



2017 National Electrical Code®

Safeguarding People and Property from
the Hazards of Electricity



NTT Salutes the NFPA

- ✓ Established 1896
- ✓ Reduces the worldwide burden of fire and other hazards on the quality of life by providing and advocating consensus codes and standards, research, training, and education.
- ✓ NTT is a proud member of the NFPA



Your Instructor: Randy Barnett, CESP



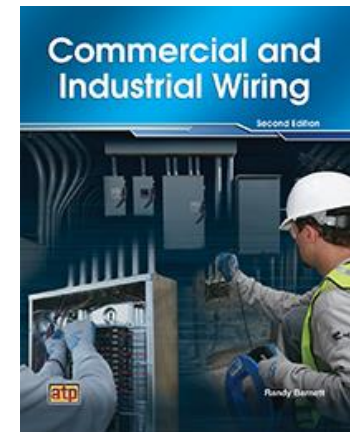
Electrical Codes & Safety Program Manager

rbarnett@nttinc.com

US mobile: 970-290-8637



- ✓ NFPA Certified
- ✓ Electrical Inspector
- ✓ Journeyman Electrician
- ✓ Author, Developer and Instructor



www.go2ATP.com

Class Logistics

- ✓ Class Times:

08:45 AM – 4:30 PM

- ✓ Lunch – 1 hour

- ✓ Breaks – morning and afternoon

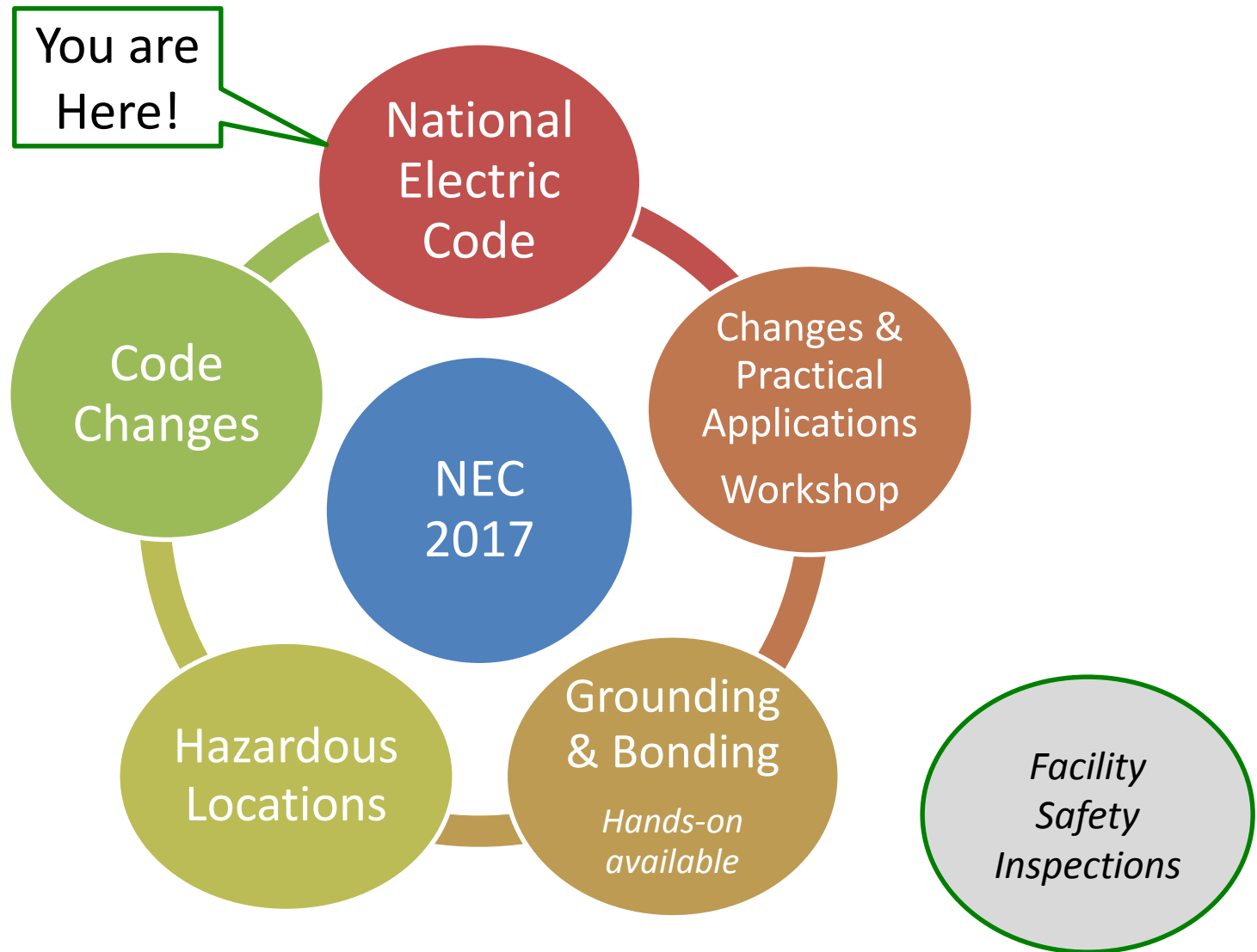
- ✓ Restrooms

- ✓ Emergency Exits

- ✓ All questions and discussion welcome!



2017 National Electrical Code® courses from NTT



NTT courses award Continuing Education Units (CEUs)



1 Day Class = 8 contact hours = 0.8 CEUs

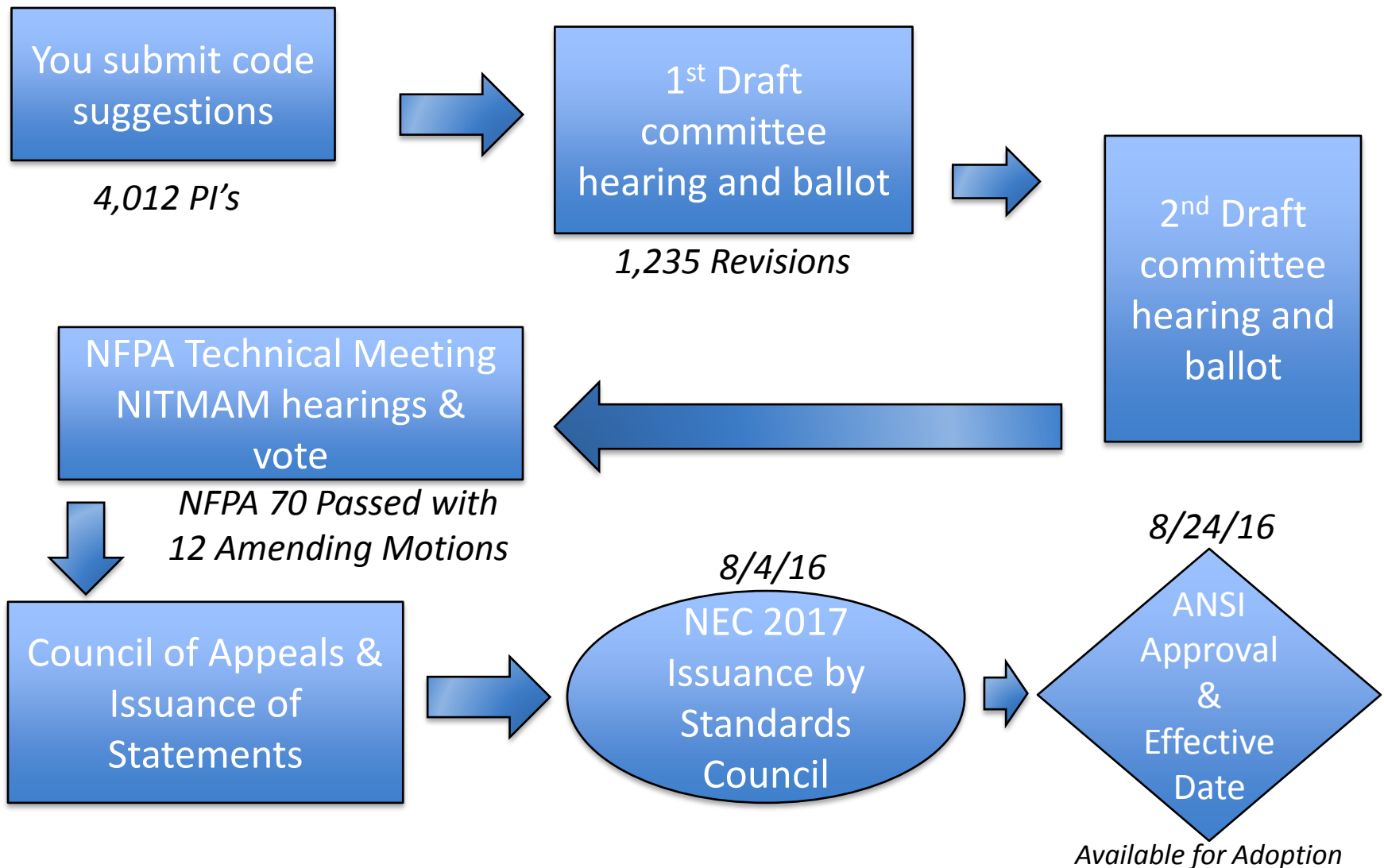
2 Day Class = 16 contact hours = 1.6 CEUs

3 Day Class = 24 contact hours = 2.4 CEUs

4 Day Class = 32 contact hours = 3.2 CEUs

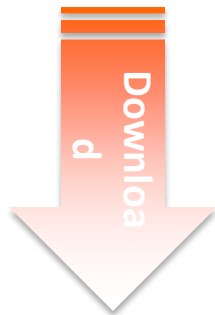
5 Day Class = 40 contact hours = 4.0 CEUs

NEC Code Making Process



2017 NEC formats available from the NFPA

PDF Version
Available
8/10/2016



Softbound
Version
Available
9/1/2016



Looseleaf
Version
Available
9/15/2016



Handbook
Version
Available
11/18/2016



States and their Current NEC Adoption Status

Georgia:
Adoption process
underway (1/1/18)

NEC® in Effect
7/1/2016



2014 NEC®
2011 NEC®
2008 NEC®
No Statewide NEC® Adoption

Source: dynamaps.net (c)

<http://www.electricalcodecoalition.org>

Where to Keep Abreast of the Latest NEC Information

The NFPA Documents Page: www.nfpa.org/70

[CODES & STANDARDS](#) | [NEWS & RESEARCH](#) | [TRAINING & EVENTS](#) | [PUBLIC EDUCATION](#) | [MEMBERSHIP](#)

CODES & STANDARDS


[Codes & Standards](#) / [All codes & standards](#) / [List of NFPA codes & standards](#) / [NFPA 70](#)

NFPA 70: National Electrical Code®

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NFPA 70:
National
Electrical Code
(NEC), 2014
Edition

[More Info](#)

What is NFPA 70?
Adopted in all 50 states, the NEC is the benchmark for safe electrical design, installation, and inspection to protect people and property from electrical hazards. [Official document scope](#)

What does NFPA 70 address?
The NEC addresses the installation of electrical conductors, equipment, and raceways; signaling and communications conductors, equipment, and raceways; and optical fiber cables and raceways in commercial, residential, and industrial occupancies. [Table of Contents](#)

Additional Information




- [Certified Electrical Safety Worker \(CESW\) Certification Program](#) (PDF, 36 KB)
- [Certified Electrical Safety Compliance Professional \(CESCP\) Certification Program](#) (PDF, 61 KB)
- [NEC Connect](#)
- [Electrical Code Coalition](#)
- [NEC First Draft Mock Meeting - Webinar](#)
- [NEC webinar on task groups](#)

Find a code or standard

By document number/title


By cycle

[Search](#) [Show All](#)

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-  [Documents accepting Public Comment](#)
-  [Documents accepting NITMAM](#)

RELATED PRODUCTS

3-day Classroom Training + Certificate



Identifying NEC Changes (Usability Features)



Shading indicates new text – *other than editorial changes*

N New sections, tables, and figures

N Next to an Article title indicates a new Article

An entire figure caption with gray shading indicates a change to an existing figure

Bullet “•” indicates where one or more complete paragraphs have been deleted



5 New Articles Published (9 were proposed)



425 Fixed Resistance and Electrode Industrial Process Heating Equipment

691 Large-Scale Photovoltaic (PV) Supply Stations

706 Energy Storage Systems

710 Stand-Alone Systems

712 Direct Current Microgrids



Article 90

Introduction

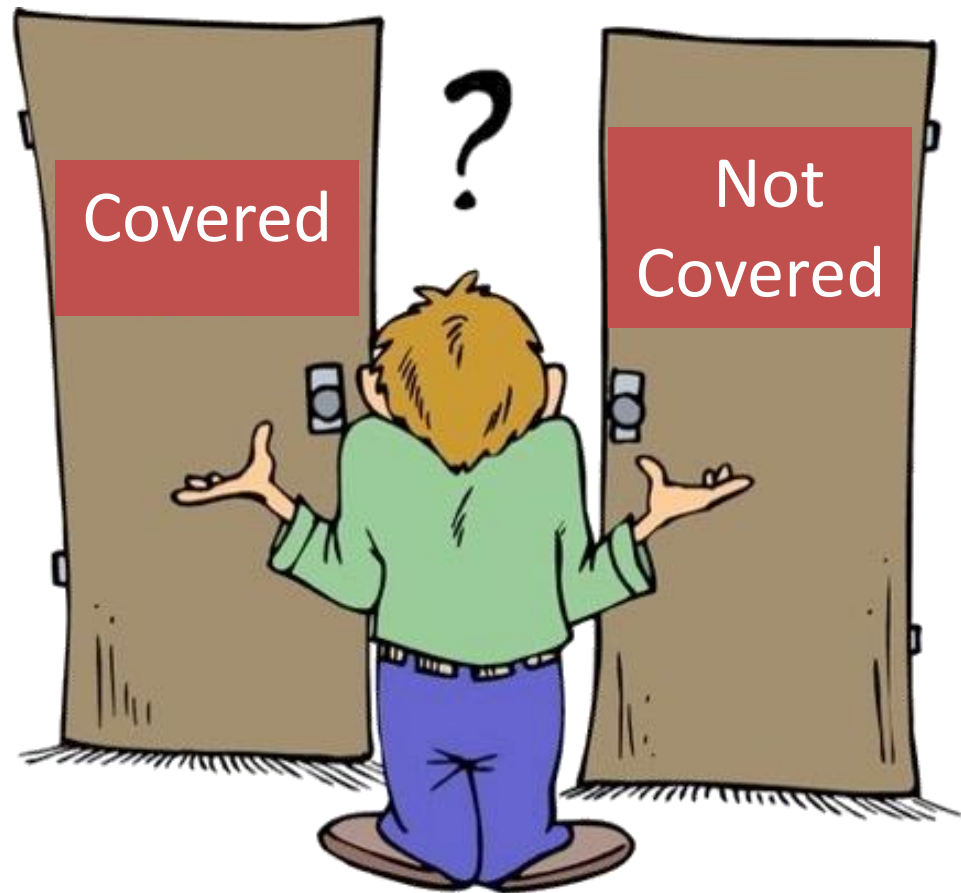
How the Code should be applied.
An introduction to Code terminology.
Lays the groundwork for NEC®



90.2 Scope

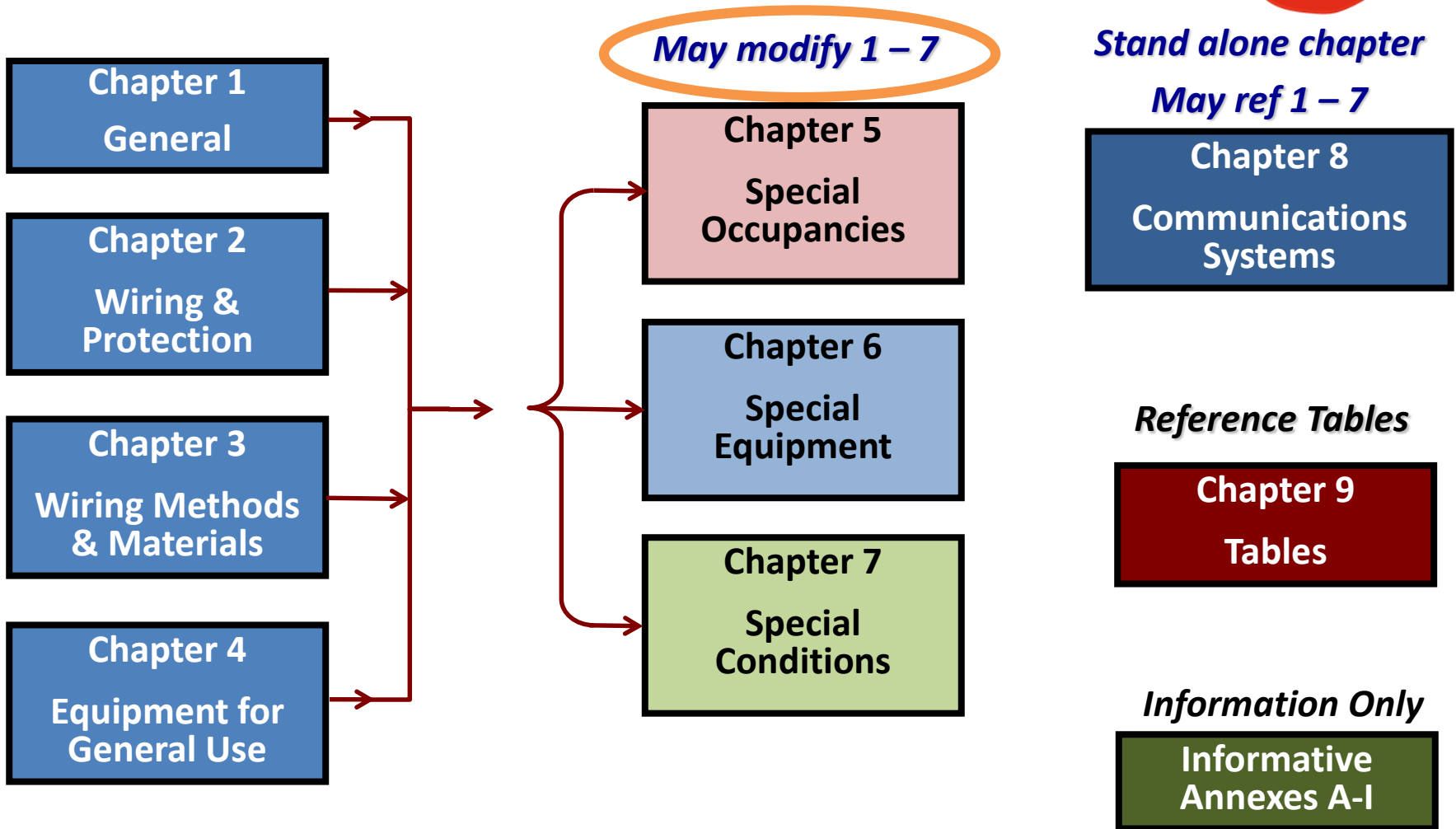


Does your work fall under (A) or (B)?



Now includes
"removal of
equipment"
& "Energy Storage"

90.3 Code Arrangement



90.7 Examination of Equipment for Safety.



- 2017 Revision adds clarity about Product Safety Standards
- “Suitability shall be determined by application of requirements that are compatible with this Code”
- Review the wording change to Informational Note No. 3
 - See *Informative Annex A, Product Safety Standards*



Chapter 1

General

Article 100, Definitions

Article 110, Requirements for Electrical Installations



Accessible, Readily (Readily Accessible)



- Capable of being reached quickly
- Does not require:
 - tools
 - to climb over or under
 - to remove obstacles, or
 - to resort to portable ladders



Review the NEW Informational Note

Accessible, Readily (Readily Accessible)



Makes it clear that a “key” is not a tool

Added to text to make it clear that “crawling under” is really not any different than to “climb over”



Building vs. Structures vs. Equipment



For clarity and accuracy:
“Building” was revised to
remove the terms:
~~therein~~
~~cut-off~~
~~fire doors~~

The NTT office is a *stand alone Building*

This is Equipment

This is a Structure





- Review the definition
 - Provides strain relief, and
 - may include an explosionproof, a dust-ignitionproof, or a flameproof seal.





NOTE:

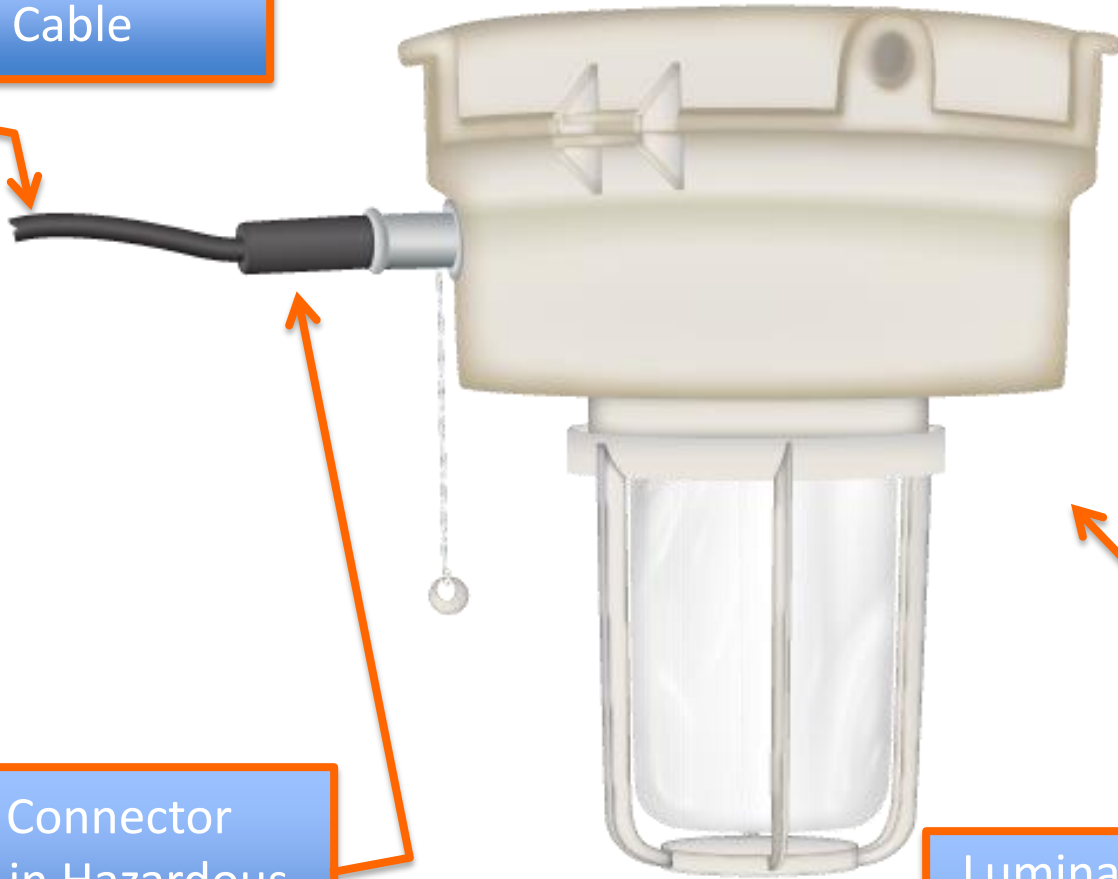
- TC-ER and TC-ER-HL is now used as a wiring method in Articles 501, 502, 503, 505, and 506
 - These cables require “Cord Connectors” (male only)
- For non-HL; Cord Connector also means “female connector”



Typical Application – Cord Connector in HZ Location



TC-ER Cable



Cord Connector applied in Hazardous (Classified) Location

Luminaire suitable for use in Hazardous (Classified) Location

Field Evaluation Body (FEB)



- AHJs are starting to mandate that the field evaluation bodies conducting evaluation of unlisted electrical equipment must conform to the requirements of NFPA 790.

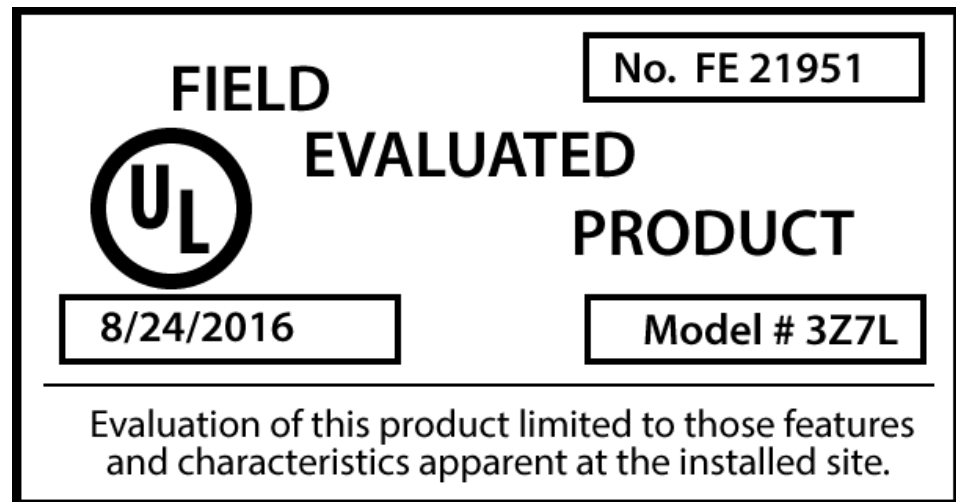
**NFPA 790:
Standard for
Competency
of Third-Party
Field
Evaluation
Bodies**



Field Labeled (as applied to evaluated products)



- Indicates the equipment or materials were evaluated and found to comply with requirements as described in an accompanying field evaluation report.



Understanding Field Evaluations



- Field Evaluations of unlisted equipment often requested by:
 - ✓ Building Departments
 - ✓ Code enforcement official
 - ✓ Fire marshals or
 - ✓ Similar AHJs

NYC Buildings

Work Permit Department of Buildings

Permit Number: 122221111 01 01 01
Issued: 04/23/2018 Expiry: 04/23/2019
Address: 12345 AVENUE
Description of Work: ALTERATION TYPE 2 - IMPROVING/REPAIRING AT ELEVATOR PIT AT INTERIALLY EXPOSED IN CORRIDOR, BOARD OF OCCUPANTS UNDER THIS APPLICATION

Emergency Telephone (Day or Night): 311

Permit Commissioner: [Signature] Commissioner of Buildings: [Signature]



- List of IAS FEB's as of 8/2016
 - Consumer Testing Services, SGS North America Inc.
 - eti Conformity Services
 - QPS Evaluation Services Inc
 - Quality Auditing Institute Ltd
 - SGS North America Inc
 - UL LLC



- Hazardous Locations

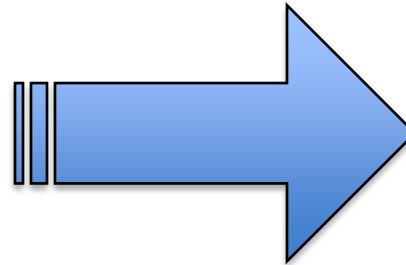
- Moved to comply with the 2011 NEC Style Manual

ARTICLE 500— HAZARDOUS
(CLASSIFIED) LOCATIONS,
CLASSES I, II, AND III, DIVISIONS
1 AND 2

500.2 Definitions

ARTICLE 504
Intrinsically Safe Systems

504.2 (3 of 5 moved)

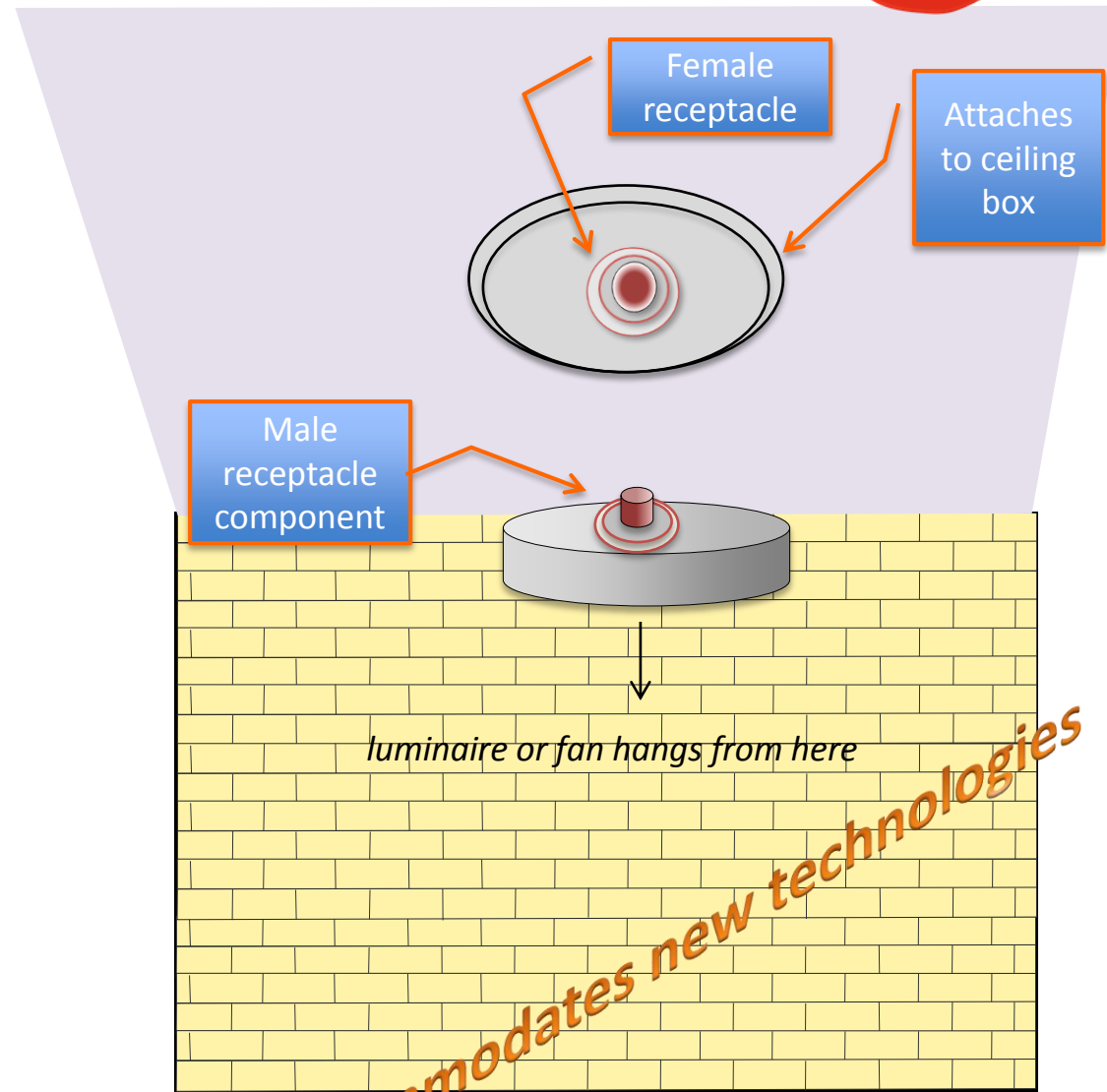


Article 100 - Definitions

Receptacle

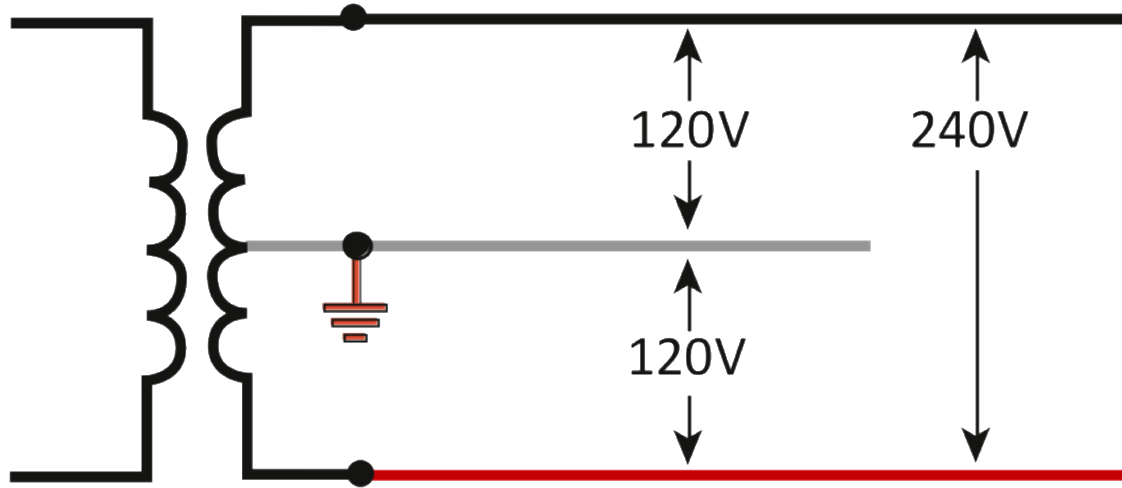


- Provides direct connection of electrical utilization equipment designed to mate with the corresponding contact device.
- *Accommodates plug-in installation for lighting and fans*



Accommodates new technologies

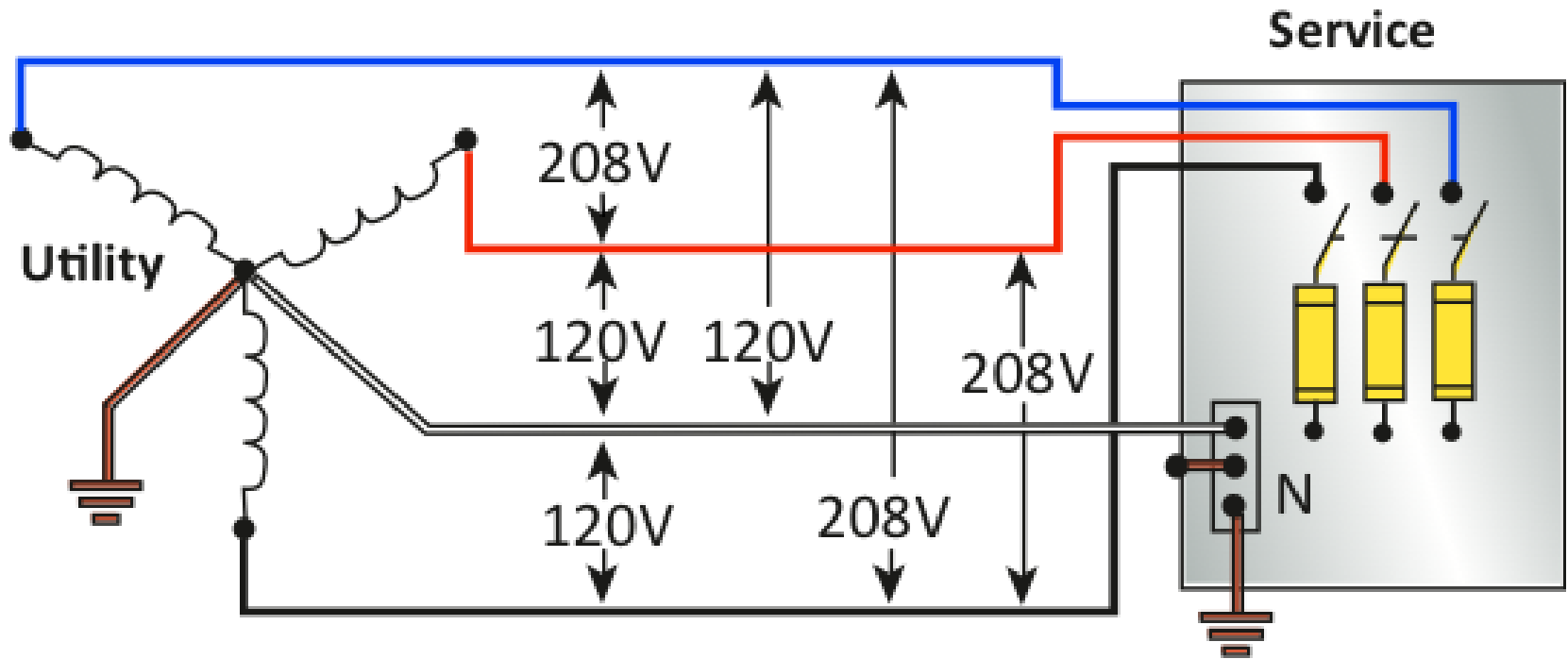
Neutral Conductor and Neutral Point



The **Neutral Conductor** is connected to the neutral point of a system and is intended to carry current

Neutral Point is the common point on a single-phase, 3-wire system.

Neutral Conductor and Neutral Point

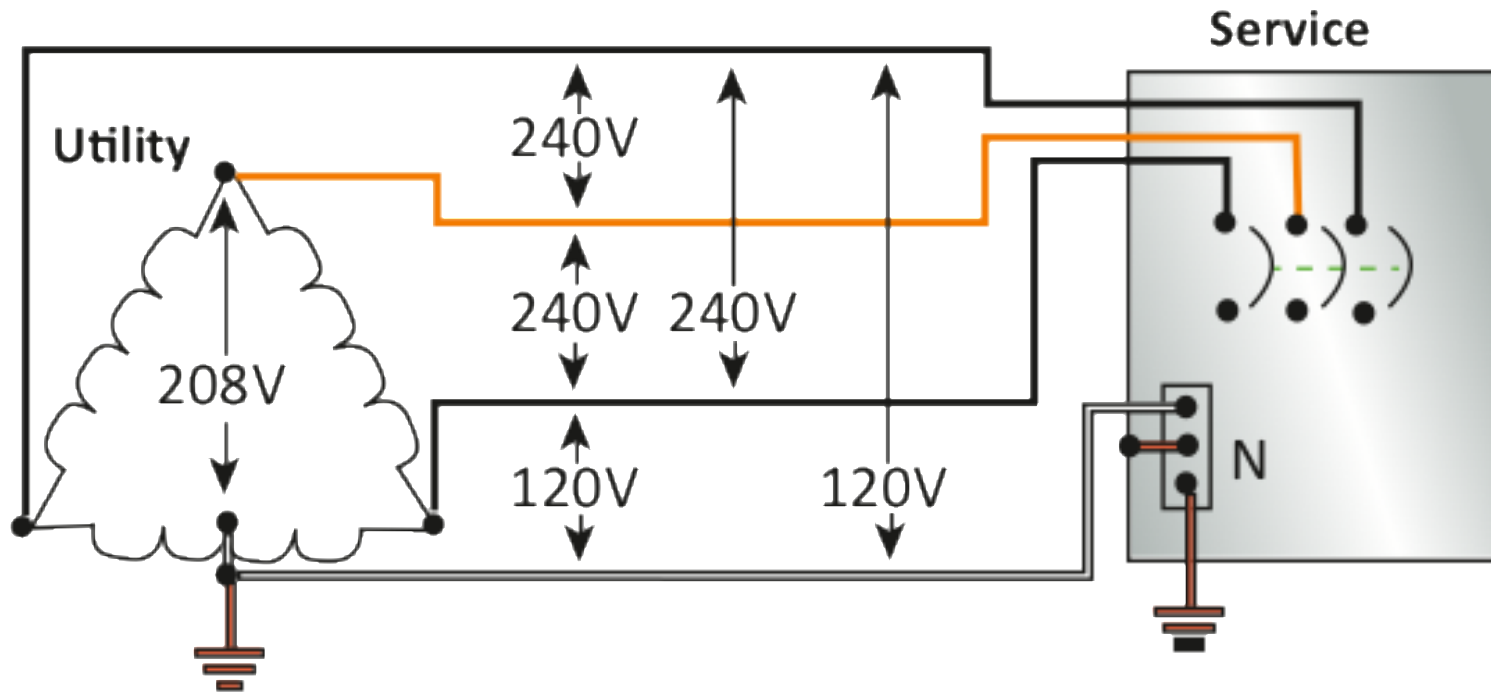


copyright 2013
NTT Inc.

208Y/120-V, 3-phase, 4-wire wye system

The common point on a wye-connection in a polyphase system

Neutral Conductor and Neutral Point



copyright 2013
NTT Inc.

120/240-V, 3-phase, 4-wire delta system

The midpoint of a single-phase portion of a 3-phase delta system, or a midpoint of a 3-wire

Overcurrent

Any current in excess of the rated current of equipment or the ampacity of a conductor.



May result from:

- ✓ overload (*see the article*)
 - ✓ short circuit or
 - ✓ ground fault
- } **Article 240**

Qualified Person

One who has **skills and knowledge** related to the construction and operation of the electrical equipment and installations and **has received safety training** to recognize and avoid the hazards involved.

- *“Qualified Persons” is used in the code over 130 times!*
- *See the IN for training requirements*



Article 110

Requirements for Electrical Installations



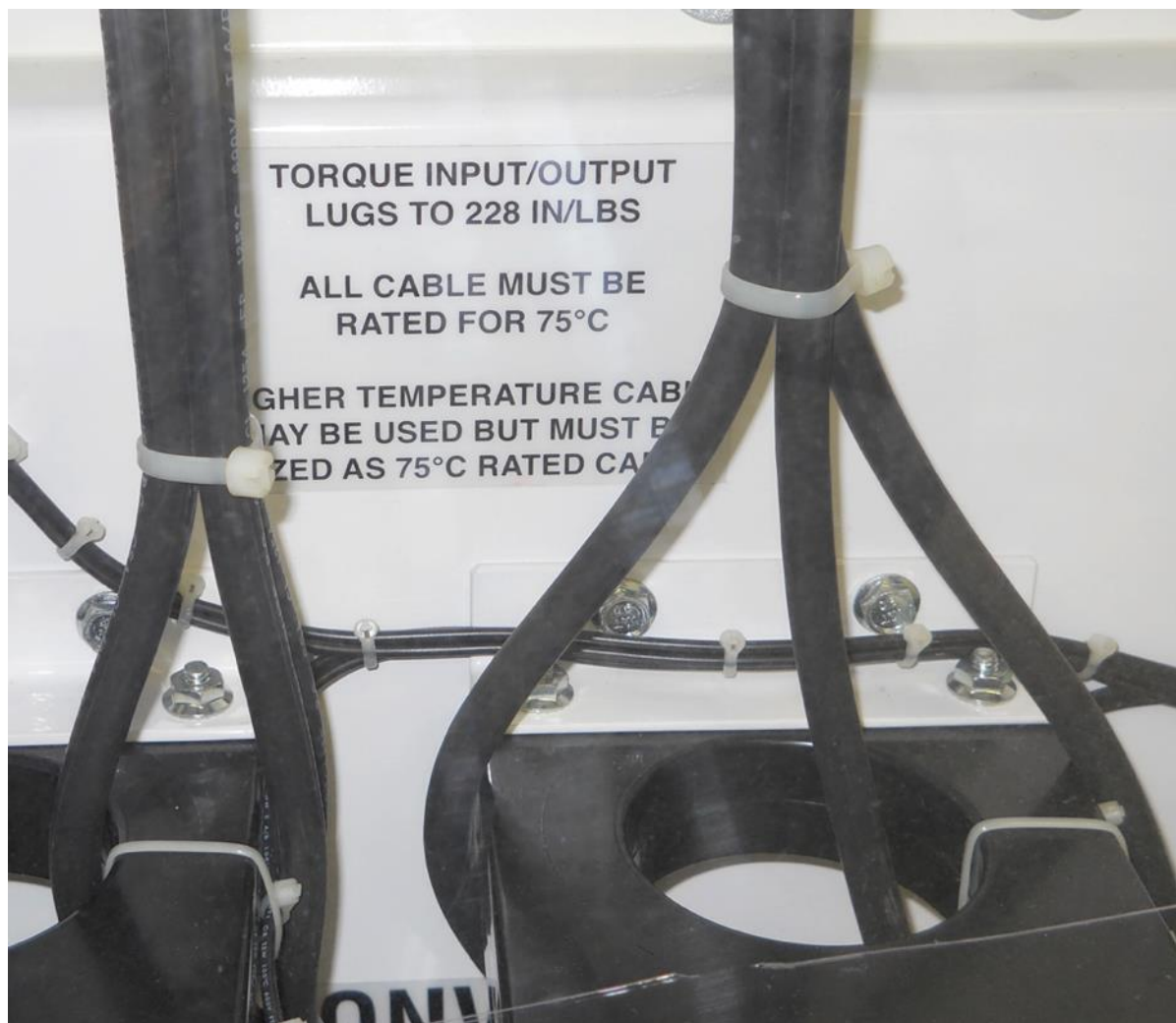
110.3(A) Examination (*review these 8 requirements*)

1. Suitability for installation and use
2. Mechanical strength and durability
3. Wire bending and connection space
4. Electrical insulation
5. Heating effects
6. Arcing effects
7. Classification by type, size, voltage, current capacity and use
8. Other factors for practical safeguarding of persons



Example 110.3(B) Example: Follow Torque Instructions per the manufacturer

Requires listed or labeled equipment to be installed and used in accordance with any instructions that are included in the listing or labeling.



110.3 Examination, Identification, Installation, and Use, and Listing (Product Certification) of Equipment



- New 110.3(C) requires product testing, evaluation, listing (product certification) be performed by recognized qualified electrical testing laboratories
 - New IN references OSHA for NRTL listing



110.12 Mechanical Execution of Work

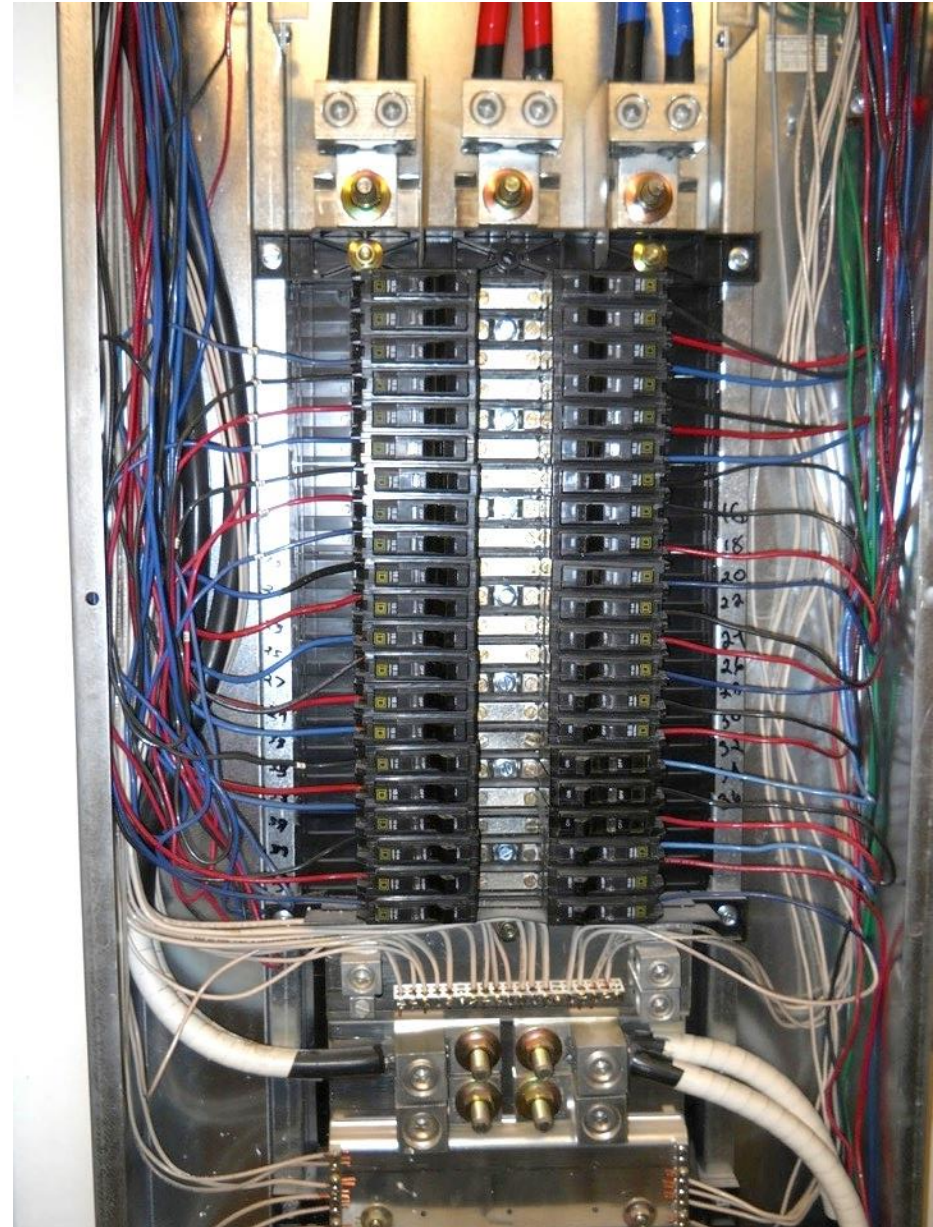
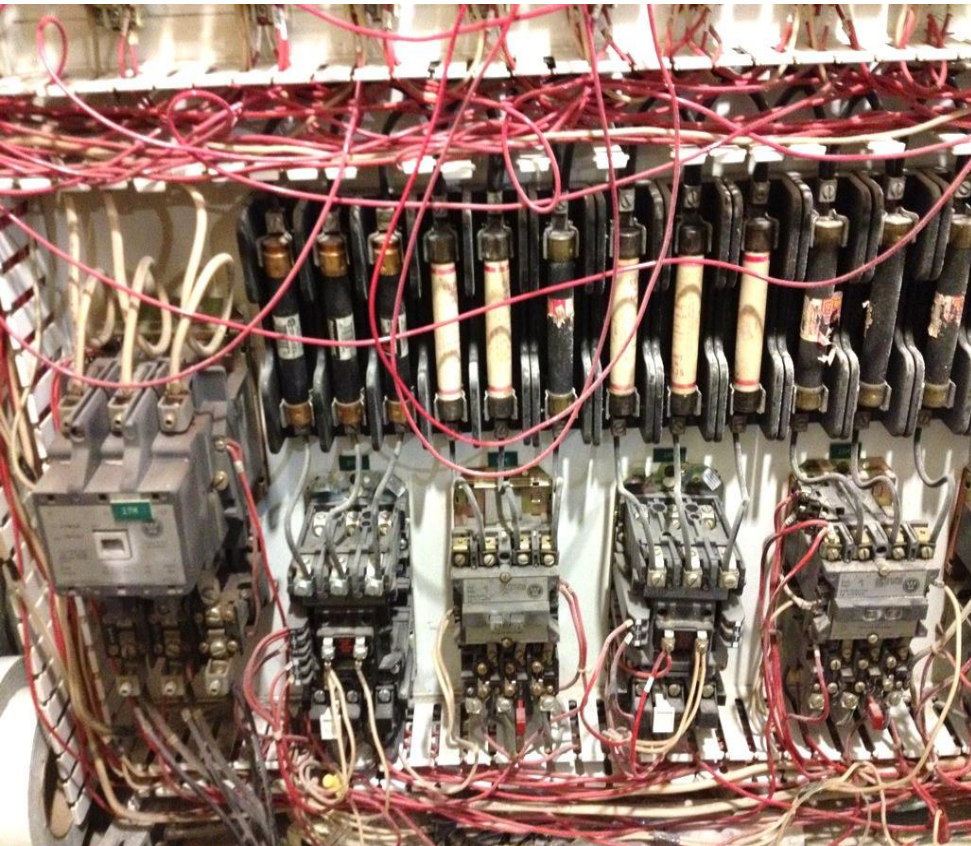
Electrical equipment shall be installed in
a neat and workmanlike manner.

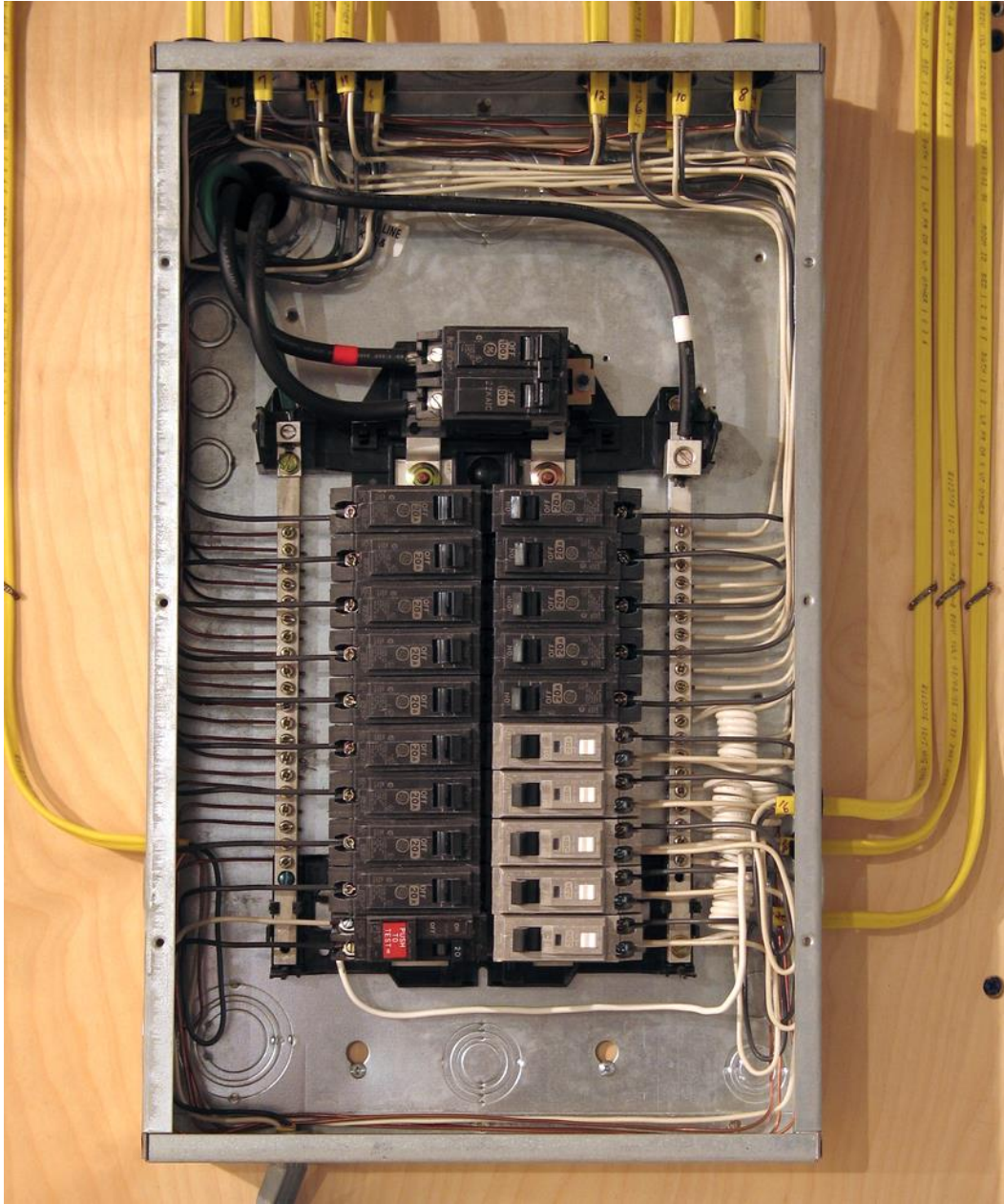
A. Unused Openings

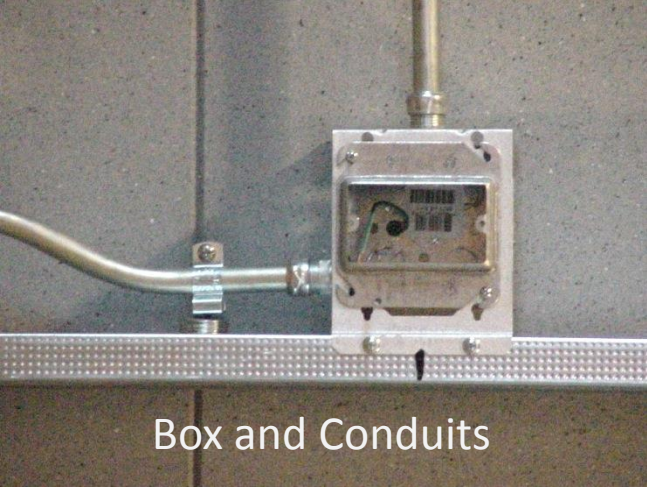
B. Integrity of Electrical Equipment and Connections

See the IN referencing the NECA Standard

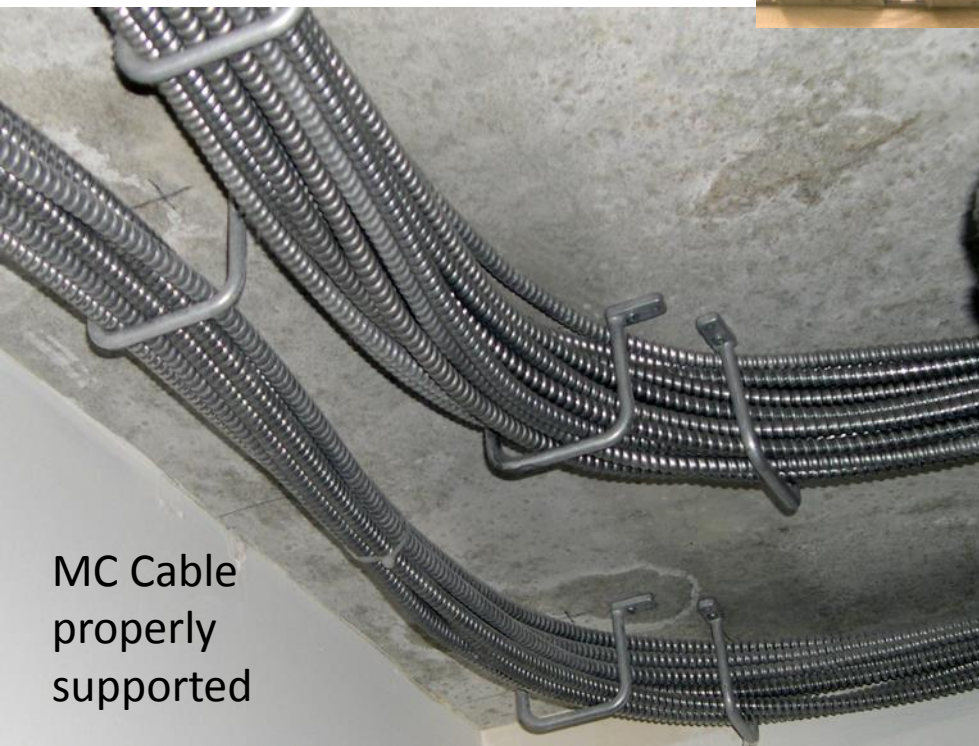








Box and Conduits



MC Cable
properly
supported



Control Panel field wired.
Shutterstock

110.14 Electrical Connections

Conductors of dissimilar metals shall not be intermixed in a terminal or splicing connector



Copper conductor

Photo by:
Randy Barnett

Aluminum conductor

**“Copper Only”
Twist-on Connector**



Label from a 20A Switch

See 404.14(C) and 406.3(C)

110.14 Requirements for Termination of Stranded Conductors

Chapter 9, Table 10 Example:

Conductor Size	Class B Stranding	Class C Stranding	Class B Stranding (AL)
14 – 2 AWG	7	19	7

- For Conductors more finely stranded than those listed in this table:
 - The terminals and connectors must be identified for the class or classes of conductor stranding and the number of strands
- Using set-screw type connectors on finely stranded conductors can break individual strands
- Crimp-on type connectors, (identified for the class stranding), is often best.

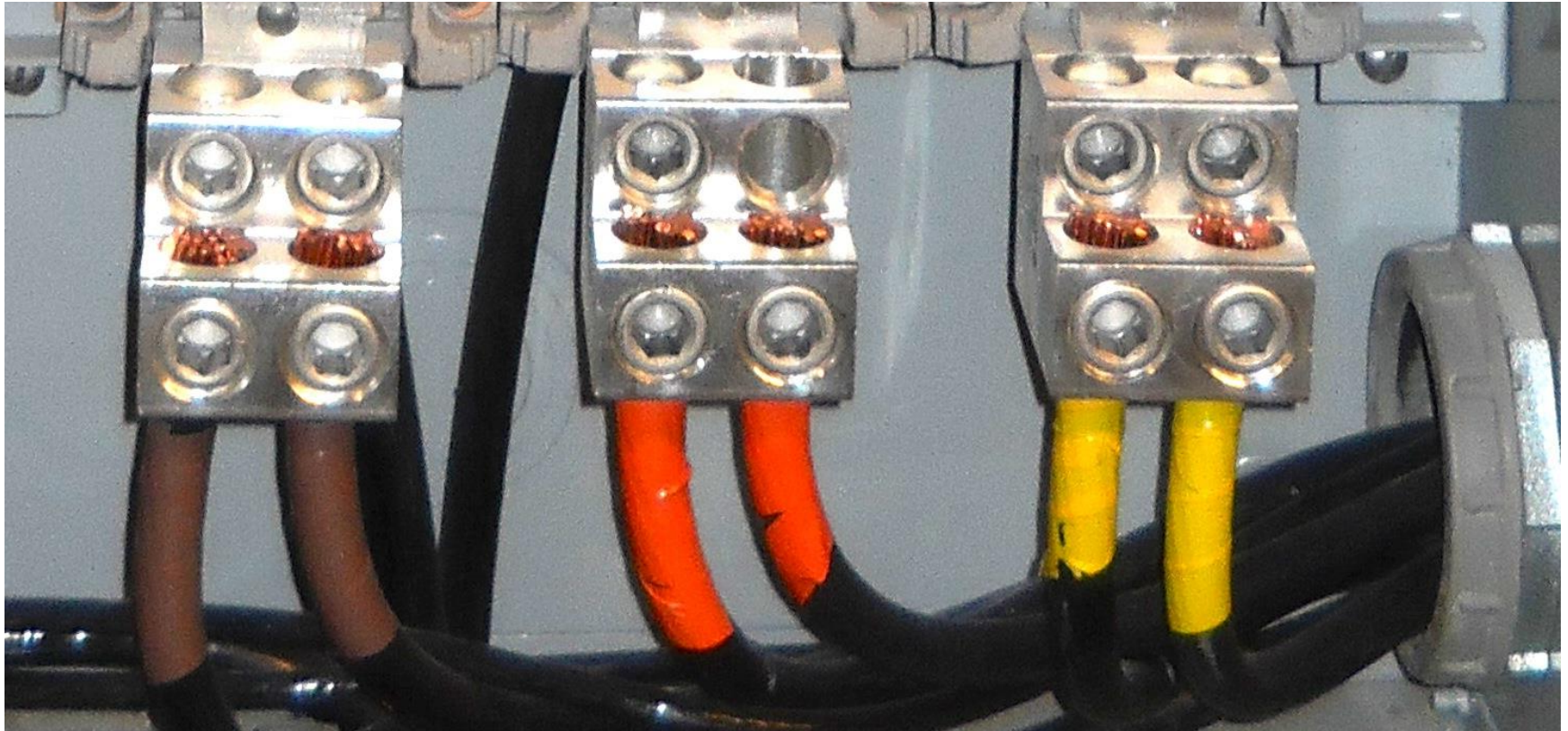
110.14(A) terminals

- ✓ Ensure a thoroughly good connection without damaging the conductors
- ✓ Use pressure connectors (including set-screw type), solder lugs, or splices to flexible leads



110.14(A) Terminals

Application of set-screw type pressure connectors

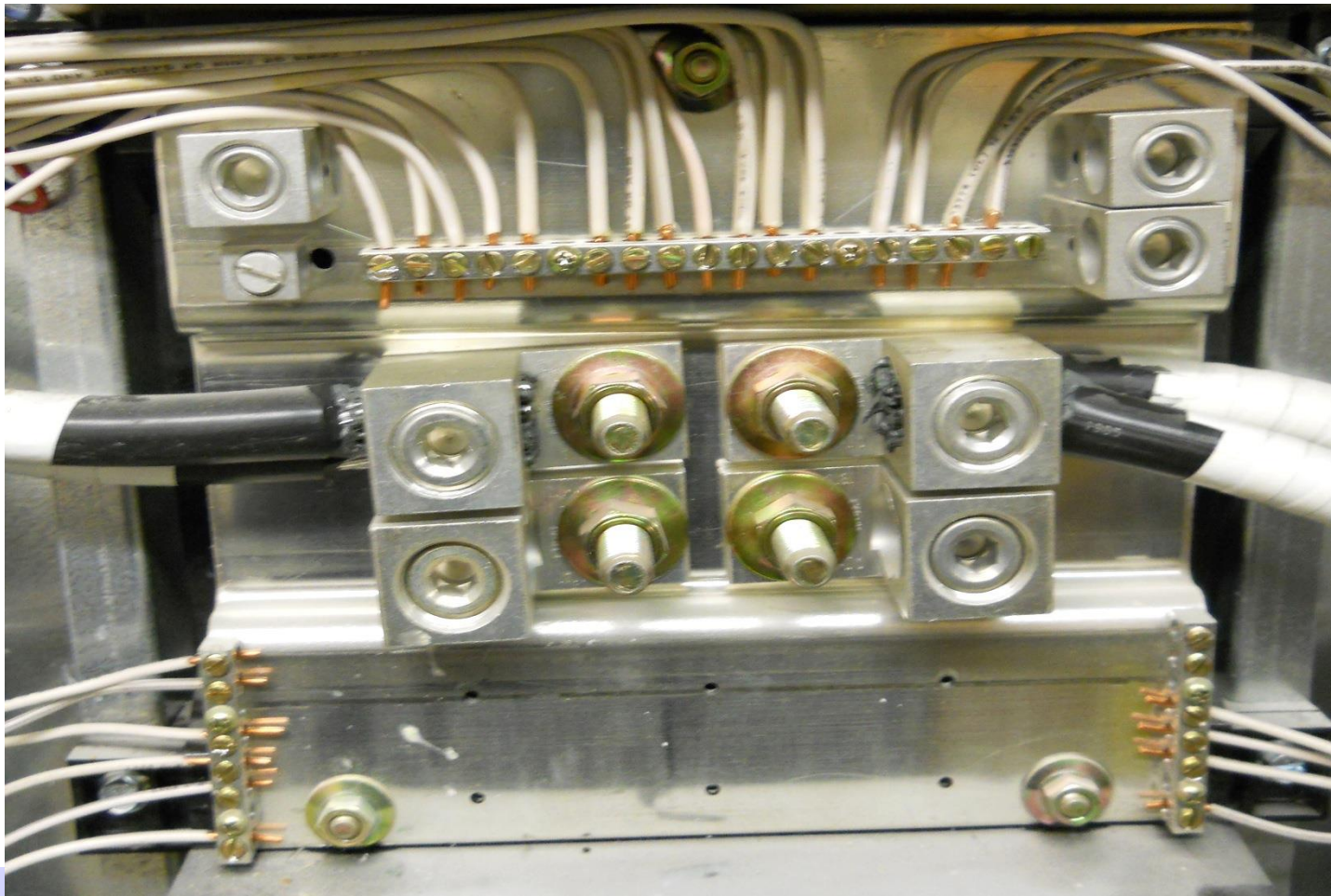


Terminations must ensure a thoroughly good connection without damaging the conductors.

110.14(A) Terminals

Terminals for more than one conductor must be identified as such, otherwise:

Only “one” wire per terminal.



110.14(B) Splices

- Conductors must be spliced or joined with splicing devices identified for the use, or
 - by brazing, welding, or soldering



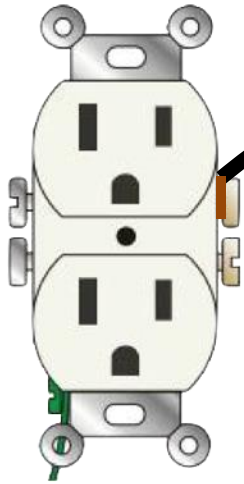
✓ Listed:

“Suitable for Use in Damp or Wet Locations.”

✓ Identified for direct burial

110.14(C) Temperature Limitations

Using Table 310.15(B)(16)



- Ampacity of 12 AWG THHN 90°C is 30A.
- Use this 30A for ambient temperature correction and adjusting for the number of conductors in the raceway or cable

- 60°C terminal per 110.14(c).
- Use the 60°C column in Table 310.15(B)(16) to determine the ampacity of the conductor.
- Allowable ampacity of the 12 AWG THHN = 20 A

110.14(C)(1) Equipment Provisions Temperature Limitations

Rated 100 amperes or less, or marked for 14 AWG through 1 AWG conductors:

- Use 60°C (140°F) conductors or base ampacity on 60°C (140°F) column in table 310.15(B)(16)
- *Unless the equipment is listed and marked otherwise*

110.14(C)(1) Equipment Provisions Temperature Limitations

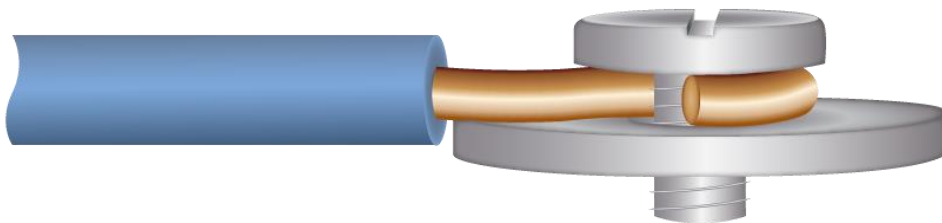
Rated over 100 amperes, or marked for conductors larger than 1 AWG:

- Use Conductors rated 75°C (167°F) or base ampacity on 75°C (167°F) column in table 310.16
- motors marked with design letters B, C, or D, 75°C (167°F)
- *Unless the equipment is listed and marked otherwise*

Article 110.14 (D) Installation

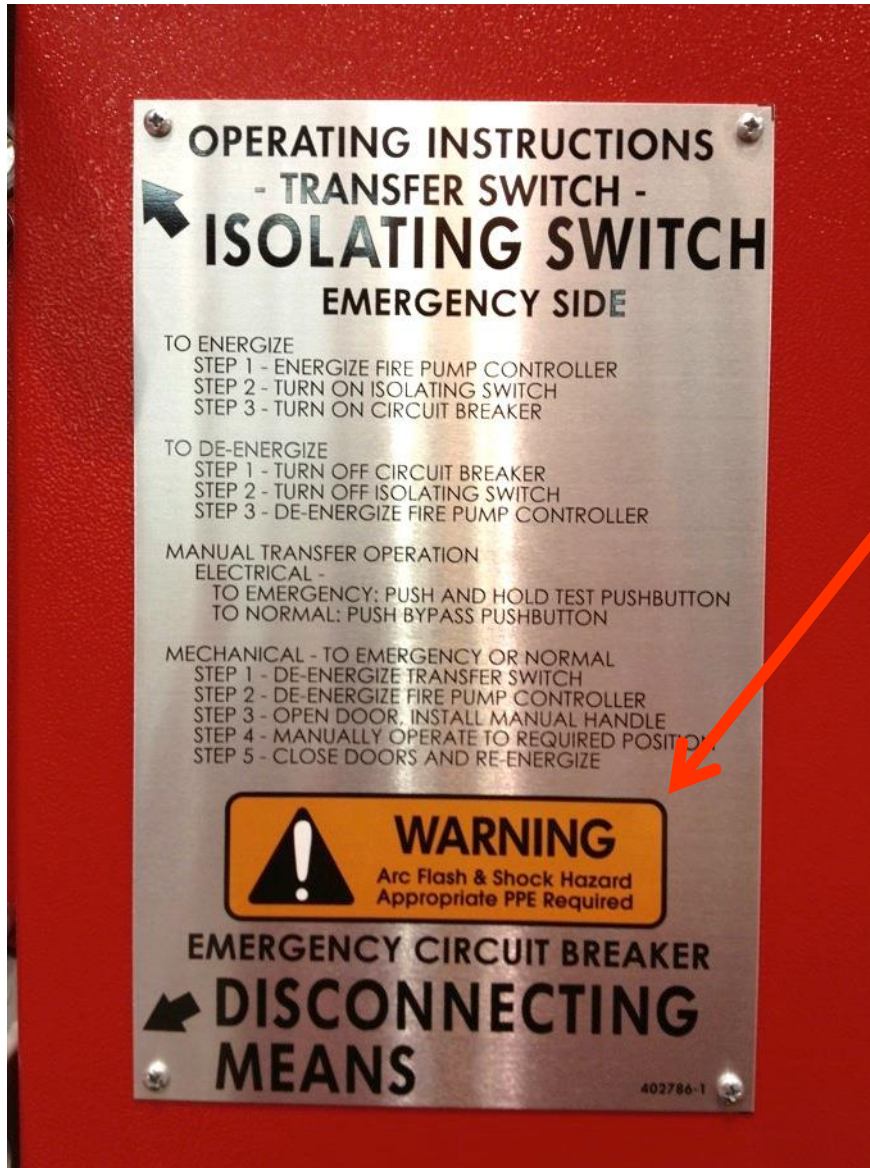


- Requires a calibrated torque tool
- Must be used unless the manufacturer has provided instructions for an alternative method of achieving the required torque



The wrong torque value is applied in up to 75% of installations unless a torque measuring tool is used.

110.16 Example: "Factory" applied label




The words "or factory" to this section makes it clear that Arc-Flash Warning Labels as required by 110.16 can be applied by the manufacturer at the factory.

110.16 Arc-Flash Hazard Warning



Informational Note references NFPA 70E, Standard for Electrical Safety in the Workplace, for specifics.

 WARNING	
Arc Flash and Shock Hazard	
Appropriate PPE Required	
43 inches	Flash Hazard Boundary
4.9 cal/cm²	Flash Hazard at 18 inches
Category 2	Cotton Underwear + FR Shirt & Pants
480 VAC	Shock Hazard when cover is removed
00	Glove Class
42 inches	Limited Approach
12 inches	Restricted Approach
1 inches	Prohibited Approach
Location:	(3122) 21-MC-007
	Prepared on: 10/15/10
	Expires On: 10/15/15*
* Warning: Changes in equipment settings or system configuration will invalidate the calculated values and PPE requirements	

110.16 Arc-Flash Hazard Warning.



- New 110.16(B) requires Service Equipment rated 1200 amperes or greater have an Arc-Flash Hazard Warning Label
- This is in addition to the requirements in 110.16(A)

110.16 Arc-Flash Hazard Warning.



Field or factory marked information:

1. Nominal system voltage
2. Available fault current at the service overcurrent protective devices
3. The clearing time of service overcurrent protective devices based on the available fault current at the service equipment
4. The date the label was applied


110.21 Marking



110.21(A) ~~Manufacturer's~~ Markings  110.21(A) Equipment Markings

NEW 110.21(A)(2) requires Reconditioned equipment be marked

- Responsible organization & Date

<i>Reconditioned Equipment</i>	
Equipment: C-H DS-2 LVPCB	
Date Reconditioned: 8/24/2016	
	NTT Engineering Services 6675 S. Kenton St. Centennial, CO 80111



110.22 Identification of Disconnecting Means

LP-32A		
32A-LTS-MAINT SHOP- LOWER 1	1 2	32A-RCPT-DATA ENTRY
32A-LTS-MAINT SHOP- LOWER 2	3 4	32A-RCPT-PAINT SHOP-1
32A-LGTS TOOL STORG.	5 6	SPARE
32A-LTS ELEC SHOP/ RESTROOM	7 8	32A-RCPT-TOOL STORAGE
32A-LTS-MAINT SHOP- UPPER	9 10	32A-RCPT-YARD STORAGE
32A-LTS-LUNCH RM/JAN/ STAIRS	11 12	32A-RCPT-MAINT SHOP- UP1
Elev Sump pump	13 14	32A-RCPT-DISHWASHER
32A-LTS-EXT LUNCH ROOM	15 16	32A-RCPT-LUCHROOM1
32-RPS-32-2	17 18	32A-RCPT-RESTRMS/ JAN.
Elec Recep Work benches South	19 20	32A-RCPT-ELEC SHOP
Elec recep work benches North	21 22	32A-RCPT-LUCHROOM 2
32A-LTS MAINTENANCE HID1	23 24	32A-RCPT-DISPOSAL
-	25 26	32A-RCPT- REFRIGERATOR
32A-LTS MAINTENANCE HID 2	27 28	32A-RCPT-MICROWAVE
-	29 30	32A-RCPT-ELVTR PIT
SPACE	31 32	32A-LTG-ELVTR CAB
SPACE	33 34	SPACE
SPACE	35 36	SPACE
SPACE	37 38	SPACE
SPACE	39 40	32A-RCPT-RANGE
SPACE	41 42	-

➤ Must be legibly marked to indicate its purpose

➤ Sufficient durability

➤ See 408.4 regarding labeling.

110.22 Identification of Disconnecting Means

- Durable
- Legible
- Identifies purpose of disconnect

Motor Control Center
(see Article 100 for definition)



Disconnecting Means

110.24 Available Fault Current

(A) Field Marking.

- Service equipment legibly marked
- Does not apply to dwellings
- Installation date & durable
- Informational Note:
 - Clarifies this requirement is for equipment rating purposes only; NOT Arc-flash analysis

110.24 Available Fault Current.



NEW sentence:

- “The calculation shall be documented and made available to those authorized to design, install, inspect, maintain, or operate the system.”
 - Ensures the accuracy of the data
 - Assures that service equipment has the right interrupting ratings and short-circuit current ratings



110.24(B) Modifications to Available Fault Current

- If modifications affect the available fault current at the service:
 - The available fault current must be verified or recalculated as necessary

Exception to 110.24

- *The field marking requirements in (A) and (B) shall not be required in industrial installations*
 - *where conditions of maintenance and supervision ensure that only qualified persons service the equipment.*



110.25 Lockable Disconnecting Means

Applies to where disconnect “Must be capable of being locked in the open position.”



Meets
Requirement:
Locking means
is permanent

Does NOT meet
Requirement:
Not permanent (but
may comply with
LOTO)



110.26 Spaces About Electrical Equipment

110.26(A)(1) Depth of Working Space

110.26(A)(2) Width of Working Space

110.26(B) Clear Spaces

110.26(C) Entrance to and Egress from Working Space

110.26(D) Illumination

110.26(E) Dedicated Equipment Space

110.26(F) Locked Electrical Equipment Rooms or Enclosures

Table 110.26(A)(1) Working Spaces

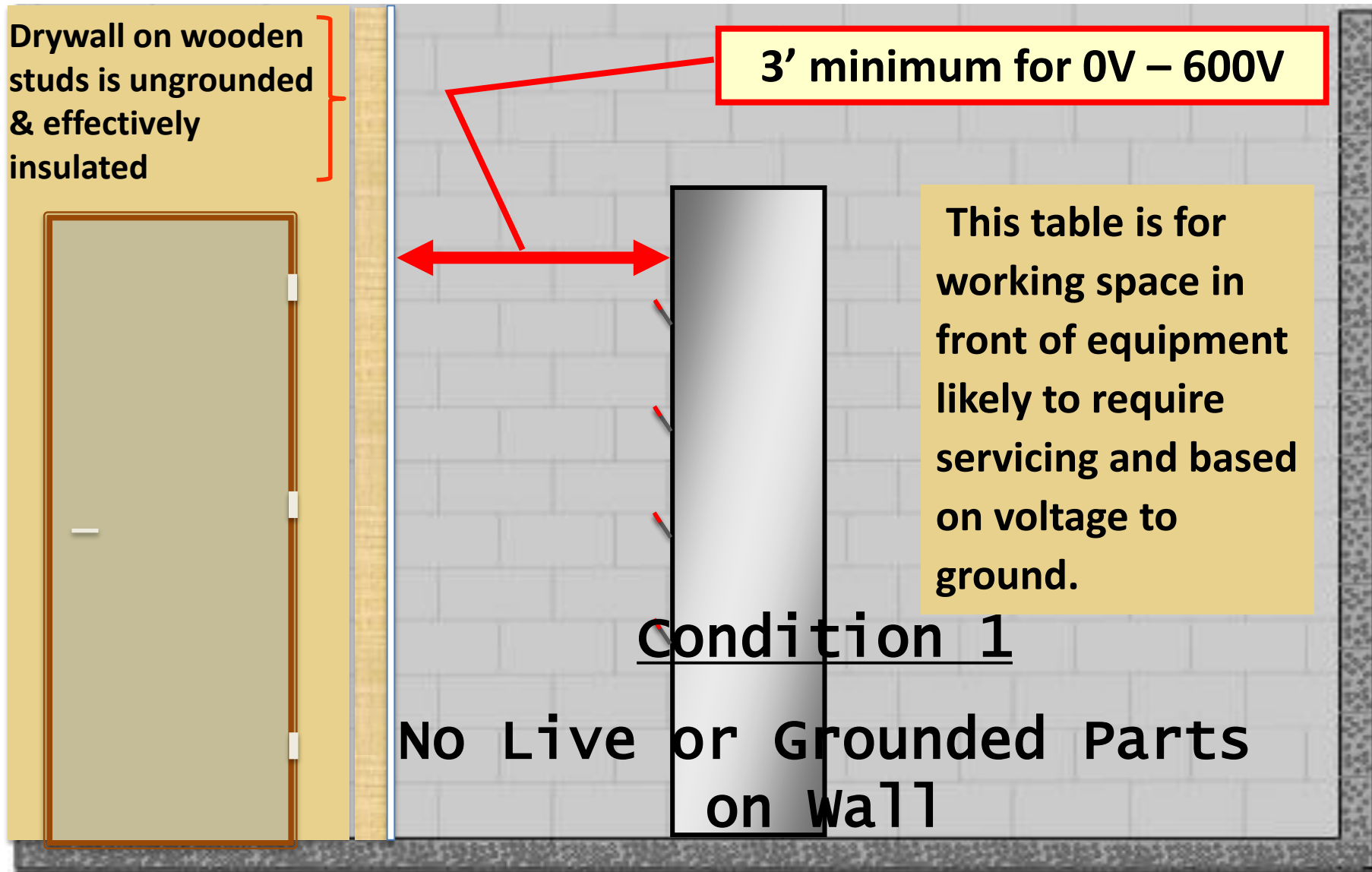


Table 110.26(A)(1) Working Spaces

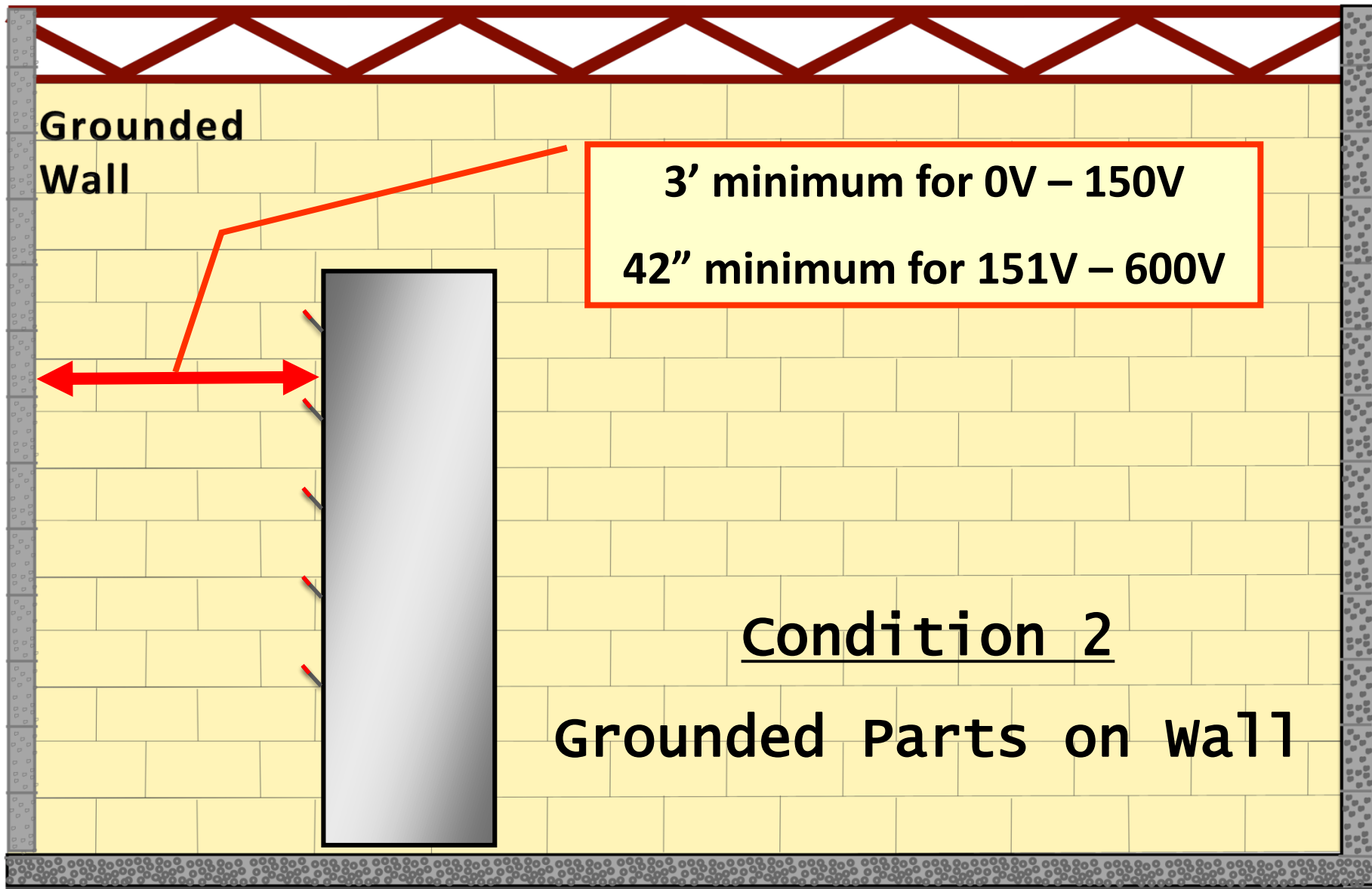
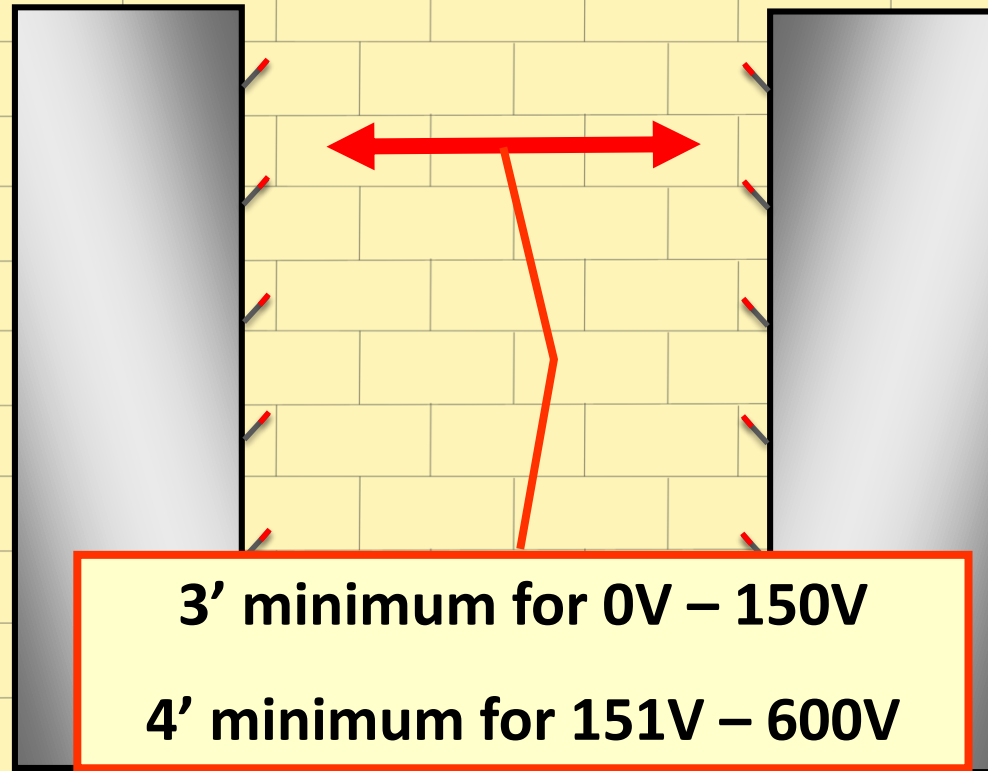


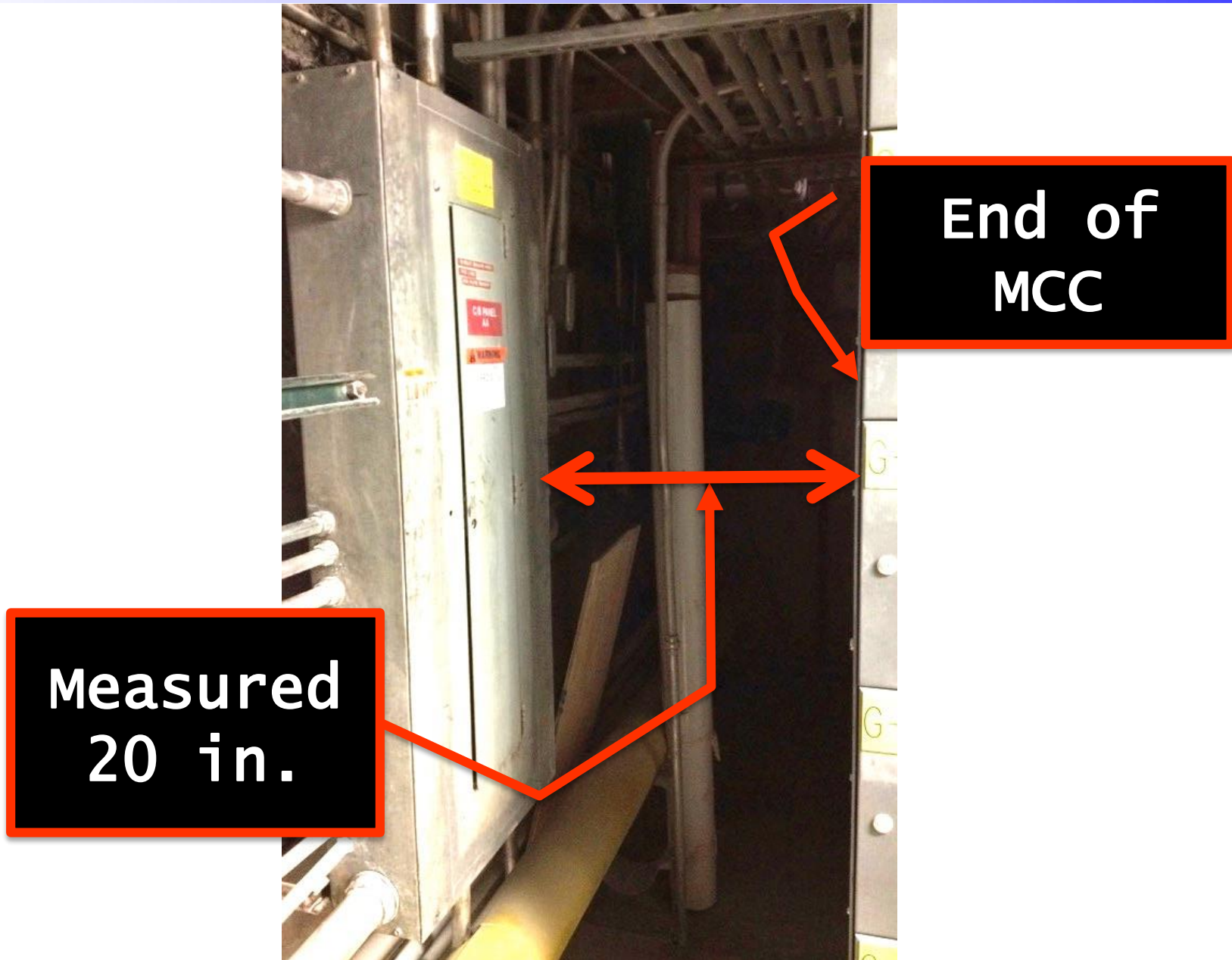
Table 110.26(A)(1) Working Spaces

Condition 3

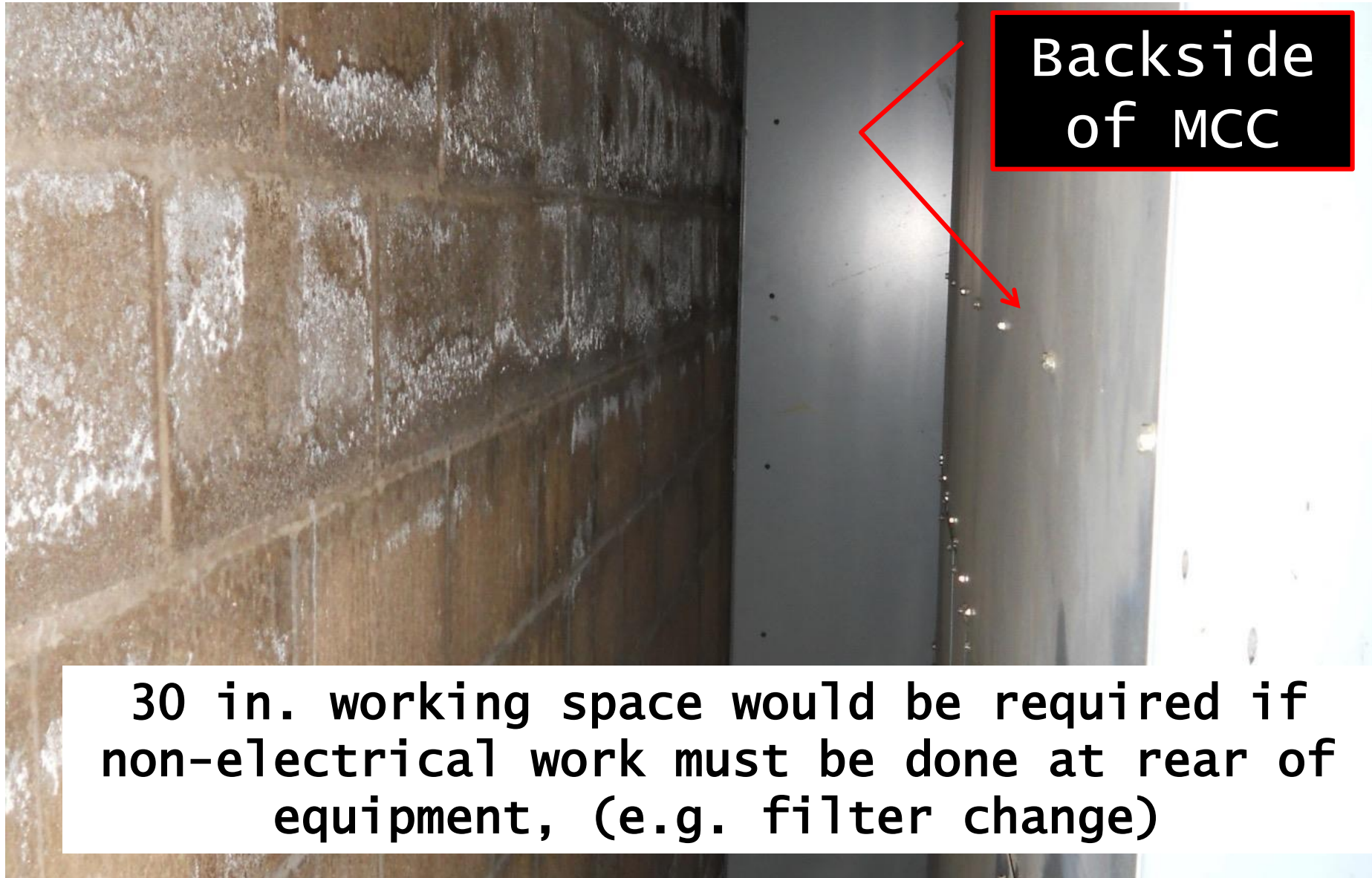
Exposed Live Parts on Both Sides



Condition 2 Violation!



110.26(A)(1)(a) Working space not required on backside of equipment.



Backside
of MCC

30 in. working space would be required if non-electrical work must be done at rear of equipment, (e.g. filter change)

110.26(A)(2) Width of Working Space



- Must be at least 762 mm (30 inches) or width of equipment, whichever is greater.
- Doors must open a full 90 degrees.

110.26 Spaces About Electrical Equipment.



- New 110.26(A)(4)
- Brings the Code requirements in line with what is being done in the field

- Spaces often do not meet the requirements of 110.26(A) for working space
- Provisions for “Limited Access” have been added to allow for compliance with installations in these locations.



110.26 (A)(4) Limited Access



Applies to:

- Equipment operating at 1000 volts, nominal, or less to ground
- Equipment that is likely to require examination, adjustment, servicing, or maintenance
- Limited Access is the new term

110.26 (A)(4) Limited Access



The following is required:

- Above a lay-in ceiling the opening must not be smaller than 559 mm × 559 mm (22 in. × 22 in.), or
 - in a crawl space, there shall be an accessible opening not smaller than 559 mm × 762 mm (22 in. × 30 in.)

110.26 (A)(4) Limited Access



The following is required:

- Width of the working space:
 - Width of the equipment enclosure or a minimum of 762 mm (30 in.), whichever is greater.
- Doors or hinged panels must open a minimum of 90 degrees.

110.26 (A)(4) Limited Access



- Must comply with the depth requirements of Table 110.26(A)(1) .
- The maximum height of the working space shall be the height necessary to install the equipment in the limited space.
 - A horizontal ceiling structural member or access panel shall be permitted in this space.

Limited Access



Once construction is complete the lay-in ceiling will provide *limited access* to the electrical equipment above.

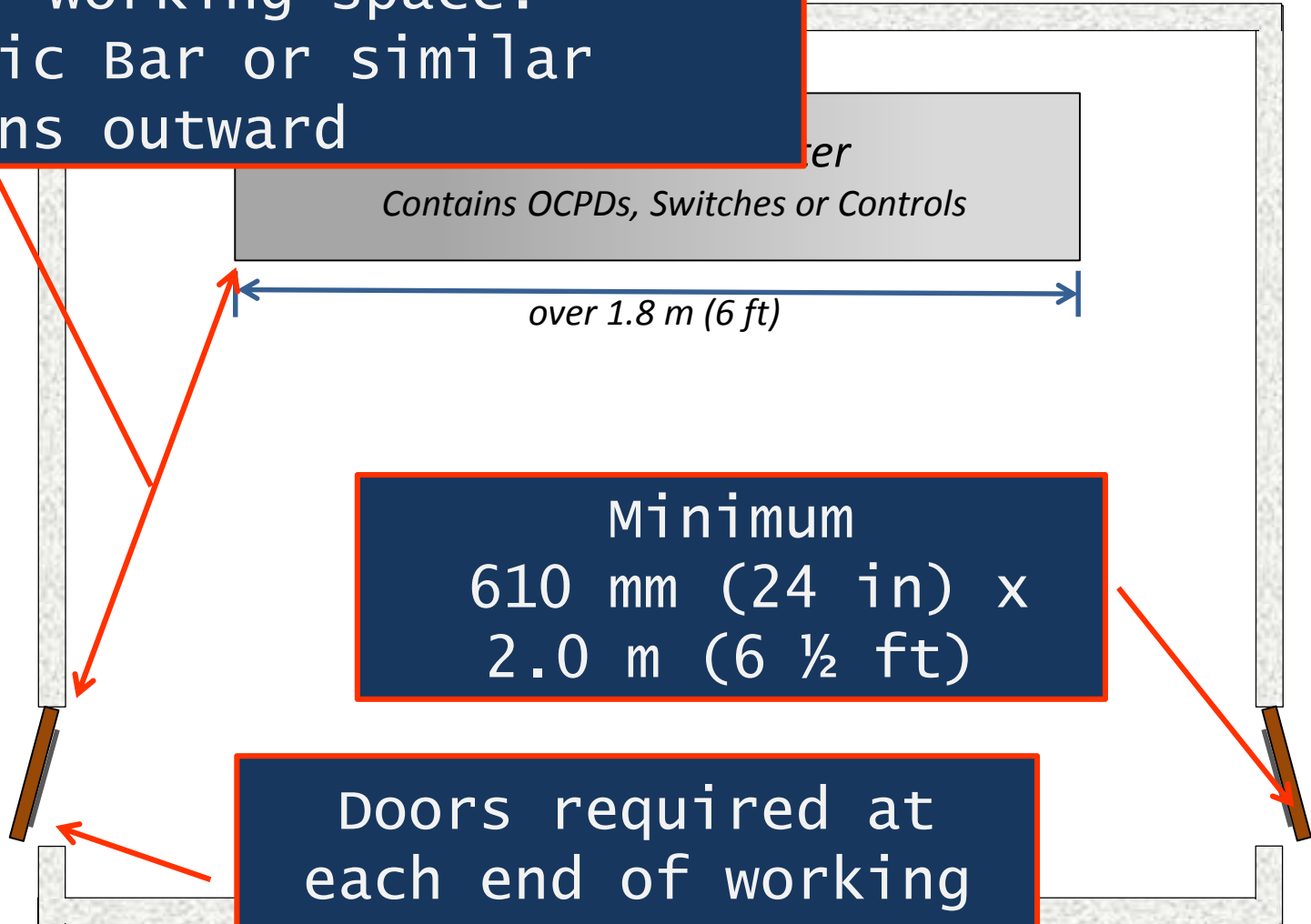
110.26(B) Storage Not Permitted

- Working space is NOT permitted to be used for storage.
- Live parts must be suitably guarded.



If door < 7.6 m (25 ft)
from nearest edge of
working space:

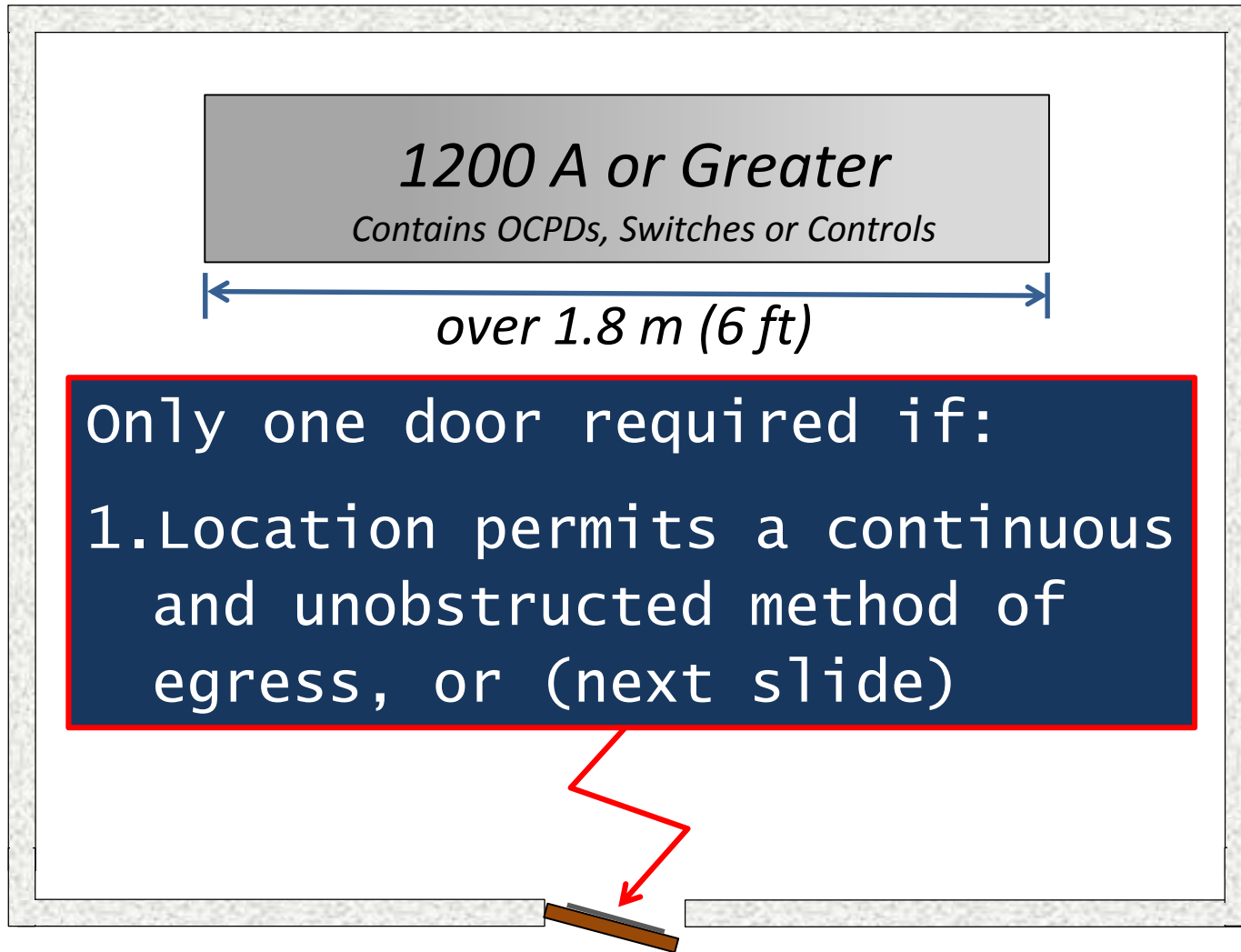
- Panic Bar or similar
- Opens outward



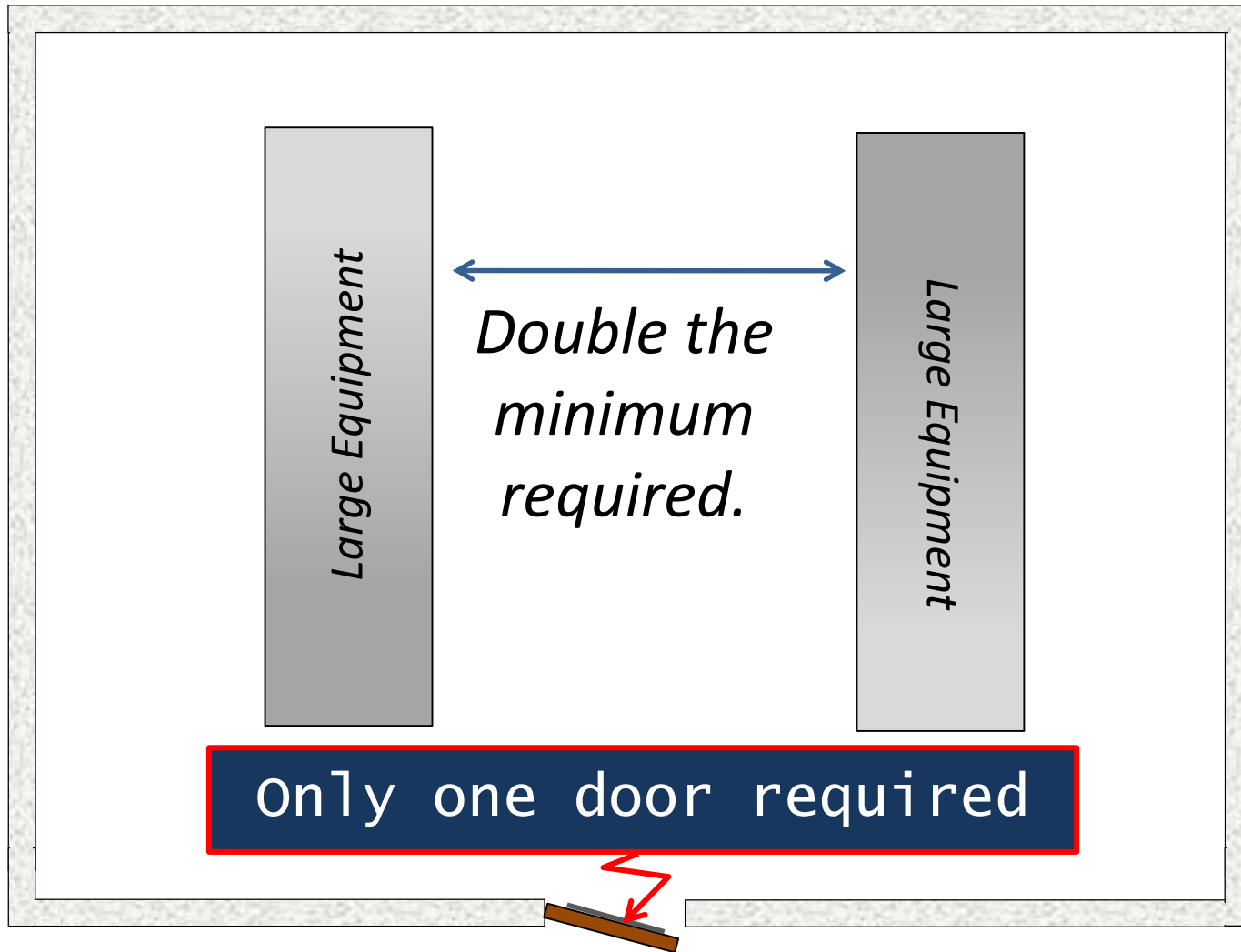
Minimum
610 mm (24 in) x
2.0 m (6 ½ ft)

Doors required at
each end of working
space

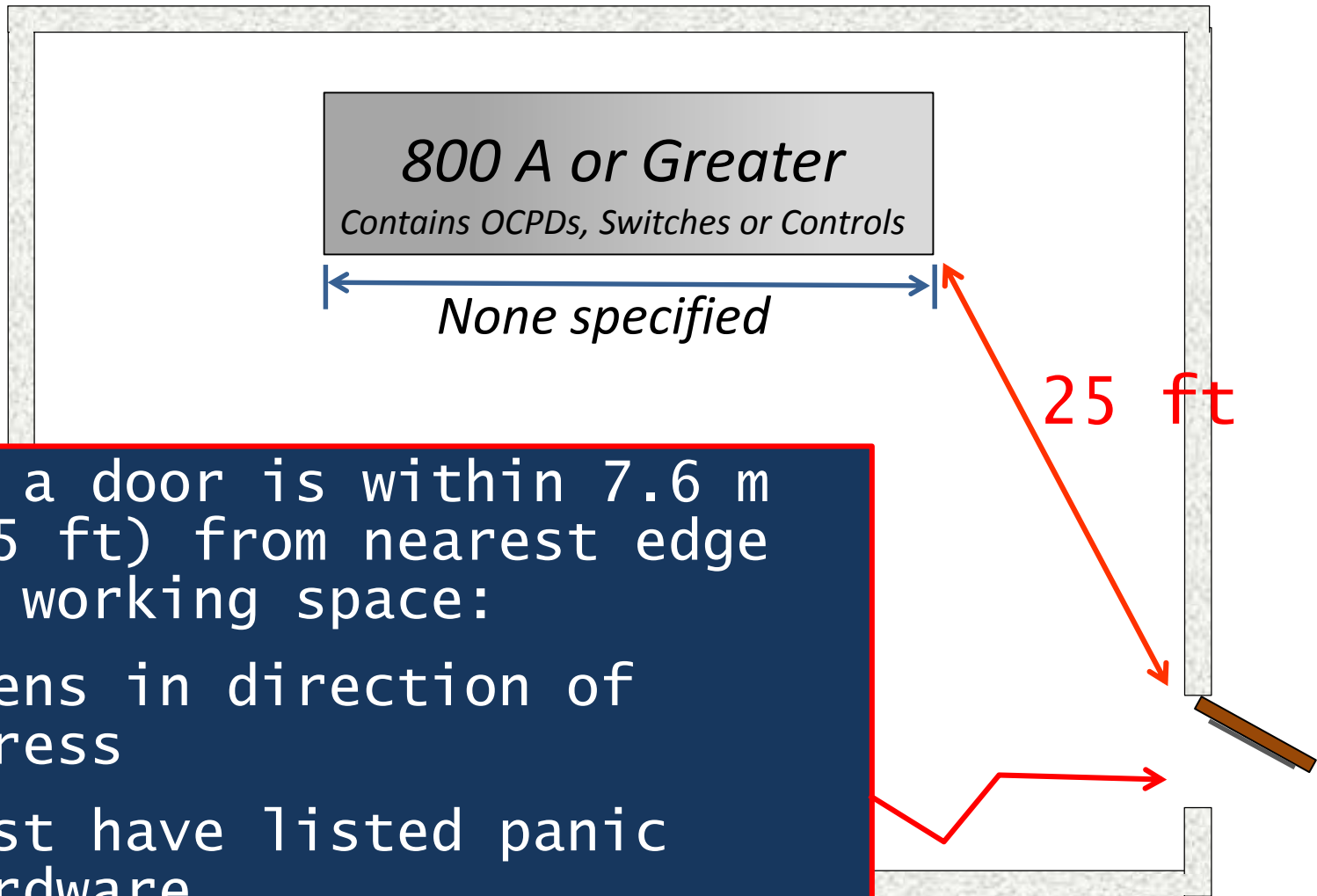
110.26(C)(2)(a) Unobstructed Egress



110.26(C)(2)(b) Extra Working Space



110.26(C)(3) Personnel Doors

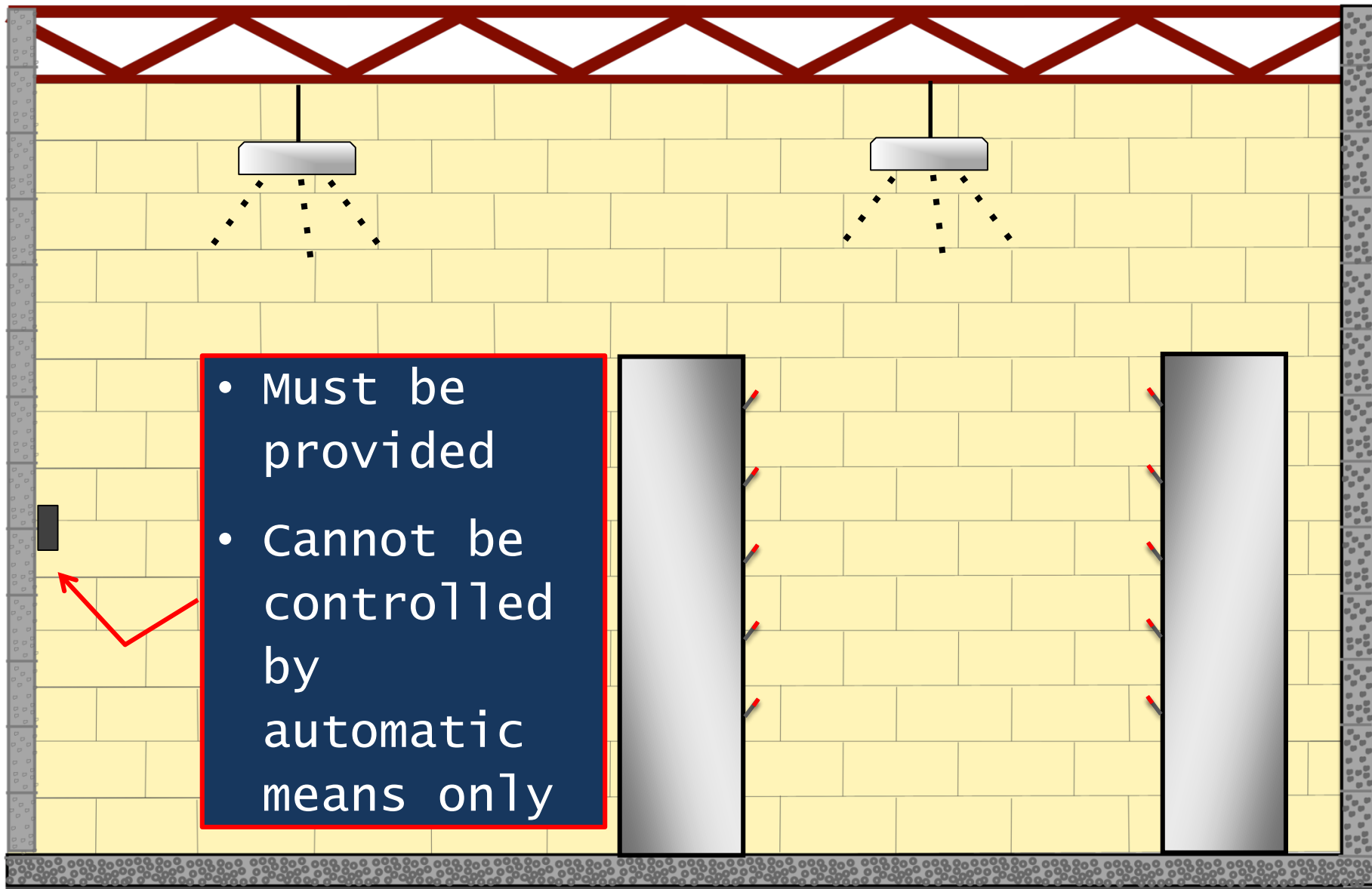


If a door is within 7.6 m (25 ft) from nearest edge of working space:

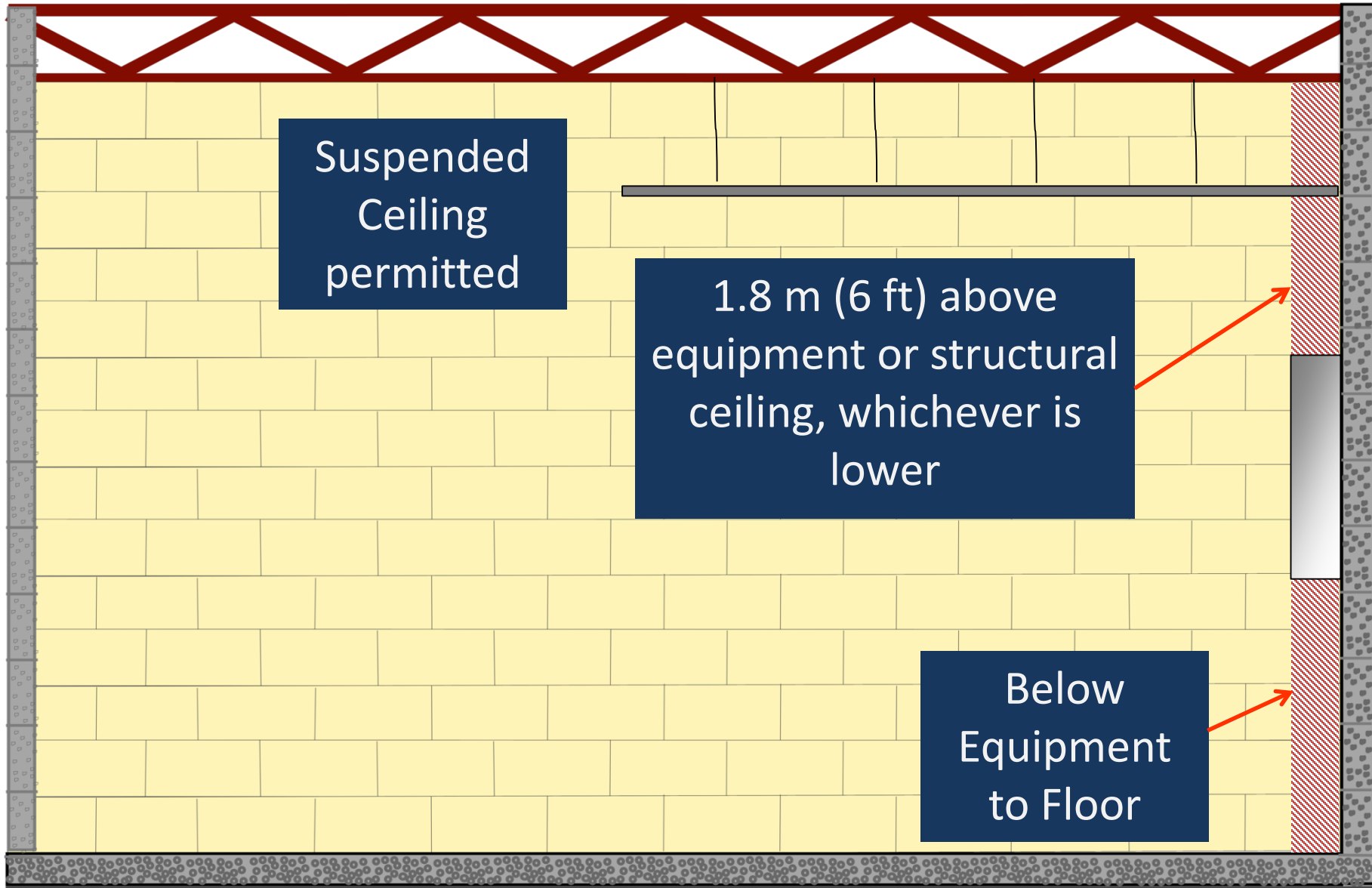
Opens in direction of egress

Must have listed panic hardware

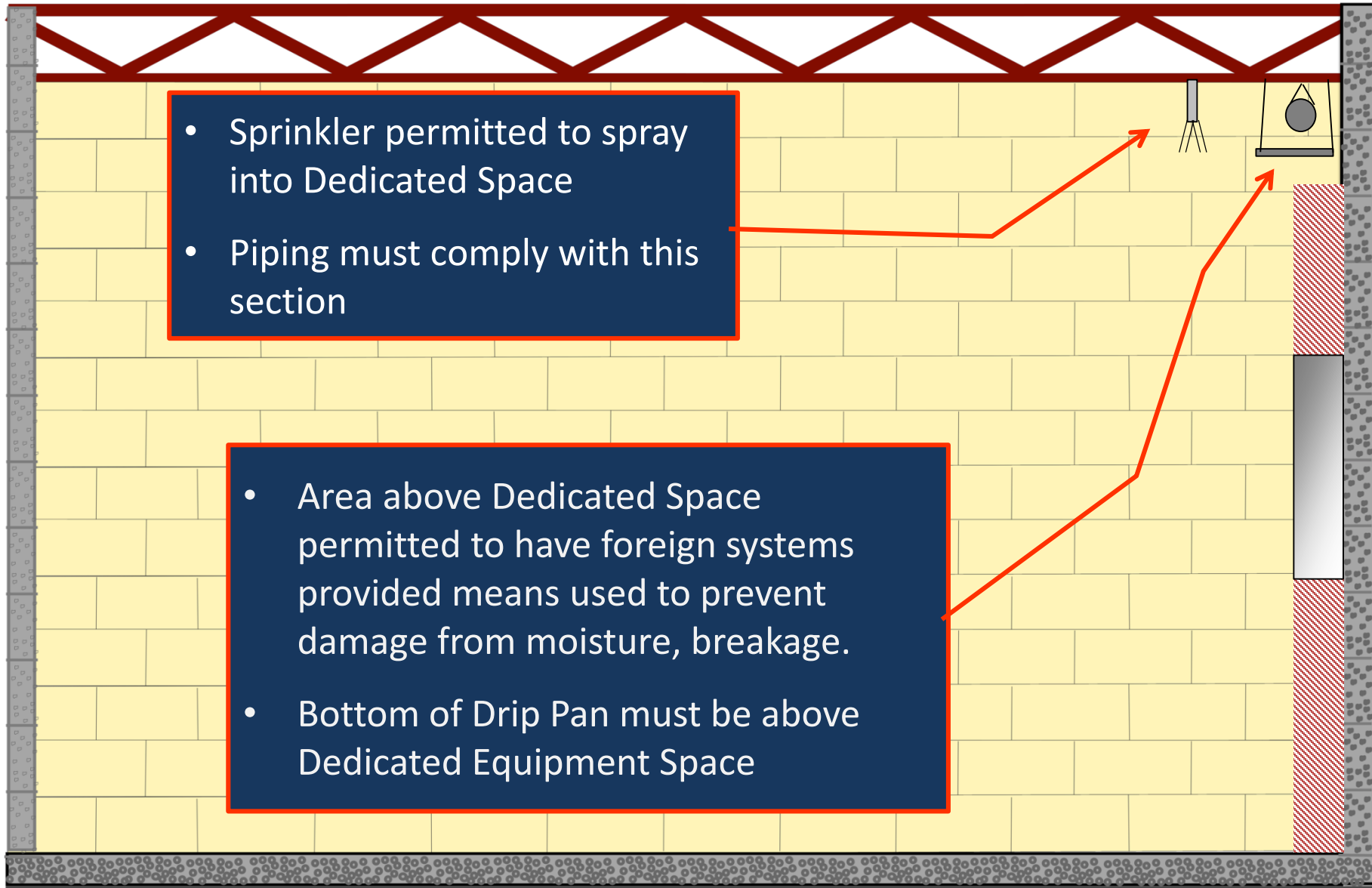
Table 110.26(D) Illumination



110.26(E) Dedicated Equipment Space



110.26(E) Dedicated Equipment Space



110.26(E)(2)(b) Outdoor Electrical Equipment



- Requires Dedicated Equipment Space
 - Equal to width and depth of equipment
 - From Grade to 1.8 m (6 ft) above
 - No piping or foreign equipment within this space



Exception now allows structural overhangs and roof extensions in the dedicated equipment space.

110.26(E)(2) Outdoor



Revised into a list format for usability.

Outdoor equipment must be:

1. Installed in suitable identified enclosures
2. Protected from accidental contact by unauthorized personnel ,
or by vehicular traffic
3. Protected from accidental spillage or leakage from piping
systems
4. In compliance with the work space described in 110.26(A) with
exception
5. In compliance with requirements for Dedicated Space



SWITCHRACK SR-M1 WIREWAY

SWITCHRACK SR-M1 WIREWAY

SR-M1

SR-M1

LGM-1

SR-M1

CAUTION

CAUTION

CAUTION

CAUTION

CATERPILLAR

DANGER
HIGH
VOLTAGE
THIS DOOR
12,000 VOLTS

XFMR INFO
NAME: TR-12-M
KVA: 500
IMP: 19
DATE INSTALLED
02-16-2012

THIS DOOR
480 VOLTS

OLYMPIAN

480 VOLTS

480 VOLTS



WARNING

WARNING

WARNING

WARNING

WARNING

WARNING

Name the Code Section Violation



Name the Code Section Violations



Name the Code Section Violation



Meets 110.26 requirements



Part III. Over 1000 Volts, Nominal

110.34 Work Space and Guarding. *(New)*



- (A) Table 110.34(A) Provides Minimum Depth of Clear Working Space at Electrical Equipment
- (B) Separation from Low-Voltage Equipment inside of vaults, room or enclosures by a suitable partition, fence, or screen if there are exposed live parts over 1000 volts.
- (C) Entrance must be kept locked unless such entrances are under the observation of a qualified person at all times. (Signage required)
- (D) Illumination must be provided and control by automatic means only not be permitted.
- (E) Elevation of Unguarded live parts above working space provided by Table 110.34(E).
- (F) Protection of Service Equipment, Switchgear, and Industrial Control Assemblies provided from foreign systems, moisture

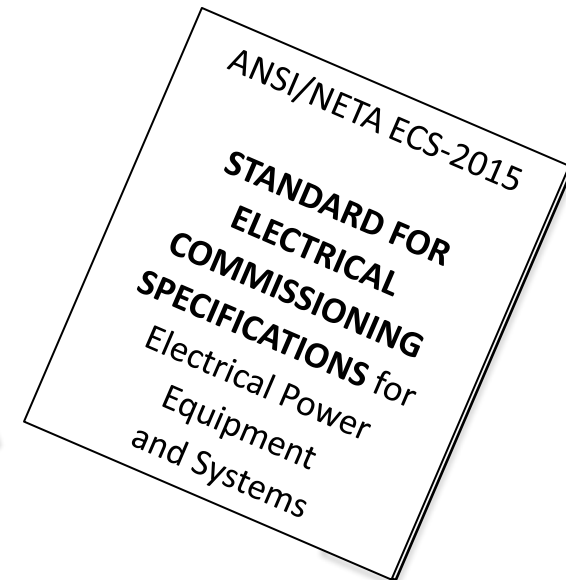
110.41 Inspections and Tests (New)



- Certain sections of the code require inspections and tests
 - This section provides the rules for pre-energization testing
- (A) requires Pre-energization and Operating Tests.
- (B) requires a Test Report be made available to the AHJ prior to energization and also made available to those authorized to install, operate, test, and maintain the system.

Examples:

- 225.56
- 230.95(C)
- 328.14





Chapter 2

Wiring and Protection



ARTICLE 200

Use and Identification of Grounded Conductors

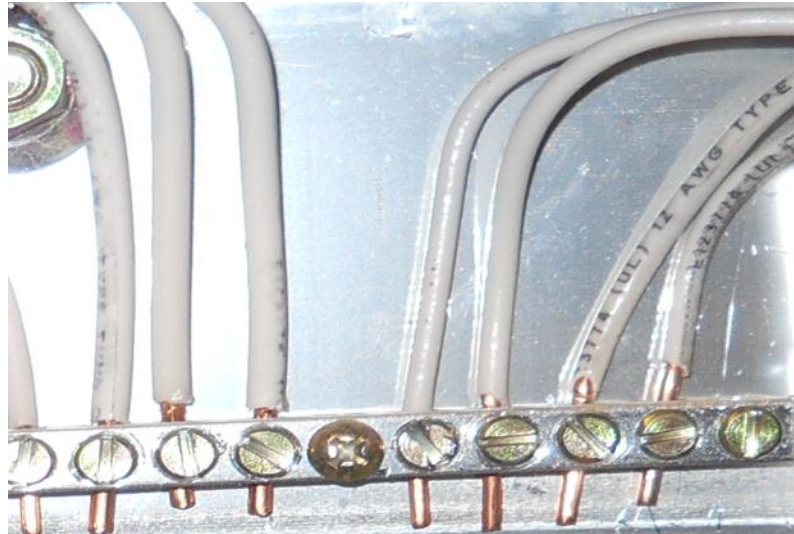
Article 100 Definition

“Grounded (Grounding). Connected (connecting) to ground or to a conductive body that extends the ground connection.”

200.6 Means of Identifying Grounded Conductors

(A) Sizes 6 AWG or Smaller

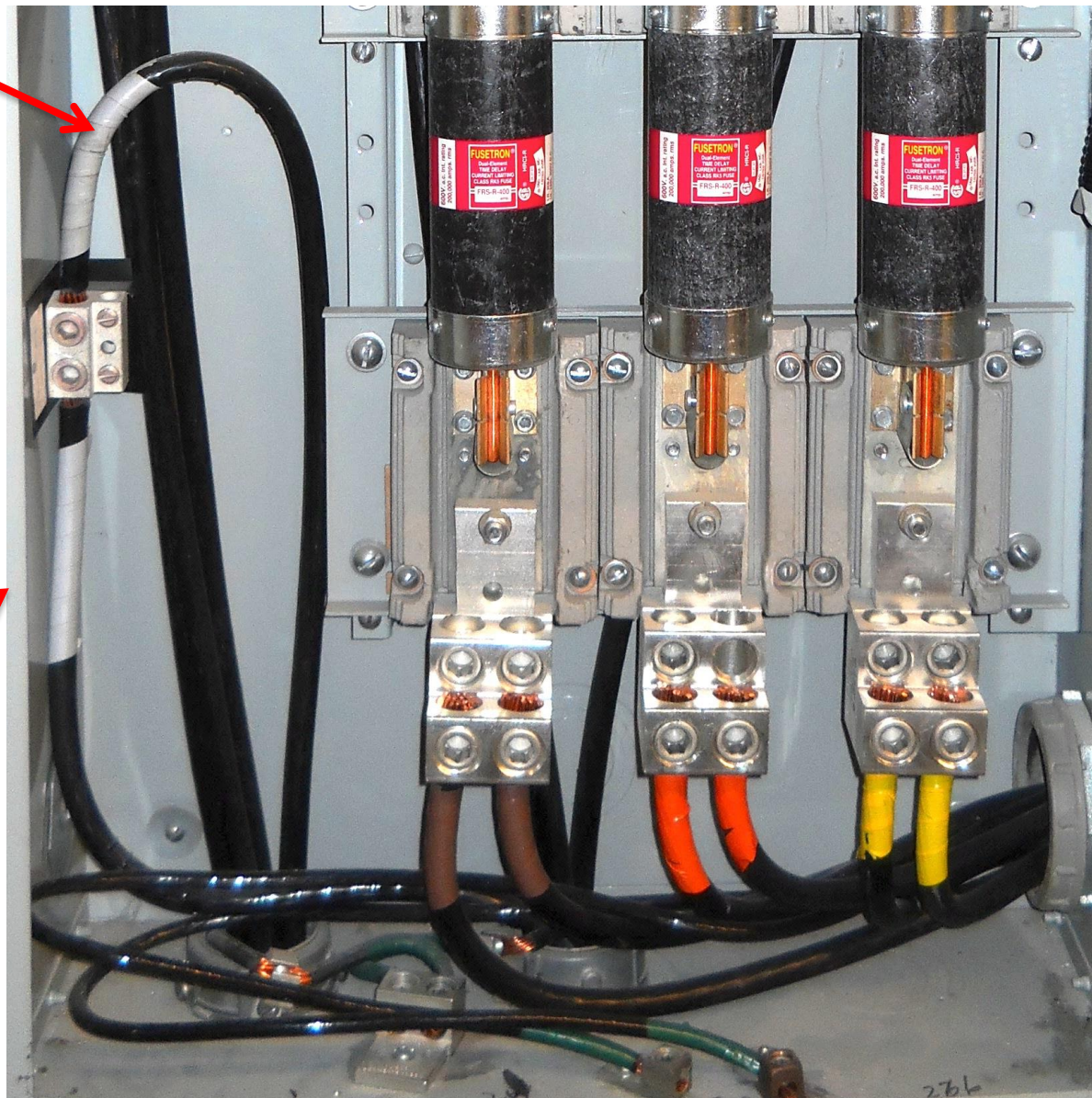
- continuous white or gray
- three continuous white stripes on other than green insulation along its entire length.



200.6 Means of Identifying Grounded Conductors

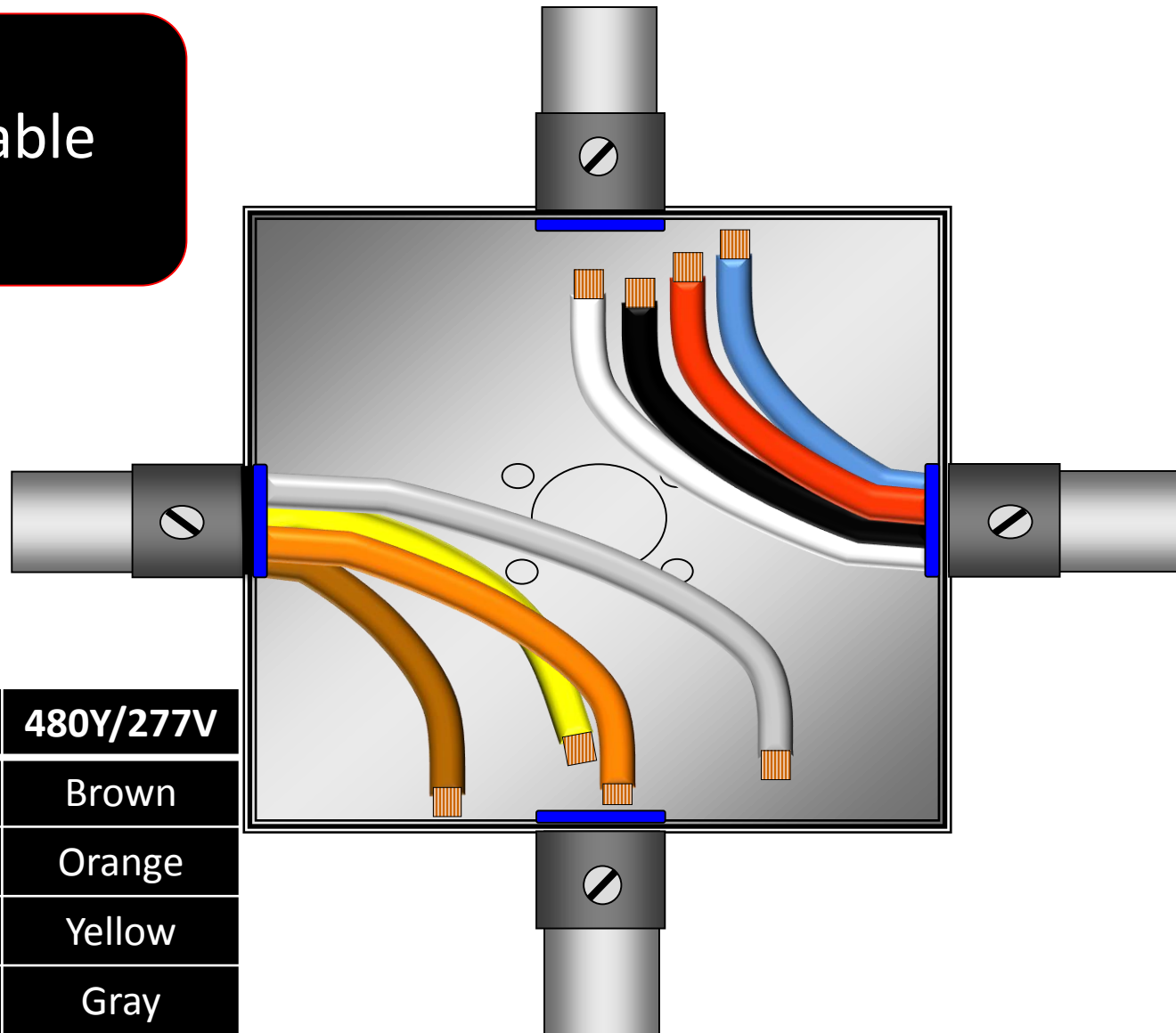
Insulation suitable for ungrounded conductors

4 AWG or larger identified at time of termination



200.6(D) Grounded Conductors of Different Systems

- Readily Distinguishable
- Posted

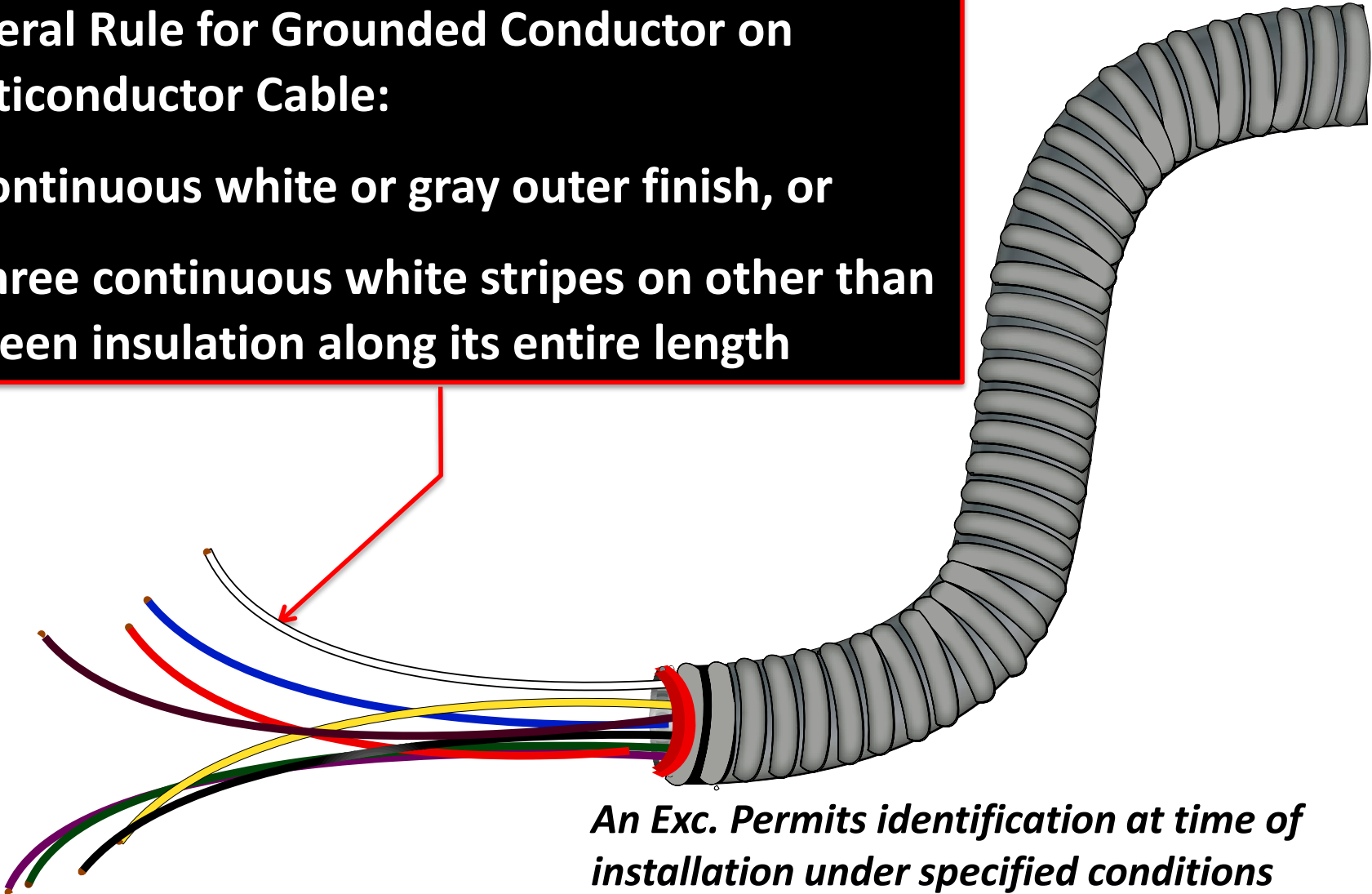


	208Y/120V	480Y/277V
Phase A	Black	Brown
Phase B	Red	Orange
Phase C	Blue	Yellow
Neutral	White	Gray

200.6(E) Grounded Conductors of Multiconductor Cables.

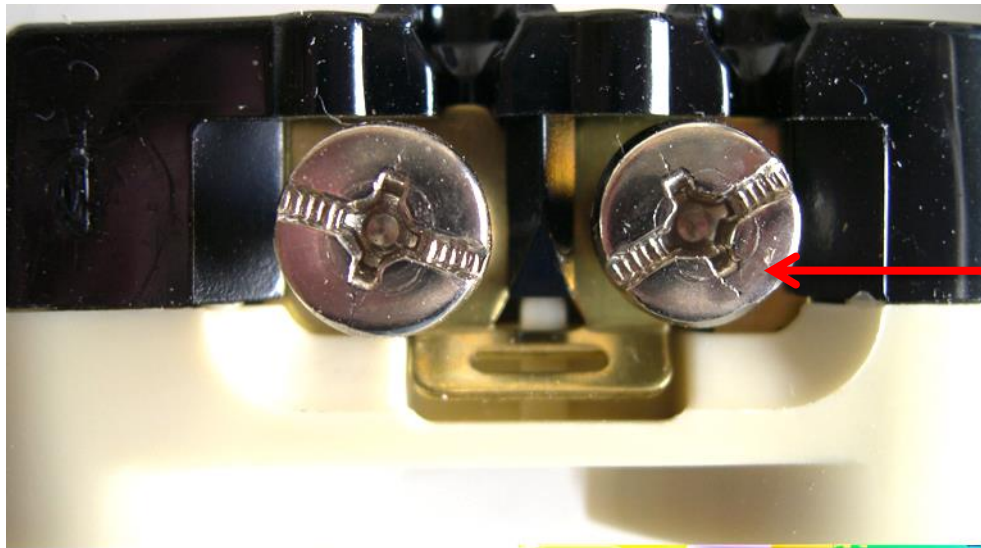
General Rule for Grounded Conductor on Multiconductor Cable:

- Continuous white or gray outer finish, or
- Three continuous white stripes on other than green insulation along its entire length



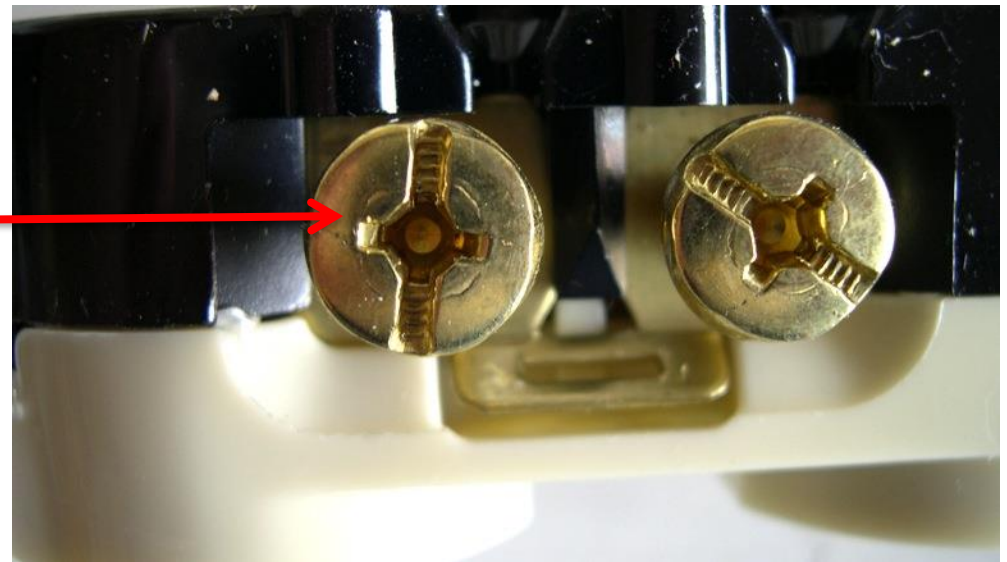
An Exc. Permits identification at time of installation under specified conditions

200.10 Identification of Terminals (receptacle example)



Grounded Conductor
Terminals:
metal or metal coating
that is substantially
white in color

Ungrounded Conductor
Terminals:
No coating. Brass
screws.



- “W” or “White” permitted
- Screw shells grounded

ARTICLE 210

BRANCH CIRCUITS

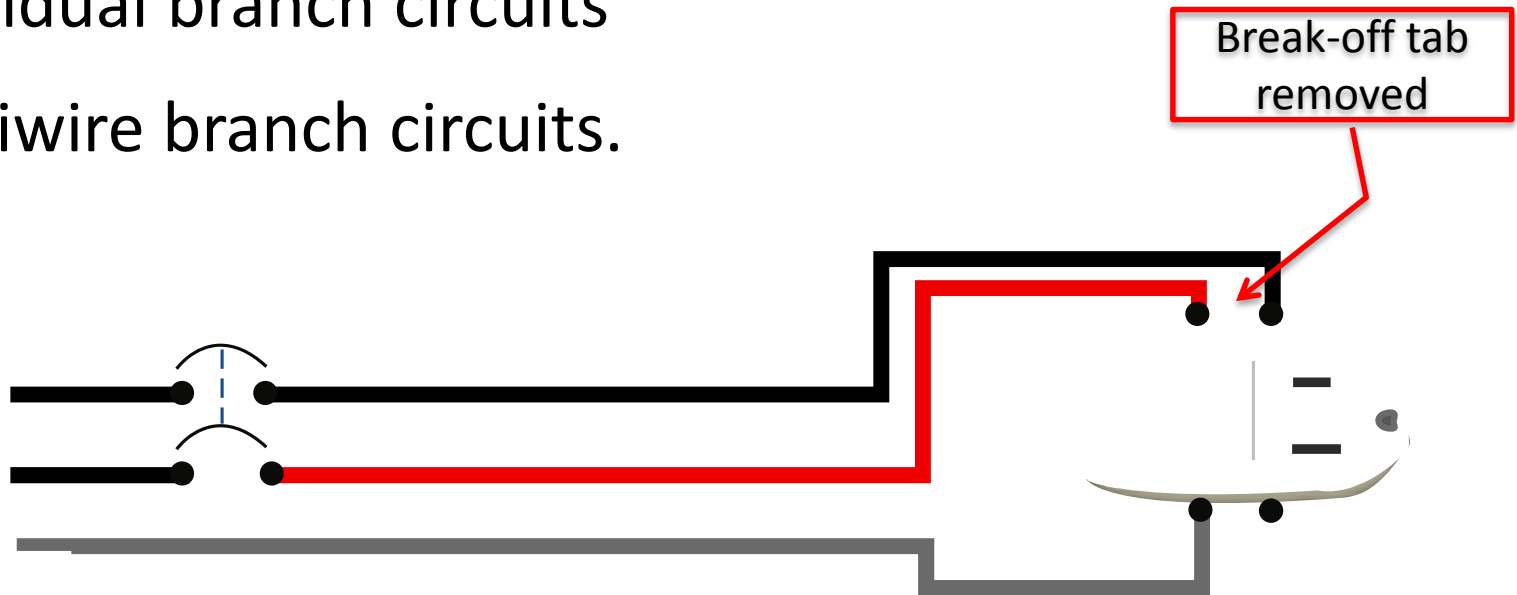
Article 100 Definition:

The circuit conductors between the final overcurrent device protecting the circuit and the outlet(s).

Types of Branch Circuit Defined in Article 100

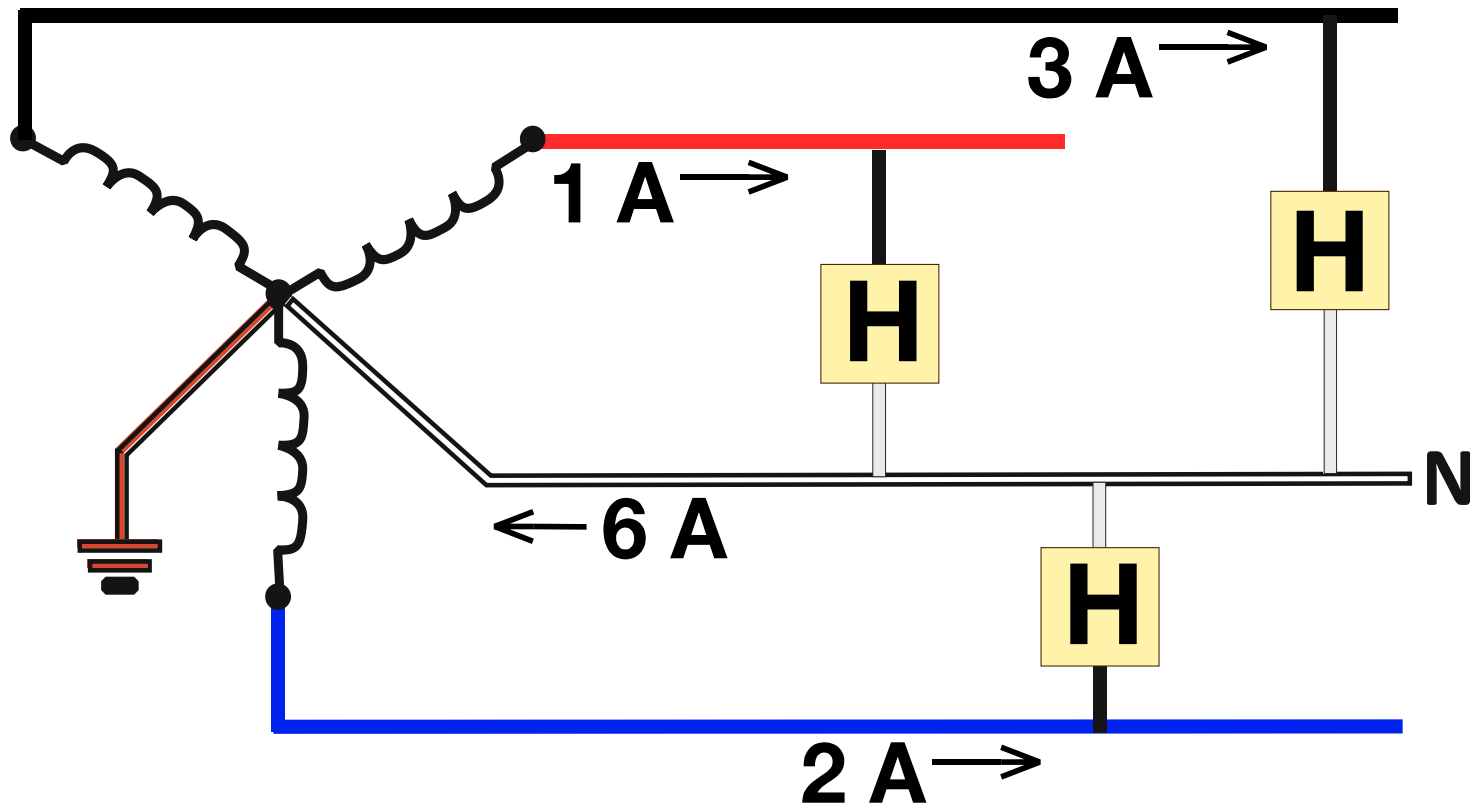
Four types of branch circuits are:

1. appliance branch circuits
2. general-purpose branch circuits
3. individual branch circuits
4. multiwire branch circuits.



Multiwire Branch Circuit

Understanding Harmonics and the Neutral



**Amps are 180 Hz harmonics on each phase.
6 amps 180 Hz total on Neutral.**

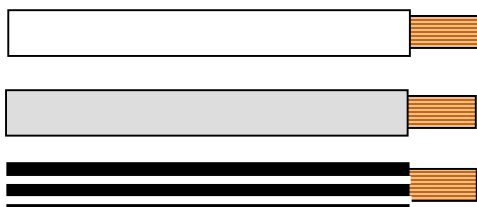
copyright 2013
NTT Inc.

210.5 Identification of Branch Circuits

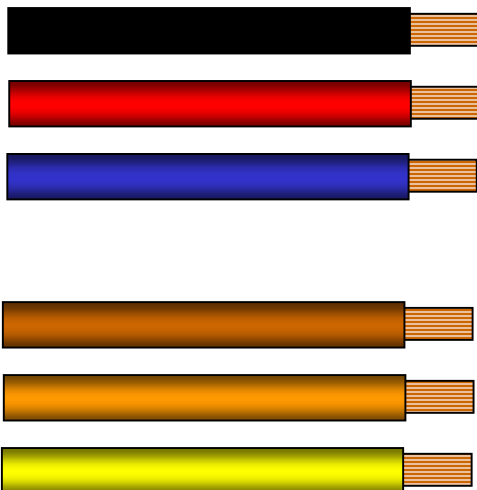


210.5(B)

250.119 for identification of Equipment Grounding Conductors



210.5(A) Review 200.6 for identification Grounded Conductors

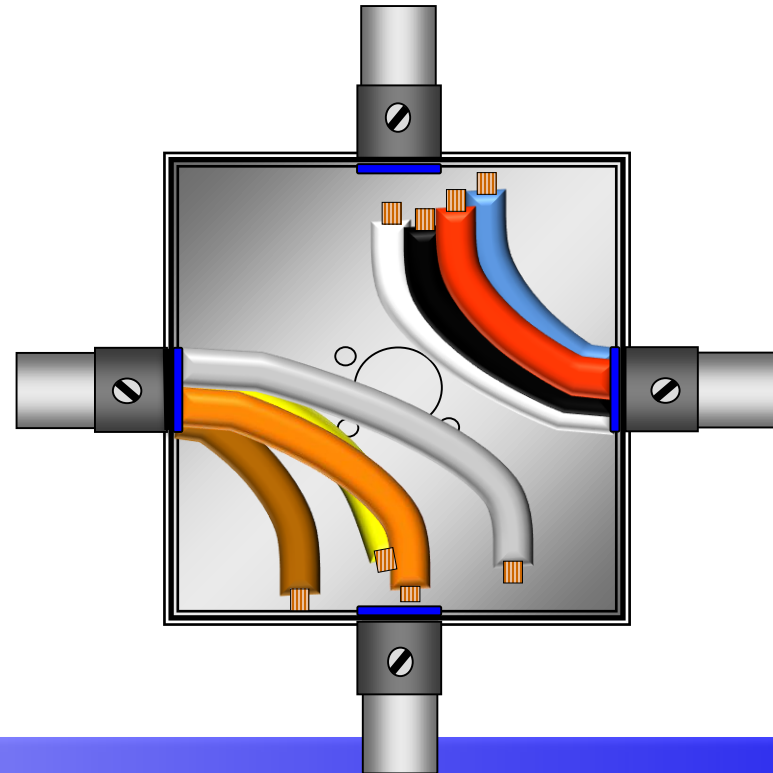


210.5(C) identification of Ungrounded Conductors

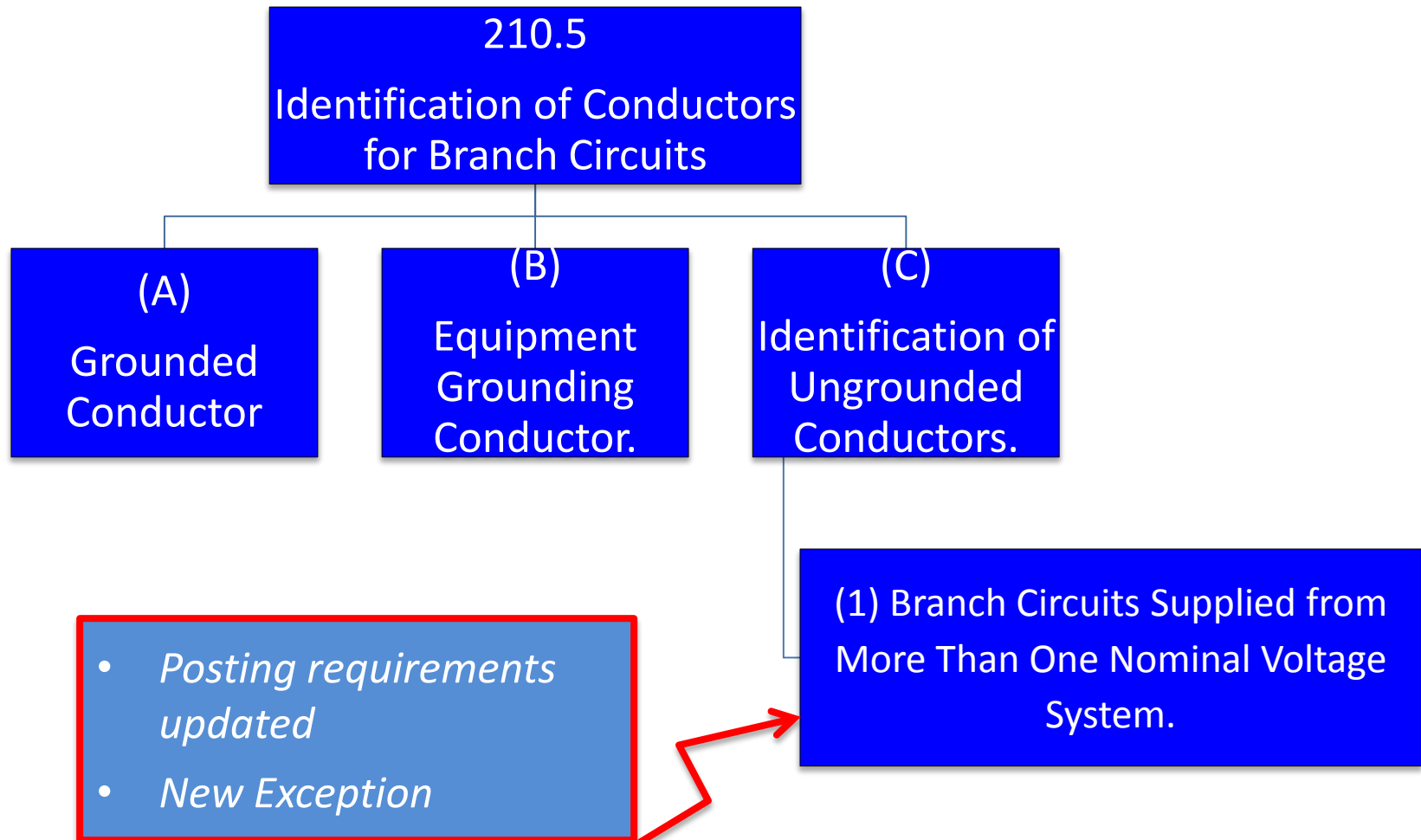
210.5(C) Identification of Ungrounded Conductors.

- Each ungrounded branch circuit is identified by phase and system at all termination, connection, and splice points.
- ✓ Must be documented and readily available, or must be permanently posted at each branch-circuit panelboard

	208Y/120V	480Y/277V
Phase A	Black	Brown
Phase B	Red	Orange
Phase C	Blue	Yellow
Neutral	White	Gray



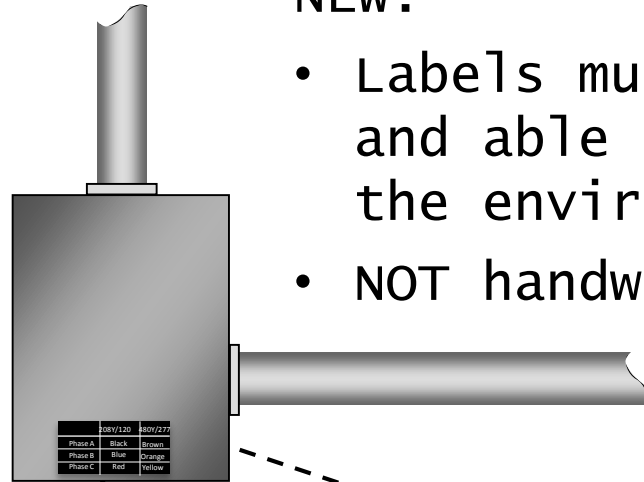
210.5(C)(1) Identification



210.5(C)(1) Identification



New Exception:
If different voltage system being added; only the new system requires marking



NEW:

- Labels must be durable and able to withstand the environment
- NOT handwritten

Must be "identified by phase or line and system at all termination, connection, and splice points"

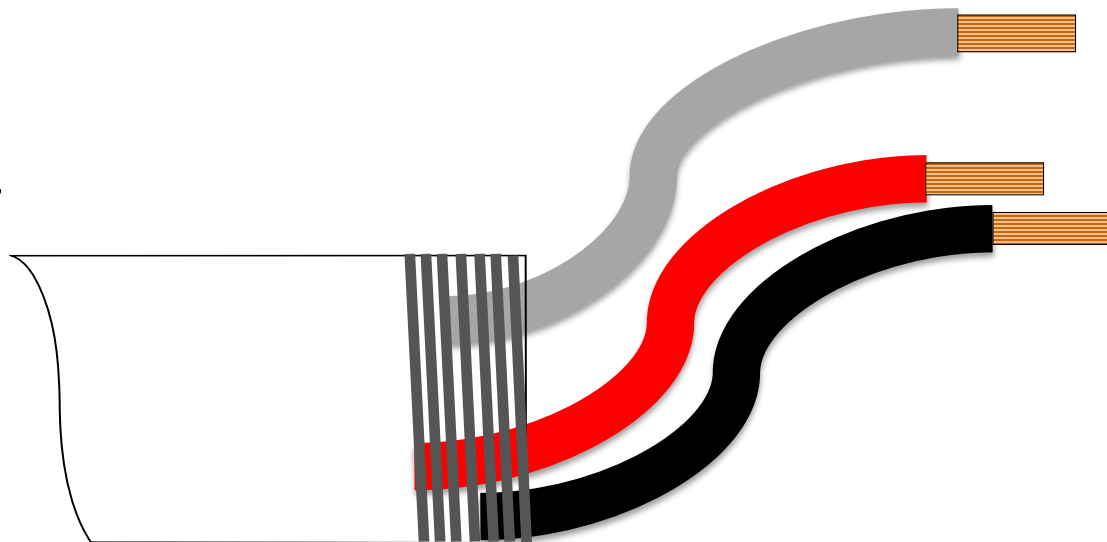
	208Y/120V	480Y/277V
Phase A	Black	Brown
Phase B	Red	Orange
Phase C	Blue	Yellow
Neutral	White	Gray

210.5(C)(2) Branch Circuits Supplied From Direct-Current Systems



- “Where a branch circuit is supplied from a dc system operating at more than ~~50~~ 60 volts”
 - DC voltages may float above 50v when charging.

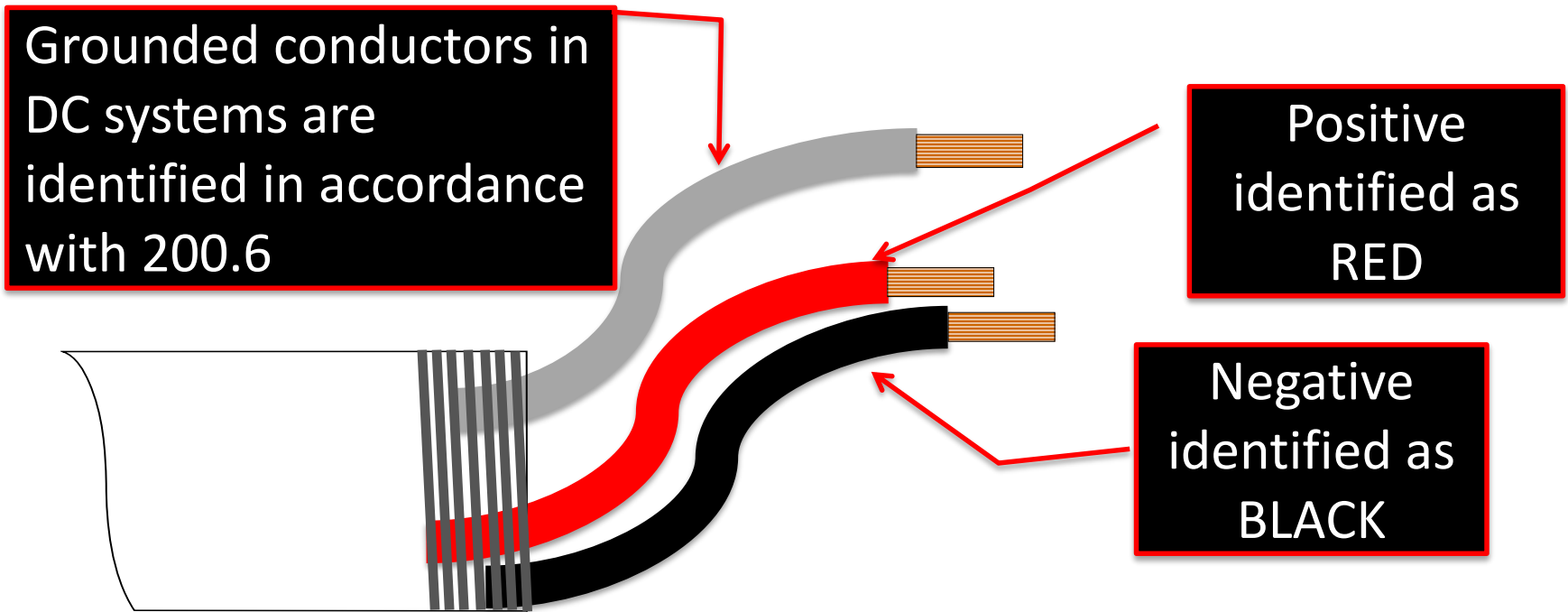
Conductors 6AWG and smaller may now be identified with sleeves or shrink tube



210.5(C)(2) DC Systems



- New requirement for Branch Circuit and Feeder conductors
- Applies to DC systems operating over 50 volts
- Applies to all applications where conductor sizes are to be:
 - 4 AWG and larger, and
 - 6 AWG and smaller



General Locations for 210.8 GFCI Protection for Personnel

210.8(A) Dwelling Units.

- Bathrooms
- Garages ...
- Crawl spaces
- Basement unfinished areas
- Kitchens
- Sinks
- Boathouses
- Bathtubs or shower stalls
- Laundry areas

210.8(B) Other than Dwelling Units

- Bathrooms
- Kitchens
- Rooftops
- Outdoors
- Sinks
- Indoor wet locations
- Locker rooms
- Garages
- Crawl Spaces
- Basement unfinished areas

(C) Boat Hoists

(D) Kitchen D/w Br. Ckt.

(E) Crawl Space Lighting Outlets

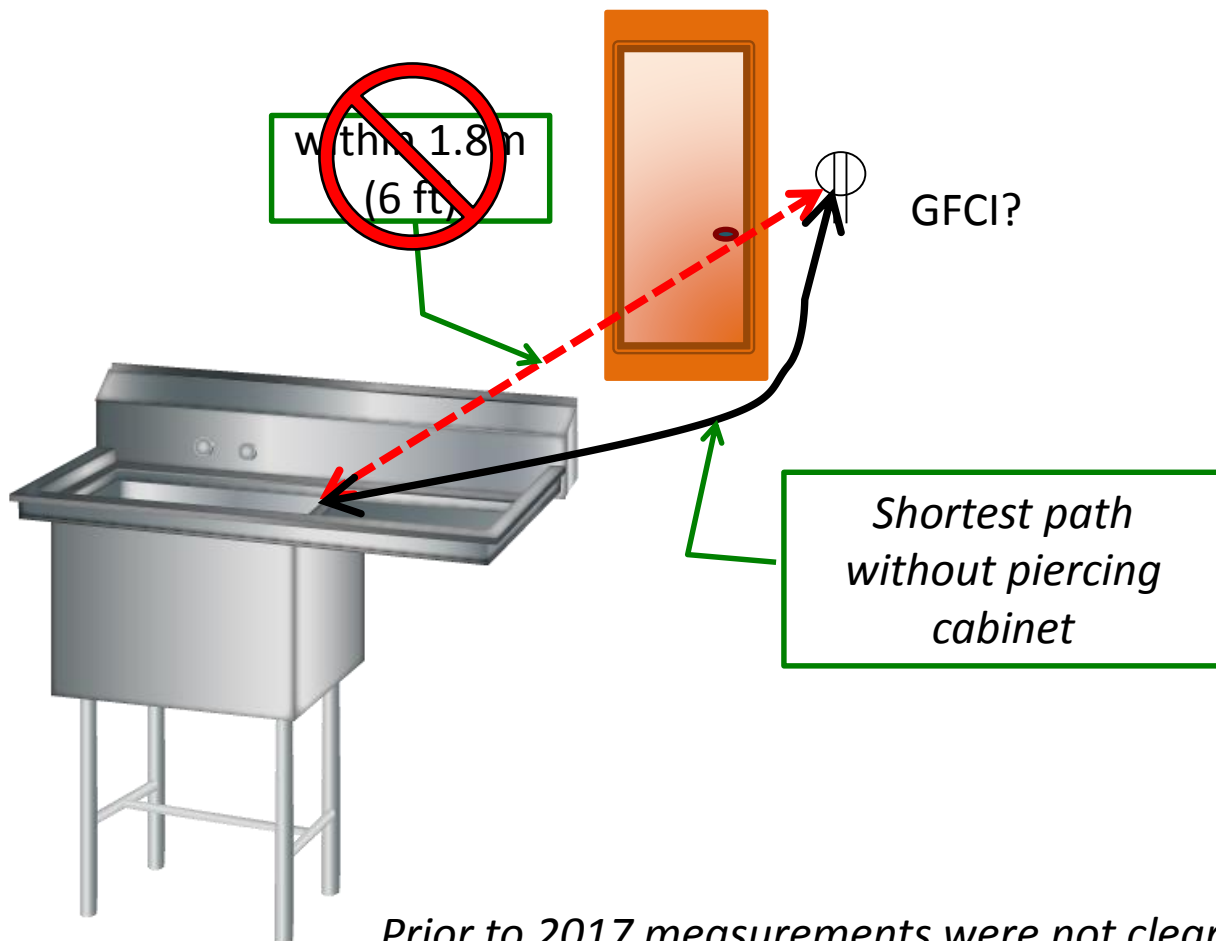
*For sinks:
Use the "shortest path" to determine the six feet & measure from top inside edge of sink*



For other GFCI requirements see the Index

Special Purpose GFCIs have been introduced in 2017!

210.8 Change applies to both Dwelling Units and Other



210.8(B) Other Than Dwelling Units.



- NEW requirements for 3-phase GFCI Protection
- Now include:
 - All single-phase receptacles rated 150 volts to ground or less, 50 amperes or less, and
 - three-phase receptacles rated 150 volts to ground or less, 100 amperes or less
- The locations required are listed in 210.8 (B) 1- 10

210.8 GFCI Protection for Personnel



New Subparagraph:

(E) Crawl Space Lighting Outlets.



210.11(C)(4) Garage Branch Circuits. (NEW)



- At least one 120-volt, 20-ampere branch circuit shall be installed to supply receptacle outlets in:
 - attached garages, and
 - in detached garages with electric power.
- NO other outlets permitted on this circuit
 - *An Exception permits the circuit to supply readily accessible outdoor receptacle outlets.*



*Garage circuit
must be 20 Amperes*

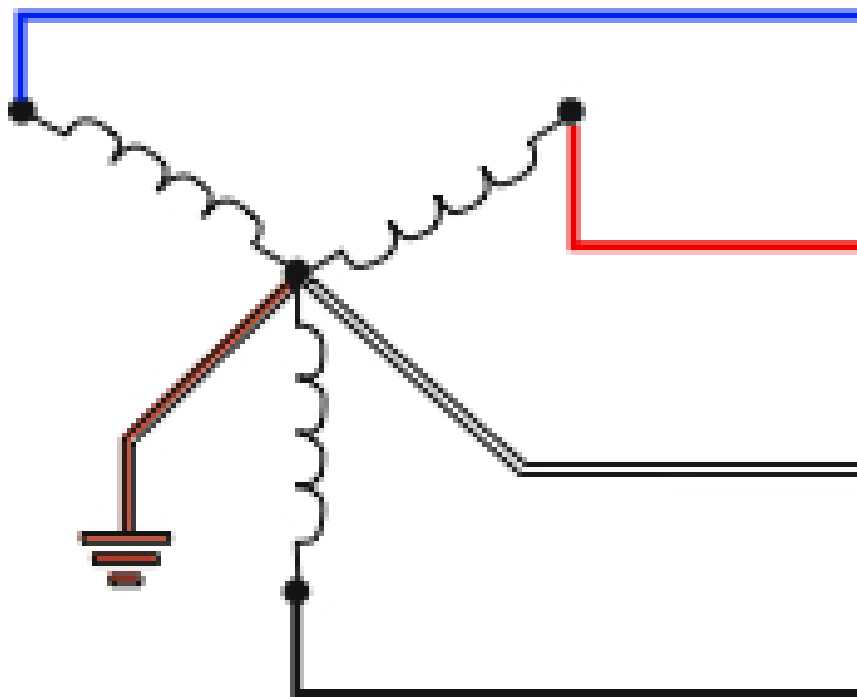
210.12(C) AFCI Protection for Guest Rooms and Guest Suites



- Applies to all 120-volt, single-phase, 15- and 20-ampere branch circuits supplying outlets and devices installed in guest rooms and guest suites of hotels and motels
- Requires same protection as for Dwelling Units as listed in 210.12(A)(1) through (6).

210.13 Ground Fault Protection of Equipment

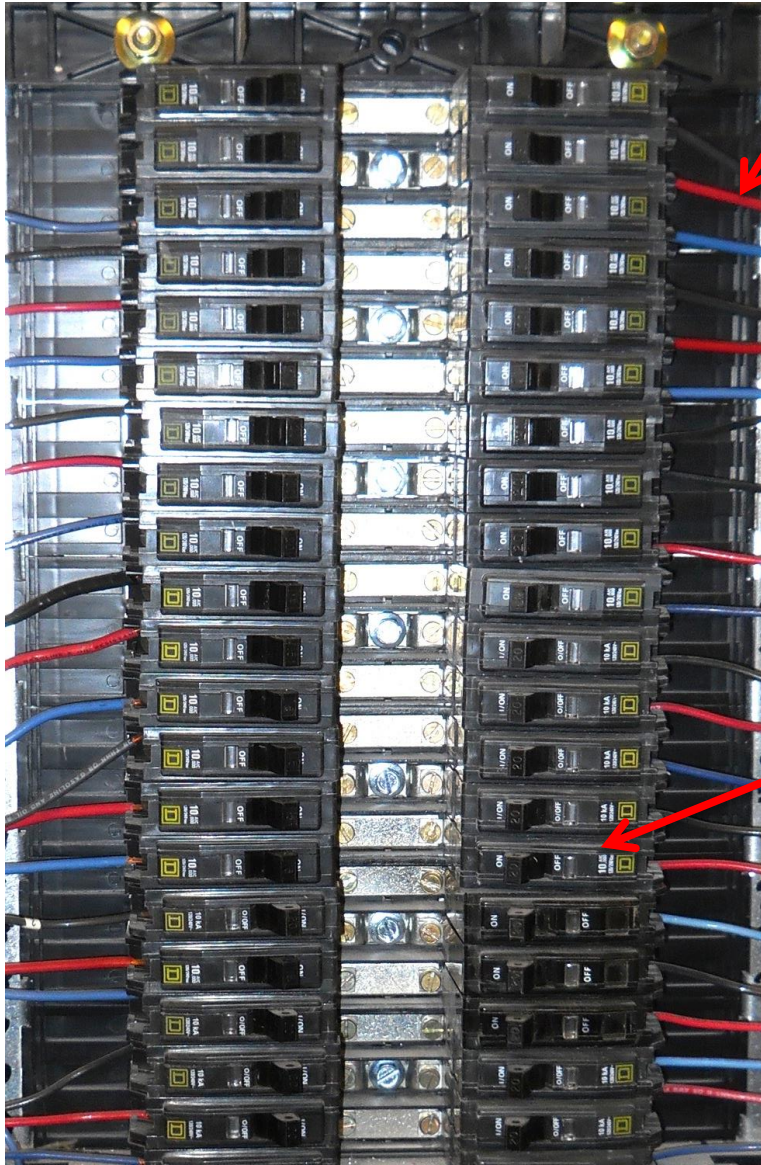
- Applies to **Branch Circuits**
- GFP now required for Branch Circuit Disconnects meeting 230.95



Fed from
480Y/277 or
600Y/347



Branch Circuit Conductor Sizing and Overcurrent Protection



210.19 Min Ampacity and Size

Allowable Ampacity of:

- 100% of Noncontinuous
- 125% of Continuous

210.20 Overcurrent Protection

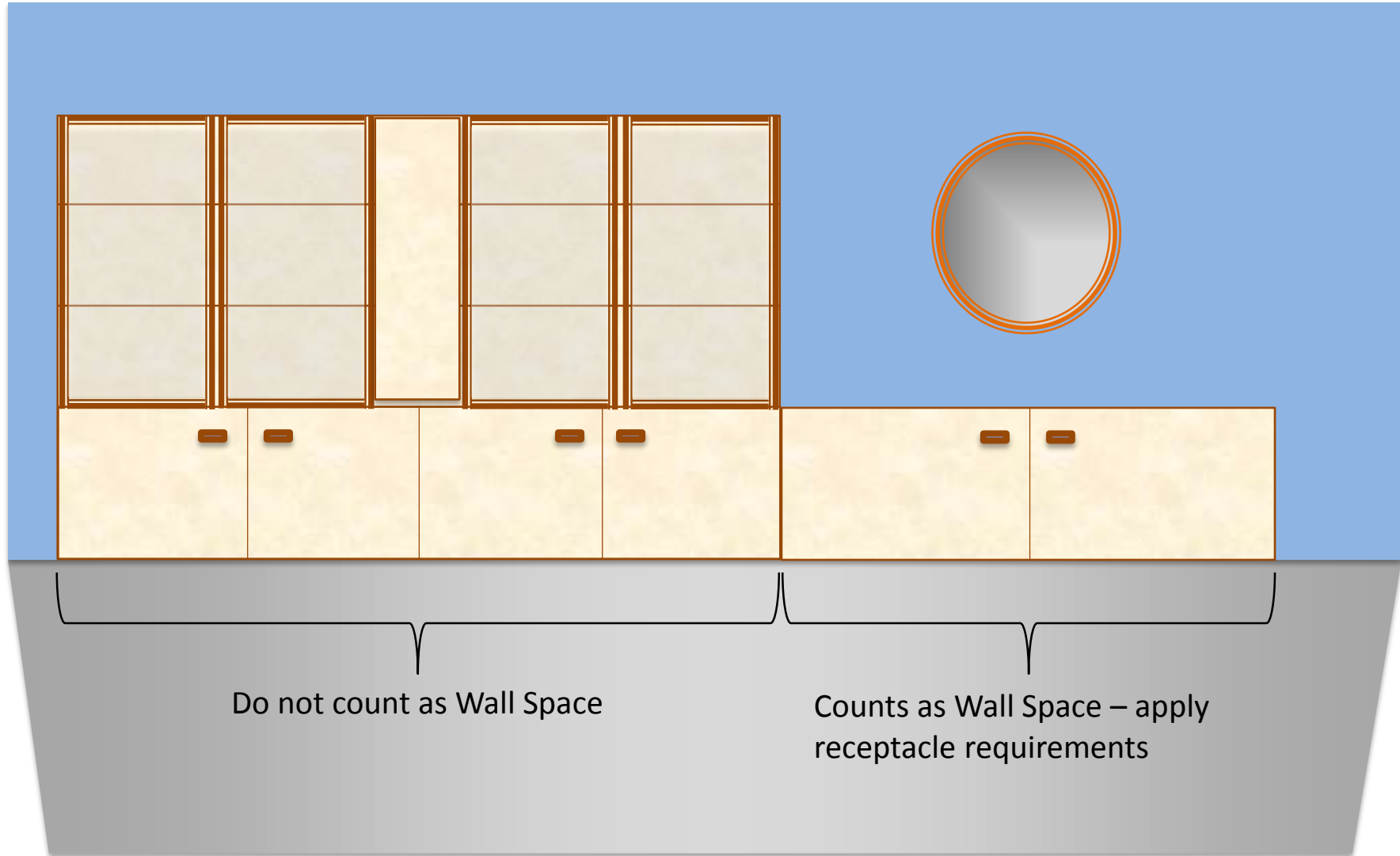
- General Rule; it is required
- Protects conductors per 240.4

210.52 Dwelling Unit Receptacle Outlets

Specified locations for 125-volt, 15- and 20-ampere receptacles in dwelling units:

- A. General Provisions
- B. Small Appliances
- C. Countertops
- D. Bathrooms
- E. Outdoor Outlets
- F. Laundry Areas
- G. Basements, Garages, and Accessory Buildings
- H. Hallways
- I. Foyers

210.52(A)(2) Wall Space



Do not count as Wall Space

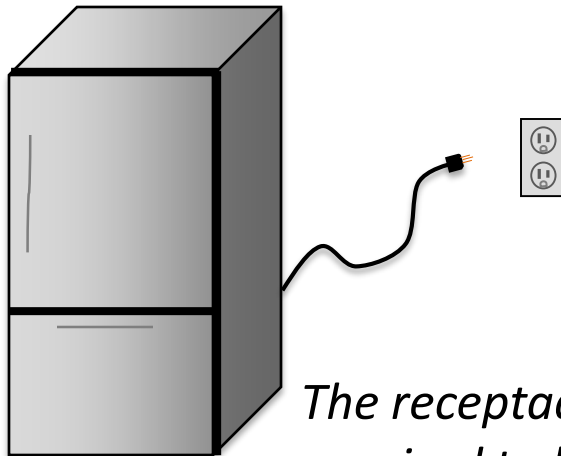
Counts as Wall Space – apply
receptacle requirements



2014 NEC:

210.52(B)(1) specifies in the dwelling unit kitchen etc.;

- **That two or more 20-ampere small-appliance branch circuits serve various outlets including those for refrigeration equipment**



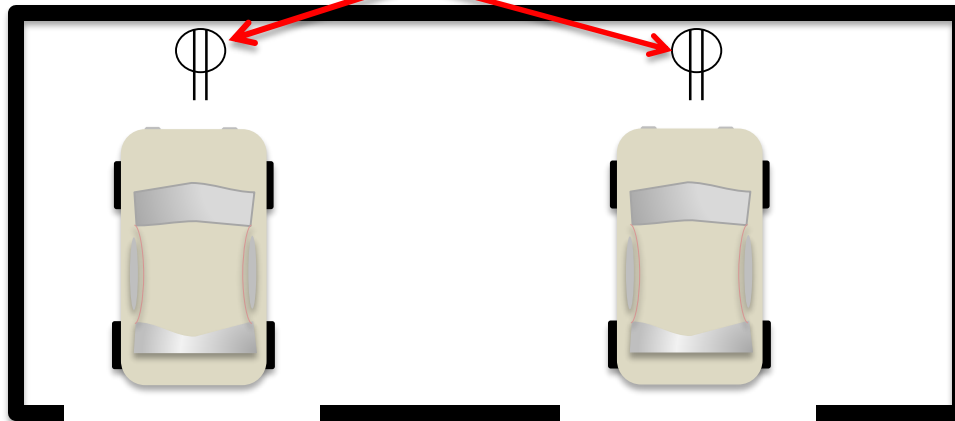
Exception now permits specific appliances to be served by individual branch circuits of 15 amperes or more

The receptacle may be 15A or greater and is not required to be part of the small appliance branch circuit. Dishwasher would also be an example.

210.52(G) Basements, Garages, and Accessory Buildings.



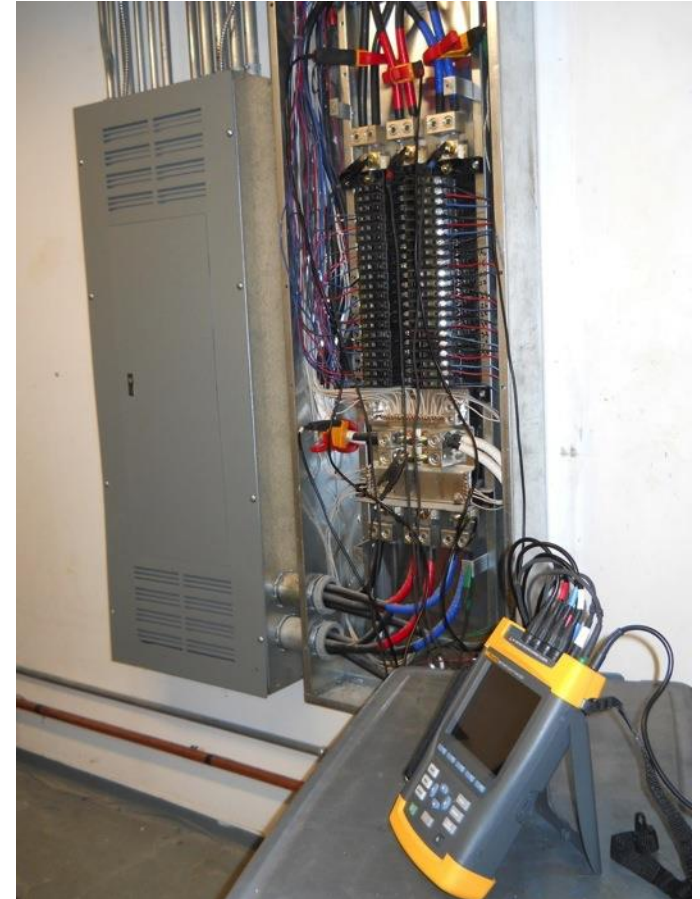
- Each garage bay is to have a minimum of 1 outlet/bay.
- 210.11(C)(4) now requires a 20 A Branch Ckt. to garage



210.64 Electrical Room or Area

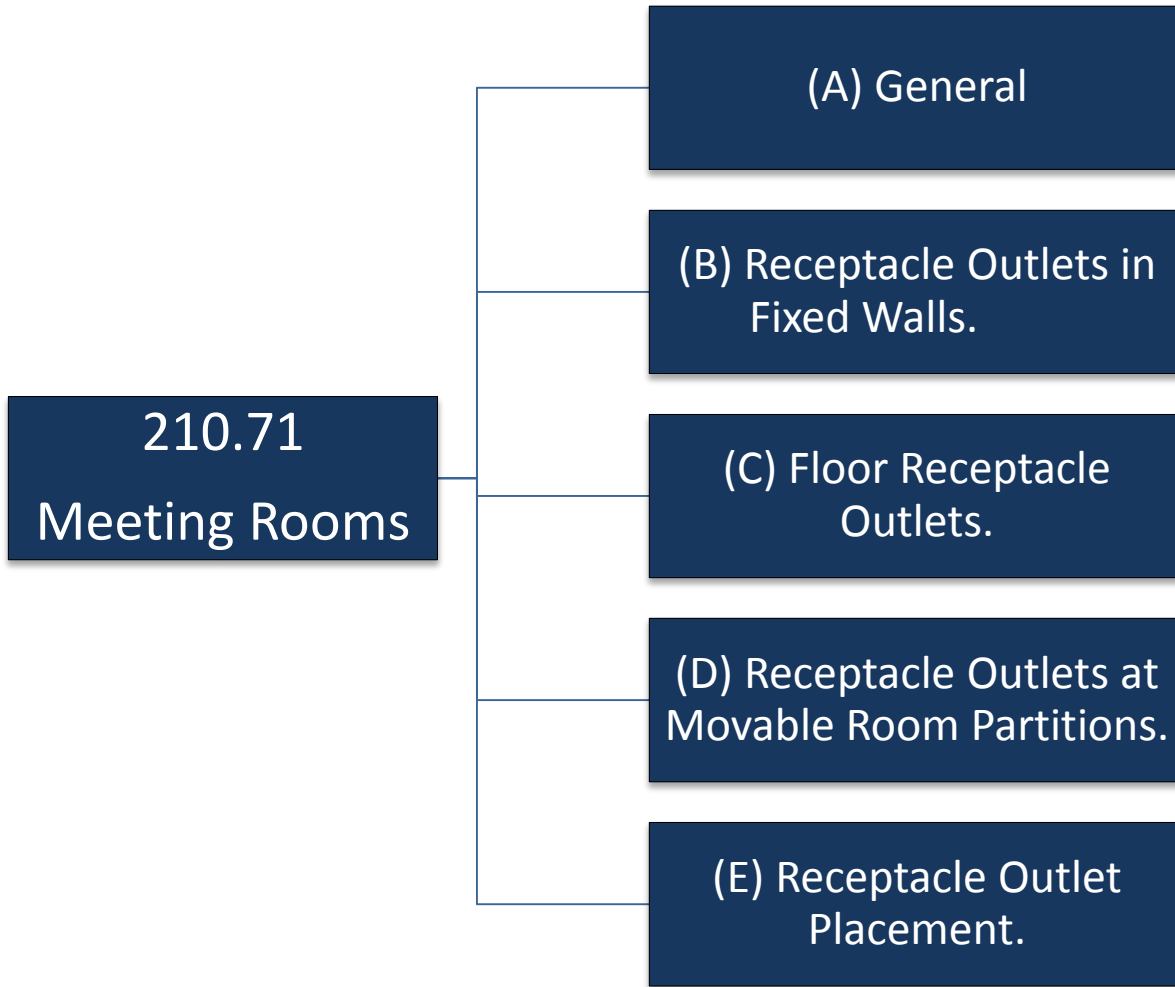
- Receptacle requirement for room or area:
 - ✓ At least one, 125v, 15A or 20A
 - ✓ Must be located within 25 ft of service equipment

Applies to Service Equipment in other than one and two-family dwelling units.



Monitoring equipment can be installed for hours to weeks a time.

Article 210.71 Meeting Rooms.



Meeting rooms must have non-locking, 125 V, 15 and 20 amp receptacles

210.71 Meeting Rooms.



- Meeting room not more than 1000 ft² must have 15 or 20 A Receptacles.
- Location determined by designer/owner

Floor \geq 12 ft wide and
area of \geq 215 ft²
At least one recep. outlet
w/in 6' of any fixed wall
for each 215 ft²

Fixed Wall: Installed per
210.52(A)(1) – (A)(4)

Article 215

Feeders

Article 100 Definition

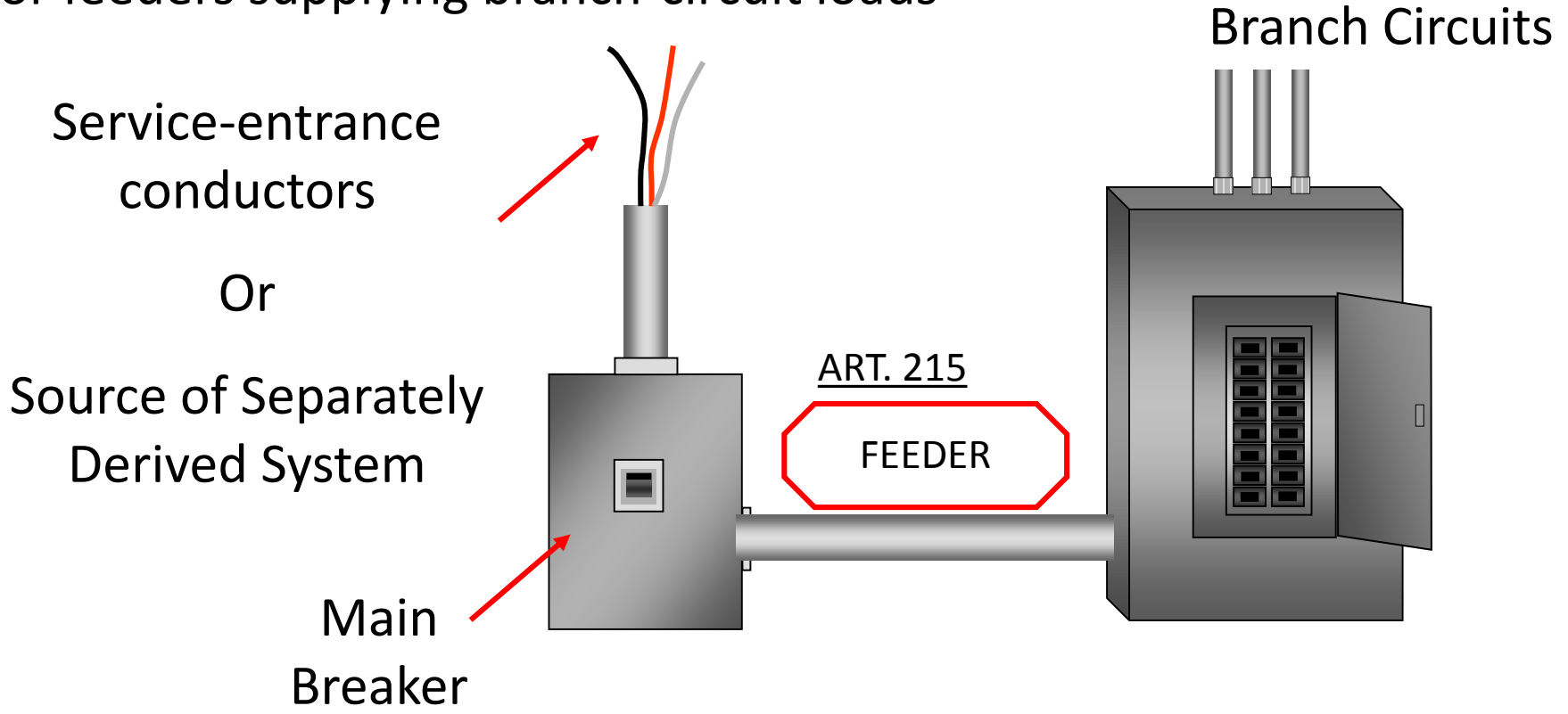
Feeder. All circuit conductors between the service equipment, the source of a separately derived system, or other power supply source and the final branch-circuit overcurrent device.

215.1 Scope

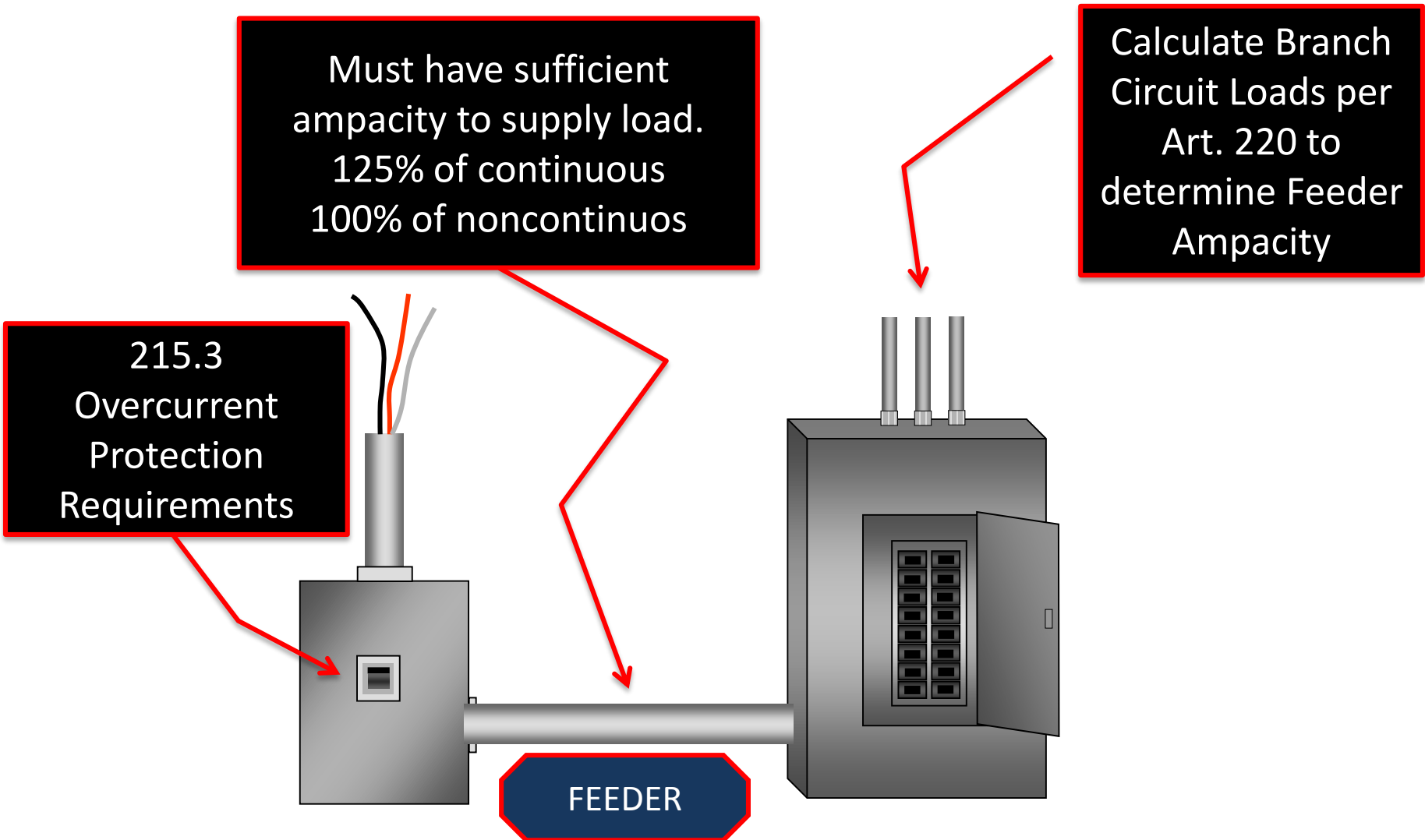
Covers the

- installation requirements,
- overcurrent protection requirements,
- minimum size, and ampacity of conductors

for feeders supplying branch-circuit loads

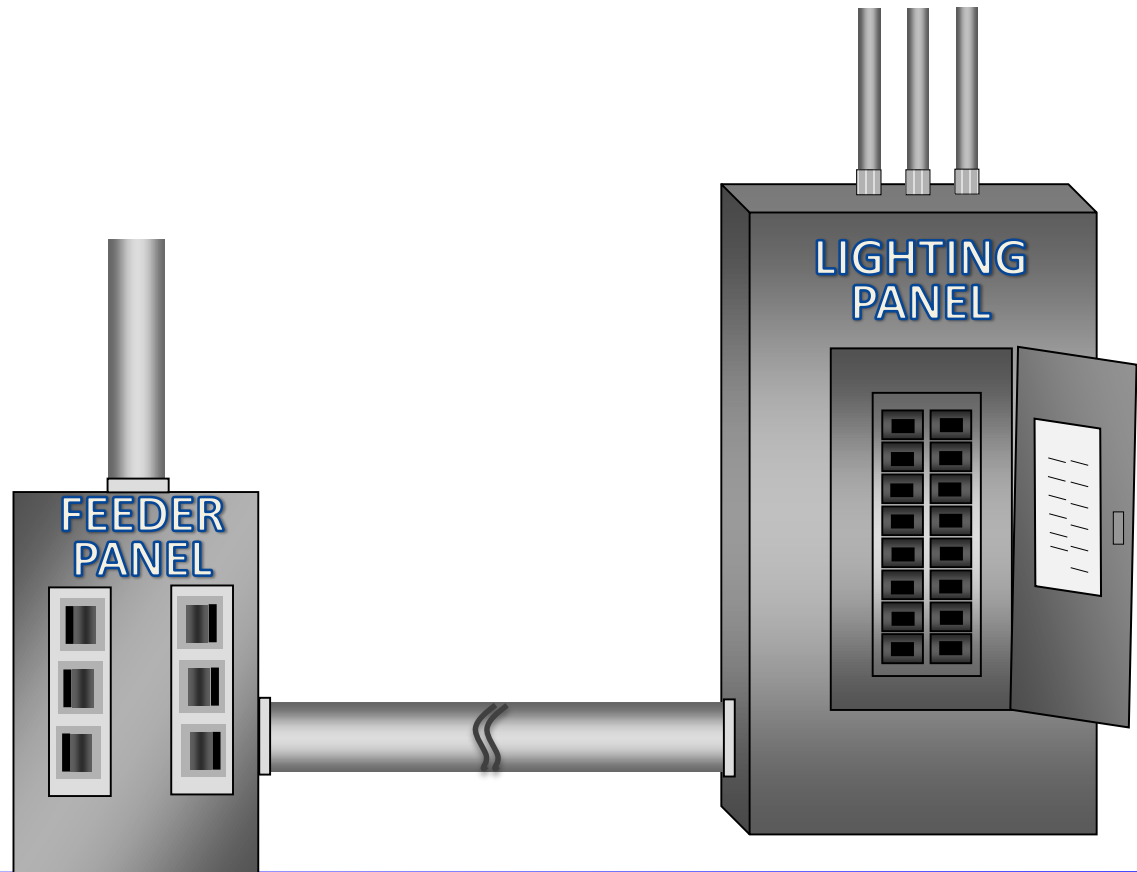


215.2 Minimum Rating and Size



Calculate the Feeder Size

- What is the minimum size THW conductor to supply this 480Y/277 volt Lighting Panel.
- Lighting panel is balanced and supplies 100 kVA



ANSWER

1. Calculate the Load:

$$I = P/E \times 1.73$$

$$I = 100,000 \text{ VA} \div (480 \times 1.73)$$

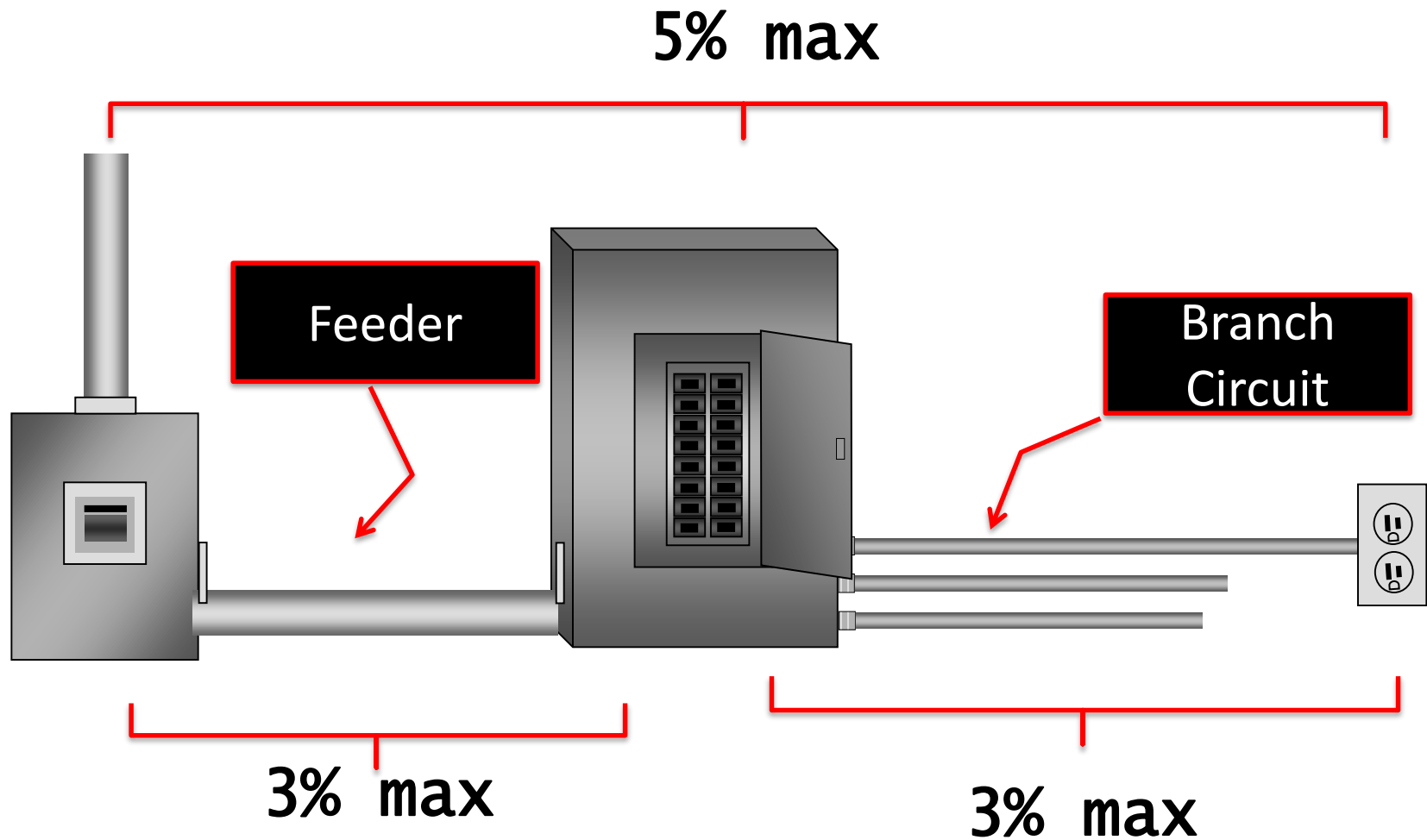
$$I = 120 \text{ A}$$

2. $120 \text{ A} \times 125\% = 150 \text{ A}$

3. From the Ampacity Table:

1/0 AWG Copper

215.2(A)(1) IN 2: Voltage Drop



See 210.19(A), IN

Article 220

Branch Circuit, Feeder, and Service Calculations

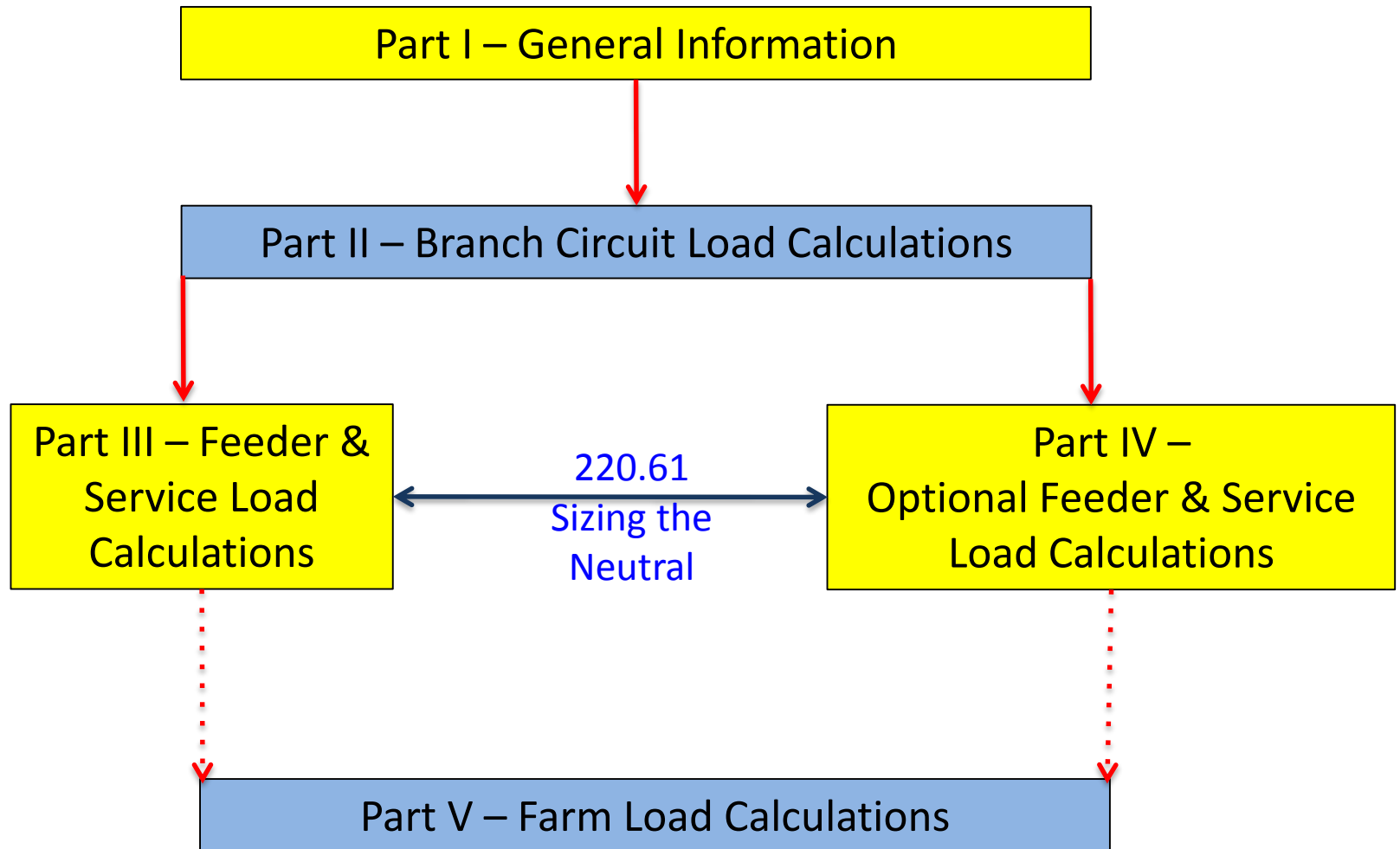
Part I provides for general requirements for calculation methods

Part II provides calculation methods for branch circuit loads

Parts III and IV provide calculation methods for feeders and services

Part V provides calculation methods for farms.

220.1 Scope



220.5 Calculations

(A) Voltages. Use the standard nominal values:

120, 120/240, 240

208Y/120

480, 480Y/277

347, 600Y/347, 600

(B) Fractions of an Ampere

less than 0.5 may be dropped

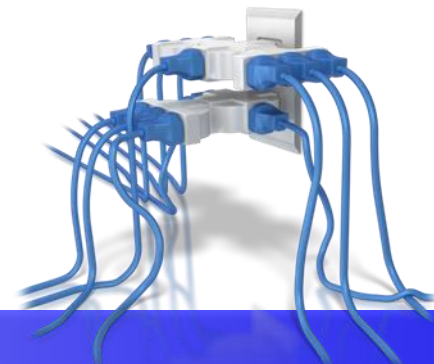
Branch-circuit Calculations per Article 220, 2017 NEC®

Branch circuit loads are calculated using the following code sections:

220.12 Lighting Load for Specified Occupancies

220.14 Other Loads — All Occupancies

220.16 Loads for Additions to Existing Installations



220.12 Lighting Load for Specified Occupancies

- Use Table 220.12 for type occupancy
- This is the minimum lighting load in VA/ft²
 - Apply demand factors of 220.42 for General Lighting
 - Floor area calculated using outside dimensions of the building, dwelling unit, or other area
- For dwelling units, floor area does not include open porches, garages, or unused or unfinished spaces not adaptable for future use

220.14 Other Loads — All Occupancies.

(A) Specific Appliances or Loads are calculated based on the ampere rating of the appliance or load served

(B) Electric Dryers and Household Electric Cooking Appliances

(C) Motor Loads

See 430.22, 430.24, and 440.6

(D) Luminaires (Lighting Fixtures).

Use the maximum volt-ampere rating of the equipment and lamps for which the luminaire(s) is rated

220.14 Other Loads — All Occupancies.

(E) Heavy-Duty Lampholders

Outlets for heavy-duty lampholders shall be calculated at a minimum of 600 volt-amperes.

(F) Sign and Outline Lighting

a minimum of 1200 volt-amperes for each required branch circuit specified in 600.5(A)

(G) Show Windows, use

The unit load per outlet as required in other provisions of this section. Or

At 200 volt-amperes per 300 mm (1 ft) of show window

220.14 Other Loads — All Occupancies.

(H) Fixed Multioutlet Assemblies

- Where appliances are unlikely to be used simultaneously
each 5 ft or fraction of 5 ft. of each separate and continuous length is considered as one outlet of not less than 180 volt-amperes, or
- Where appliances are likely to be used simultaneously
each 1 foot, or fraction of 1 foot is considered as an outlet of not less than 180 volt-amperes.

Diversity vs. Demand

- Diversity factor is the ratio of the sum of the individual maximum demands of the various subdivisions of a system (or part of a system) to the maximum demand of the whole system (or part of the system) under consideration. Diversity is usually more than one.
- Demand factor is the ratio of the sum of the maximum demand of a system (or part of a system) to the total connected load on the system (or part of the system) under consideration. Demand factor is always less than one.

Email me for a link to the article:

rbarnett@nttinc.com

Subject Line: IEEE Atlanta

Article 230

Services

Article 100 Definition:

“Service. The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.”

230.2 Number of Services

The general rule is that a building or other structure can be supplied by only one service. However, 230.2(A) through (D) permit additional services for the following:

- (A) Special Conditions – review how many and what they are
- (B) Special Occupancies – review the two types.
- (C) Capacity Requirements – there are three.
- (D) Different Characteristics
- (E) Identification

230.3 One Building or Other Structure Not to Be Supplied Through Another

- Service conductors that supply a building or other structure are not allowed to pass through the interior of another building or other structure
- 230.6 provides requirements specifying when conductors are considered outside the building.

230.6 Conductors Considered Outside the Building

These conductors are considered outside of a building or other structure:

- 1) Under not less than 50 mm (2 in.) of concrete beneath a building or other structure
- 2) Within a building or other structure: raceway encased in concrete or brick not less than 50 mm (2 in.) thick
- 3) Vaults per Article 450, Part III
- 4) If installed in conduit and under not less than 450 mm (18 in.) of earth beneath a building
- 5) RMC or IMC when used to meet clearance requirements

Article 230 Services

230.7 Conductors other than service conductors are not be installed in the same service raceway or service cable

230.8 Raceway Seal

- Underground service raceway where it enters must be sealed in accordance with 300.5(G)
- Spare or unused raceways must also be sealed
- Sealants shall be identified for use

230.10 Vegetation as Support.

- Vegetation is not to be used for support of overhead service conductors

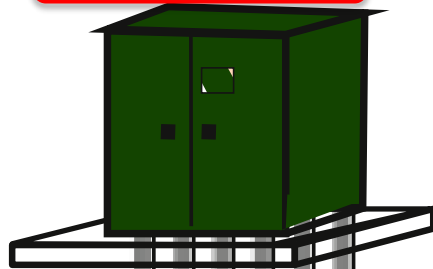
Services

230.2 general rule:
A building or other
structure can be
supplied by only one
service

Service Equipment
Part V – General
Part VI – Disconnecting
Means

300.5 addresses
Protection of
Underground
Conductors

Utility Supply



J
B
O
X

Service Lateral

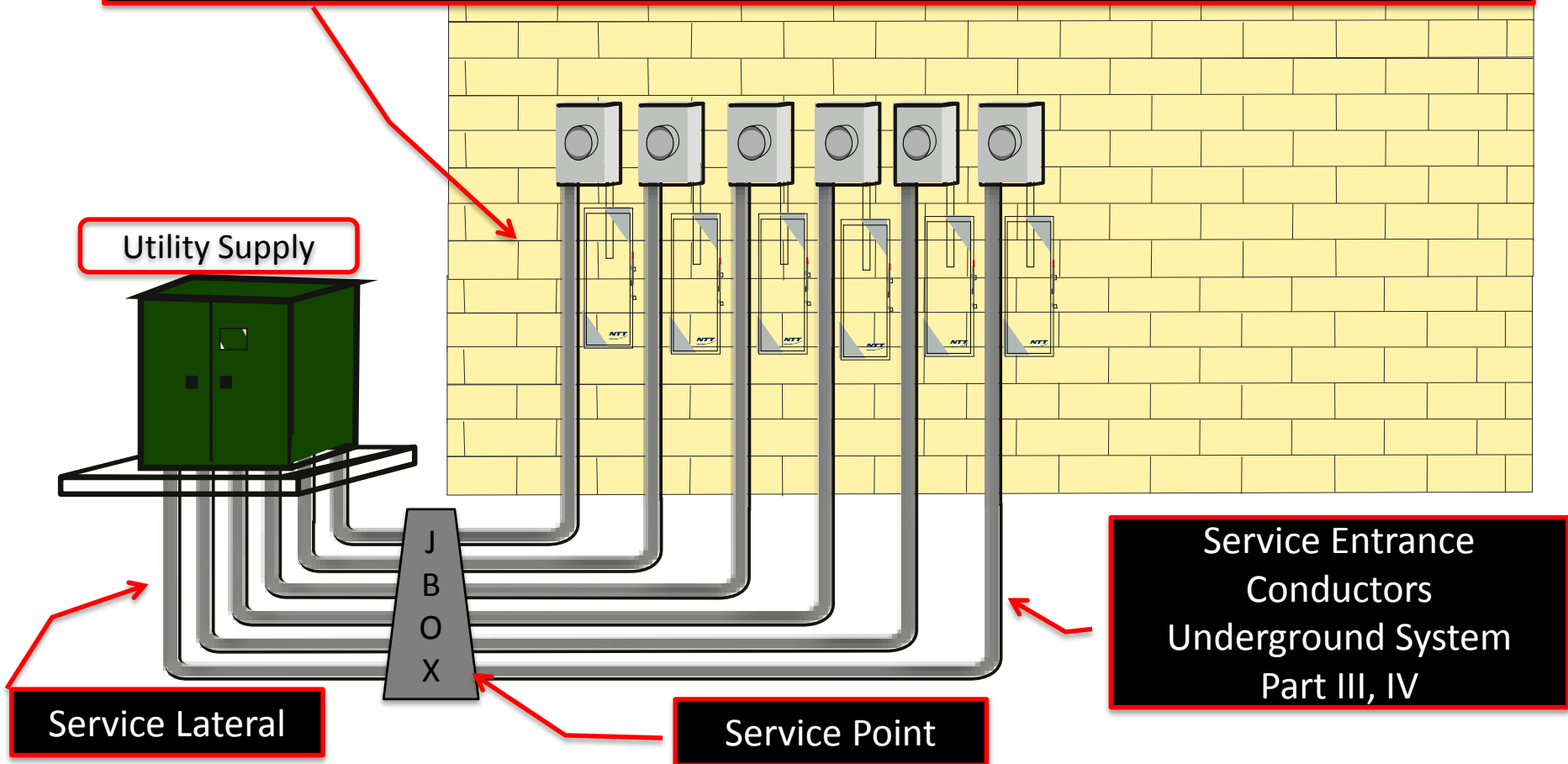
Service Point

Service Entrance
Conductors
Underground System
Part III, IV

230.40 Number of Service-Entrance Conductor Sets

General rule: service conductors can supply only one set of service-entrance conductors.

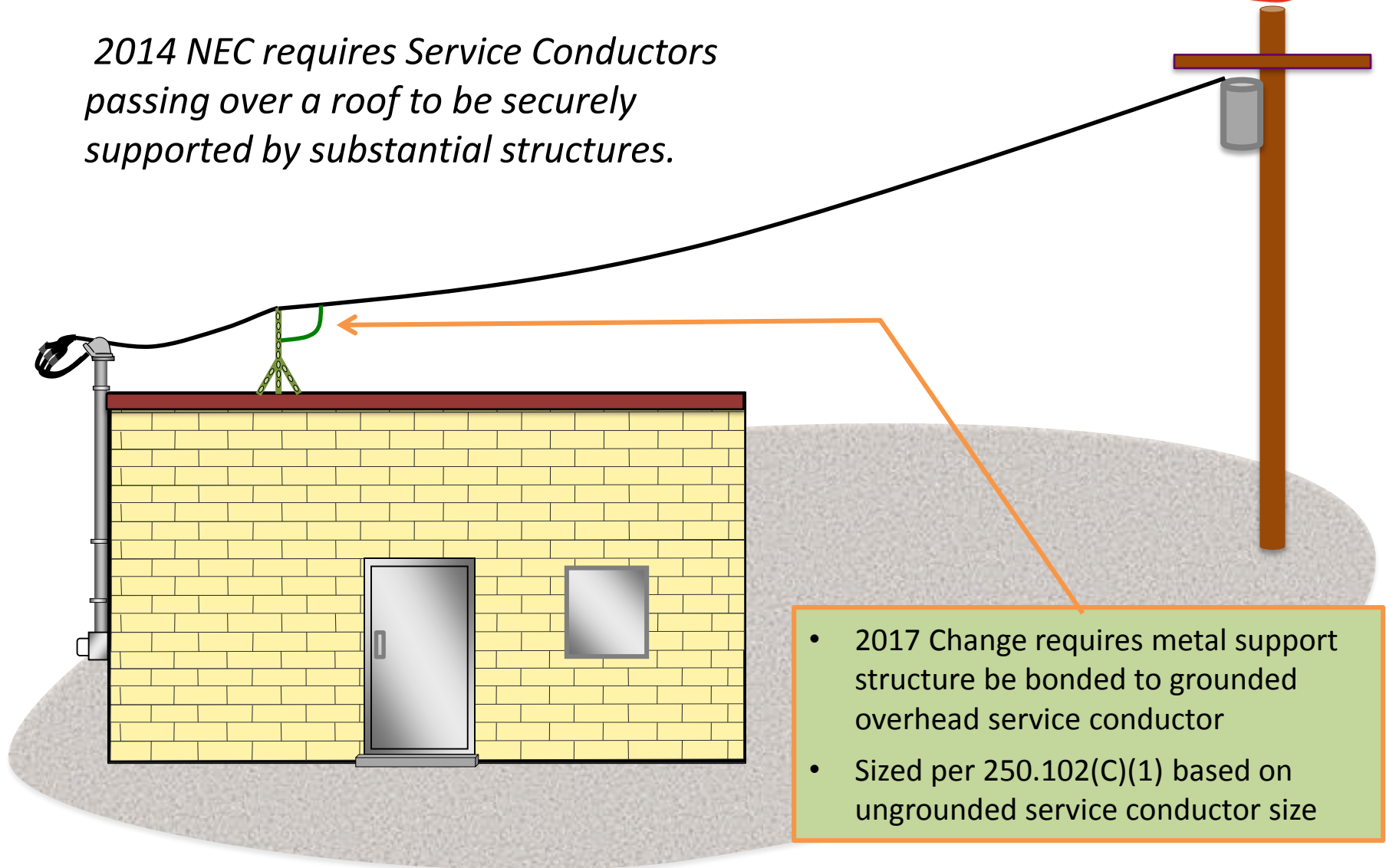
Exception No. 1: For a building with more than one occupancy



230.29 Supports over Buildings.

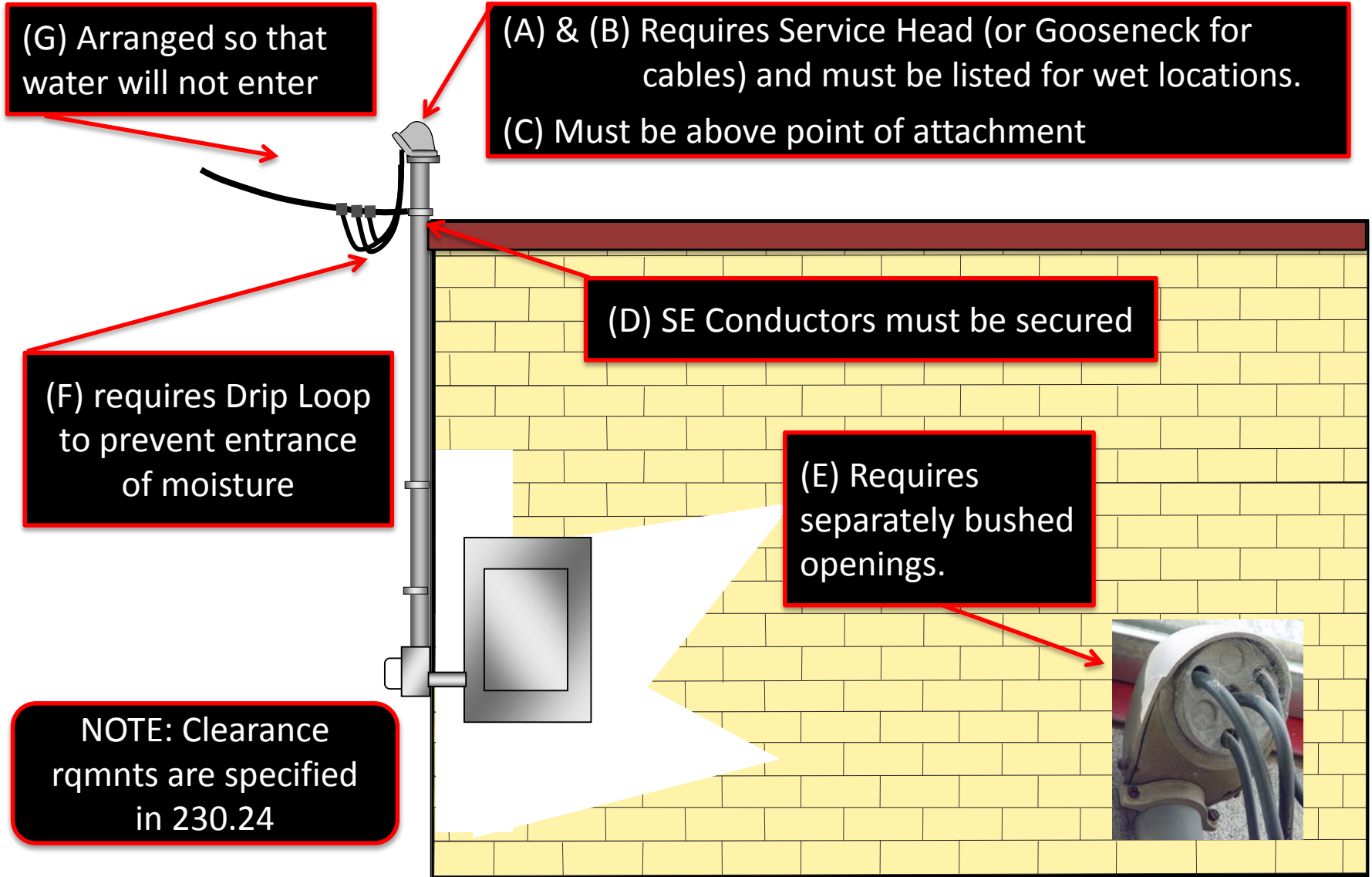


2014 NEC requires Service Conductors passing over a roof to be securely supported by substantial structures.



- 2017 Change requires metal support structure be bonded to grounded overhead service conductor
- Sized per 250.102(C)(1) based on ungrounded service conductor size

230.54 Overhead Service Locations



PART V. Service Equipment — General

230.62 Must be Enclosed or Guarded

230.66 Marking Requirements

- Must be listed
- If rated at 1000 volts or less must be marked to identify it as being “suitable for use as service equipment”



Part VI. Service Equipment — Disconnecting Means

230.70 General

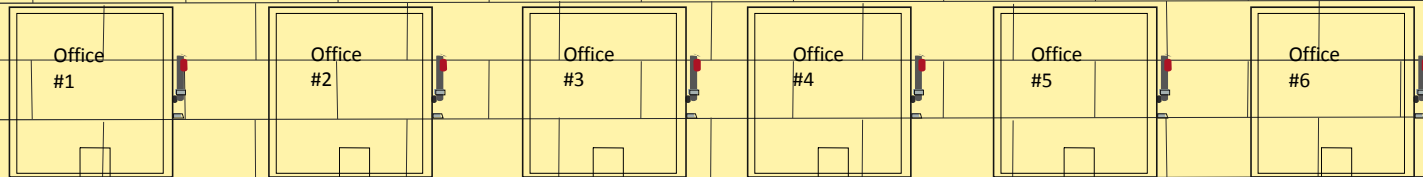
- Disconnect premises wiring from the SE
- Location requirements:
 - Readily accessible location
 - Can be outside or inside
 - Must be nearest the point of entrance of the service conductors.
 - May not be in a bathroom
 - Even if a Remote Control is used to actuate the Service Disconnect, it must still be readily accessible

230.71 Maximum Number of Disconnects

Not more than six switches or circuit breakers for the service disconnecting means

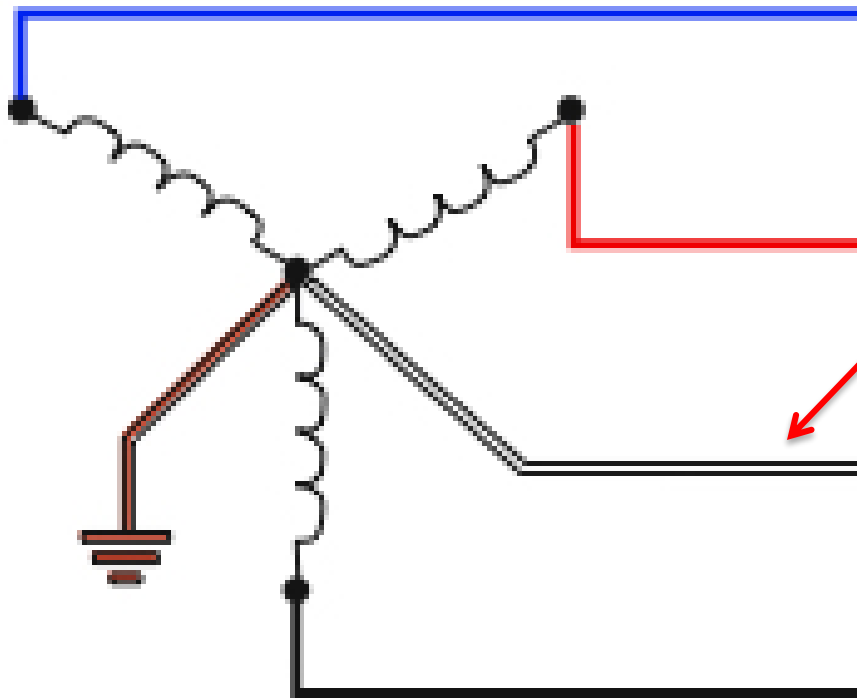
“switchgear”
added for
2014

230.72 Grouping of Disconnects is required.
Must be marked with load served



230.95 Ground-Fault Protection of Equipment

Since 1971 Code



Solidly
Grounded
WYE

480Y/277

Or

600Y/347



Application

What “cables” are permitted to be used as service-entrance conductors?

1. What is the question about?

➤ Service-entrance conductors, wiring method permitted

2. Refer to the Index: “Service-entrance conductors” then “wiring methods”

3. Locate 230.43 and read answer

Article 240

Overcurrent Protection

Article 100 Definition

Overcurrent. Any current in excess of the rated current of equipment or the ampacity of a conductor. It may result from overload, short circuit, or ground fault.

240.4 Protection of Conductors

240.4 specifies the overcurrent protection requirements for conductors

- (A) Overload protection is not required for equipment such as fire pumps
- (B) for devices rated 800 Amperes or less the next higher size overcurrent protective device is permitted if the required protection is not one of the standard device ratings
- (C) for devices rated over 800 Amperes, the next lower rated device is used for protection

240.4 continued

(D) Specifies maximum overcurrent protection requirements for small conductors:

- for 18 AWG max allowed is 7 Amperes if certain conditions are met
- for 16 AWG max allowed is 10 Amperes if certain conditions are met
- for 14 AWG max allowed is 15 Amperes
- for 12 AWG max allowed is 20 Amperes
- for 10 AWG max allowed is 30 Amperes

240.6 Standard Ampere Ratings

- (A) Review the standard Ampere Ratings for fuses and inverse time circuit breakers

Note this also includes 1, 3, 6, 10 and 601 ampere fuses.

Devices are available in other ratings, however, they are not “standard” sizes.

- (B) Adjustable –trip breakers may be set to their maximum setting.

Article 240 Overcurrent Protection

240.9 Thermal Devices

- May be used to protect motor branch-circuit conductors from overload in accordance with 430.40

240.10 Supplementary Overcurrent Protection

- May not be used as a substitute for required branch-circuit overcurrent devices or in place of the required branch-circuit protection
- Supplementary overcurrent devices not required to be readily accessible

240.21 Location in Circuit

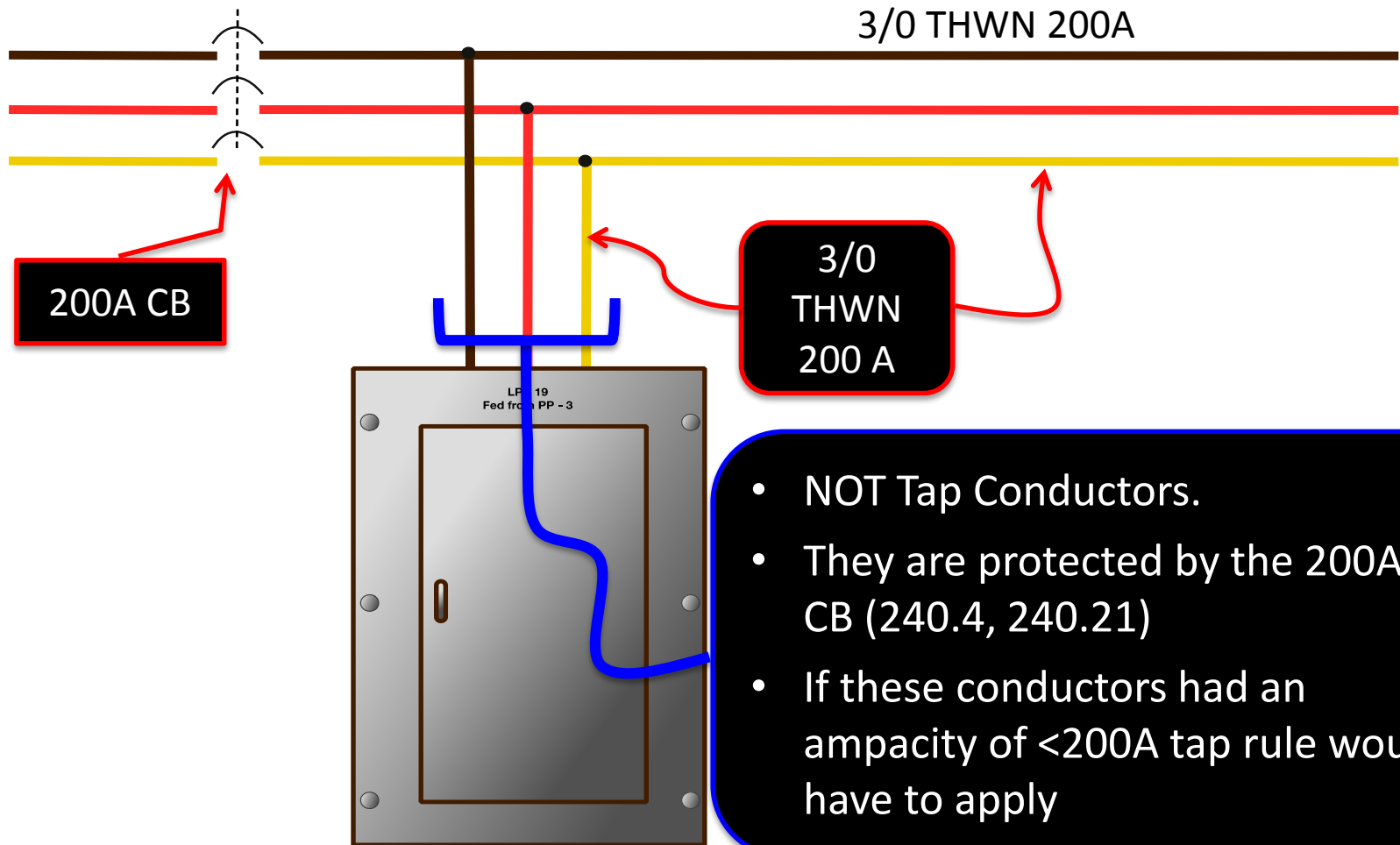
- General rule is that overcurrent protection must be provided for ungrounded conductors at the source where they receive their power.
- This section contain the “Tap Rules” which provide exceptions to this general rule

Review the 5 Feeder Tap Rules of 240.21(B)

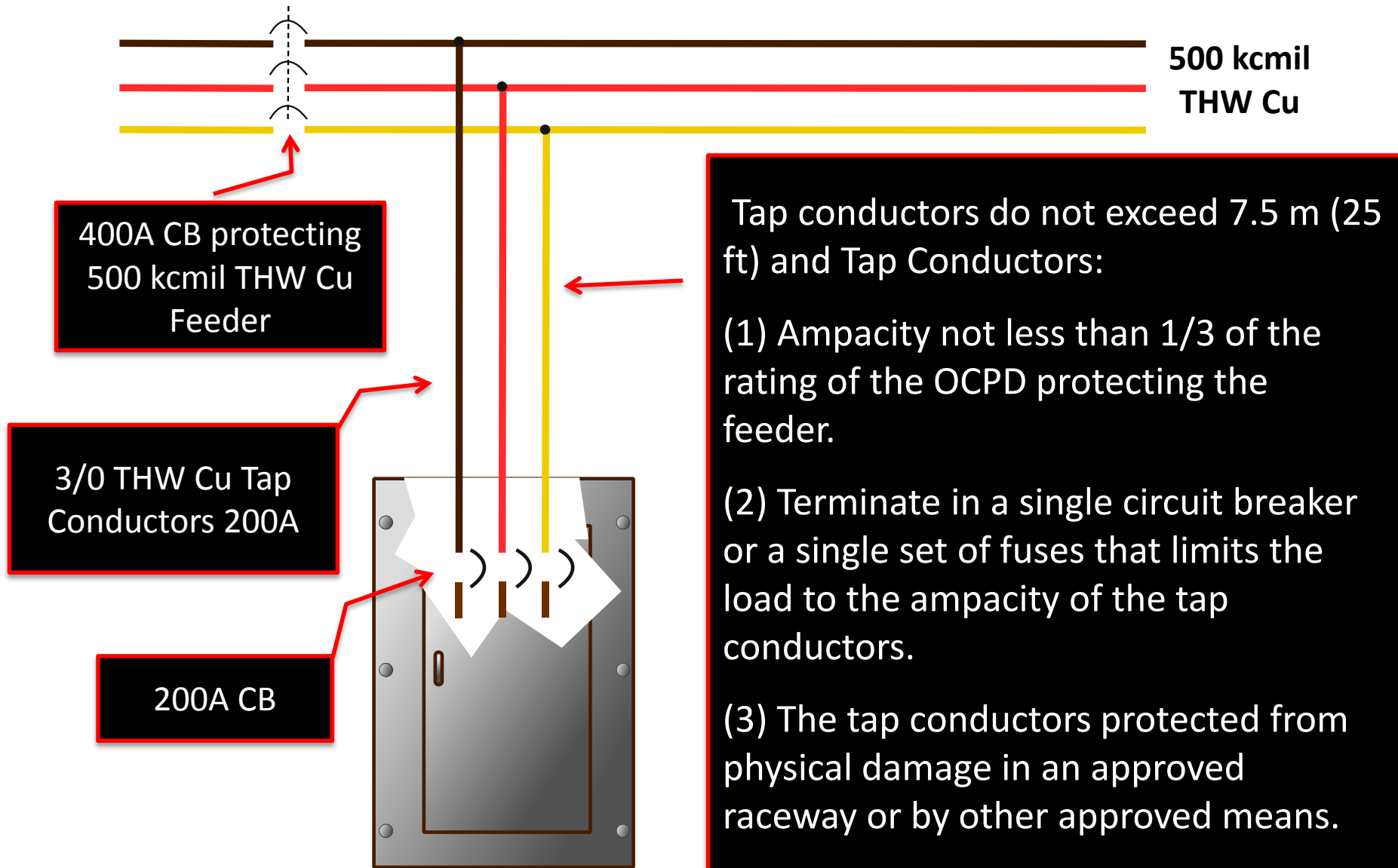
NEC FACTS – Understanding Tap Rules



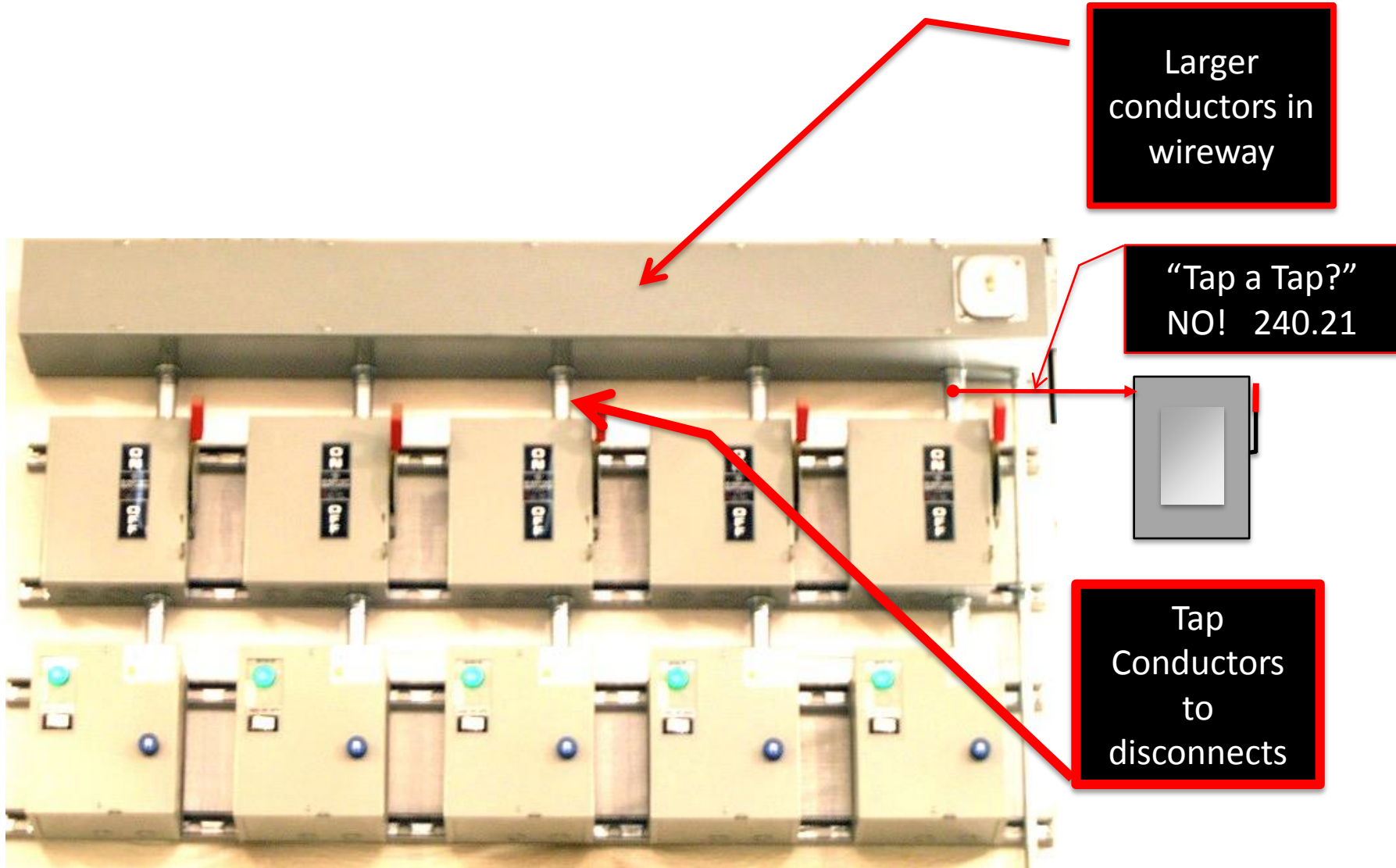
General Rule: Overcurrent protection is provided in each ungrounded conductor at the point of their supply



240.21(B)(2)(2) Taps Not over 7.5 m (25 ft) Long.



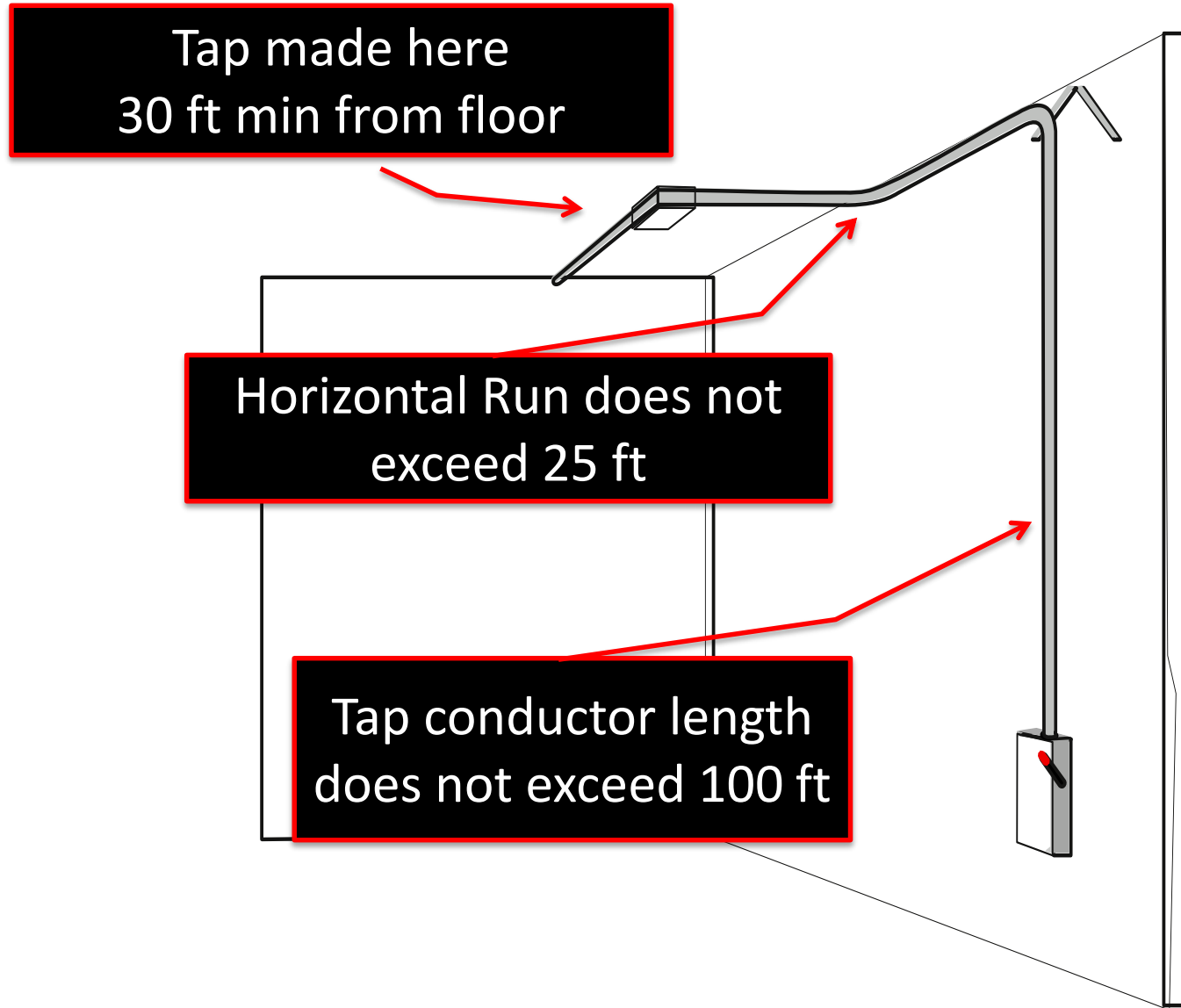
Typical Application of the 10 ft Tap Rule



240.21(B)(4) Applies to High Bay Manufacturing Areas



240.21(B)(4) Taps over 7.5 m (25 ft) Long



240.67 Arc Energy Reduction



- New section requires arc-energy reduction for fuses.
- 240.87 for circuit breakers was added to the 2011 NEC
- Arc-energy reduction now required for *fuses* 1200 A and greater
- Delayed implementation: January 1, 2020

Compare the requirements of 240.67 to 240.87 for cb's

240.87 Arc Energy Reduction



Provides methods to help protect workers during maintenance activities by reducing clearing time:

1. Zone-selective interlocking
2. Differential relaying
3. Energy-reducing maintenance switching with local status indicator
4. Energy-reducing active arc flash mitigation system
5. An instantaneous trip setting that is less than the available arcing current
6. An instantaneous override that is less than the available arcing current
7. An approved equivalent means



VIII. Supervised Industrial Installations

240.90 General information

- Provides alternative approaches to overcurrent protection for 600 volt and less distribution system
- Only applies to:
 - ✓ Supervised industrial installation, and
 - ✓ large manufacturing plants or industrial processes



240.91 Protection of Conductors in these types of establishments

Two options are provided to protect conductors

(A) permits use of 240.4

(B) If the overcurrent device is rated over 800 amperes, the ampacity of the conductors it protects must be equal to or greater than 95 percent of the rating of the overcurrent device

- ✓ The conductors are protected within recognized time vs. current limits for short-circuit currents
- ✓ All equipment in which the conductors terminate is listed and marked for the application

240.91 Protection of Conductors in Supervised Industrial Installations

- In a supervised industrial installation, the ampacity of a set of parallel feeder conductors is determined to be 1,145 A.
- Engineering has selected a 1,200 Amp Power Circuit Breaker. Is this a correct choice?

1. YES

2. NO

IX. Overcurrent Protection Over 1000 Volts, Nominal

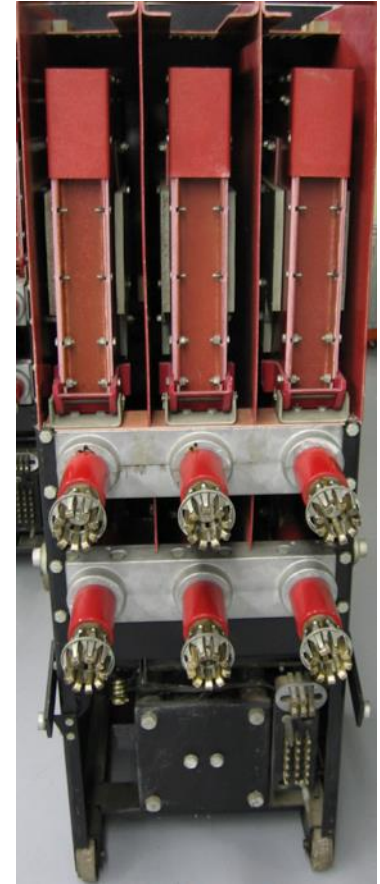
240.100 Feeders and Branch Circuits

- (A) Feeder and branch circuit conductors must have overcurrent protection in each ungrounded conductor
 - Is located at the point where the conductor receives its supply, or
 - an alternative location in the circuit when designed under engineering supervision
- The overcurrent protection must be either:
 - Overcurrent Relays and Current Transformers, or
 - Fuses

IX. Overcurrent Protection Over 600 Volts, Nominal



**Typical 4160v Switchgear and
Circuit Breakers (front and back
views.)**



Article 250

Grounding & Bonding

- Understanding how Grounding and Bonding works to protect people and property from the hazards arising from the use of electricity.
- What are the major issues and problems associated with grounding and bonding.
- Understanding the rules and applying Article 250.

The Planet Earth as Our Reference



***NEC® Article 100 Definition
for Ground!***

What is Bonding?

Article 100:

Bonded (Bonding).

“Connected to establish electrical continuity and conductivity.”

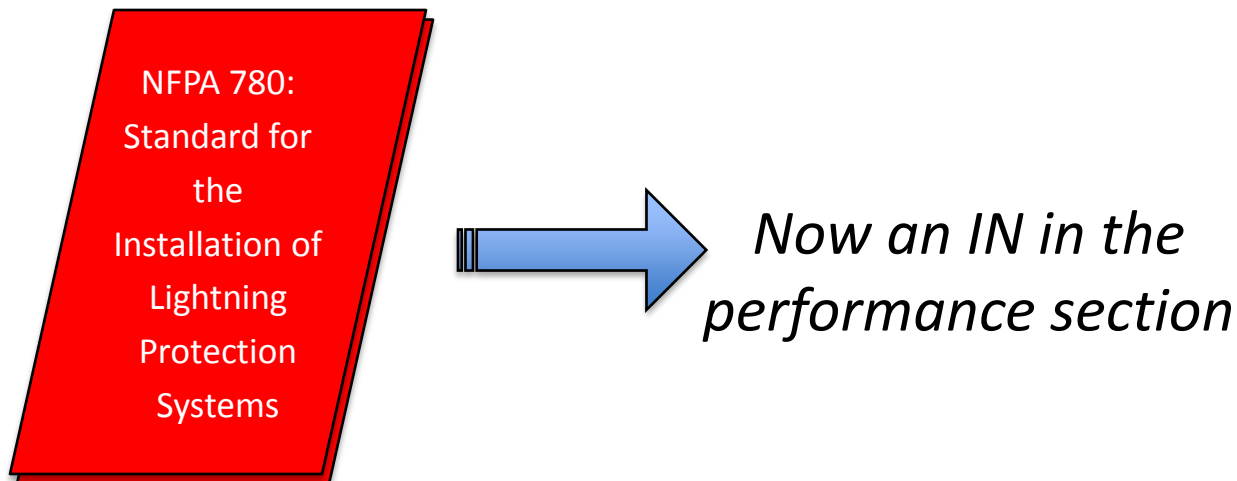
250.4 General Requirements for Grounding and Bonding

- The **prescriptive** methods contained in Article 250 shall be followed to comply with the performance requirements of this section.
 - What do we mean by “**prescriptive** methods?”
 - ✓ Found in the rest of Article 250
 - What do we mean by “performance requirements?”
 - ✓ Stated in 250.4(A) for Grounded Systems
 - ✓ Stated in 250.4(B) for Ungrounded Systems

250.4 General Requirements for Grounding and Bonding



- New Informational Notes added for:
 - 250.4(A)(1) and 250.4(B)(1)
- This performance section requires grounding to limit the effects caused by lightning
 - Now there is a reference for guidance



Other references to 780:



250.106 Lightning Protection Systems.

500.4(B) Reference Standards for HZ locations

620.37 Wiring in Hoistways, Machine Rooms, Control Rooms, Machinery Spaces, and Control Spaces.

690.4(B) Tower Grounding and Bonding.

810.18 Clearances — Receiving Stations.

250.4(A)(1) Electrical System Grounding

- What is meant by:

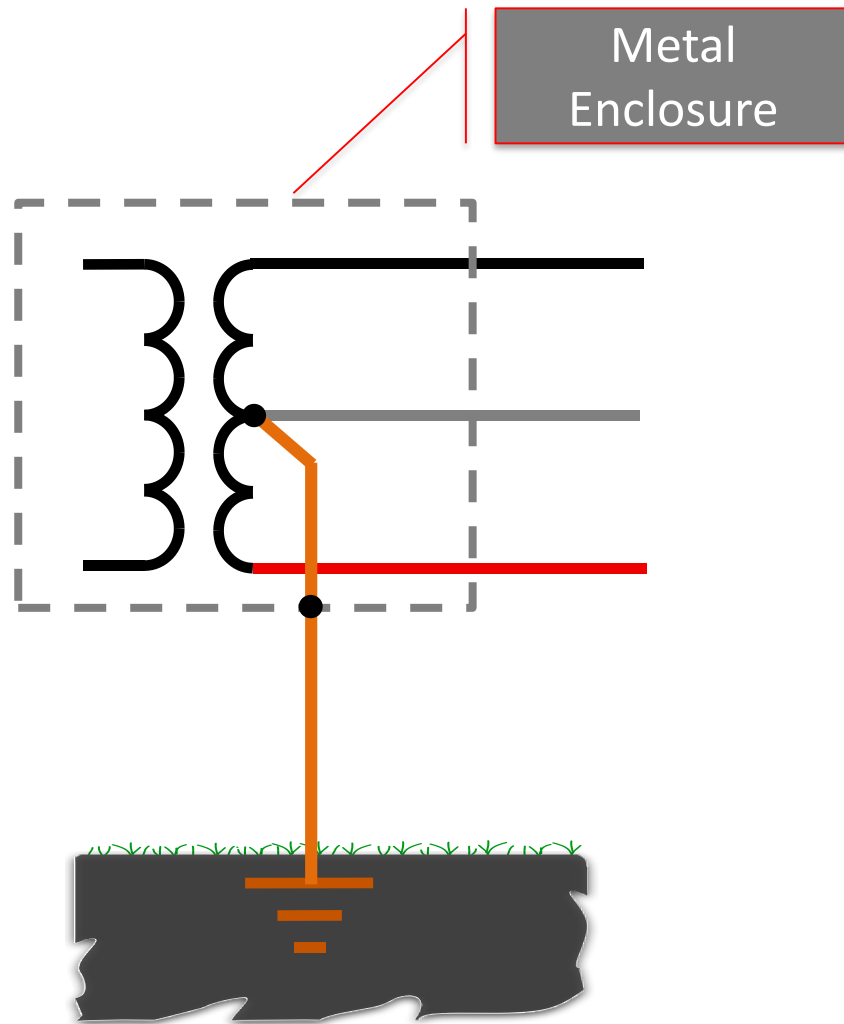
“without disturbing the permanent parts of the installation”

- Generally means extra (heroic) efforts not required to route these conductors. For example:
 - ✓ Drilling through partitions
 - ✓ Drilling through block walls
- ✓ However, always make sure you are following the intent of the rule

What do your grounding paths look like?

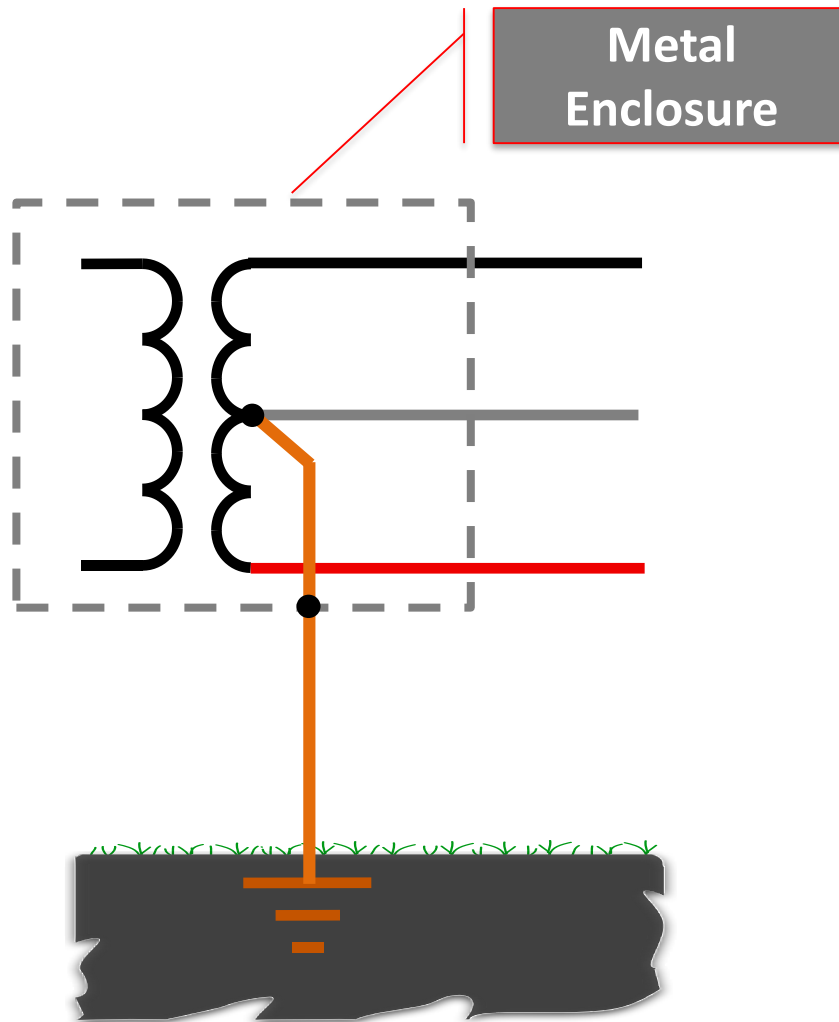


Reason #2: 250.4 (A)(2)... Stabilize the voltage to earth during normal operation



Requirements to ground this distribution system will appear later in Article 250.

Stabilizing Voltage – Grounded System



- Ground (the Earth) is always at zero potential.
- By connecting to ground; the capacitance issue is eliminated.
- Voltage will not vary as load is varied (Stabilized)

250.4(A)(2) Grounding of Electrical Equipment

- Applies to:
 - Normally non-current-carrying conductive materials enclosing electrical conductors or equipment, or forming part of such equipment
- The prescriptive method:
 - ✓ shall be connected to earth
- The performance requirement:
 - ✓ so as to limit the voltage to ground on these materials.

250.4(A)(3) Bonding of Electrical Equipment

- Applies to:
 - Normally non–current-carrying conductive materials enclosing electrical conductors or equipment, or forming part of such equipment,
- Must be connected together and to the electrical supply source in a manner that establishes an **effective ground-fault current path**.

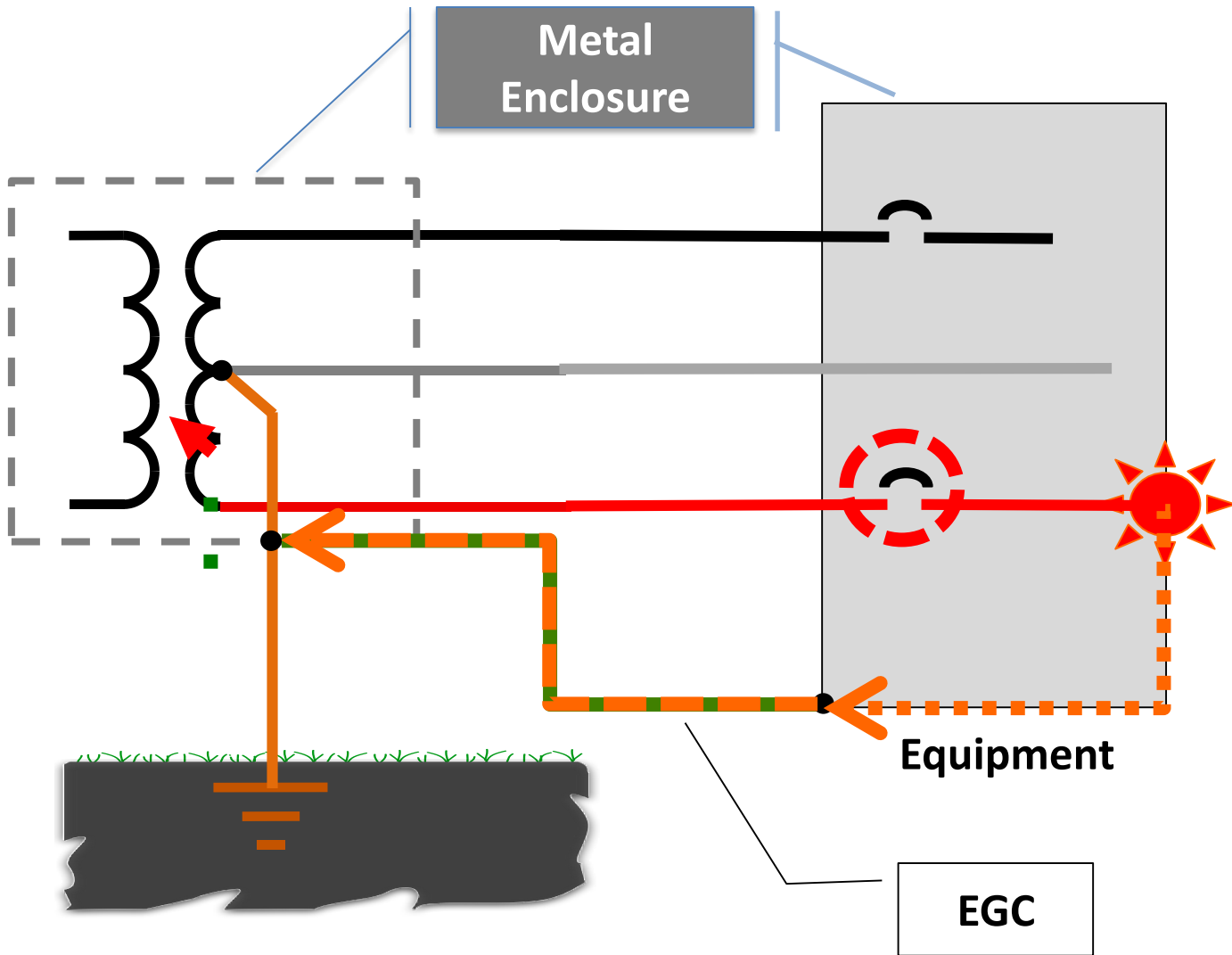
250.4(A)(4) Bonding of Electrically Conductive Materials and other Equipment

- Applies to:
 - Normally non-current-carrying electrically conductive materials that are likely to become energized
- Must be connected together and to the electrical supply source
- The connection(s) must establish an **effective ground-fault current path.**

What is: An Effective Ground Fault Current Path – ART. 100

- ✓ Intentionally constructed
- ✓ Low-impedance electrically conductive path
- ✓ Designed and intended to carry current under ground-fault conditions
 - from the point of a ground fault on a wiring system
 - to the electrical supply source
- ✓ Facilitates operation of the overcurrent protective device or ground fault detectors on high-impedance grounded systems.

Facilitating the OCPD



Points of:
*unintentional
electrically
conducting
connections*

250.4(A)(5) Effective Ground-Fault Current Path

- Must be capable of safely carrying the maximum ground-fault current likely to be imposed on it
 - from any point on the wiring system where a ground fault may occur to the electrical supply source.
- The earth shall not be considered as an effective ground-fault current path.

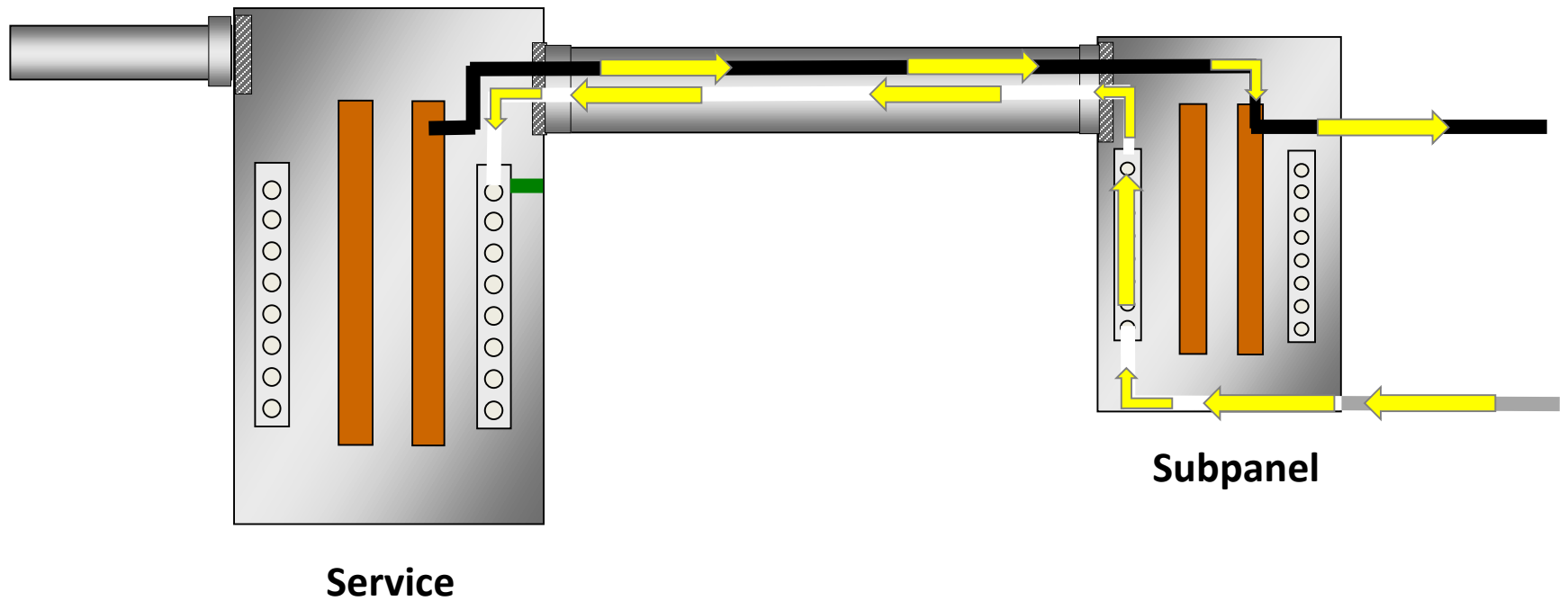


250.4(B) Ungrounded Systems

Review 250.4(B) Ungrounded Systems & compare to 250.4(A) for AC Systems

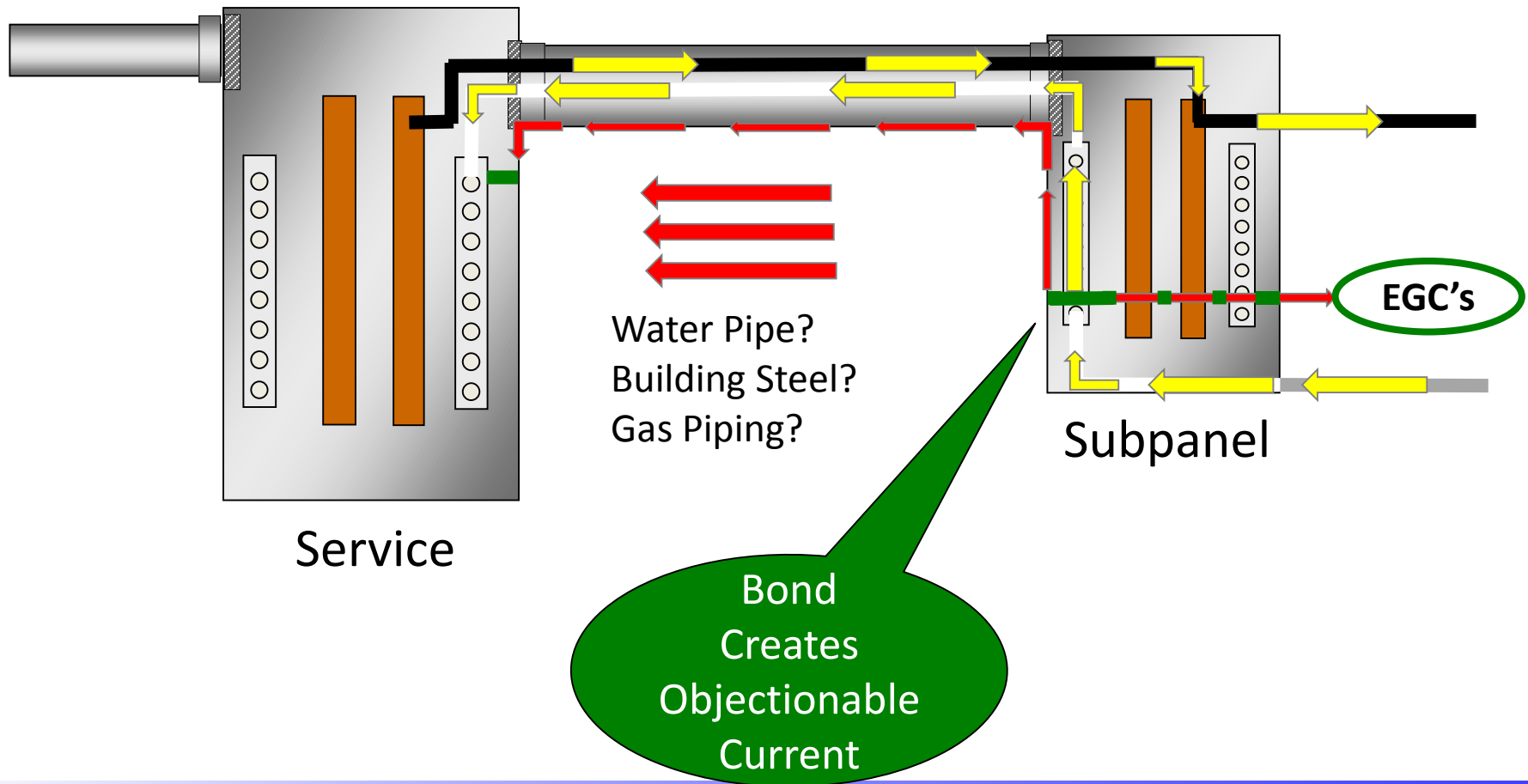
1. Grounding Electrical Equipment to limit the voltage to ground
2. Bonding of Electrical Equipment: to create a low-impedance path for ground-fault current
3. Bonding of Electrically Conductive Materials and Other Equipment: to create a low-impedance path for ground-fault current
4. Path for Fault Current: to facilitate the operation of overcurrent devices should a second ground fault from a different phase occur

NEC 250.6 Prohibits Objectionable Current



GR11_vers1.0

Objectionable Current



250.8 Connection of Grounding and Bonding Equipment

- Section (A) requires one of eight methods be used for connecting
 - equipment grounding conductors
 - grounding electrode conductors, and
 - bonding jumpers
- 250.12 also requires “clean surfaces”

250.8 Connection of Grounding and Bonding Equipment

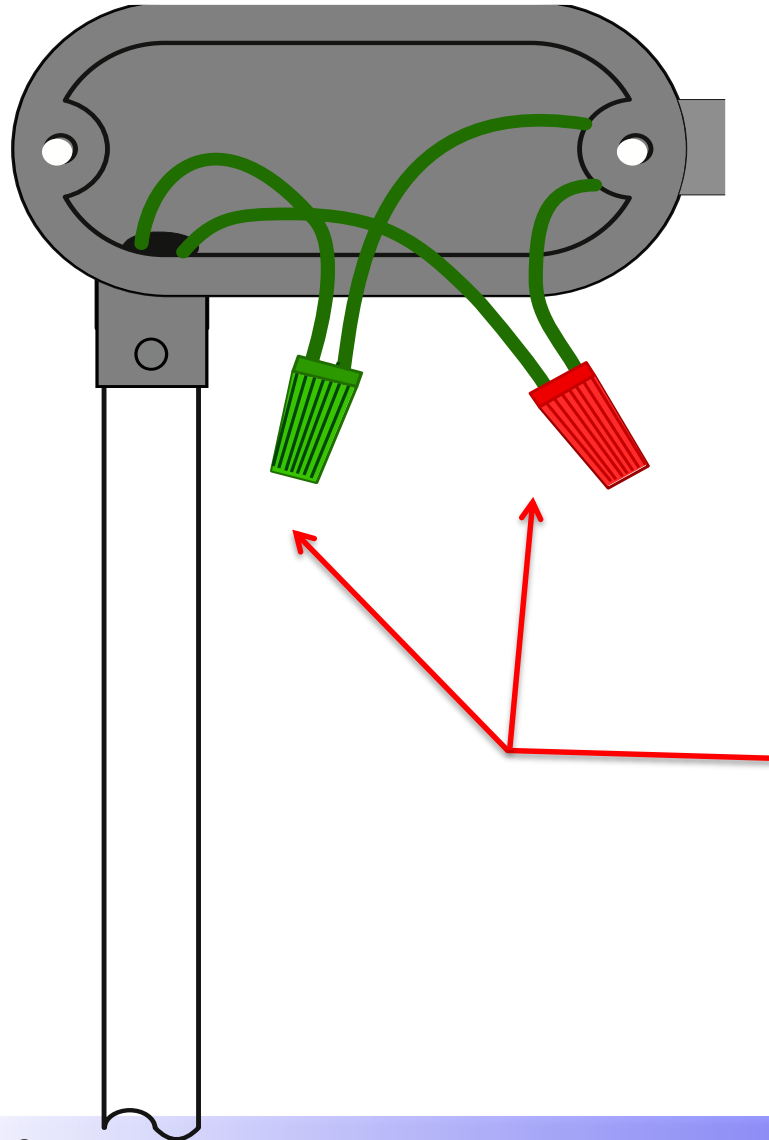
1. Listed pressure connectors
2. Terminal bars
3. Pressure connectors listed as grounding and bonding equipment
4. Exothermic welding process
5. Machine screw-type fasteners that engage not less than two threads or are secured with a nut

250.8 Connection of Grounding and Bonding Equipment

6. Thread-forming machine screws that engage not less than two threads in the enclosure
7. Connections that are part of a listed assembly
8. Other listed means

1. Listed Pressure Connectors

Includes conventional twist-on wire connectors.



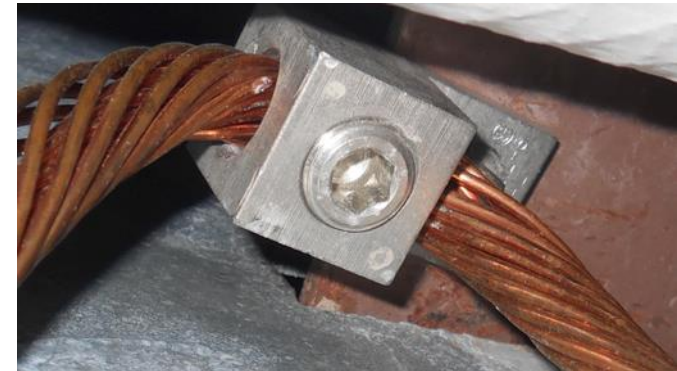
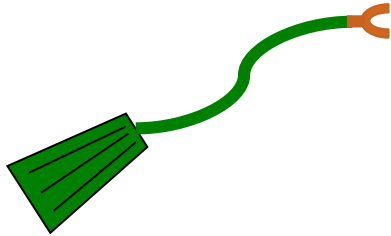
Either are permissible for
use with the EGC

2. Terminal Bar

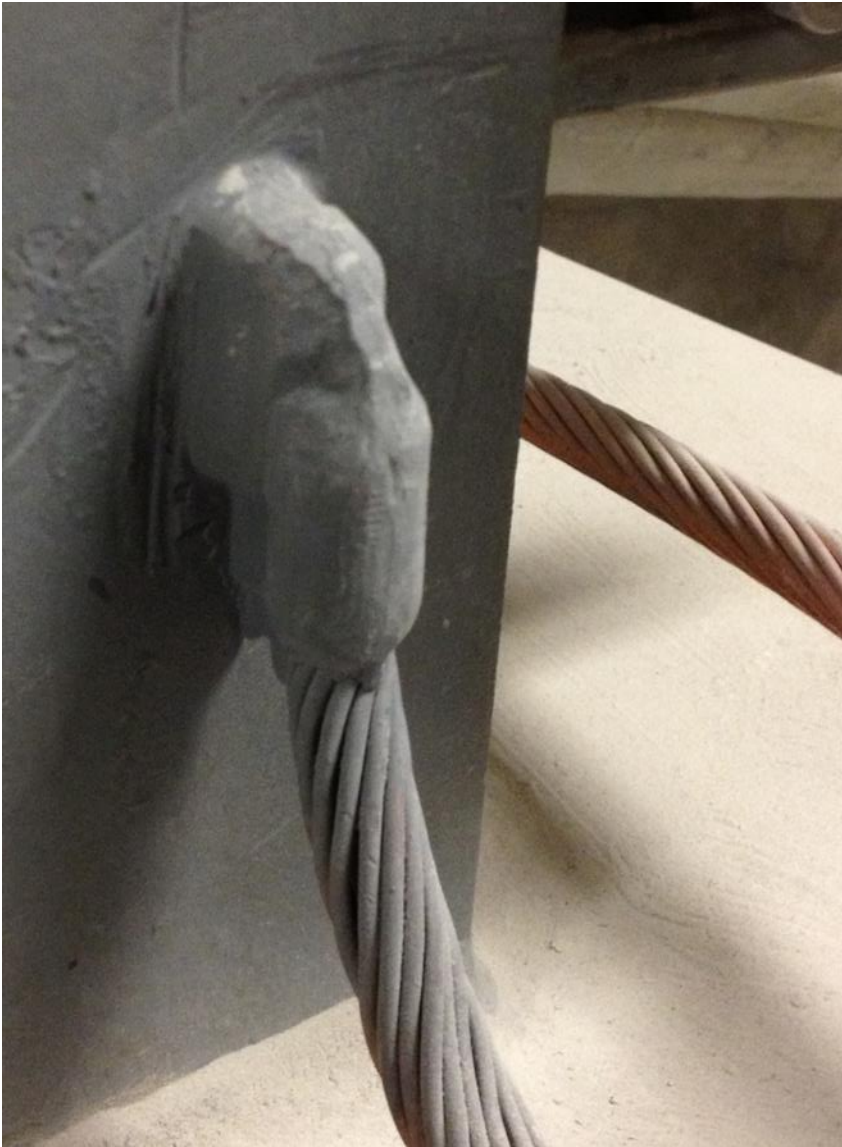
- Commonly installed in panels, switchboards, motor control centers
- Also installed where the NEC prohibits conventional splicing devices.
 - Example: 680.23(F)(2) grounding luminaires



3. Pressure connectors listed as grounding and bonding equipment



4. Exothermic welding process



Exothermic Weld to a vertical steel surface.

5. A machine screw that engages no fewer than two threads

- For 10-32 screw pitch is 32 threads per inch
 - $1/16^{\text{th}}$ inch thick metal enclosure then would allow two threads to be engaged.
 - If not $1/16^{\text{th}}$ inches thick
 - Manufacturer may have provided a screw for the purpose, or
 - the use of a nut is allowed.

6. Thread-forming machine screws that engage not less than two threads in the enclosure
- These are not “thread-cutting” screws
 - Sharp edges cut metal and leave shavings behind
 - Thread forming screws
 - Leaves no material behind.
 - Three "lobes" that stick out and shape the material into a thread.
 - Formed threads tend to be stronger than cut threads.

7. Connections that are part of a listed assembly

- Equipment comes with grounding terminals.
- Equipment, including grounding and bonding means supplied, must be used in accordance with its listing.

Listed pressure connectors are attached to the Grounding Bus per equipment manufacturer's instructions



GR11_vers1.0

8. Other listed means

- ✓ Article 100 provides definitions for “Listed” and “Labeled”
- ✓ UL White Book provides detailed information (KDER)
 - ground clamps
 - grounding and bonding bushings and locknuts
 - ground rods
 - armored grounding wire
 - Protector grounding wire
 - grounding wedges
 - ground clips
 - water meter shunts, and similar equipment.
 - Devices requiring a special tool specified by the manufacturer

The UL White Book (KDER: *Other Listed Means*)

- Ground clips are intended to be pressed on the flat surface of a square, rectangular, or octagonal box to hold a grounding conductor against the sidewall of the box.
- Not intended for use with round boxes.
- Typically used for connecting the grounding conductor of various wiring methods to outlet boxes or for connecting the bonding jumper from a receptacle, switch or other device to an outlet box.



Understanding Part II

250.20, 21 and 22

What systems do I ground?

250.24 – How to ground a Service

250.26 – Which conductor do I ground?

250.30 – How to ground a Separately Derived System

250.32 – How to ground a building supplied by a feeder

250.34 and 35 – How to ground generators

250.36 – How to ground High-Impedance Systems

250.20 Alternating-Current Systems to Be Grounded

- This section specifies 4 specific systems to be grounded.
- *Some systems are permitted to be grounded*
 - And if they are, obviously they must comply with Article 250
- Informational Note provides an example of a system permitted to be grounded as the **corner-grounded delta** transformer connection.
 - See 250.26(4) for conductor to be grounded

250.20 Alternating-Current Systems to Be Grounded

Subsection (A) requires systems less than 50 volts to be grounded if any of the following are true:

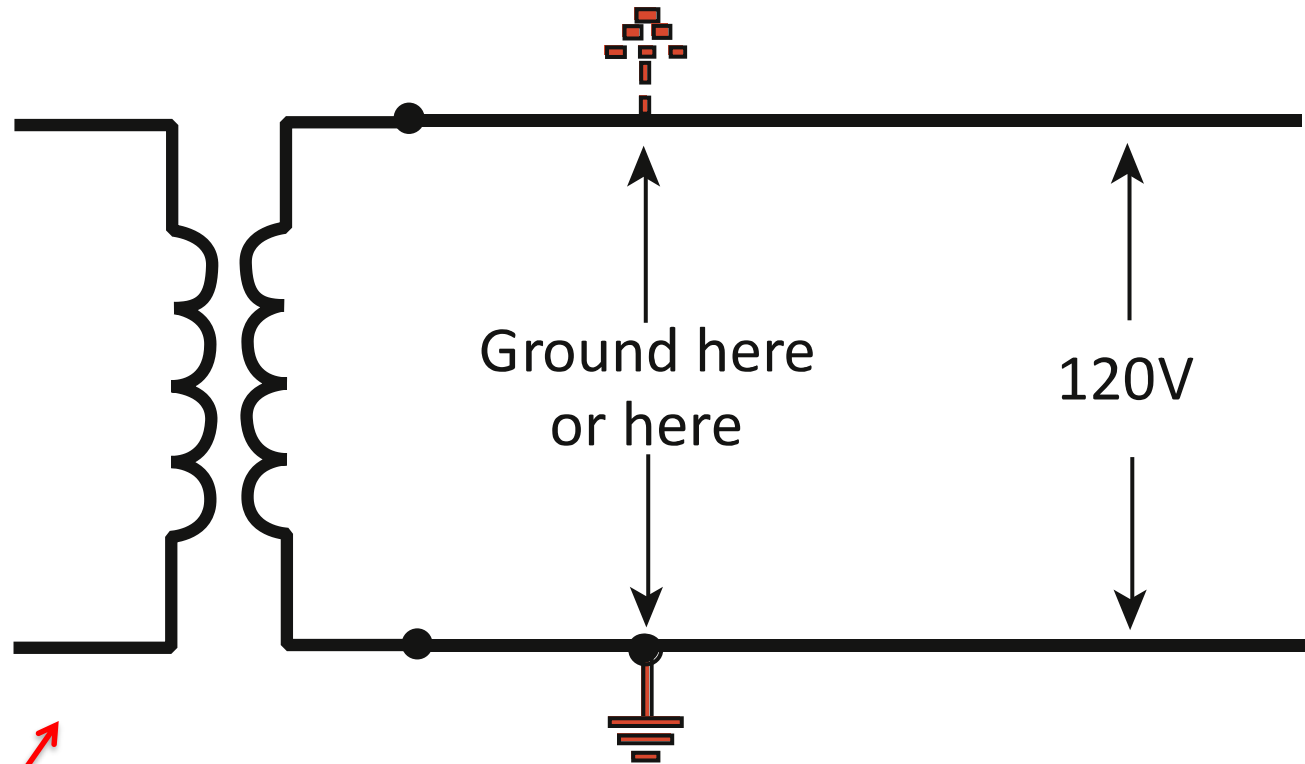
1. If the transformer supplying the system has a supply system that exceeds 150 volts.
2. If an ungrounded supply system supplies the transformer
3. If installed outside as overhead conductors

250.20 Alternating-Current Systems to Be Grounded

Subsection (B) requires systems of 50 volts to less than 1,000 vac to be grounded if any of the following are true:

1. If the system can be grounded so that the maximum voltage to ground does not exceed 150 volts
2. It is a 3 \emptyset , 4-wire system Wye and the neutral is used as a current carrying conductor
3. It is a 3 \emptyset , 4-wire system Delta and the center of one phase is used a current carrying conductor.

250.20(B) Alternating-Current Systems of 50 Volts to 1000 Volts

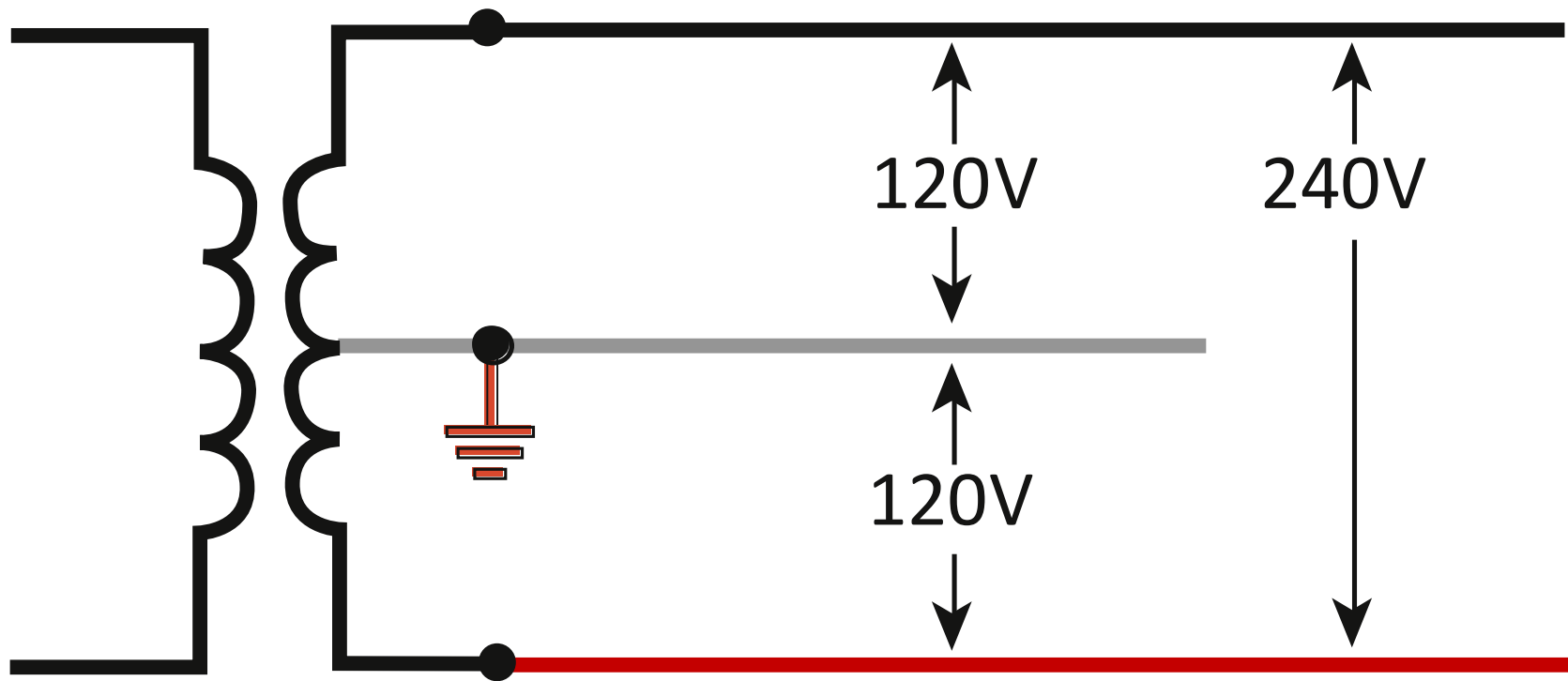


120-V, single-phase, 2-wire system

copyright 2013
NTT Inc.

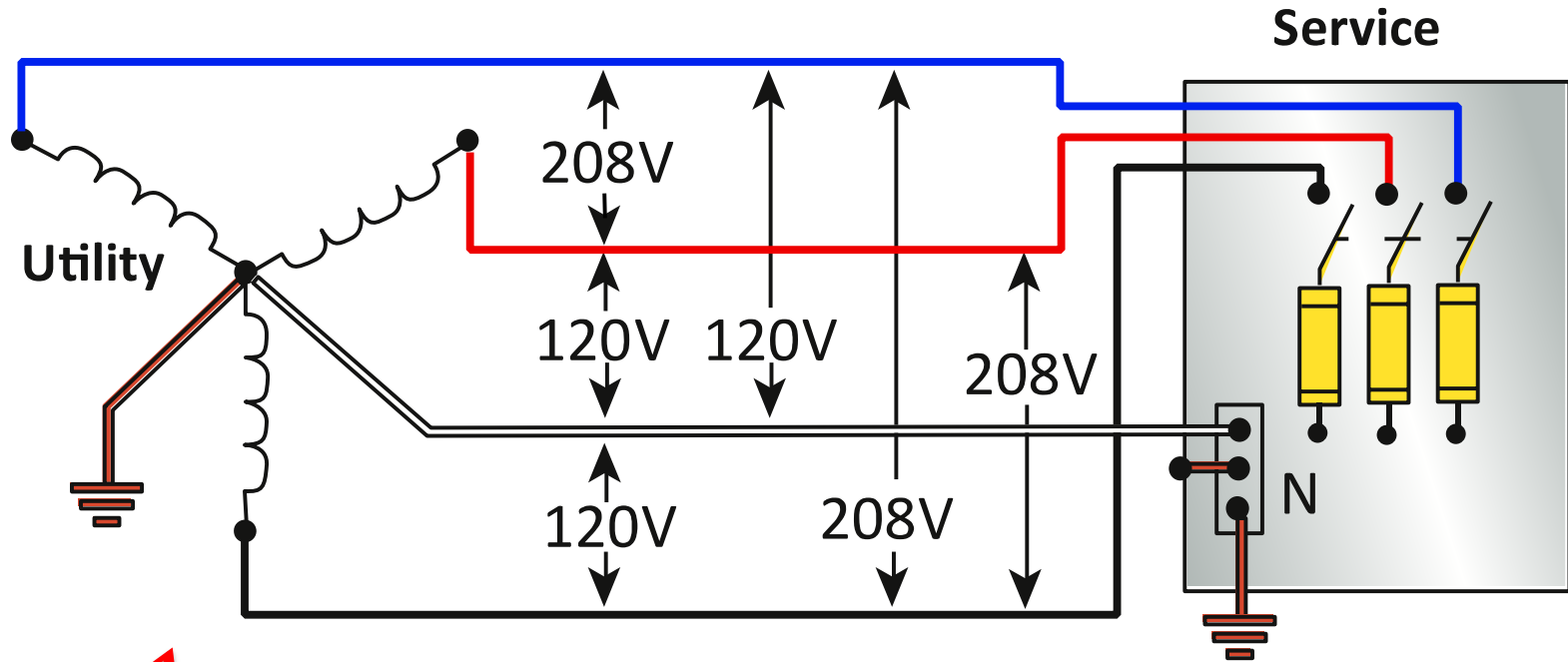
(1) Where the system can be grounded so that the maximum voltage to ground on the ungrounded conductors does not exceed 150 volts

250.20(B) Alternating-Current Systems of 50 Volts to 1000 Volts



(1) Where the system can be grounded so that the maximum voltage to ground on the ungrounded conductors does not exceed 150 volts

250.20(B) Alternating-Current Systems of 50 Volts to 1000 Volts

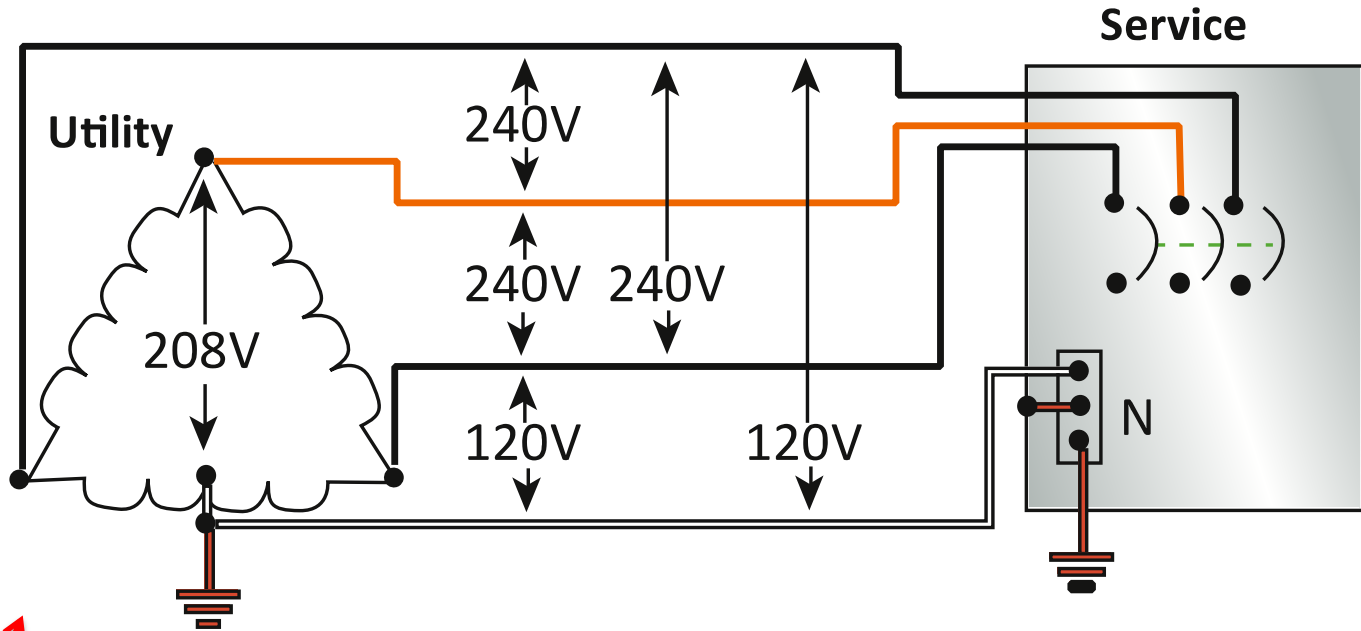


208Y/120-V, 3-phase, 4-wire wye system

copyright 2013
NTT Inc.

(2) Where the system is 3-phase, 4-wire, wye connected in which the neutral conductor is used as a circuit conductor

250.20(B) Alternating-Current Systems of 50 Volts to 1000 Volts



120/240-V, 3-phase, 4-wire delta system

copyright 2013
NTT Inc.

(3) Where the system is 3-phase, 4-wire, delta connected in which the midpoint of one phase winding is used as a circuit conductor

250.21 Alternating-Current Systems of 50 Volts to Less Than 1000 Volts Not Required to Be Grounded

Permitted (but not required to be grounded):

1. Electrical systems used exclusively to supply industrial electric furnaces for melting, refining, tempering, and the like
2. Separately derived systems used exclusively for rectifiers that supply only adjustable-speed industrial drives



250.21 Alternating-Current Systems of 50 Volts to Less Than 1000 Volts Not Required to Be Grounded

Permitted (but not required to be grounded):

1. Separately derived systems used exclusively for rectifiers that supply only adjustable-speed industrial drives



The transformer supplying the rectifier portion of this 5,000 Hp is permitted to be grounded.

250.21 Alternating-Current Systems of 50 Volts to Less Than 1000 Volts Not Required to Be Grounded

Permitted (but not required to be grounded):

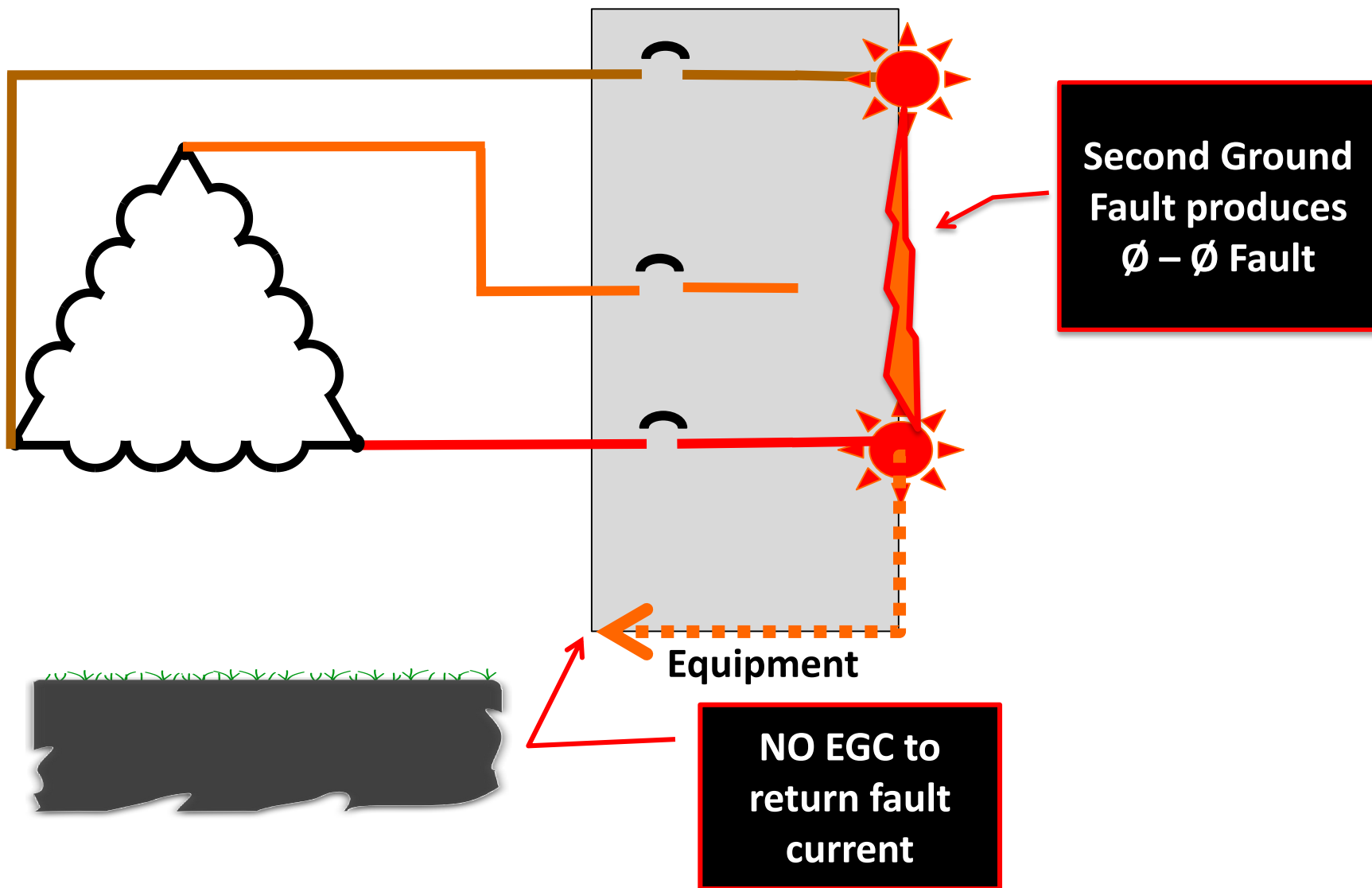
3. Separately derived systems supplied by transformers and must have a primary voltage rating less than 1000 volts, and meet all the following conditions:
 - a. The system is used exclusively for control circuits.
 - b. The conditions of maintenance and supervision ensure that only qualified persons service the installation.
 - c. Continuity of control power is required.
4. Other systems that are not required to be grounded
 - ✓ These are covered in 250.20 (B)

250.21(B) Requires Ground Detectors

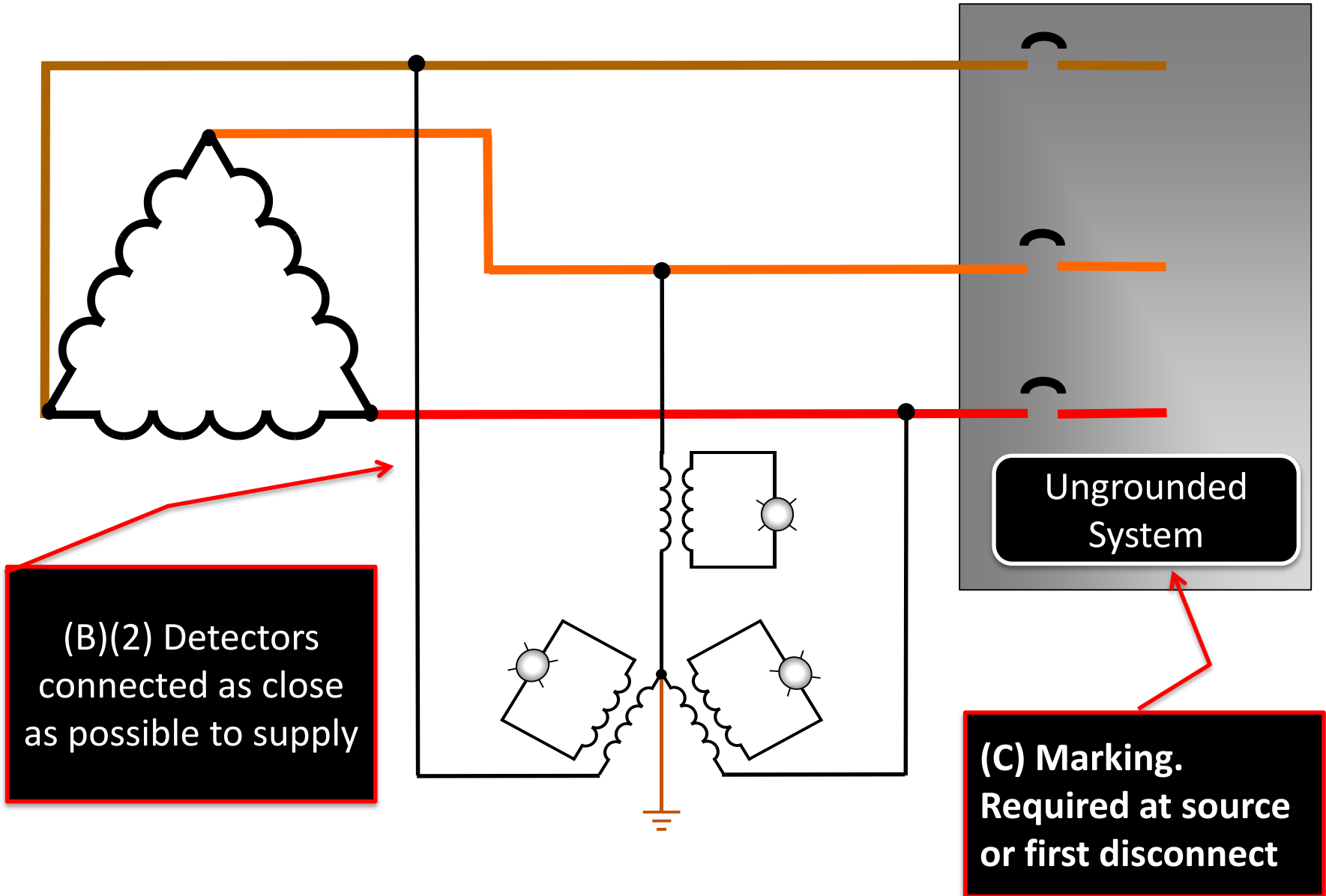
The two requirements:

- Ungrounded alternating current systems discussed in 250.21(A)(1) through (A)(4) must have ground detectors installed on the system.
 - These are systems operating at not less than 120 volts and not exceeding 1000 volts
- The ground detection sensing equipment shall be connected as close as practicable to where the system receives its supply.

First and Second Ground Faults on Ungrounded System



250.21(B) Ground Detectors Required



250.22 Specifies Circuits Not Permitted to be Grounded

- Cranes that operate over combustible fibers in Class III locations [503.155]
- Health care facilities (Isolated power systems and circuits in Article 517)
- Electrolytic Cells (Article 668)
- Low-voltage lighting systems as specified in 411.5(A)
- Secondary circuits of lighting systems as provided in 680.23(A)(2)

250.22 Circuits Not to Be Grounded.



- 2017 Change adds one additional circuit not to be grounded:
 6. Class 2 load side circuits for low-voltage suspended ceiling power distribution systems as provided in 393.60(B)
- These low-voltage systems have no means for a grounding conductor.

250.24 Grounding Service-Supplied Alternating-Current Systems

This section is broken into 4 important subsections:

(A) System Grounding Connections

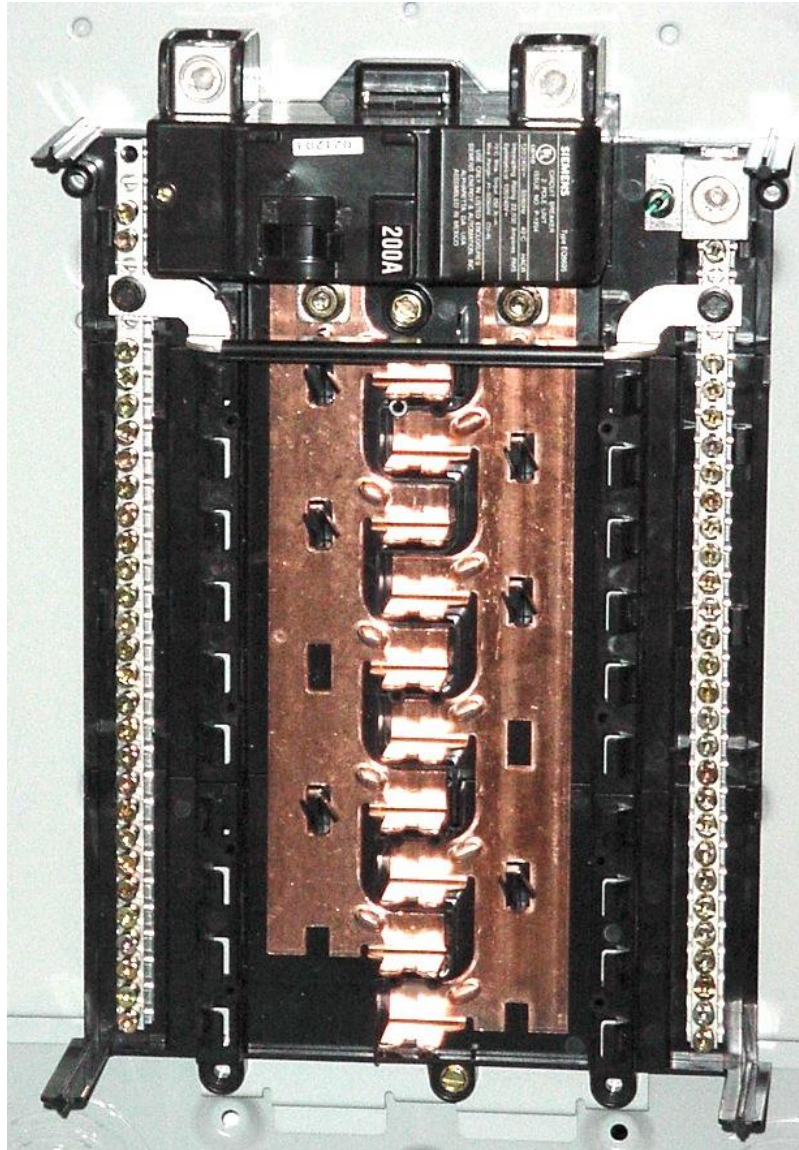
(B) Main Bonding Jumper

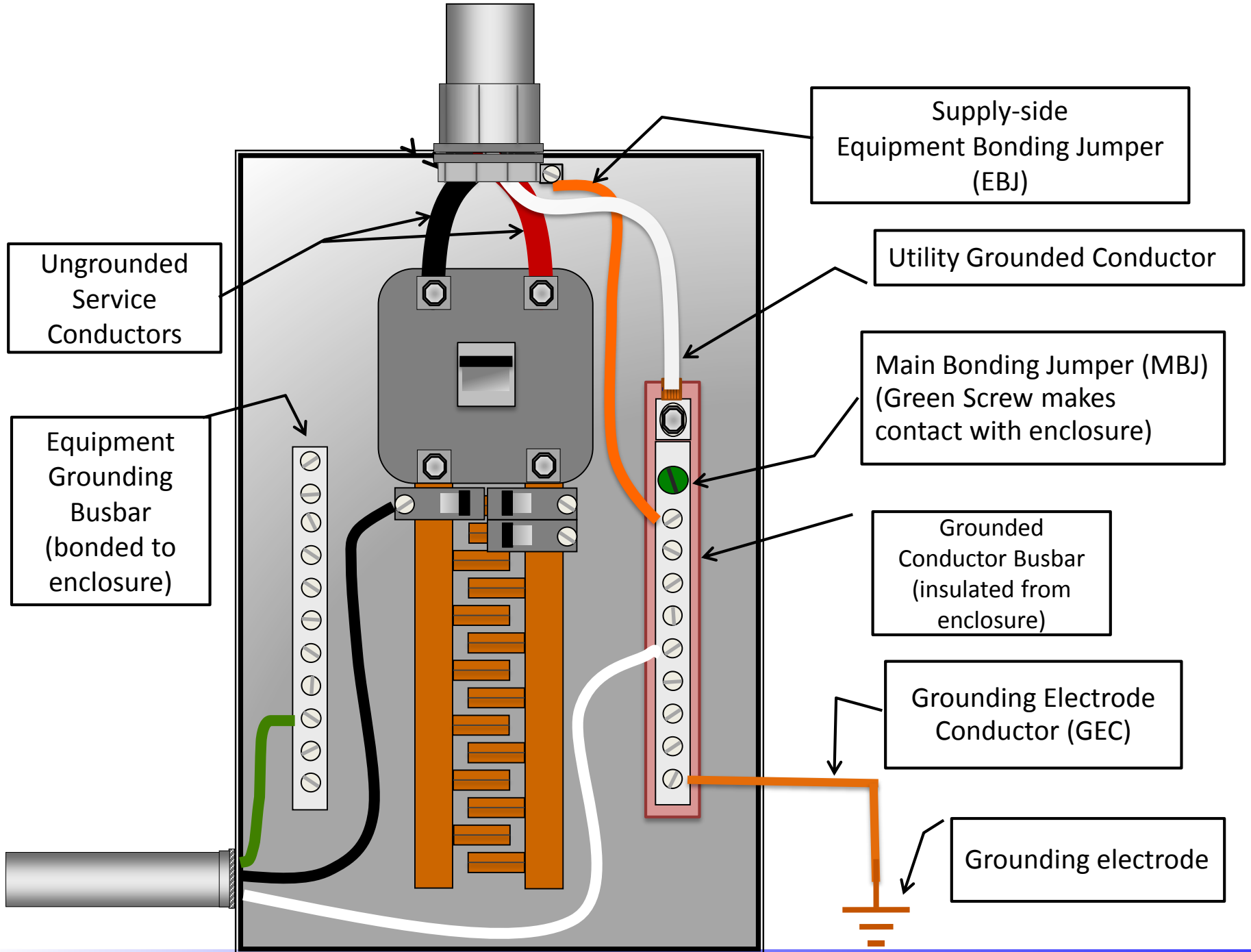
(C) Grounded Conductor Brought to Service Equipment

(D) Grounding Electrode Conductor

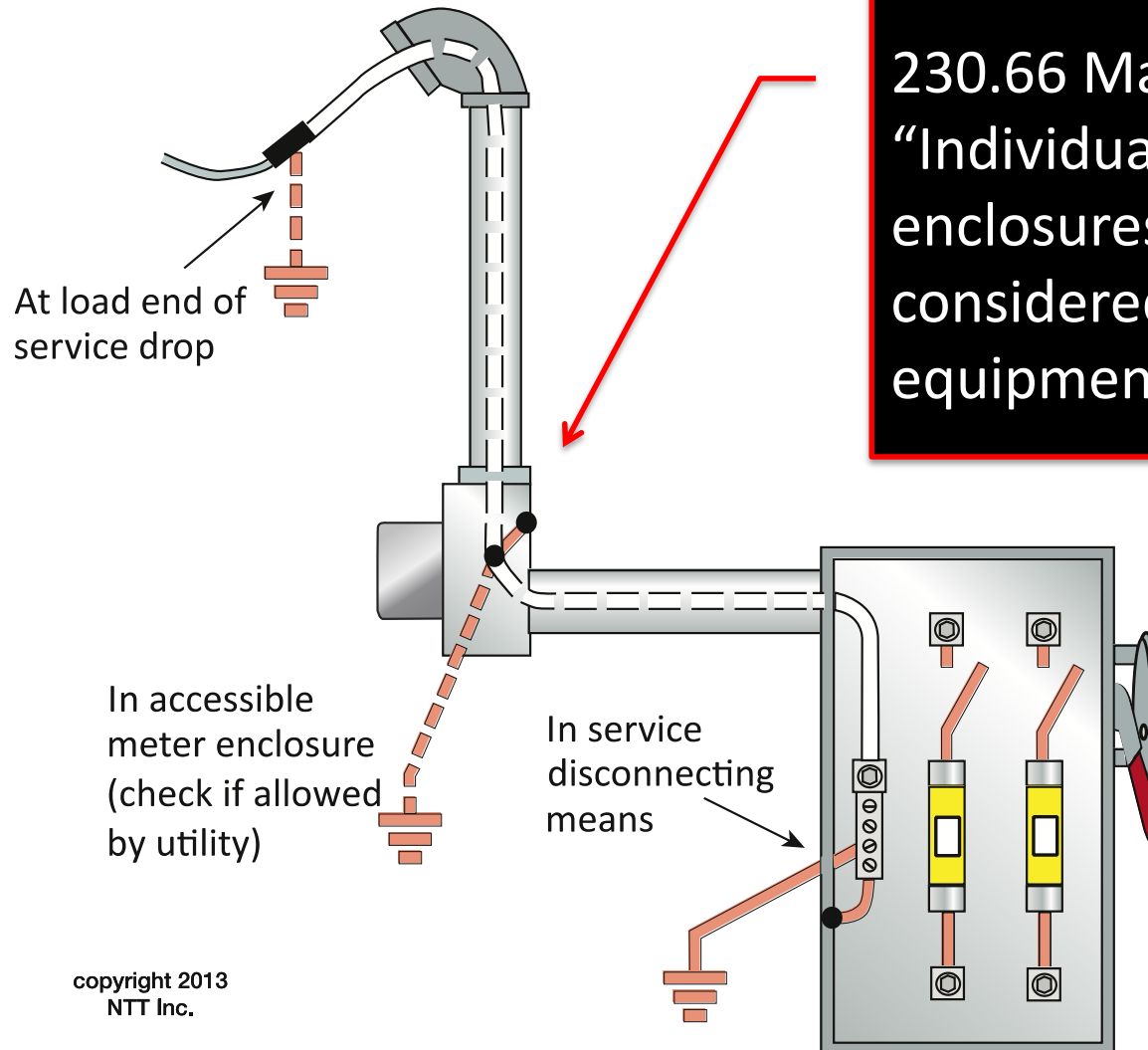
(E) Ungrounded System Grounding Connections

Panelboards are mounted in Cabinets or Cutout Boxes





250.24(A) specifies location of the GEC



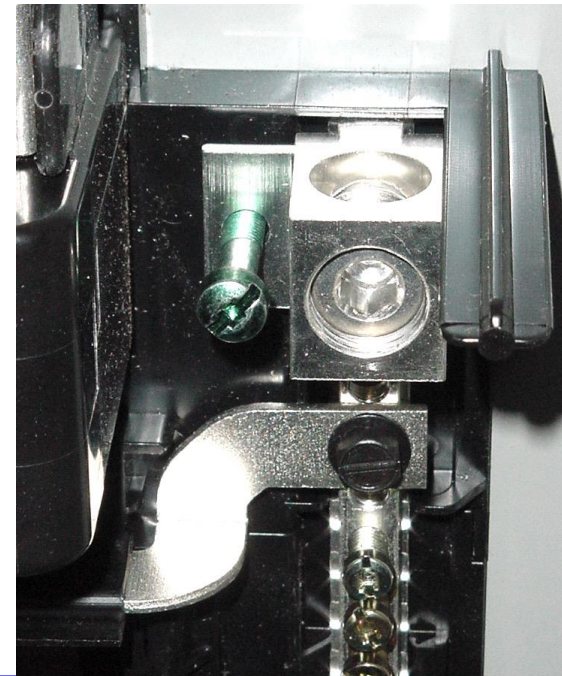
230.66 Marking ...
"Individual meter socket enclosures shall not be considered service equipment."

copyright 2013
NTT Inc.

250.28 Main Bonding Jumper and System Bonding Jumper

Main and system bonding jumpers must:

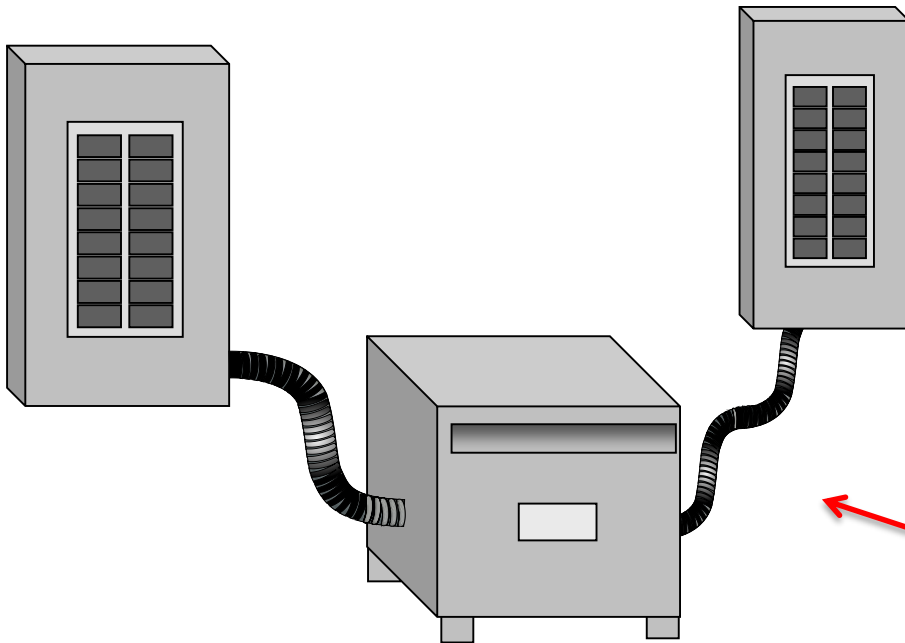
- Copper or other corrosion-resistant material
 - ✓ Must be a wire, bus, screw, or similar suitable conductor.
- If it is a screw only, the screw have a green finish that is visible with the screw installed.
- Must be connected as specified in 250.8
- Can not be smaller than Table 250.102(C)(1)



250.30 Grounding Separately Derived Alternating-Current Systems

Separately derived system that meets the criteria in 250.20(A) or (B) (*AC Systems to be Grounded*) are required to be grounded

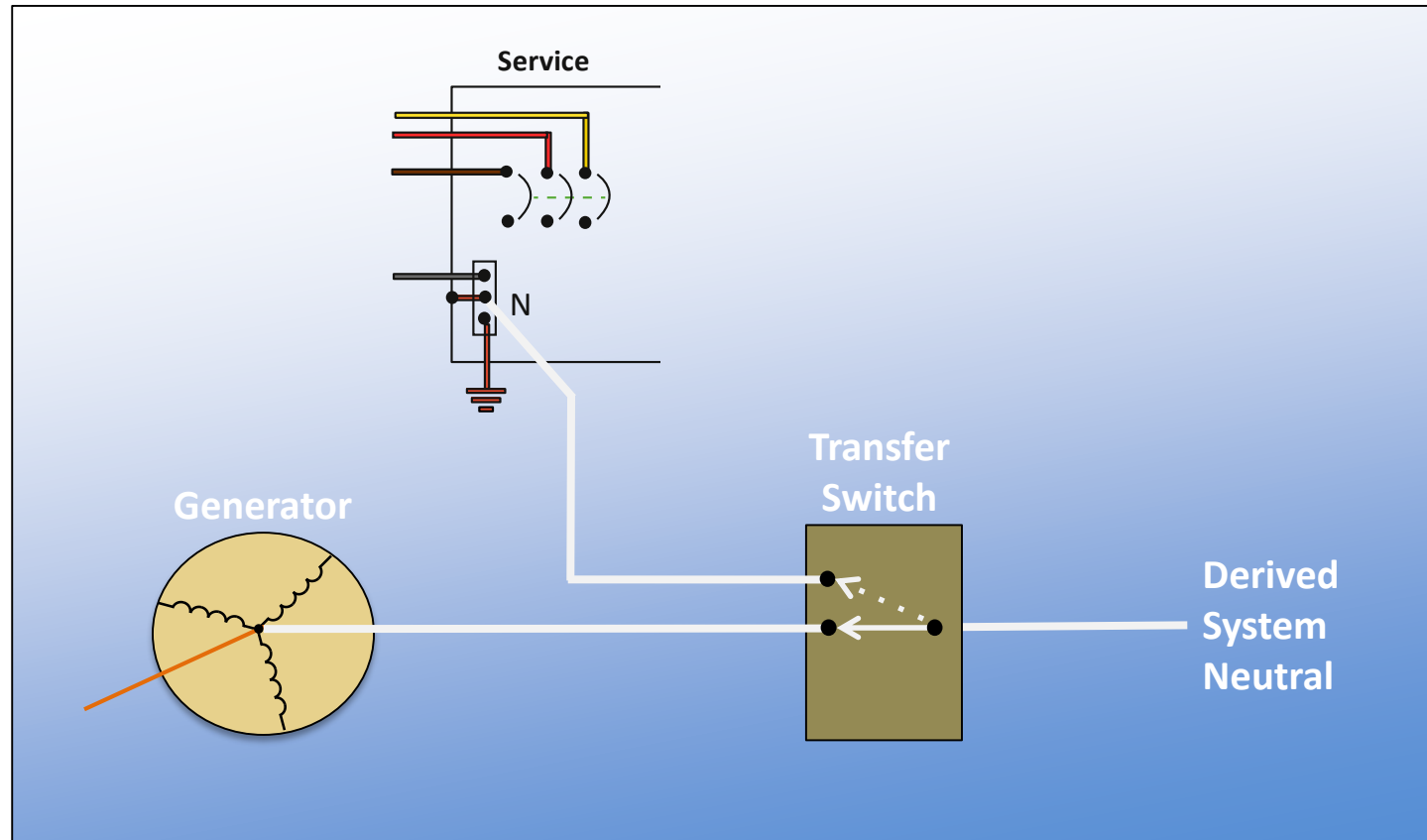
- ✓ Ground these systems in accordance with 250.30
- ✓ Each voltage level must be grounded at its source



250.20(B) requires systems to be grounded if:

- Max V-G does not exceed 150v, or
- 3 ϕ , 4-wire if Neutral used to carry current, or
- Delta connected with a neutral on one phase

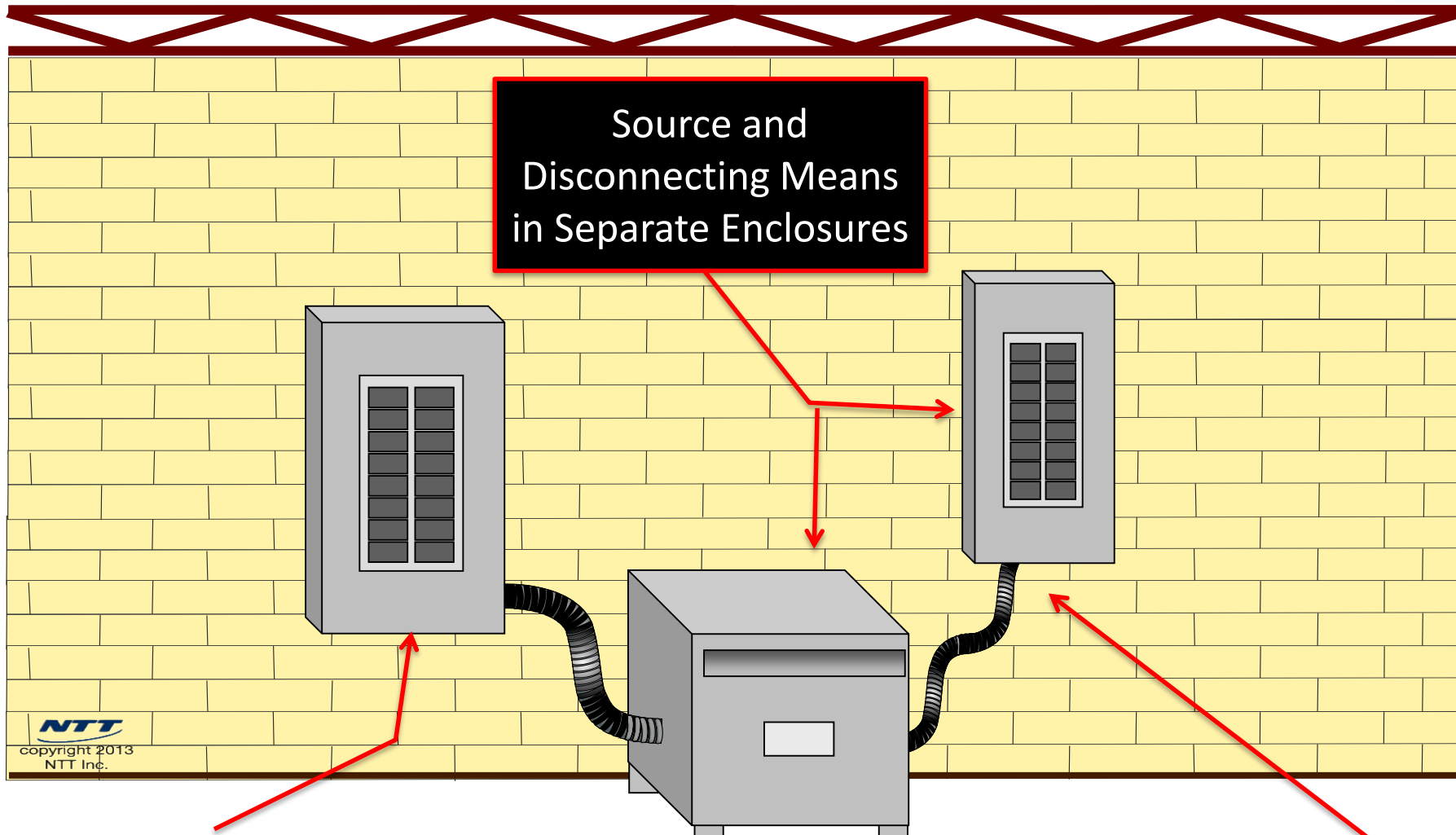
Generator – neutral is switched in the Transfer Switch from Service Neutral to Generator Neutral



250.30 Grounding Separately Derived Alternating-Current Systems

- If the source of a separately derived system and the first disconnecting means are located in separate enclosures, a supply-side bonding jumper is required to be installed with the circuit conductors from the source enclosure to the first disconnecting means
- Supply-side bonding jumper not required to be larger than the derived ungrounded conductors
- See 250.30(A)(2)

250.30(A)(2) Supply-Side Bonding Jumper



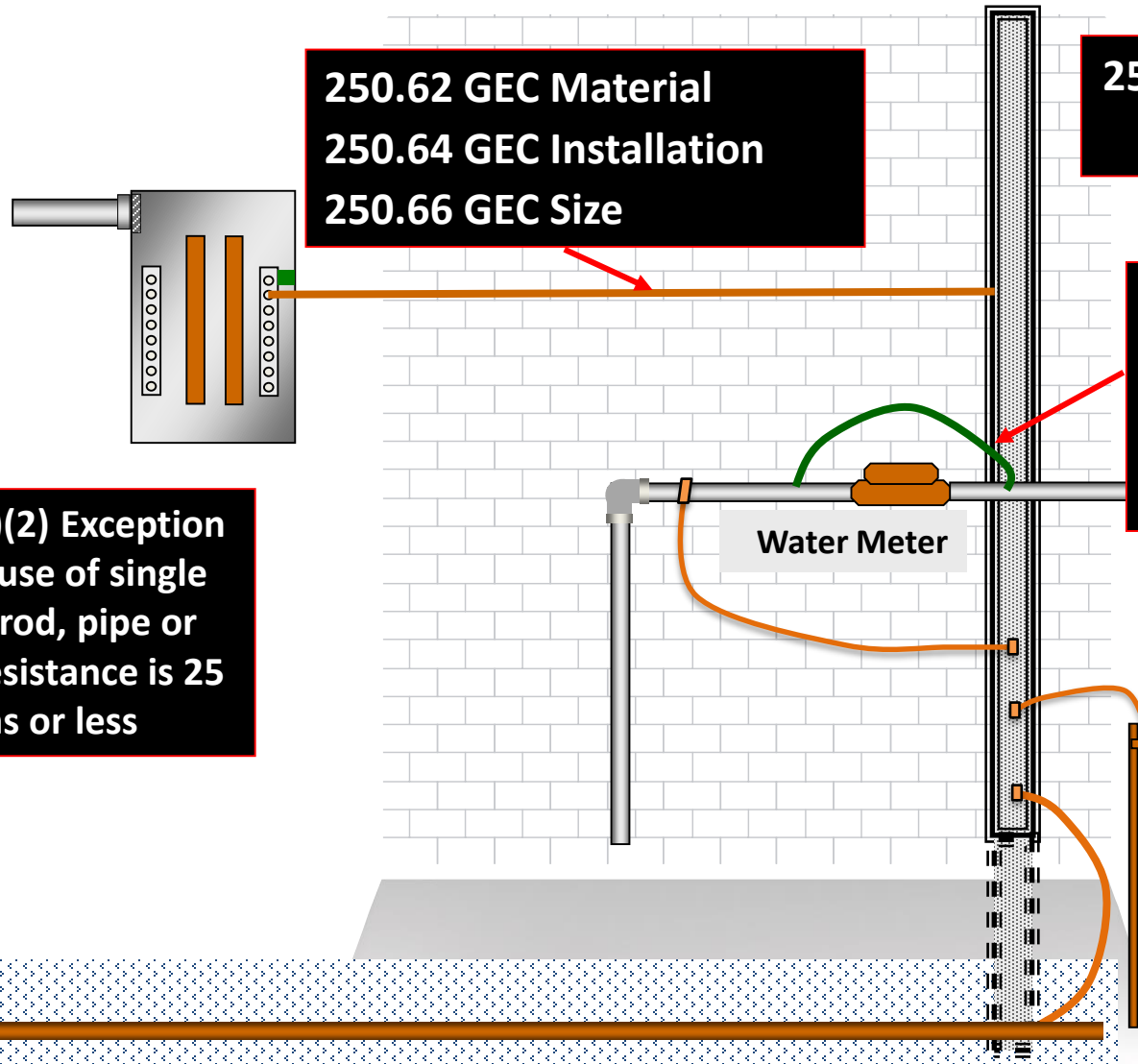
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- SSBJ installed with the circuit conductors
- From the source enclosure to the first disconnecting means

Supply-Side Bonding Jumper (*cont.*)

- Supply-side bonding jumper permitted to be of nonflexible metal raceway type or of the wire or bus type as follows:
 - Wire type is sized per 250.102(C), based on the size of the derived ungrounded conductors
 - The bus type must have a cross-sectional area not smaller than a supply-side bonding jumper of the wire type found in 250.102(C)
- 250.30(A)(2) requires a SSBJ be run from the source enclosure to the first disconnect if disconnect located separately from the source.

Article 250 Part III Grounding Electrode System



250.62 GEC Material
250.64 GEC Installation
250.66 GEC Size

250.52(A)(2) describes use of the building frame

250.68(B)
Bonding Jumper required around insulated joints

250.53(A)(2) Exception permits use of single ground rod, pipe or plate if resistance is 25 ohms or less

250.52 Grounding Electrodes
(A) Lists the 8 types permitted for grounding
(B) Lists what is not permitted

250.52(A)(3) Rebar

250.54 permits Auxiliary GEC's.

250.52(A)(2) and (A)(3)



Metal frame of the building or structure that is connected to the earth by either:

- Being in direct contact with the earth for 10 ft or more, or
- Hold-down bolts securing steel column to a Concrete-Encased Electrode.



250.52(A)(2)(2)

- ✓ **Hold-down bolts securing the structural steel column that are connected to a concrete-encased electrode located in the support footing or foundation.**
- ✓ **Hold-down bolts are connected to the concrete-encased electrode by an approved means.**



250.50 Grounding Electrode System

- All grounding electrodes in 250.52(A)(1) through (A)(7) that are present must be bonded together to form the grounding electrode system.
- If none of these grounding electrodes exist, then
 - one or more of the grounding electrodes specified in 250.52(A)(4) through (A)(8) must be installed and used:
 4. Ground Ring
 5. Rod or Pipe
 6. Other Listed
 7. Plate Electrodes
 8. Other Local Underground Systems or Structures

250.52 Grounding Electrodes

(A) Electrodes Permitted for Grounding.

- (1) Metal Underground Water Pipe
- (2) Metal Frame of the Building or Structure
- (3) Concrete-Encased Electrode
- (4) Ground Ring
- (5) Rod and Pipe Electrodes
- (6) Other Listed Electrodes
- (7) Plate Electrodes
- (8) Other Local Metal Underground Systems or Structures

250.52 Grounding Electrodes

(B) The following shall not be used as grounding electrodes:

- (1) Metal underground gas piping system
- (2) Aluminum electrodes

An Informational Note references to 250.104(B) for bonding requirements of gas piping

250.104(B) has an IN referencing section 7.13 of NFPA 54 – 2012; the National Fuel Gas Code

(A) Electrodes Permitted for Grounding.

(2) “Metal In – Ground Support Structures” is a new term and the section has been revised for clarity



The metal frame of this building is not really in “direct” contact with the earth. Pilings, etc. support the building and contact the earth





(A) Electrodes Permitted for Grounding.

(2) Metal In – Ground Support Structures.

New terminology

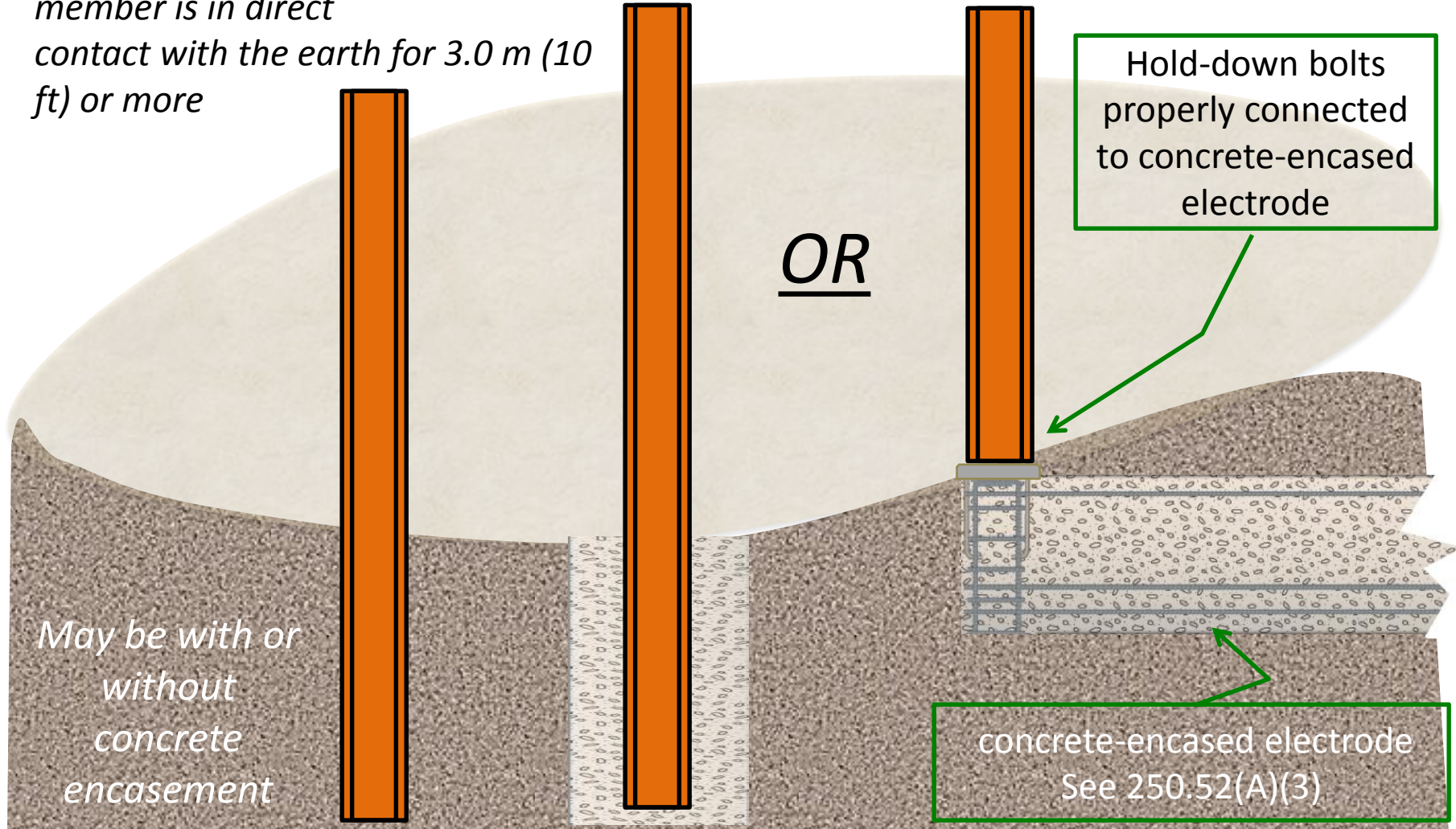
- (2) One or more metal in-ground support structure(s) in direct contact with the earth vertically for 3.0 m (10 ft) or more, with or without concrete encasement. If multiple metal in-ground support structures are present at a building or a structure, it shall be permissible to bond only one into the grounding electrode system.

NEW Informational Note provides examples: pilings, casings, and other structural metal.

250.52 (A) Electrodes Permitted for Grounding.



At least one structural metal member is in direct contact with the earth for 3.0 m (10 ft) or more



May be with or without concrete encasement

OR

Hold-down bolts properly connected to concrete-encased electrode

concrete-encased electrode
See 250.52(A)(3)



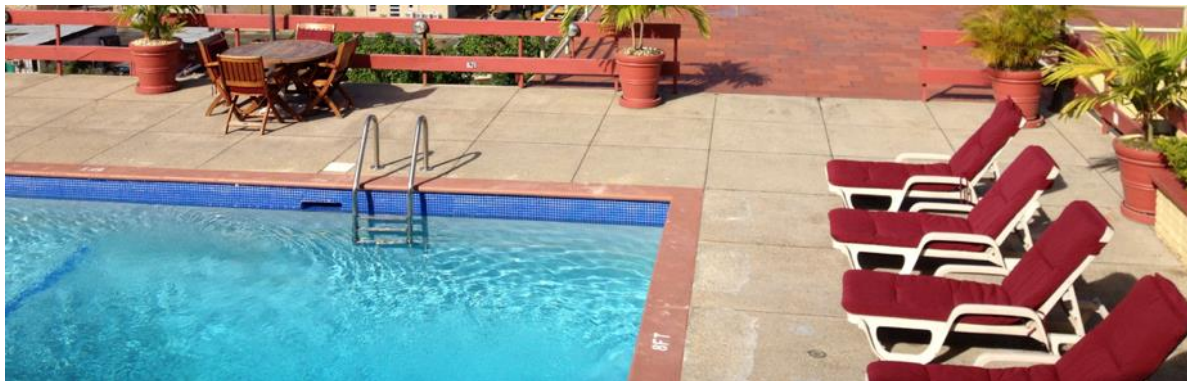
250.52(B) Not Permitted for Use as Grounding Electrodes.

- A new item (3) has been added to this list:

“The structures and structural reinforcing steel described in 680.26(B)(1) and (B)(2)”

- These are conductive pool shells and the perimeter surfaces described in Article 680 Swimming Pools, Fountains, and Similar Installations

680.26 provides for Equipotential Bonding – not grounding electrode systems.



250.53 Grounding Electrode System Installation

This section is divided to address the installation requirements for grounding electrodes as follows:

- (A) Rod, Pipe, and Plate Electrodes
- (B) Electrode Spacing
- (C) Bonding Jumper
- (D) Metal Underground Water Pipe
- (E) Supplemental Electrode Bonding Connection Size
- (F) Ground Ring
- (G) Rod and Pipe Electrodes
- (H) Plate Electrode

250.54 Auxiliary Grounding Electrodes



- One or more grounding electrodes shall be permitted to be connected to the equipment grounding conductors specified in 250.118
- They must not be required to comply with the electrode bonding requirements of 250.50 or 250.53(C) or the resistance requirements of 250.56
- The earth shall not be used as an effective ground-fault current path as specified in 250.4(A)(5) and 250.4(B)(4)

V. Bonding 250.90 General

Bonding is provided where necessary to ensure

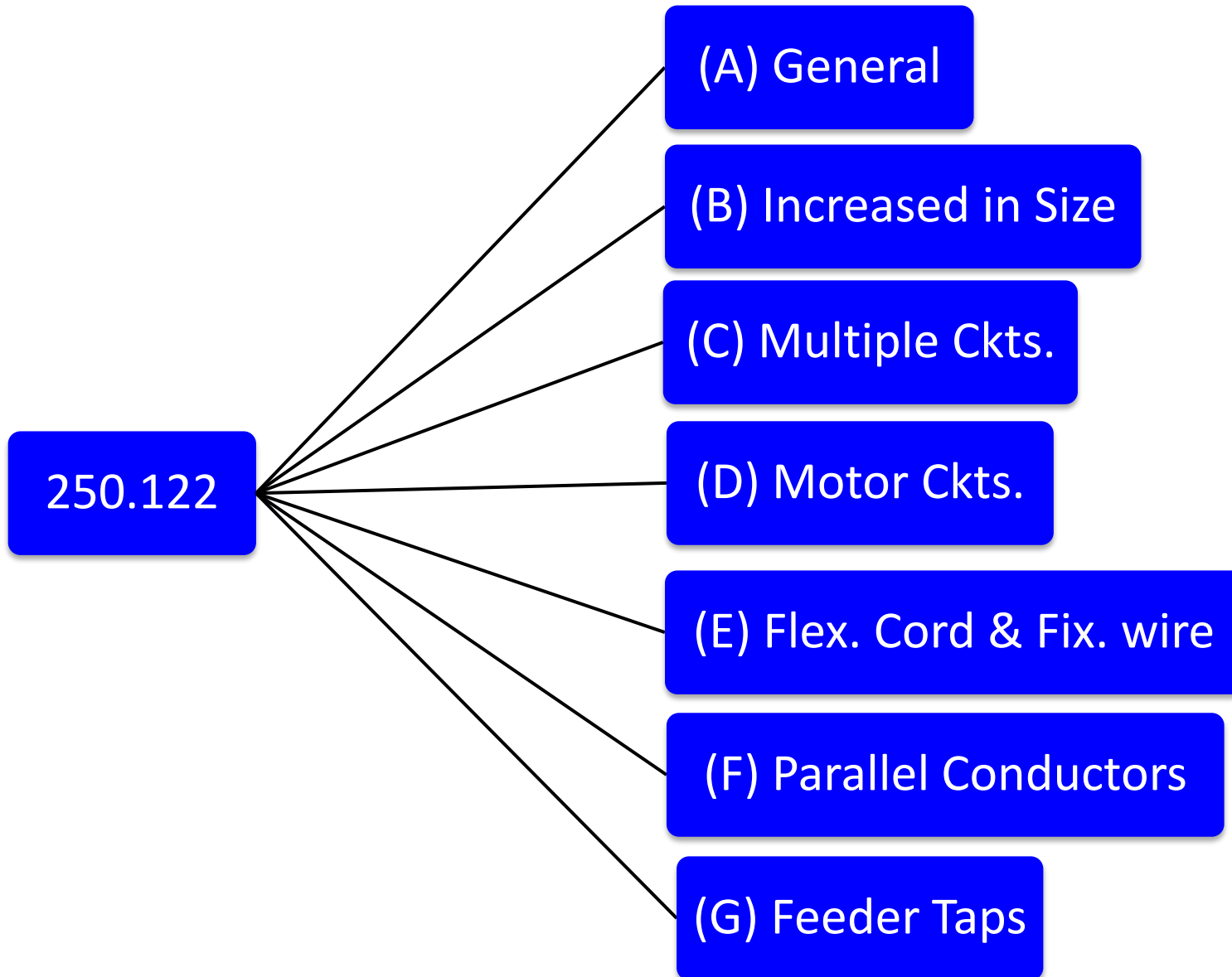
- electrical continuity and
- the capacity to conduct safely any fault current likely to be imposed.



Table 250.102 (C)(1) Sizing Grounded Conductors and Bonding Jumpers

- Provides minimum size for:
 1. Supply-side bonding jumpers
 2. Grounded Conductors
 3. Main Bonding Jumpers
 4. System Bonding Jumpers
- ✓ Four “Notes” appear at the bottom of this table.
- References to this table appear in appropriate sections

250.122 Size of Equipment Grounding Conductors



250.122(B) Increased in Size Application

- A 240-V, single-phase, 250-A load is supplied from a 300-A breaker located in a panelboard 500 ft away.
- The conductors are 250 kcmil copper, installed in rigid nonmetallic conduit, with a 4 AWG copper EGC.
- If the conductors are increased to 350 kcmil, what is the minimum size for the EGC based on the proportional-increase requirement?

Step 1. Calculate the size ratio of the new conductors to the existing conductors:

$$\text{Size ratio} = \frac{350,000 \text{ circular mils}}{250,000 \text{ circular mils}} = 1.4$$

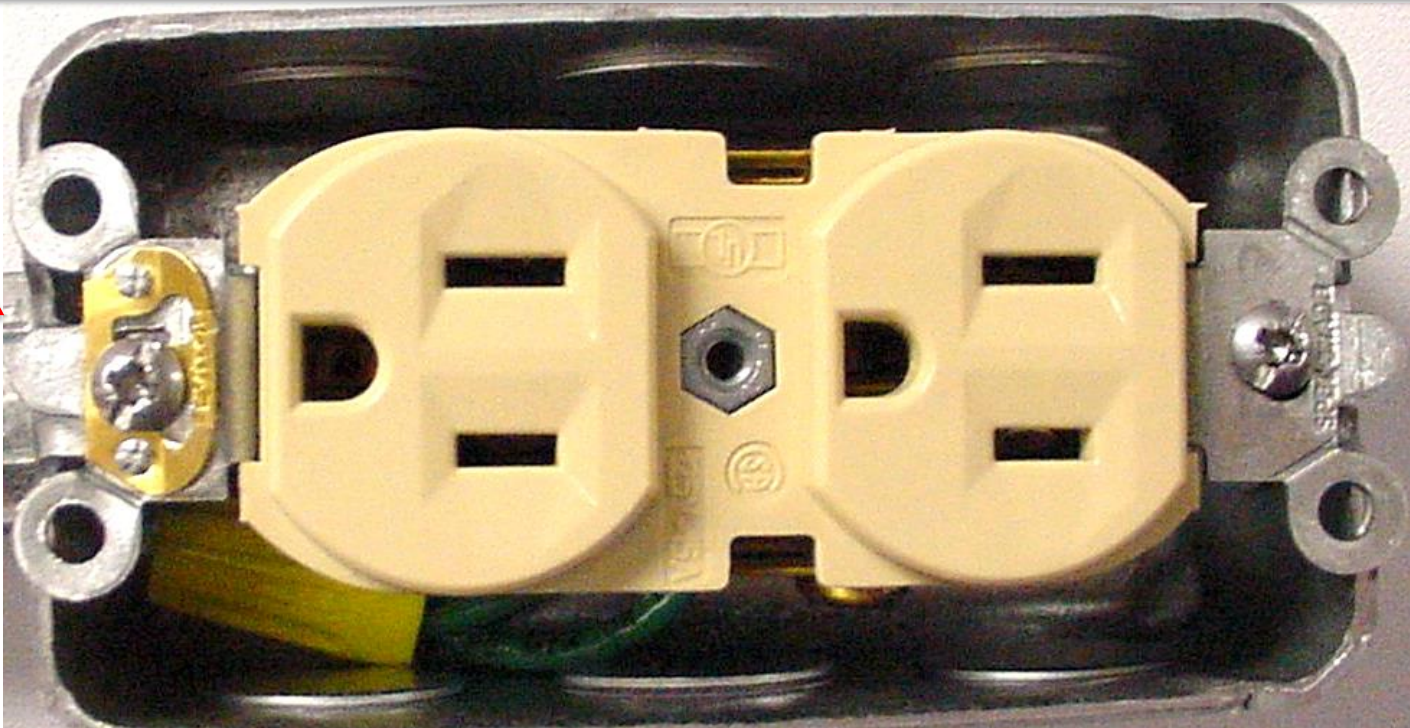
Step 2. Calculate the cross-sectional area of the new EGC

$$41,740 \text{ circular mils} \times 1.4 = 58,436 \text{ circular mils}$$

- Per Chapter 9, Table 8: 4 AWG = 41,740 cm
- 2 AWG copper EGC = 66,360 cm

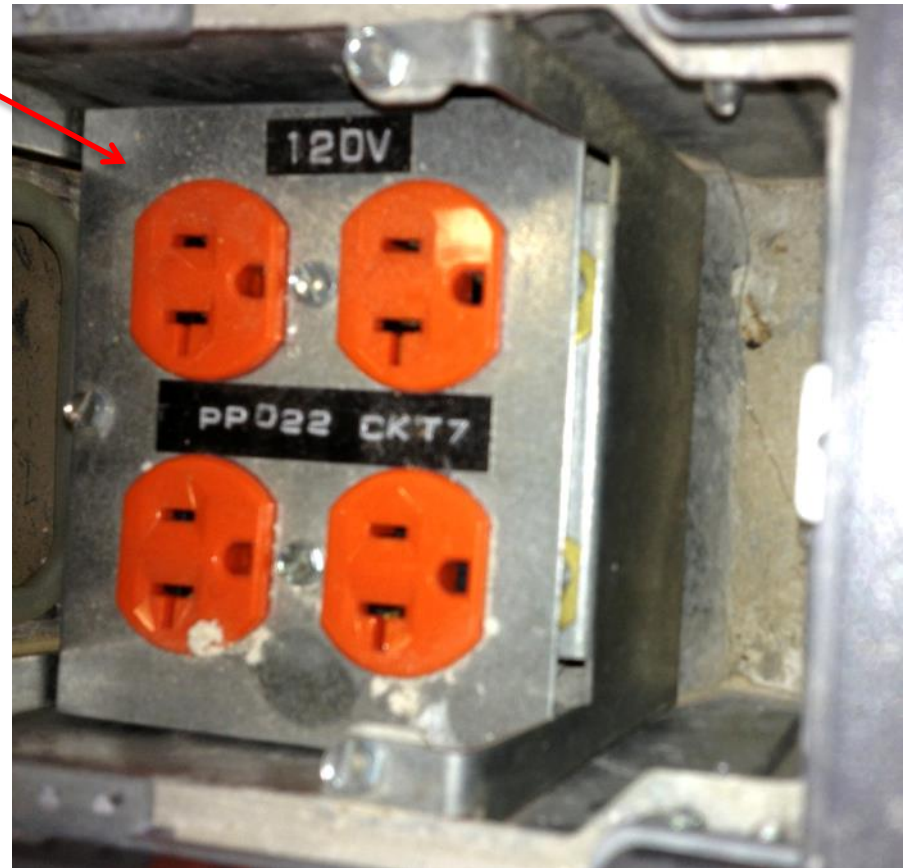
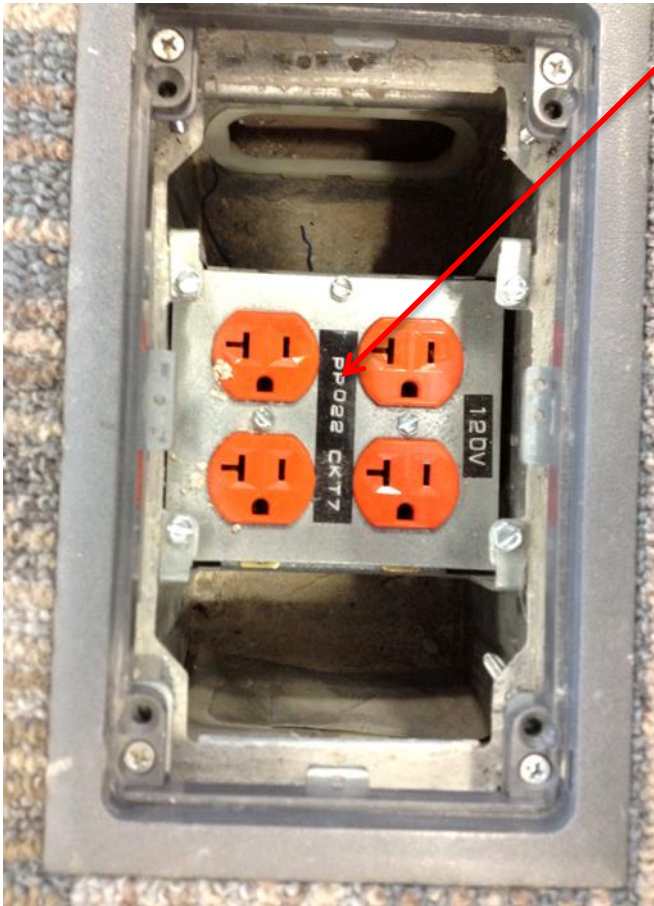
250.146 (B) Contact Devices or Yokes

- Listed spring-type grounding strap for holding the mounting screw and establishing the grounding circuit so that an equipment bonding jumper is not required
- Permitted only on flush-type box mounting

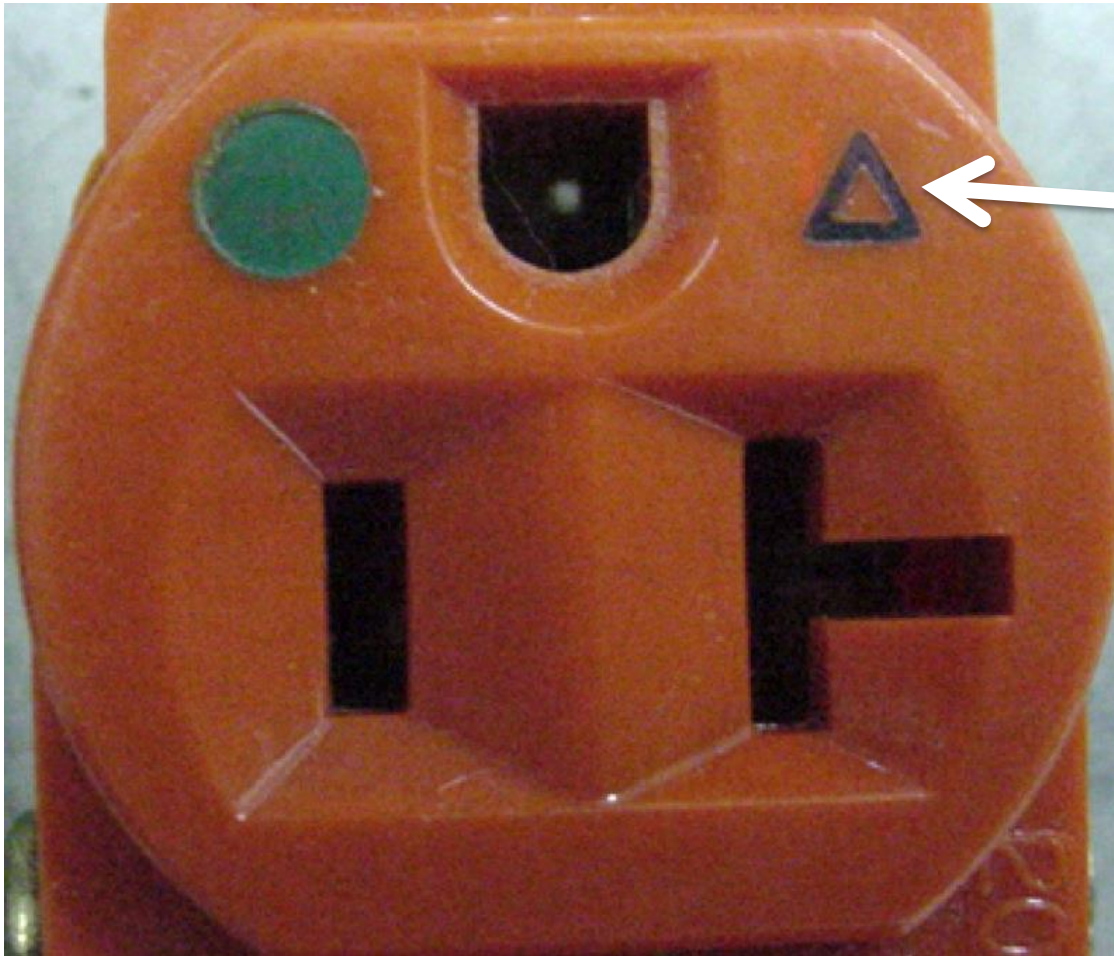


250.146(C) Permits Floor Boxes

Floor boxes must be designed for and listed as providing satisfactory ground continuity between the box and the device



250.146(D) Isolated Receptacle



Orange Triangle
indicates Isolated
ground receptacle

250.146(D) Isolated Receptacle

- This section allows an isolated-ground–type receptacle to be installed without a bonding jumper between the metal device box and the receptacle grounding terminal.
- However, the performance requirement specified by 250.4 (A)(5) has to be complied with, and
 - the isolated equipment grounding conductor must create an effective path for ground-fault current between the receptacle grounding terminal and the source of the branch circuit supplying the receptacle.

250.119 Identification of Equipment Grounding Conductors

- Equipment grounding conductors may be
 - Bare, covered, or Insulated
- Continuous outer finish that is either
 - green or
 - green with one or more yellow stripes
- Conductors Larger Than 6 AWG may be identified at the time of installation



250.194 Grounding and Bonding of Fences and Other Metal Structures

- Applies to Substations
- Covers requirements for bonding and grounding
 - Fences around substations
 - Other metal structures



Should be



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Chapter Three

Wiring Methods and Materials

Covers the methods and materials used for building an electrical distribution system



Article 300

General Requirements for Wiring Methods and Materials

- ✓ Provides the general rules for all the wiring methods and wiring materials for each type of raceway or cable
- ✓ Prevents repeating of these rules in subsequent articles

Table 300.1(C)

Metric Designator	Trade Size
-------------------	------------

12	3/8
----	-----

16	1/2
----	-----

21	3/4
----	-----

27	1
----	---

35	1 1/4
----	-------

41	1 1/2
----	-------

53	2
----	---

63	2 1/2
----	-------

78	3
----	---

91	3 1/2
----	-------

103	4
-----	---

129	5
-----	---

155	6
-----	---

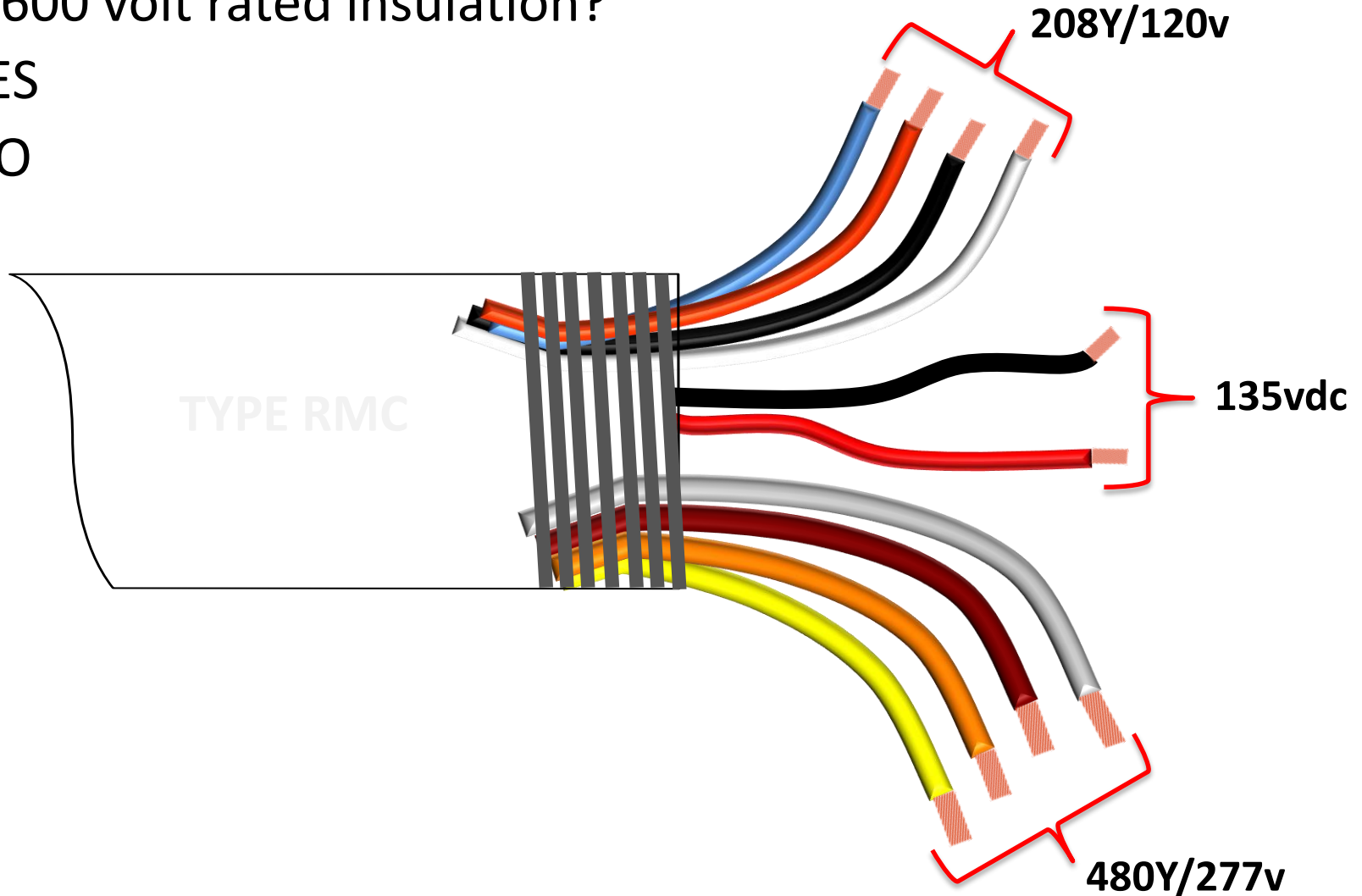


Larger conduit sizes require electrical benders such as this one.

300.3 Application Question

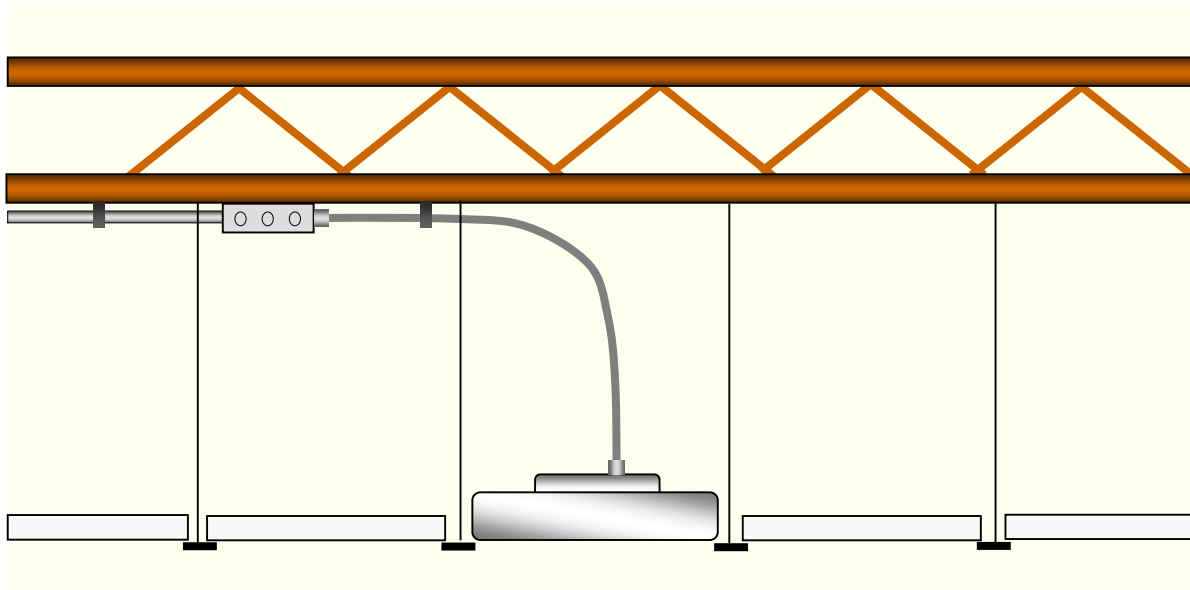
Is this permitted if all conductors have 600 volt rated insulation?

1. YES
2. NO



300.23 Panels Designed to Allow Access

- Cables, raceways, and equipment installed behind panels designed to allow access
 - including suspended ceiling panels
- Must be arranged and secured so as to allow the removal of panels and access to the equipment.



ARTICLE 310

CONDUCTORS FOR GENERAL WIRING

- ✓ Addresses the conductors themselves used in general wiring methods.
- ✓ Includes information, such as: Type designations for conductors, insulation types and temperature limits, conductor construction and marking requirements and, tables for determining conductor ampacity.

310.1 Ampacities for Conductors Rated 0–2000 Volts

(A) General.

- Ampacity values are determined by Tables or under Engineering Supervision

Informational Note's provide the following:

- **Ampacities provided by this section do not take voltage drop into account**
- **See NFPA 79-2002, Electrical Standard for Industrial Machinery for the allowable ampacities of Type MTW wire.**
- **Review 110.14(C) for conductor temperature limitations due to termination provisions**

310.15 Ampacities for Conductors Rated 0-2000 Volts



(B) Tables.

(3) Adjustment Factors.

(c) Raceways and Cables Exposed to Sunlight on Rooftops.

No longer use "Roof Top Adder" Table, instead use adjustment factor of 60 degrees F, when within 7/8" of roof.

Application

What is the ampacity of a 10-AWG THW conductor in an ambient temperature of 76°F?

- A. 24 amperes
- B. 30 amperes
- C. 35 amperes
- D. 37 amperes

Application Exercise

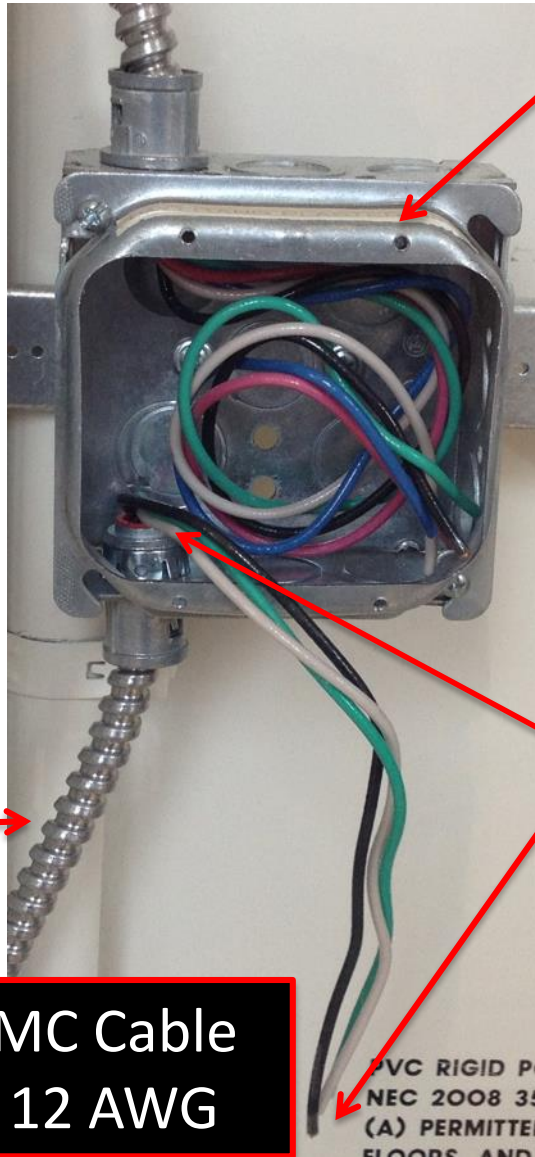
You must pull-in:

- ✓ Two (2), 3-wire 3Ø circuits into a conduit
 - ✓ Circuits are supplying two, 3Ø motors, Design B
 - ✓ Using THWN conductor
 - ✓ Each circuit is to be 50 amps.
-
- What size conductors are needed?
 - Ambient Temp: 100 degrees F:
 - 6 conductors:

ARTICLE 314

OUTLET, DEVICE, PULL, AND JUNCTION BOXES;
CONDUIT BODIES; FITTINGS AND HANDHOLES

314.16 Number of Conductors in Outlet, Device, and Junction Boxes, and Conduit Bodies



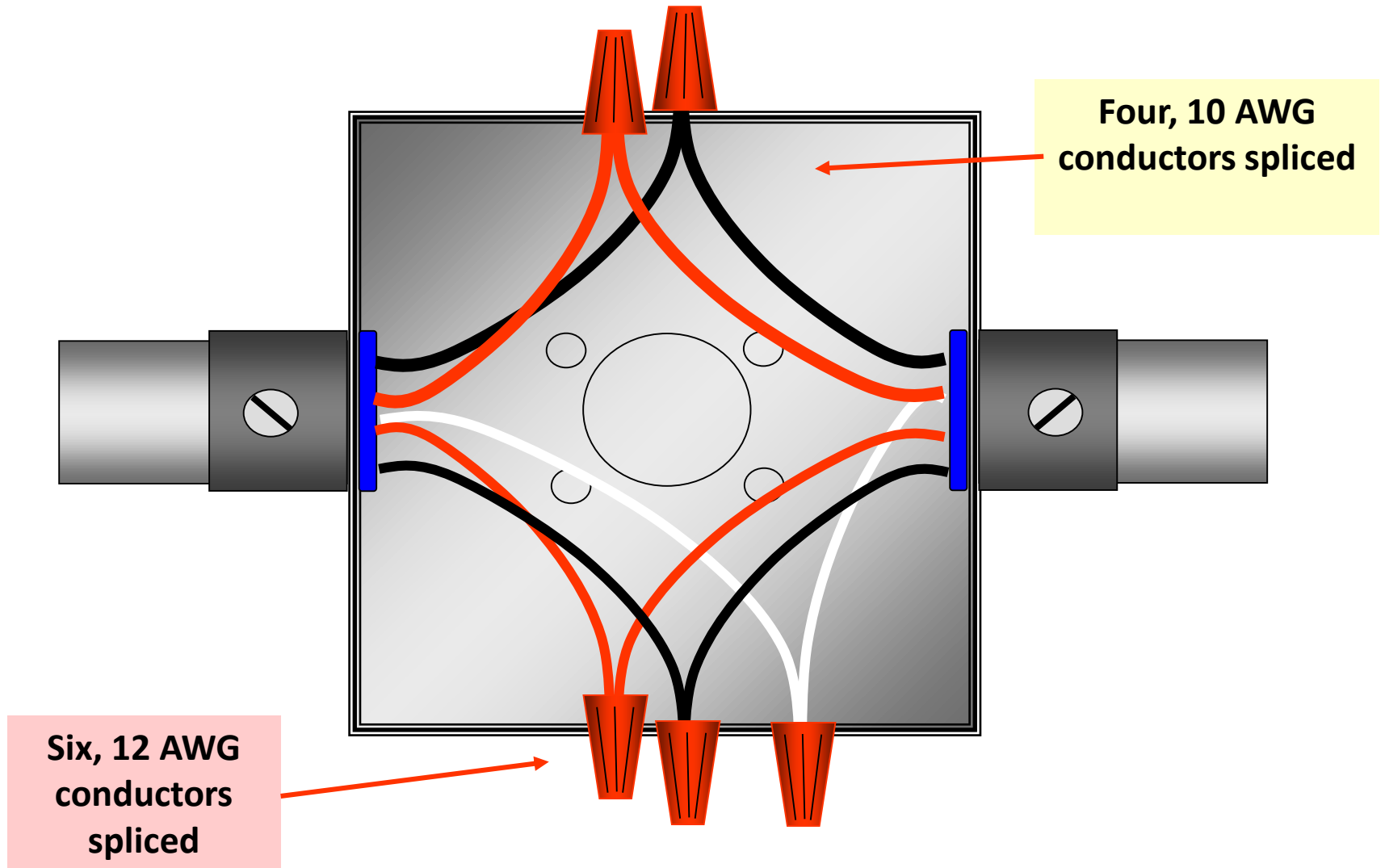
Plaster Ring

The volume of the box, as calculated in 314.16(A), must not be less than the fill calculation as calculated in 314.16(B)

Minimum length 6 in. from where conductor leaves the sheath

MC Cable
12 AWG

314.16 Example 3-6: What is the minimum size square metal box needed?



3-6. 314.16 Box Fill Example

What is the minimum size square metal box required that will have six 12 AWG, and four 10 AWG conductors that will all be spliced in the box?

Solution:

1. Per Table 314.16(B):

six 12 AWG x's 2.25 in^3 each = 13.5 in^3

four 10 AWG x's 2.5 in^3 each = 10.0 in^3

Add $13.5 \text{ in}^3 + 10.0 \text{ in}^3 = 23.5 \text{ in}^3$

2. The minimum size box is 23.5 in^3

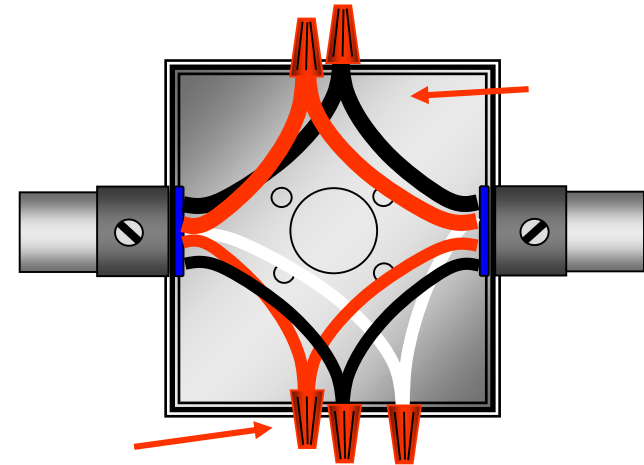
3. Refer to Table 314.16(A) Metal Boxes:

In the minimum volume find a volume that equals or exceeds 23.5 in^3

A. $4 \times 2\text{-}1/8$

B. $4\text{-}11/16 \times 1\text{ }1/4$

C. $4\text{-}11/16 \times 1\text{ }1/2$





Review and Answer Questions about some of the more commonly used Raceways by referring to the appropriate section in the Article:

- .1 Scope
- .2 Definitions
- .10 Uses Permitted
- .12 Uses Not Permitted
- .24 Bending Radius
- .30 Securing and Supporting
- .100 Construction



Sizing Conduit Example #1

What size Type EMT is needed for 15 – 12 AWG THHNs?

◆ ANSWER

- All conductors are the same size
- Refer to the appropriate Table in Annex C

Sizing Conduit Example #2

- What size Rigid Conduit is needed for the following:
 - 6 – 8 AWG THW
 - 3 – 10 AWG THHN
 - 1 – 12 AWG THHN

◆ ANSWER

- Refer to Table 5 to find individual conductor areas
- Total all conductor areas
- Refer to Table 4 for Rigid Conduit

Sizing Conduit Example #2

- What size Rigid Conduit is needed for the following:

6 – 8 AWG THW $6 \times 0.0437 \text{ in}^2 = 0.2622$

3 – 10 AWG THHN $3 \times 0.0211 \text{ in}^2 = 0.0633$

1 – 12 AWG THHN $1 \times 0.0133 \text{ in}^2 = \underline{0.0133}$

0.3388 in^2

-

Sizing Conduit Example #2

- What size Rigid Conduit is needed for the following:

6 – 8 AWG THW	$6 \times 0.0437 \text{ in}^2 = 0.2622$
3 – 10 AWG THHN	$3 \times 0.0211 \text{ in}^2 = 0.0633$
1 – 12 AWG THHN	$1 \times 0.0133 \text{ in}^2 = \underline{0.0133}$
-	0.3388 in^2

◆ Solution

- Refer to Table 5 to find individual conductor areas
- Total all conductor areas

Sizing Conduit Example #2

- What size Rigid Conduit is needed for the following:

0.3388 in²

◆ Solution

- Refer to Table 4 for Rigid Conduit

Application Exercise

Conductor: TFE

Load: 52 A

Ambient Temperature: 95°F

12 conductors in Type RMC Conduit

- What minimum size conductor is required?

- What minimum size Type RMC conduit is required:

Application Exercise

Conductor: TFE

Load: 52 A

Ambient Temperature: 95°F

12 AWG: $1.01 \times 54 = 54.54 = 55 \text{ A}$

Adjustment: $0.50 \times 55 = 27.5 \text{ A}$

12 conductors in Type RMC Conduit

- What minimum size conductor is required?

- What minimum size Type RMC conduit is required:



Chapter 4

Equipment for General Use

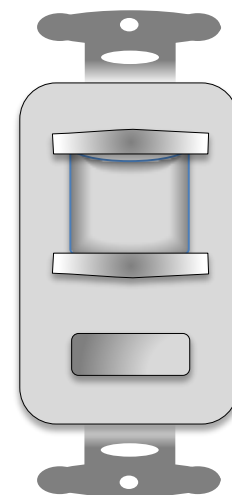




404.22 Electronic Lighting Control Switches.

- Shall be listed.
- Shall not introduce current on the equipment grounding conductor during normal operation.
- The requirement to not introduce current on the equipment grounding conductor shall take effect on January 1, 2020.

Some manufacturer's instructions may direct the installer to use the "equipment grounding conductor" to be connected to the device to act as the grounded conductor to power the electronics.

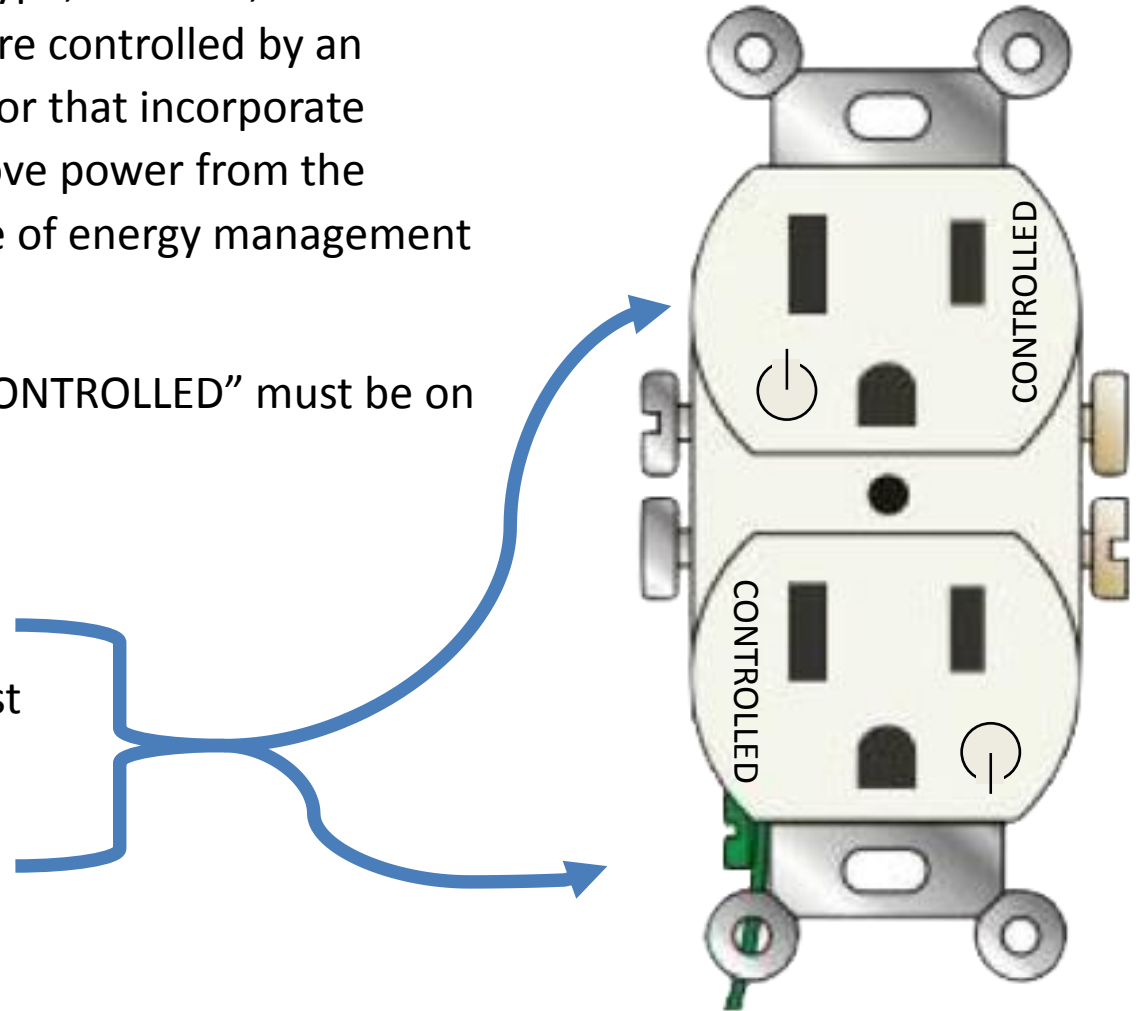


Article 406.3 Receptacle Rating and Type.



- Applies to all nonlocking-type, 125-volt, 15- and 20-ampere receptacles that are controlled by an automatic control device, or that incorporate control features that remove power from the receptacle for the purpose of energy management or building automation.
- Both Symbol and word “CONTROLLED” must be on the face of the receptacle.

The required marking must denote which contact device(s) are controlled.



406.3(F) Receptacle with USB Charger



- Applies to 125-volt 15- or 20-ampere receptacle that additionally provides Class 2 power
- They must be listed and constructed such that the Class 2 circuitry is integral with the receptacle.





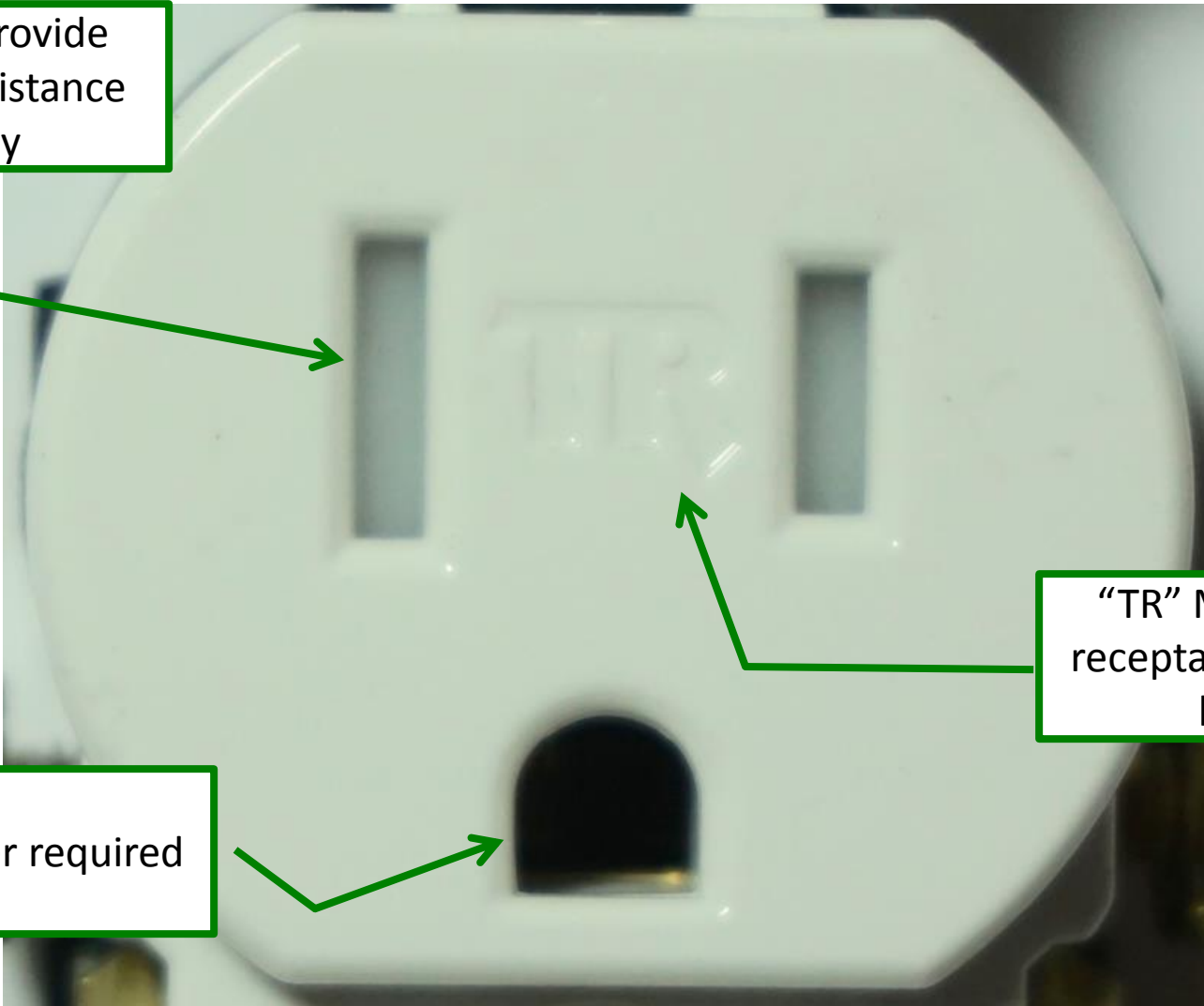
Required Locations.

- (1) Dwelling Units.
- (2) Guest Rooms and Guest Suites of Hotels and Motels.
- (3) Child Care Facilities.
- (4) Preschools and Elementary Education Facilities.
- (5) Business Offices, Corridors, Waiting Rooms and the Like in Clinics, Medical and Dental Offices and Outpatient Facilities.
- (6) Subset of Assembly Occupancies Described in Article 518.2 to Include Places of Waiting Transportation, Gymnasiums, Skating Rinks, and Auditoriums.
- (7) Dormitories.

406.12 Tamper – Resistant Receptacles



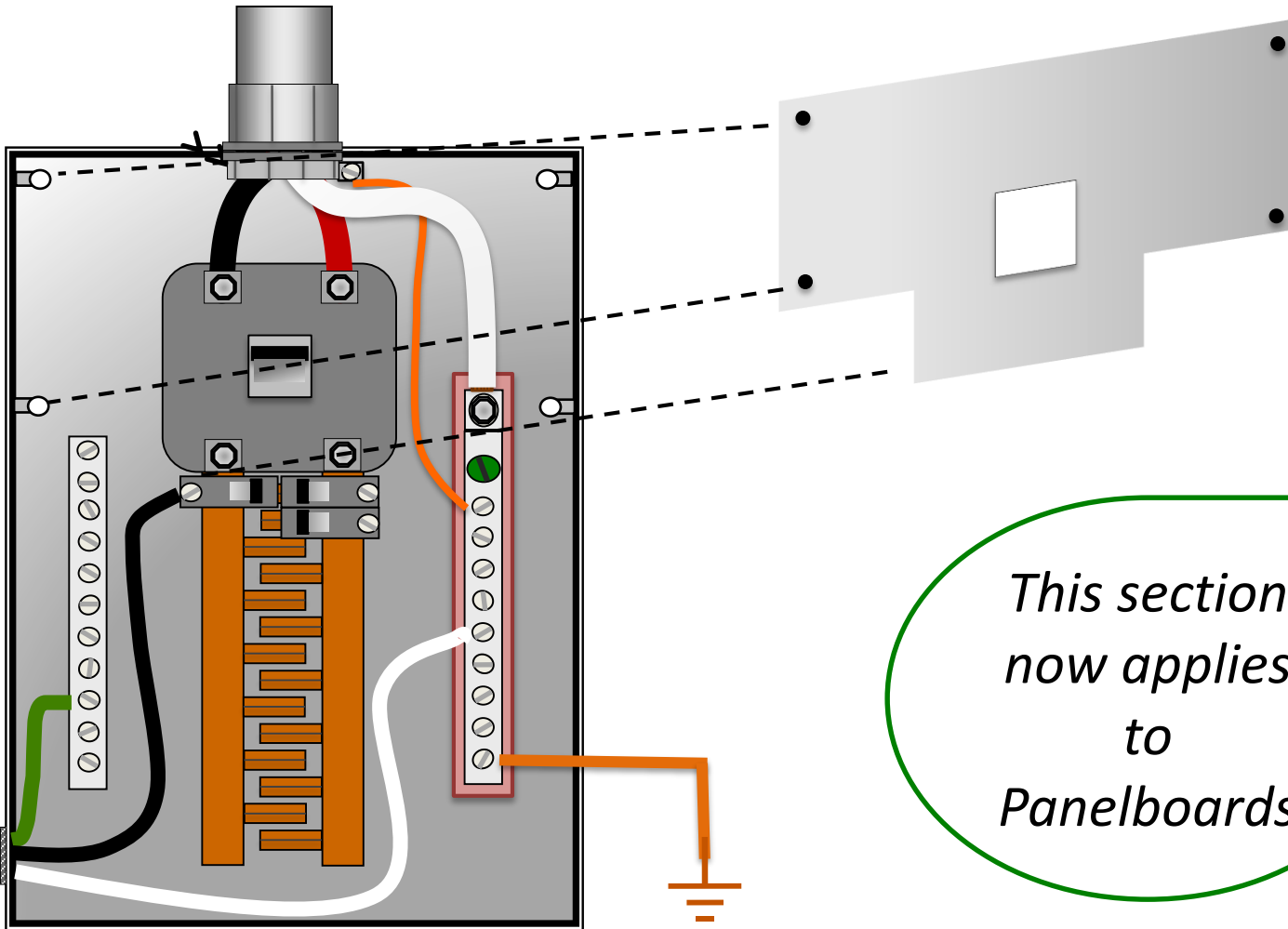
Shutters provide
Tamper-resistance
quality



“TR” Marking on
receptacle required
by UL

No shutter required

408.3(A)(2) Service Panelboards, Switchboards, and Switchgear



*This section
now applies
to
Panelboards*


430.99 Available Fault Current



NEW Section requires NEW Documentation:

- The available short circuit current at the motor control center
- The date the short circuit current calculation was performed
- Must be documented and made available to those authorized to inspect the installation



 WARNING
Maximum Available Fault Current: 48,000 Amperes
Date: August 24, 2016


Chapter 4 Articles

Article 400 Flexible Cords and Cables

Article 402 Fixture Wires

Article 404 Switches

Article 406 Receptacles, Cord Connectors, and Attachment Plugs
(Caps)

Article 408 Switchboards, Switchgear, and Panelboards

Article 409 Industrial Control Panels

Article 410 Luminaires, Lampholders

Article 411 Lighting Systems Operating at 30 Volts or Less and
Lighting Equipment Connected to Class-2 Power
Sources

Article 422 Appliances

Chapter 4 Articles

Article 426 Fixed Outdoor Electric Deicing & Snow-Melting Equip.

Article 427 Fixed Electric Heating Equipment for Pipelines and Vessels

Article 430 Motors, Motor Circuits, and Controllers

Article 440 Air-Conditioning and Refrigerating Equipment

Article 445 Generators

Article 450 Transformers and Transformer

Article 455 Phase Converters

Article 460 Capacitors

Article 470 Resistors and Reactors

Article 480 Storage Batteries

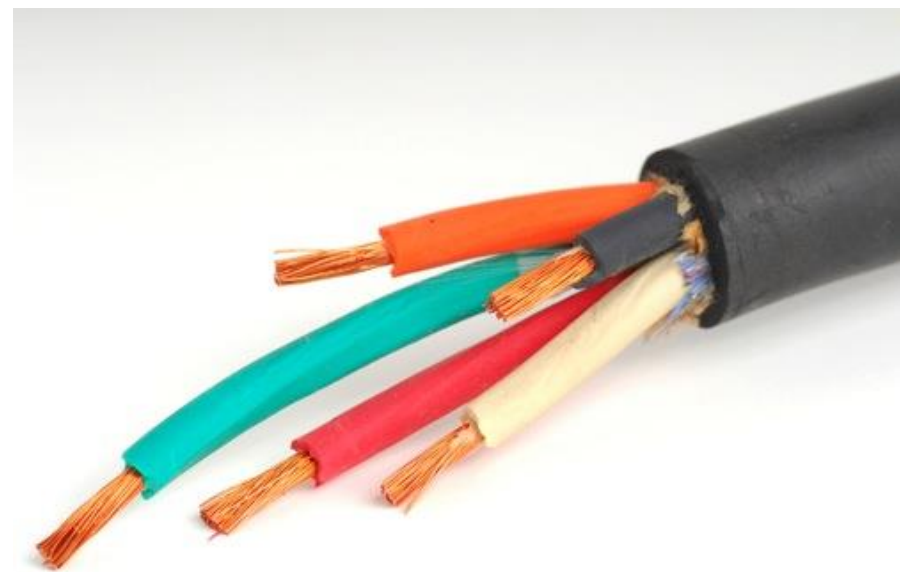
Article 490 Equipment Over 1000 Volts, Nominal

ARTICLE 400

FLEXIBLE CORDS AND CABLES

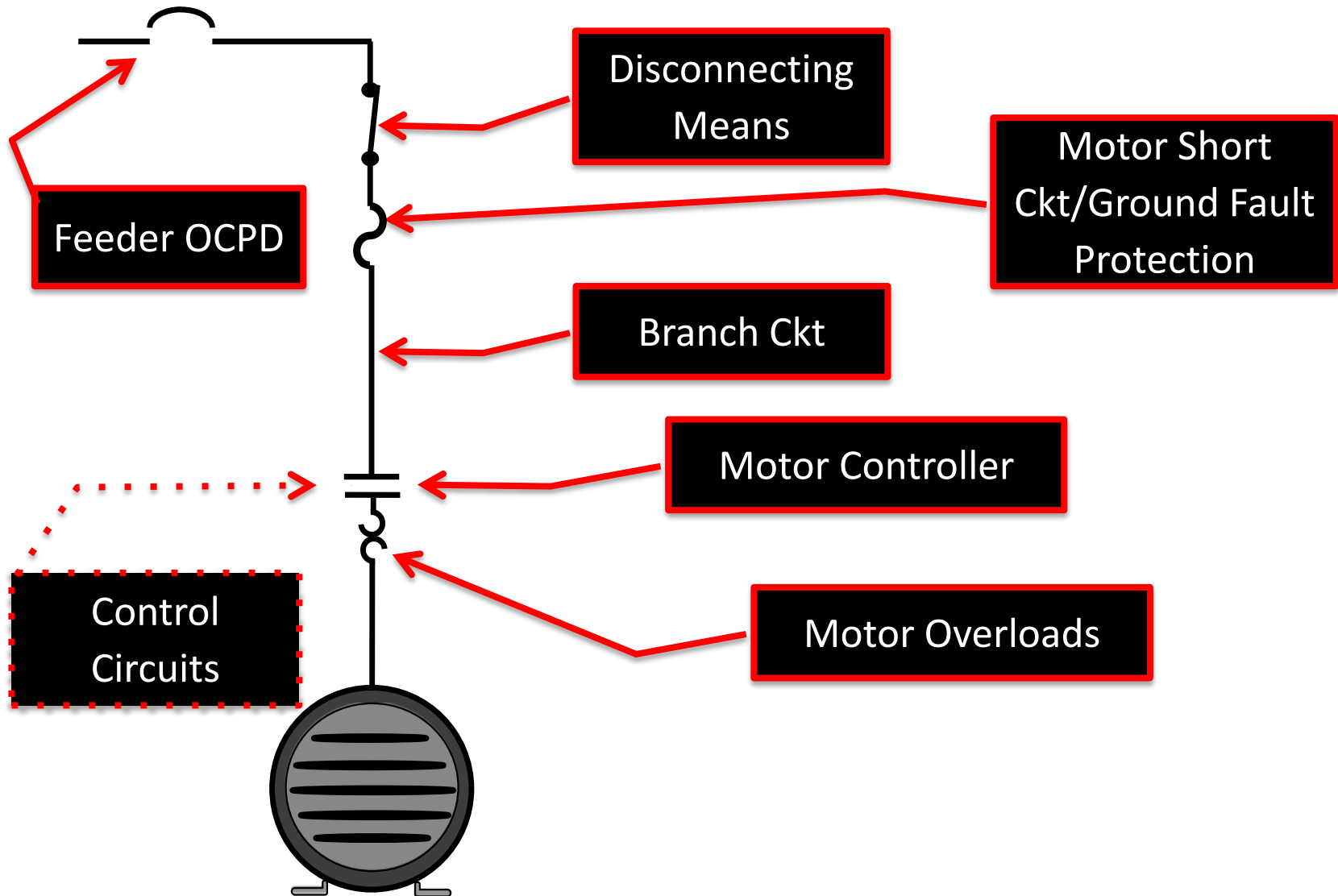
400.5 Ampacities for Flexible Cords and Cables

- Table 400.4 provides Types of Cables
- Table 400.5(A)(1) provides the allowable ampacities, and
- Table 400.5(A)(2) provides the ampacities for flexible cords and cables with not more than three current-carrying conductors



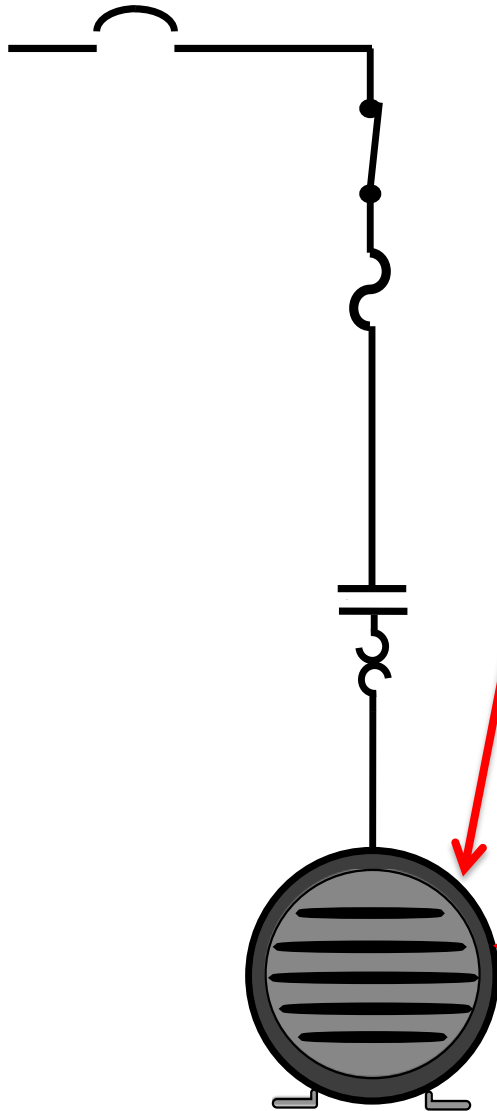
ARTICLE 430
MOTORS, MOTOR CIRCUITS, AND
CONTROLLERS

430.1 Scope



430.6 Ampacity and Motor Rating Determination

- Conductors sized per 310.15
- Flexible cords, if used, size per 400.5



(A)(1) For General Motor Applications use the Table Values, NOT the nameplate

(A)(2) Use nameplate value for sizing separate overloads

Disconnect (indoor location)

Type: 1

Recommended Size: 60 A

Controller Size: NEMA 2 or 25 hp

Overloads Size: 40 A

**430.102
Disconnecting
Means Location**

(A) Controller

(B) Motor

Type RMC

Size: 3/4

Supports? 10 ft / 3 ft

460v, 3-ph

Squirrel Cage

25 hp

FLA 32 A

Design B

SF 1.15

Time-delay Fuse:

Type: _____

Size: 60 A

Type LFMC

Size: 3/4

Supports? 3 ft

35-152-7
Controller

THW Cu Phase Conductor AWG: 8 AWG

EGC AWG: 10 AWG

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Disconnect (indoor location)

Type: see Table 110.28

Recommended Size: 60A

Controller Size: 30 Hp

Overloads Size: 125%

430.102
Disconnecting
Means Location

- (A) Controller
- (B) Motor

Type RMC

Size: 3/4

Supports? _____

460v, 3-ph
Squirrel Cage
30 hp
FLA 36.1 A
Design B
SF 1.15

Time-delay Fuse:

Type: _____

Size: 50

Type LFMC

Size: 3/4

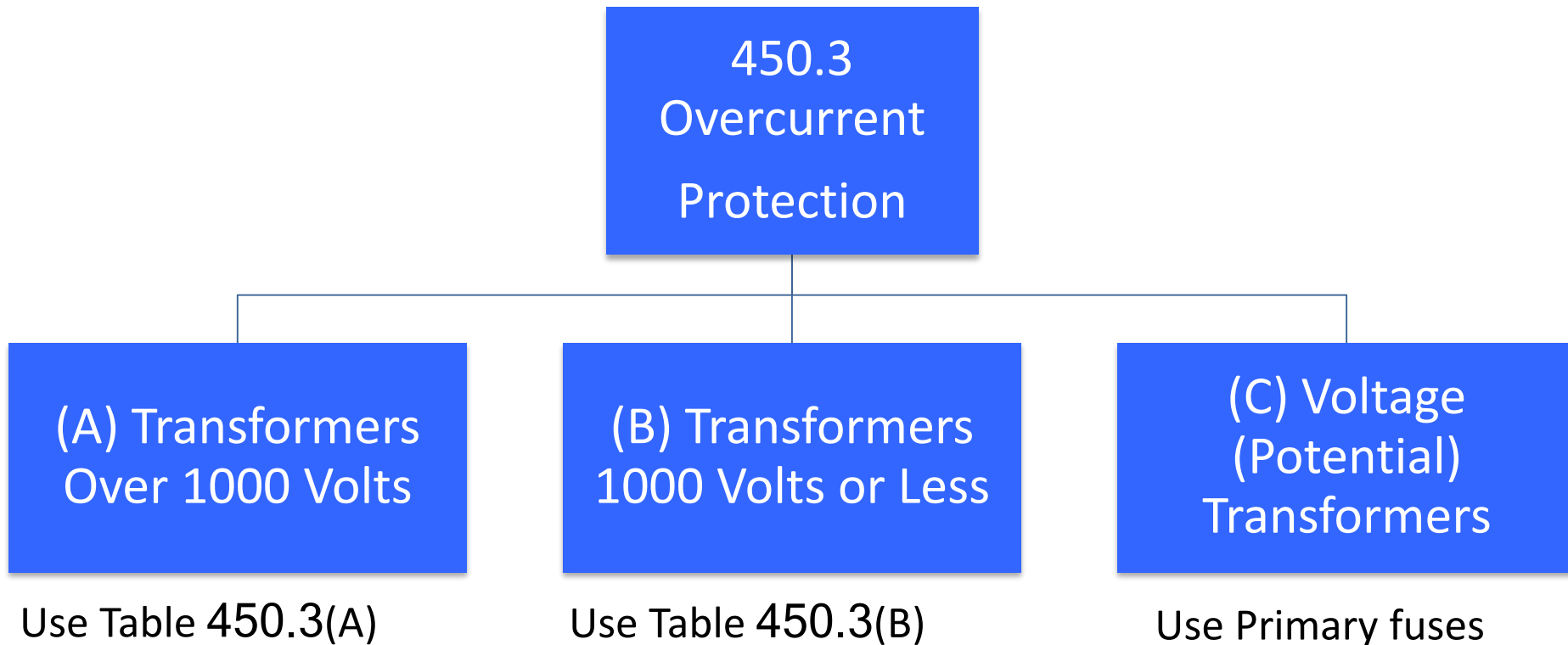
Supports? _____

THW Cu Phase Conductor AWG: 8

EGC AWG: 10

ARTICLE 450
TRANSFORMERS AND TRANSFORMER
VAULTS (INCLUDING SECONDARY TIES)

Transformer Protection



Overcurrent Protections for:

450.4 Autotransformers

450.6 Secondary Ties

Example Problem

1. What is the maximum overcurrent protection rating or setting of a transformer primary rated at 55 Amperes that has primary protection only?

Review the table: 125% of 55A = 68.75 Amps OCPD

2. If this OCPD is not a standard size identified in 240.6, what size may be used?

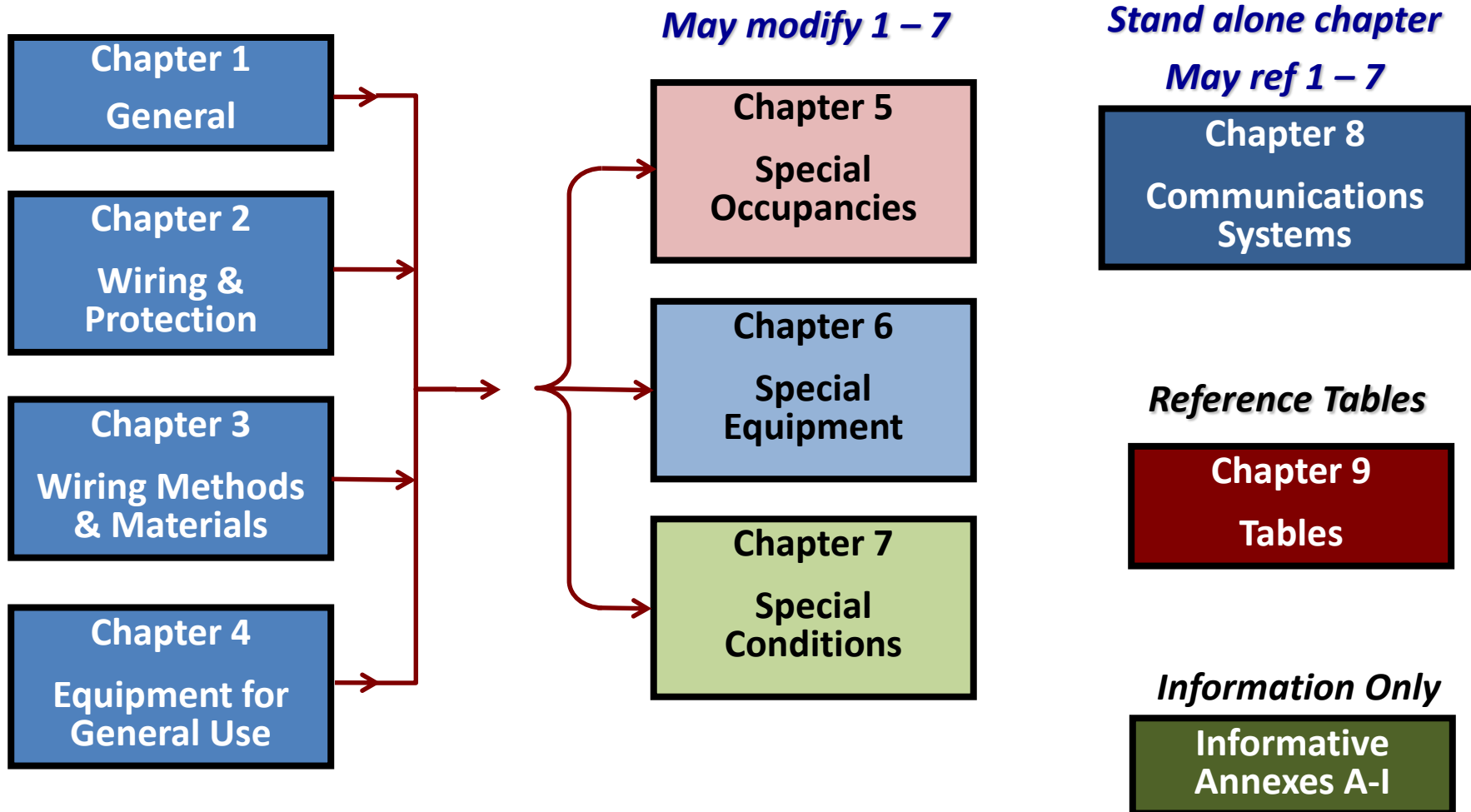
See Note 1: go to next higher size. So, a 70 amp breaker or fuse may be used.



Overview of Chapters 5, 6, 7 and 8



90.3 Code Arrangement





Chapter 8

Communications Systems



Chapter 8 Layout

