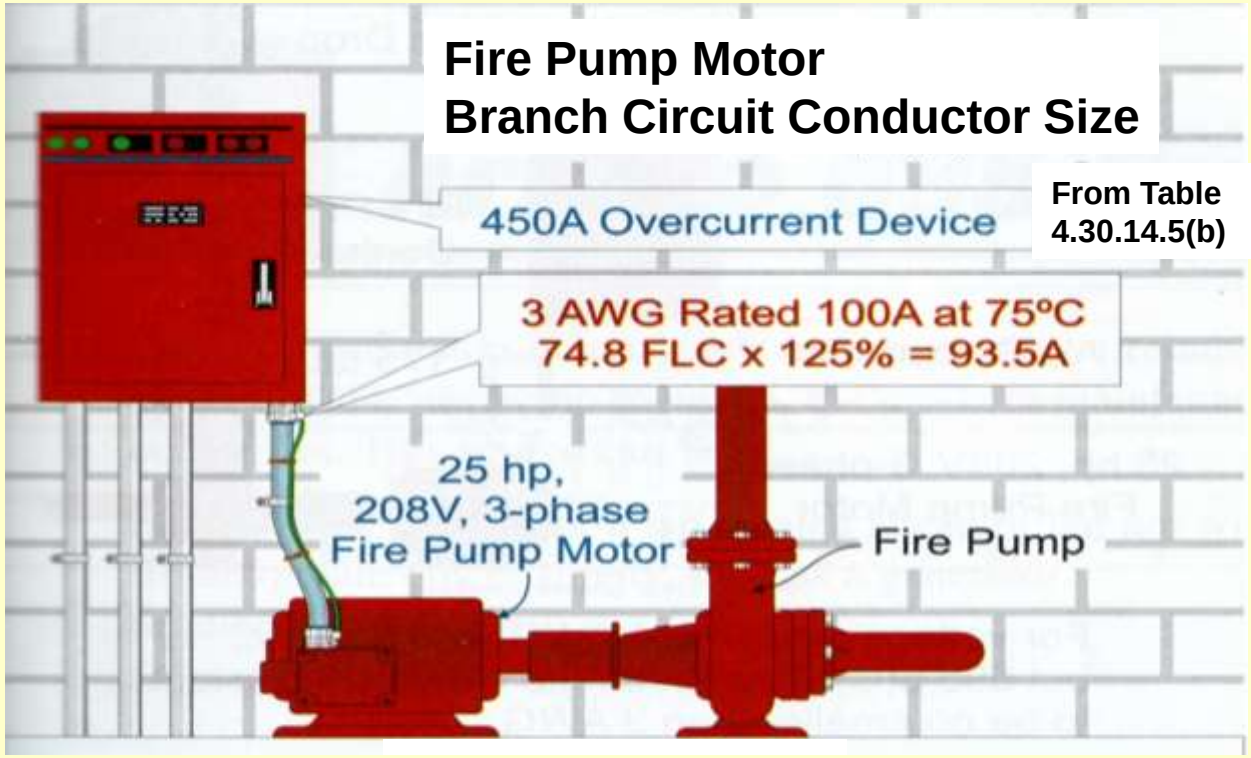
6.95.1.6 Power Wiring

b) Circuit Conductors.

Fire pump supply conductors on the load side of the final disconnecting means and overcurrent device(s) must be kept entirely independent of all other wiring. They can be routed through a building using one of the following methods:

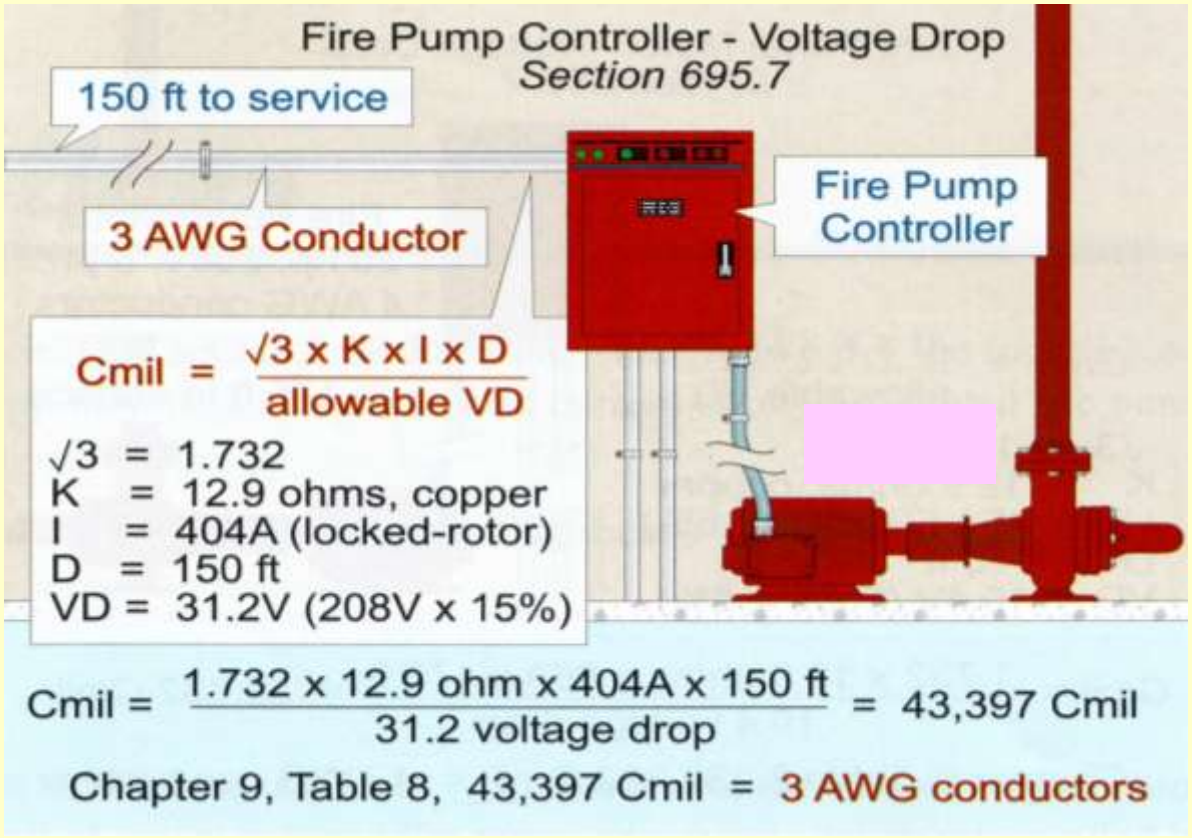
1) **Be encased in a minimum 2 inches or 50 mm of concrete**
2) **Be within an enclosed construction dedicated to the fire pump circuit(s) and having a minimum of a 1-hour fire-resistant rating**
3) **Be listed electrical circuit protective system with a minimum 1-hour fire rating.**

6.95.1.6(c)(2) BC Conductor Size



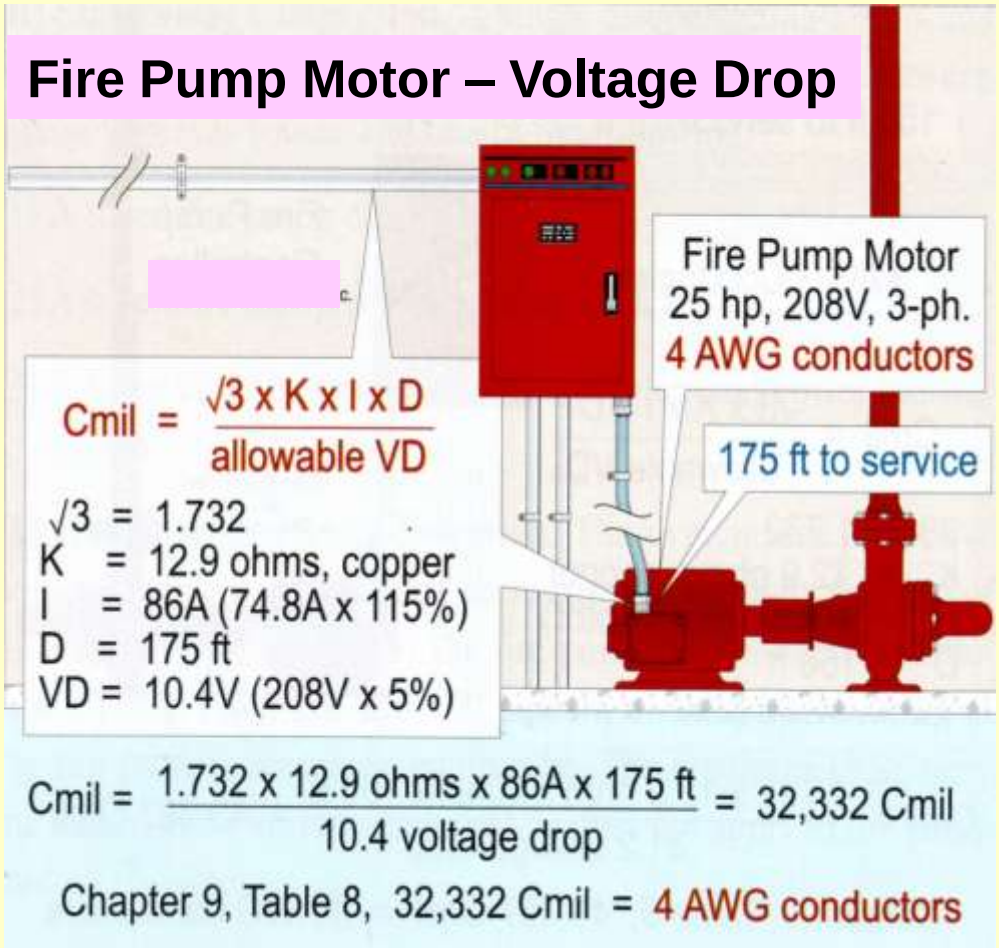
Branch circuit conductors to a single fire pump motor must have a rating not less than 125% of the motor
FLC as listed in Table 4.30.14.2 or 4.30.14.4

6.95.1.7 Voltage Drop

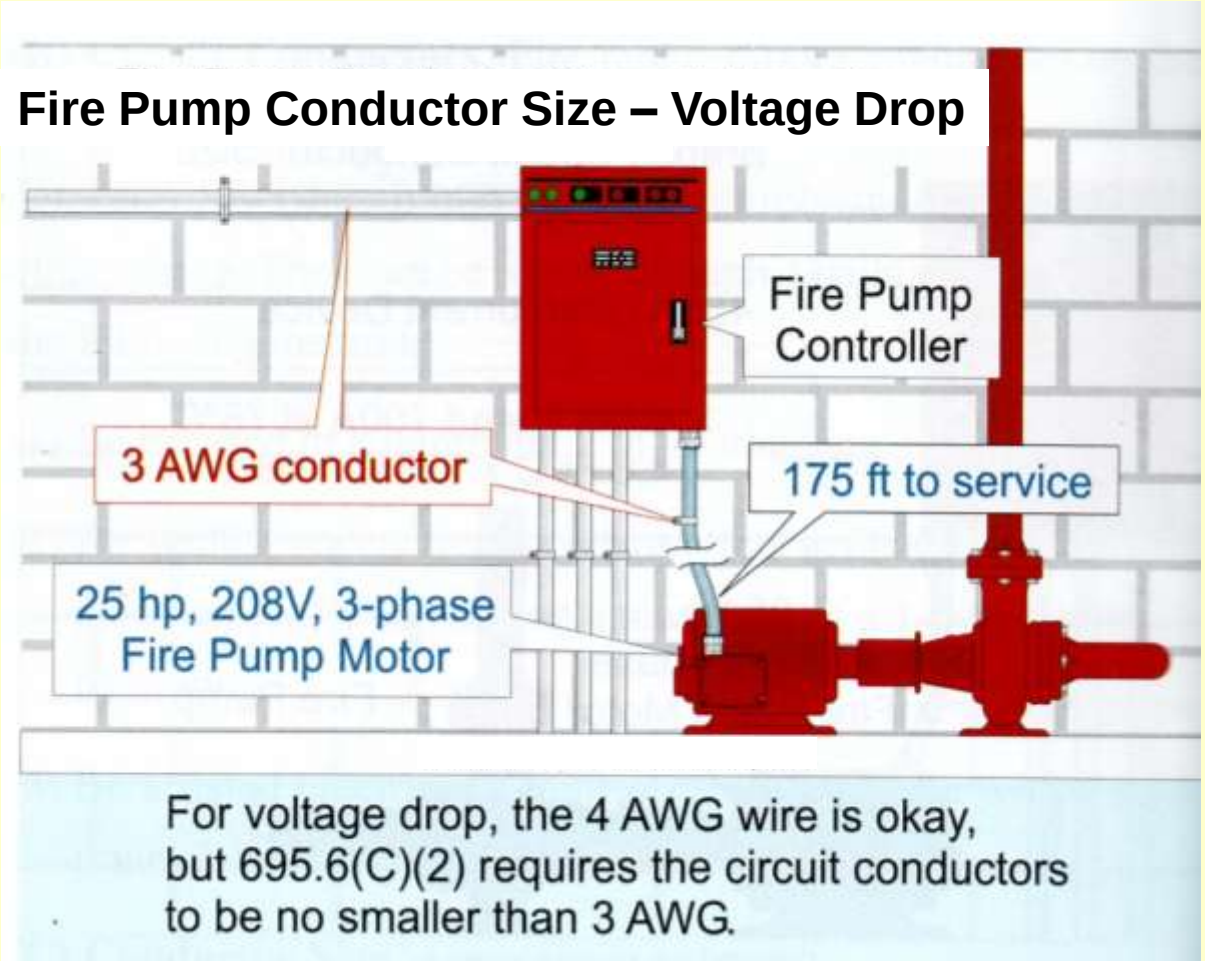


The voltage drop at the line terminals of the controller when the motor starts (locked-rotor current), must not drop more than 15% below the controller's rated voltage.

6.95.1.7 Voltage Drop



6.95.1.7 Voltage Drop



1. **It is important to *ground* metal parts to a suitable *grounding electrode*, so that in the event of a ground fault, dangerous *ground-fault current* will be shunted into the earth away from persons, thereby protecting them against electric shock.**
2. **Electrical equipment must be *grounded* to ensure that dangerous voltage on metal parts resulting from a *ground fault* can be reduced to a safe value.**
3. **Electrical equipment must be *grounded* so that sufficient fault current will flow through the circuit protection device to quickly open and clear the *ground fault.* For example, a 20 A circuit breaker will trip and de-energize a 240 V ground fault to a metal pole that is grounded to a 25 ohm ground rod.**
4. **When electrical current is given multiple conductive paths on which to flow, current will only take the path of least resistance.**

Thank You

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Chairman, Distribution Management Committee

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