Board of Building Standards

EDUCATION COMMITTEE MEETING
AGENDA (AMENDED FEBRUARY 16, 2023)

DATE: FEBRUARY 16, 2023
TIME: 10:00 AM
LOCATION: BBS LIBRARY, 6606 TUSSING ROAD, REYNOLDSBURG, OHIO
Click here to join the meeting

Call to Order

Consent Agenda

Course Applications

ER-1 Pumps for Fire Protection (National Fire Sprinkler Association)
All certifications (8 hours)
Staff Notes: This is a request for retroactive certification of a course presented on January 25. Caleb Armbrust of NFPA plans to attend. In spite of how the application is filled out, the course is just a single session.
Committee Recommendation:

ER-2 Standpipe Systems and NFPA 14 (National Fire Protection Association)
All certifications (8 hours)
Staff Notes: This is a request for retroactive certification of a course presented on January 25. Caleb Armbrust of NFPA plans to attend. In spite of how the application is filled out, the course is just a single session.
Committee Recommendation:

ER-3 Using Black and White Codes in a World of Grey (Fire Code Academy)
1 hour, all certifications
Staff Notes: Submitted after final agenda update released 2/15/23. Recommend approval.
Committee Recommendation:

Old Business

New Business

Adjourn

EDUCATION COMMITTEE MEETING
CONSENT AGENDA

Course Applications

EC-1 Special Waste Piping Systems (Ohio Association of Plumbing Inspectors)
All certifications (1 hour)

EC-2 Replacement Water Heaters (Ohio Association of Plumbing Inspectors)
All certifications (1 hour)
Existing Building instruction

EC-3 Valves 101 (Ohio Association of Plumbing Inspectors)
All certifications (1 hour)

EC-4 Water and Fuel Gas Press Fit Connections (Ohio Association of Plumbing Inspectors)
All certifications (1 hour)

EC-5 2023 NEC Changes and Updates Chapters 1-3 (Labriola Training Agency)
All certifications (4 hours)

EC-6 2023 NEC Changes and Updates Chapters 3-7 (Labriola Training Agency)
All certifications (4 hours)

EC-7 One Hundred 2023 NEC Changes and Updates (Labriola Training Agency)
All certifications (8 hours)

EC-8 National Electric Code 2017 Review with Update of Changes (Electrical League of Ohio)
All certifications (two sessions of 4 hours each)

EC-9 National Electric Code 2017 Wire and Raceway Sizing for Electrical Systems (Electrical League of Ohio)
All certifications (4 hours)

EC-10 NEC 2020 Soares Grounding and Bonding Fundamentals (Ohio Division of Industrial Compliance)
All certifications (three six-hour sessions)

EC-11 2023 NEC Changes (Jade Learning)
All certifications (16 hours)

EC-12 2023 NEC Code Changes Part 1 (Wink Electric)
All certifications (5 hours)

EC-13 2023 NEC Code Changes Part 2 (Wink Electric)
All certifications (5 hours)

EC-14 Certified Line Pressure Regulator Training (Maxitrol)
All certifications (1 hour)

EC-15 Dry Sprinklers for Commercial and Residential Fire Protection (Victaulic)
All certifications (1 hour)

EC-16 Enforcing NFPA 25: Deficiencies, Impairments, Observations (Fire Code Academy)
All certifications (1 hour)

EC-17 Fire Pump Plan Review (Fire Code Academy)
All certifications (1 hour)

EC-18 General Gas Pressure Regulator Training (Maxitrol)
All certifications (1 hour)

EC-19 Key Changes to the 2022 Edition of NFPA 72 (Fire Code Academy)
All certifications (1 hour)

EC-20 Mass Timber and Type IV Construction (3-hour version) (American Wood Council)
All certifications (3 hours)

EC-21 Mass Timber and Type IV Construction (4-hour version) (American Wood Council)
All certifications (4 hours)

EC-22 Plan Examiner Round Table (Columbus)
All certifications (12 additional hours)

EC-23 Residential Code Round Table on Sections 328 and 507 (Miami Valley Building Officials Association)
Residential certifications only (2 hours)

EC-24 Significant Changes to the NEC 2023 (Electrical Trades Center)
All certifications (20 hours in three sessions: 8, 8, and 4)

EC-25 Sizing Building Drains and Stacks (Richardson)
All certifications (2 hours)

EC-26 Understanding the Residential Mid-Rise Fire Problem from a Fire Protection Perspective (Fire Code Academy)
All certifications (1 hour)

EC-27 Updates to the 2022 Edition of NFPA 13 (Fire Code Academy)
All certifications (1 hour)

EC-28 Victaulic VicFlex Sprinklers (Victaulic)
All certifications (1 hour)

File Attachments for Item:

ER-1 Pumps for Fire Protection (National Fire Sprinkler Association)

All certifications (8 hours)

Staff Notes: This is a request for retroactive certification of a course presented on January 25. Caleb Armbrust of NFPA plans to attend. In spite of how the application is filled out, the course is just a single session.

Committee Recommendation:

Ohio | Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: Ron Ritchey

Organization: National Fire Sprinkler Association (NFSA)

Address: 514 Progress Drive, Suite A, Linthicum Heights, MD 21090

E-mail: ritchey@nfsa.org Telephone:

Website: www.nfsa.org

Conference Sponsor (if applicable) Conference Email:

Check here if Course Renewal: Prior course number (*i.e. BBS2018-429*)

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: Pumps for Fire Protection

Course instructor: Michael Joanis P.E., NFSA Chief Engineer

Course description: See attached word document - Seminar Information Sheet

Instructional hours per session: 8 hours Number of Sessions: 12 Modules

Course Date(s) and Location: 11/25/23 - Mason Fire Dept - Station 51
4420 Mason Montgomery Road
Mason, OH 45040

Special Content:

Code Administration:
Existing Buildings:
Electrical Instruction:
Plumbing Instruction:

Conference Course:
Conference Name:
Conference location:

Course to be offered online? NO **On Demand** **Webinar**

Course Website:

Detail online course participation confirmation method (*i.e. test, quizlets, participant activity confirmation*):

Course applicable for the following certifications

Residential Certifications Only:
Commercial Certifications: X
Administrative Course, All Certifications:

Application materials included:

X Course Outline or Course Learning Objectives
X Presentation Materials/Slides (not required for roundtable courses)
Assessment Materials (for online courses)
X Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

NFSA
NATIONAL FIRE SPRINKLER ASSOCIATION

Seminar Information Sheet

Seminar Title: Pumps for Fire Protection

Seminar Description: This program covers a number of advanced topics in the design and selection of fire pumps including the evaluation of water supplies to calculate suction pressure, the selection of fire pumps under a variety of water supply situations, and the evaluation of discharge pressure to make sure that system pressure does not get too high, especially in high-rise buildings. Balancing the pressure in the system to meet all of the requirements of NFPA 14 and NFPA 20 both with and without pressure reducing devices and situations with multiple water supplies (with different pressures) will be discussed. The use of break tanks as permitted by NFPA 22 will also be discussed. Due to the advanced nature of the program, it is recommended that only those already knowledgeable in basic hydraulic calculations (including use of the Hazen Williams formula and adjustments for elevation) attend. This program will be an excellent study session for those people seeking NICET Level III and Level IV certification. Total Instructional Time: 8 Contact Hours

Intended Audience: Sprinkler system layout technicians, sprinkler system contractors, Authorities Having Jurisdiction, Building Owners, Facilities Managers

Duration: 8 contact hours

Learning Outcomes:

At the conclusion of this program, the participant will be able to:

1. Identify and discuss the purpose of fire pumps.
2. Evaluate the best type of pump for each application.
3. Evaluate the advantages various suction pipe arrangement.
4. Apply the requirements for pump suction piping.
5. Apply the requirements for pump discharge piping.
6. Determine the need and uses for pumps in series and in parallel.
7. Select fire pump controllers and proper sensing line arrangements.
8. Use hydraulic formulas including those for friction loss and evaluation change.
9. Size a fire pump with a single water supply.
10. Size a fire pump with multiple water supplies.
11. Identify the requirements for pumps in high rise and very tall buildings.
12. Identify the acceptance testing requirements for pumps.

Seminar Format(s): Lecture, case studies, code review and interactive exercises.

Participant Materials: Participant Guide.

Seminar Schedule:

Module 1 – Introduction to the purpose of fire pumps .5 hours

Objectives: Discuss the reasons for using a fire pump.
Understand the relationship between laws, codes, and standards.

Module 2 – Types of pumps 1 hour

Objectives: Understand the various types of pumps and the "why" each type is used.
Distinguish the differences in scope of NFPA 13, 14, 20 and 25.

NFSA
NATIONAL FIRE SPRINKLER ASSOCIATION

Seminar Information Sheet

Module 3 – Suction piping arrangements .5 hour

Objectives: Learn the different possible suction pipe arrangements
Understand how and why each arrangement is used

Module 4 – Equipment in the suction pipe .5 hour

Objectives: Identify the NFPA 20 requirements for suction piping
Understand how devices in the pump suction effect the pump's performance

Module 5 – Equipment is the discharge pipe .5 hours

Objectives: Discuss the NFPA pump discharge arrangement and equipment requirements
Identify how devices in the pump discharge pipe effect the pumps performance

Module 6 – Pumps in parallel and in series .5 hour

Objectives: Identify how pumps in series are used
Identify how pumps in parallel are used

Module 7 – Controllers and sensing line arrangement 1 hour

Objectives: Identify the proper pump controllers, functions and alarms
Identify the proper sensing line arrangement, function and equipment

Module 8 – Hydraulic formulas 1 hour

Objectives: Apply the Hazen Williams friction loss formula
Apply the formula for calculating pressure change due to elevation change

Module 9 – Fire pump sizing 1 hour

Objectives: Understand the seven step process for sizing a fire pump
Size a fire pump based on a single water supply

Module 10 – Using a pump with multiple water supplies .5 hours

Objectives: Discuss how multiple water supplies affect pump sizing and the seven step process

Module 11 – Pumps for high rise and very tall buildings .5 hours

Objectives: Understand how the use of pumps for high rise building function with separate pressure zones and the additional NFPA 20 requirements

Module 12 – Acceptance testing of a fire pump .5 hours

Objectives: Discuss the NFPA 20 requirements for fire pump acceptance testing

7

NFSA
NATIONAL FIRE SPRINKLER ASSOCIATION

Seminar Information Sheet

Review the NFPA 25 requirements for inspection testing and maintenance of fire pumps

Seminar Schedule

Module 1 – Introduction to the purpose of fire pumps	**8:00 – 8:30 (.5 hour)**
Module 2 – Types of pumps	**8:30 – 9:30 (1 hour)**
Module 3 – Suction piping arrangements	**9:30 – 10:00 (.5 hour)**
Module 4 – Equipment in the suction pipe	**10:00 – 10:30 (.5 hour)**
Module 5 – Equipment is the discharge pipe	**10:30 – 11:00 (.5 hour)**
Module 6 – Pumps in parallel and in series	**11:00 – 11:30 (.5 hour)**
Lunch	**11:30 – 12:00**
Module 7 – Controllers and sensing line arrangement	**12:00 – 1:00 (1 hour)**
Module 8 – Hydraulic formulas	**1:00 – 2:00 (1 hour)**
Module 9 – Fire pump sizing	**2:00 – 3:00 (1 hour)**
Module 10 – Using a pump with multiple water supplies	**3:00 – 3:30 (.5 hour)**
Module 11 – Pumps for high rise and very tall buildings	**3:30 – 4:00 (.5 hour)**
Module 12 – Acceptance testing of a fire pump	**4:00 – 4:30 (.5 hour)**

Michael Joanis, PE is the Chief Engineer at the NFSA. He obtained his Bachelor of Science degree in Fire Protection Engineering from the University of Maryland, College Park. He has been a registered professional engineer in several states since 1996. He is a member of NFPA and the Society of Fire Protection Engineers. He is currently a member of six NFPA technical committees including Sprinkler System Discharge Criteria and Hanging and Bracing. Michael is a licensed sprinkler contractor and serves as the NFSA staff liaison for the Contractors Council and Quality Assurance Committee.

Contact Information: Michael J. Joanis, PE
Director of Contractor Services
NFSA
514 Progress Drive, Suite A
Linthicum Heights, MD 21090
Tel: 410-983-9417
E-mail: joanis@nfsa.org

NFSA
NATIONAL FIRE SPRINKLER ASSOCIATION
The Voice of the Fire Sprinkler Industry



PUMPS FOR FIRE PROTECTION





CITY OF MASON
FIRE – RESCUE – EMS
OHIO



1

COPYRIGHT

This presentation is protected by US and international copyright laws. Any reproduction, recording, distribution, display, or use of the presentation without written permission of the **National Fire Sprinkler Association (NFSA)** is prohibited.

©National Fire Sprinkler Association 2022

NFSA
NATIONAL FIRE SPRINKLER ASSOCIATION

2

INTRODUCTIONS



Michael Joanis, PE

- NFSA's Chief Engineer
- Responsible for delivery of technical services to our members
- University of Maryland, College Park
- Registered professional engineer
- NFPA 13 (discharge, hanging & bracing), 20, 200, 232, 241, 909/914
- NFSA Contractors and Manufacturers Councils
- Engineering & Standards, Quality Assurance, UL/FM Committees
- 28 years of experience as a sprinkler contractor and consulting engineer.
- Licensed sprinkler & special hazards contractor
- Fire Sprinkler Institute
- joanis@nfsa.org
- 410-983-9417

3

3

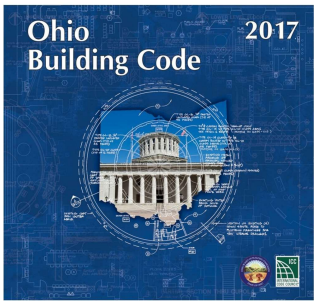
Fire Pump Systems

1. Introduction and purpose of fire pumps
2. Types of pumps
3. Suction piping arrangements
4. Equipment in suction pipe
5. Equipment in discharge pipe
6. Pumps in parallel and in series
7. Controllers and sensing line arrangement
8. Hydraulic formulas
9. Fire pump sizing
10. Using a pump with multiple water supplies
11. Pumps for High Rise and “Very Tall Buildings”
12. Acceptance testing of a fire pump

4

The Building Code

- Start in the applicable building code.
- Does provide some installation requirements.
- Supersedes NFPA 20.
- High rise Section 403.4.8
- Fire pumps Section 905 & 913



5

2017 Ohio Building Code

4101:1-35-01 – Referenced Standards effective 11/01/2017

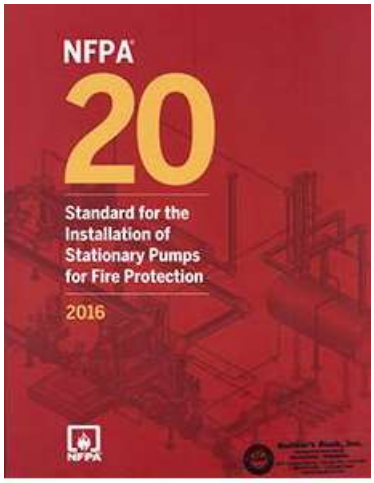
NFPA 14 – 2016 Edition

Currently adopted in Ohio

6

The Installation Standard

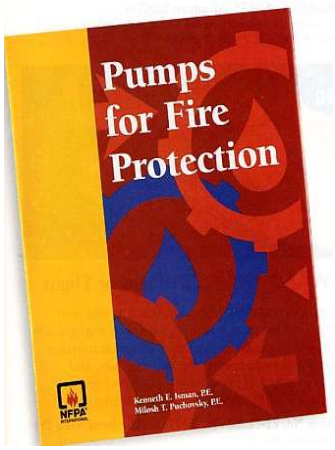
- All sections referenced in this program are from the 2016 edition of NFPA 20 unless otherwise noted
- These are installation rules and have been in all recent editions unless otherwise noted
- Review Scope



7

References

- Pumps for Fire Protection by Isman and Puchovsky
- Published by NFPA



8

1. Purpose of Fire Pumps

- When the water supply can provide sufficient flow, but does not have the pressure to meet the demand of the fire protection system, pump can be used
- Pumps will not increase flow

= X gpm OUT
= Y psi + added pump pressure OUT



X gpm IN
Y psi IN

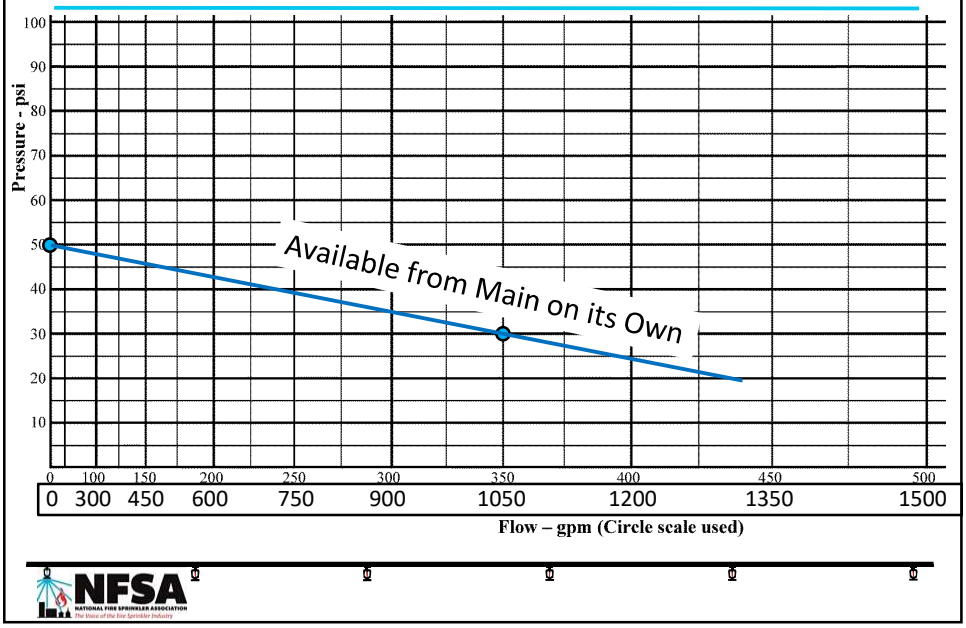
9

Use of Pumps

- Boosting the pressure from a private or public water main
- Taking suction from a tank
  - Tank at the same level as the pump
  - Tank elevated above the pump
  - Pressure tank

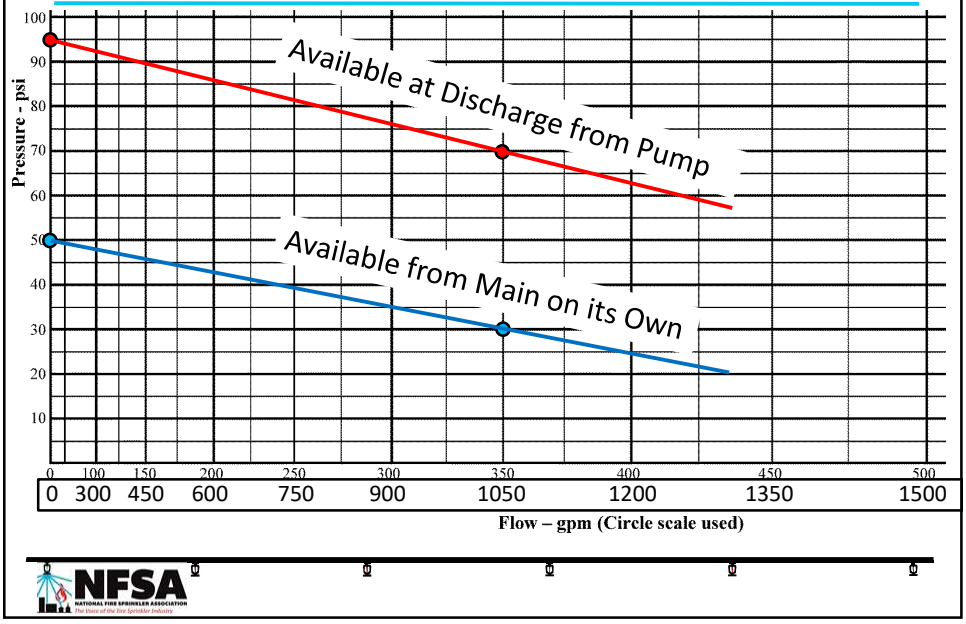
10

Public or Private Main



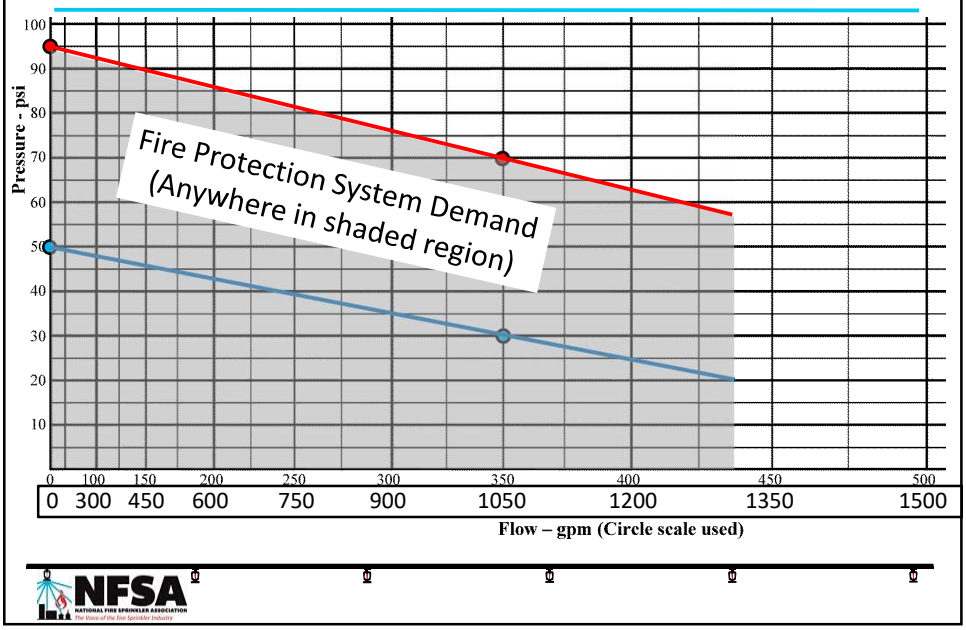
11

Main Plus Pump



12

Main Plus Pump



13

2. Types of Pumps

- Positive Displacement Pumps
  - Piston & Rotary Gear
  - Can pump air (priming pump on FD apparatus)
  - Very accurate
  - Can generate very high pressures
    - Water mist
  - Very good at pumping viscous liquids
- Centrifugal Pump
  - End Suction Pump
  - Horizontal Split Case Pump
  - In-Line Pump
  - Vertical (Line) Shaft Turbine Pump
  - Must have positive suction pressure

14

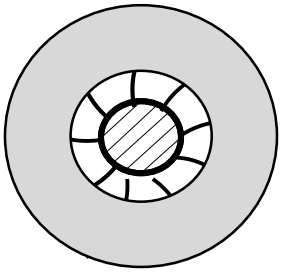
How a Centrifugal Pump Works

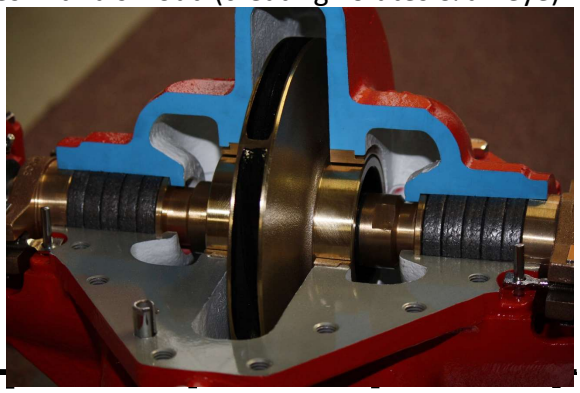


15

The Pump Impeller

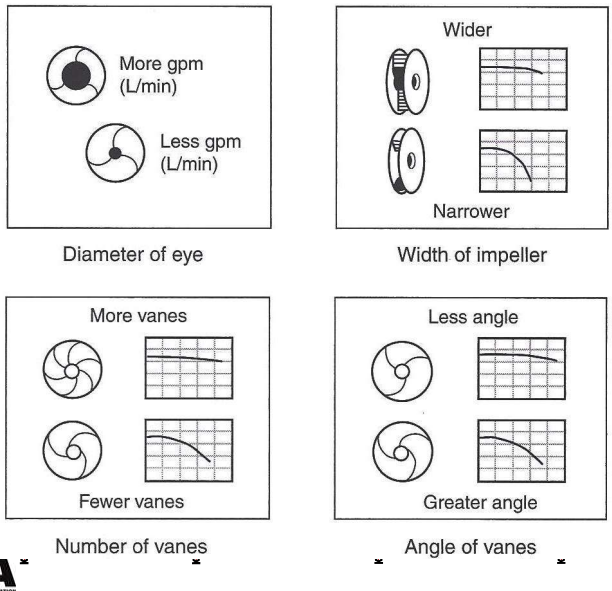
- Start with a ring
- Set it on a drive shaft
- Attach some vanes
- Cover it on both sides with a shroud (creating volutes & an eye)





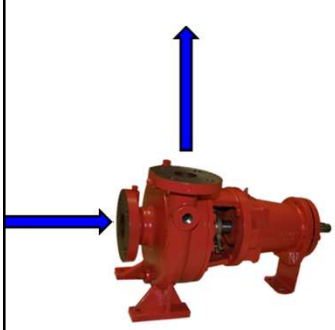
16

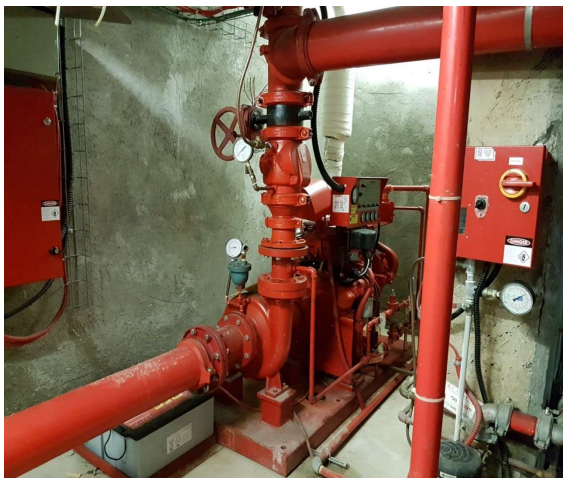
Impact on Performance



17

End Suction Pump





18

Horizontal Split Case Pump



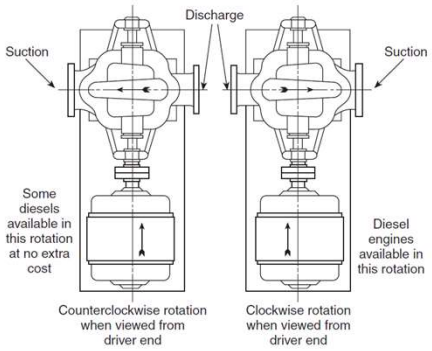
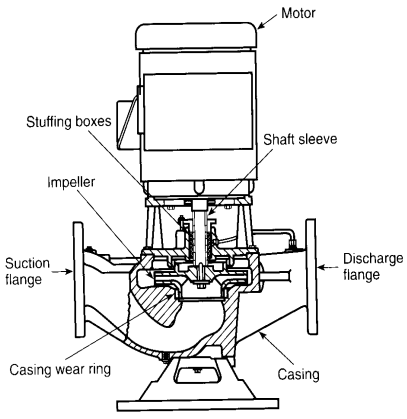
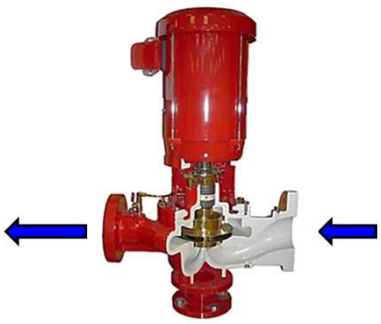


FIGURE A.4.23(a) Horizontal Pump Shaft Rotation.

19

Vertical In-Line Pump



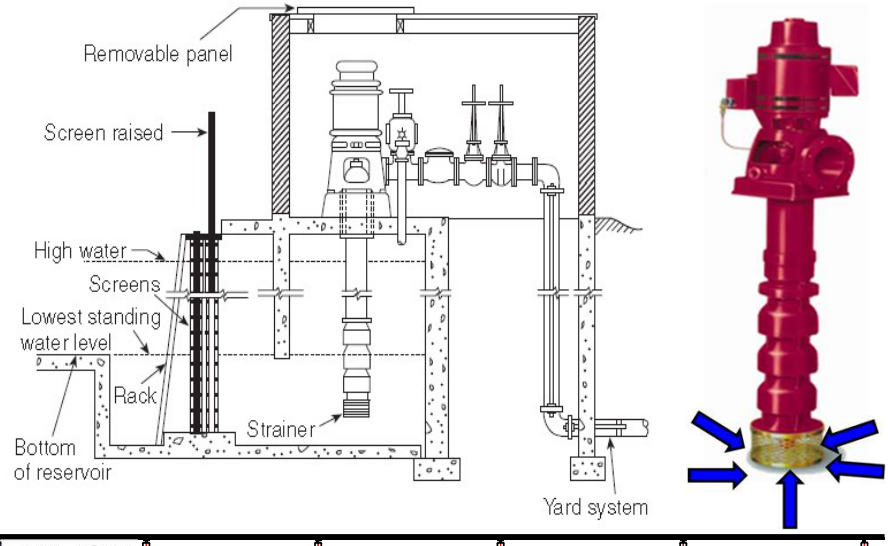


20



21

Vertical Shaft Turbine Pump



22



23

Pump Room Requirements

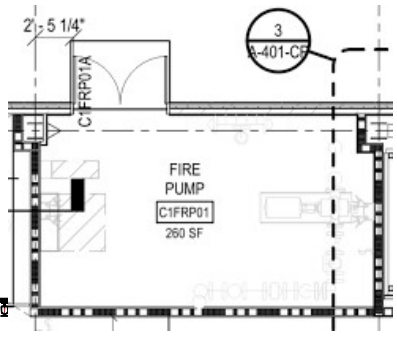
- Location & access to
  - Approved by the AHJ
  - Free of non essential items
    - Exception for domestic water equipment
  - Direct or rated access to the exterior
- Size & clearances
- Protection (rated room)of the fire pump unit- indoors
  - Hi rise building
  - Non hi- rise building
- Protection of the fire pump unit- outdoors

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION

24

Pump Room Requirements cont

- Heat
- Lighting
  - Normal
  - Emergency
- Ventilation
- Drainage
- Guards



25

General Rules for All Pumps

- Means must be provided for qualified personnel to determine the pump is operating satisfactorily
- The fire pump unit (pump, motor & controller) must perform as an entire unit
- Water supply must be reliable
- Pump must be dedicated to fire service & listed for such
  - Each pump shall have its own motor, & each motor its own controller, and each controller its own sensing line
- Must not be able to over pressurize the system components

26

General Rules for All Pumps cont

- Each pump must have its own name plate
- Each pump must have suction & discharge gauges
- Each pump shall have a circulation relief valve (except where permitted to eliminate this requirement)
- Indoor units must be protected from surrounding occupancies
- Outdoor units must be protected against possible interruption
- Steel pipe must be used above ground

27

General Rules for All Pumps cont

- Pump must have a positive suction pressure (≥ 0psi)
  - Exception for tanks
- Valves must be supervised
- All pumps part of a series unit shall be in the same pump room
  - Some exceptions with strict conditions
- No more than three pumps allowed in series as part of a series fire pump unit
  - Reduced to two for variable speed pumps

28

General Rules for All Pumps cont

- Pumps must have means of testing
- Means of maintaining pressure in the system for pressure activated fire pumps without using the main fire pump
- Earthquake protection applies to the fire pump unit

29

3. Suction Pipe Arrangement

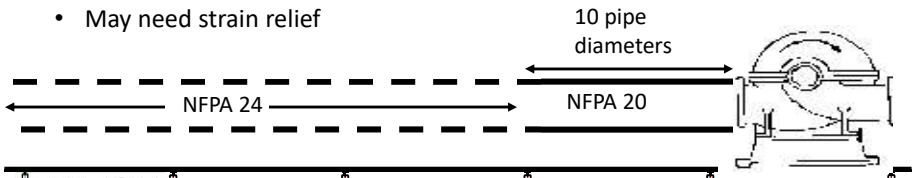
- Straight run to suction flange
- Vertical bend (elbow or tee) into suction flange
- Horizontal bend (elbow or tee) into suction flange

30

The Suction Pipe

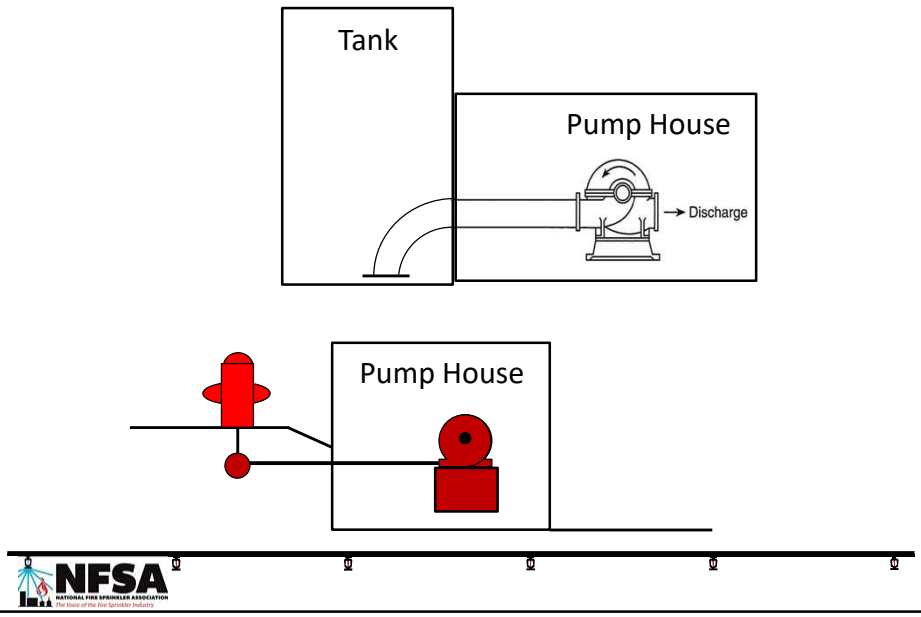
- Starts at the pump suction flange
- Continues back to the water source
- NFPA 24 governs the suction piping
- NFPA 20 takes over at 10 pipe diameters before the suction flange

- Water Supply must be adequate in
  - Quality
  - Quantity
  - Pressure
  - May need strain relief



31

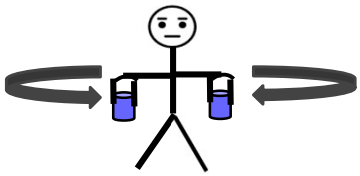
Straight Run to Suction Flange

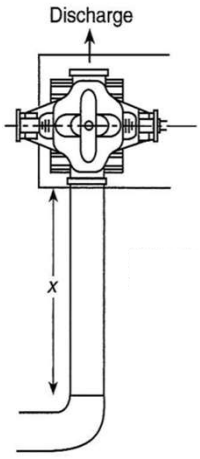


32

Horizontal Bend into Suction Flange

- Plan View of Horizontal Split Case Pump
- Only permitted if X≥10 times pipe diameter



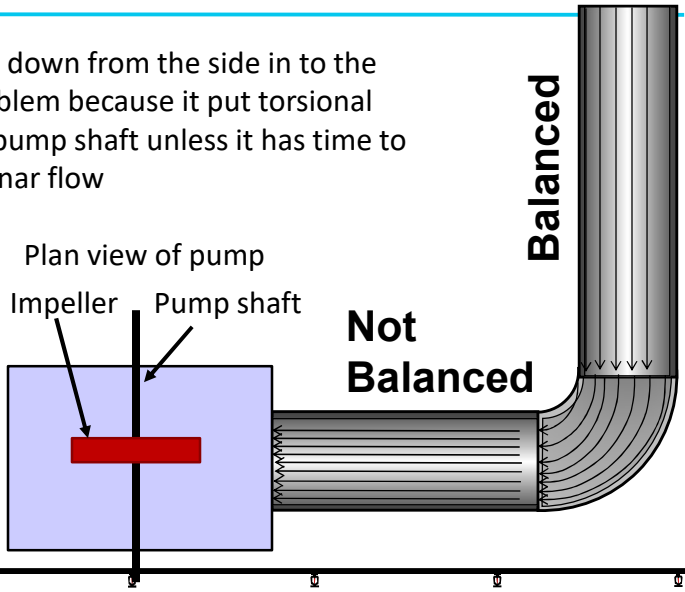


NFSA

33

Balanced & Unbalanced Flow

Water coming down from the side in to the pump is a problem because it put torsional stress on the pump shaft unless it has time to return to laminar flow



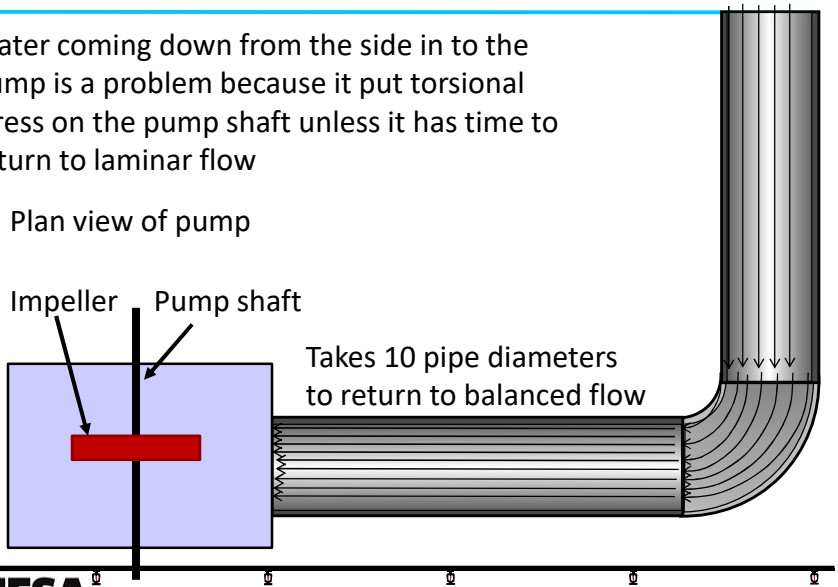
NFSA

34

Balanced & Unbalanced Flow

Water coming down from the side in to the pump is a problem because it put torsional stress on the pump shaft unless it has time to return to laminar flow

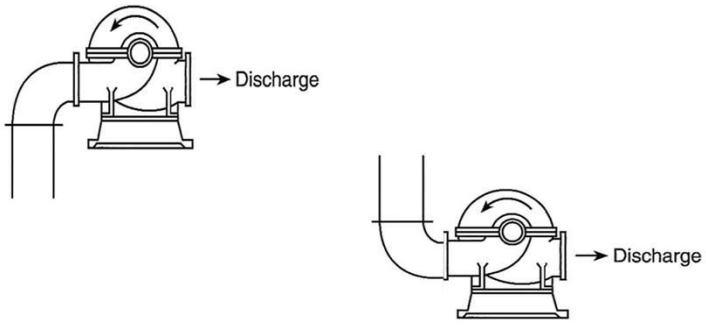
Plan view of pump



35

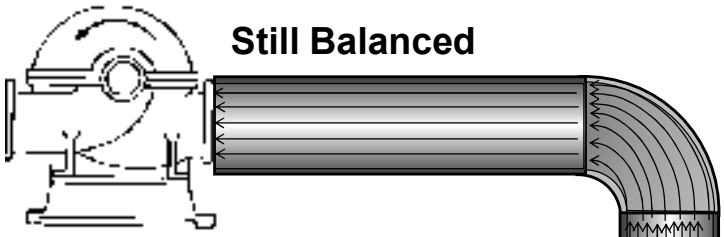
Vertical Bend into Suction Flange

Note: All required valves are not shown

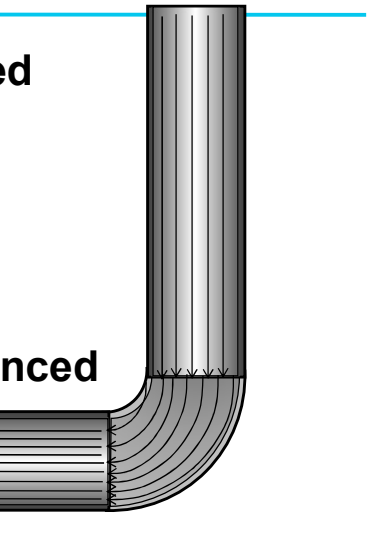


36

Balanced & Unbalanced Flow



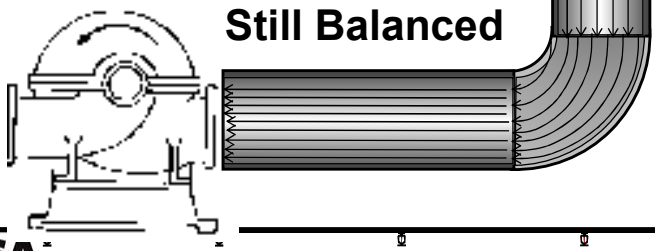
Water coming up from the floor and straight in to the pump is not a problem. It does not put torsional stress from the side on the impellers



37

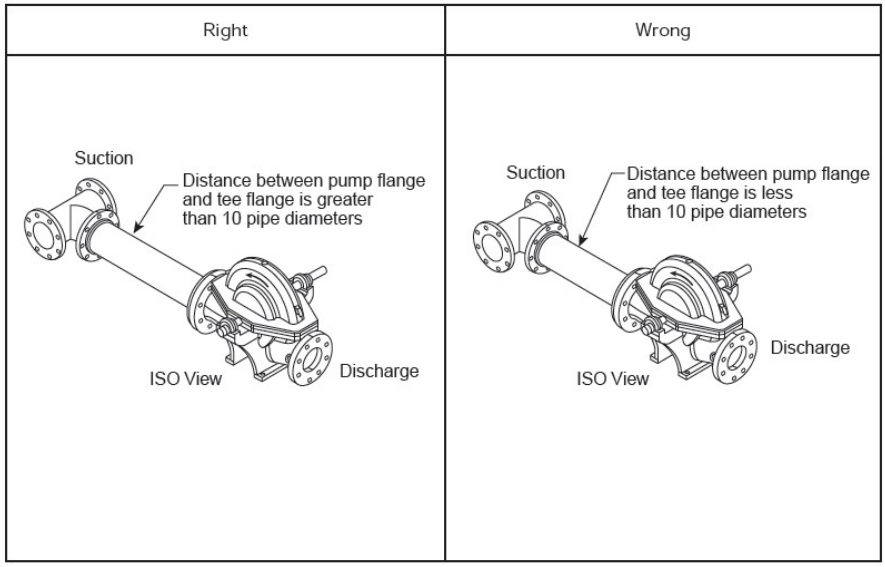
Balanced & Unbalanced Flow

Water coming down from the ceiling and straight in to the pump is not a problem. It does not put torsional stress from the side on the impellers



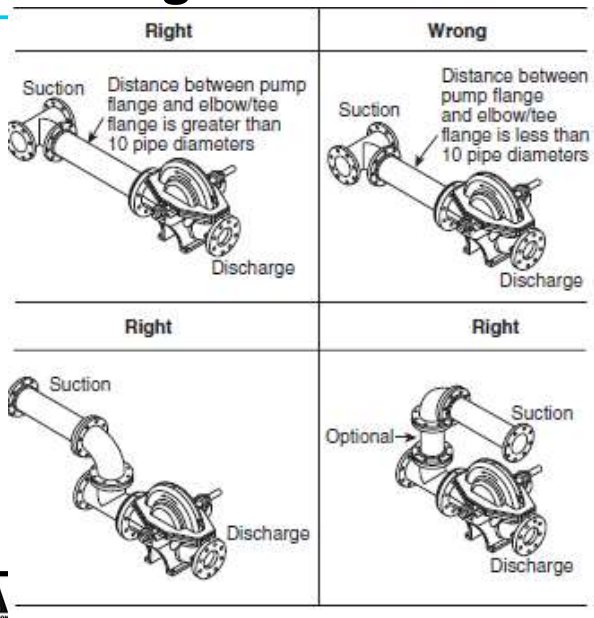
38

Figure A.4.16.6



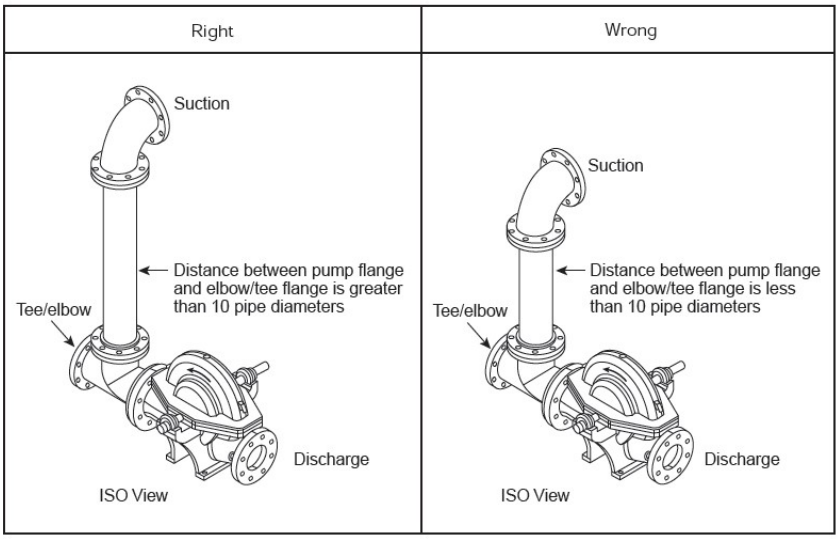
39

Figure A.4.16.6



40

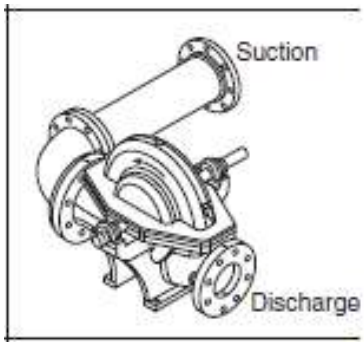
Figure A.4.16.6



41

Figure A.4.16.6

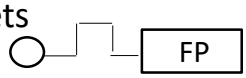
Right or wrong?



42

4. Equipment in Suction Pipe

- Design and installation in accordance with NFPA 24
- Must avoid air pockets

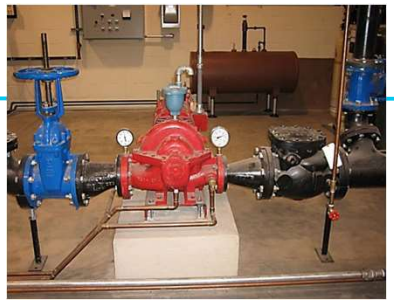


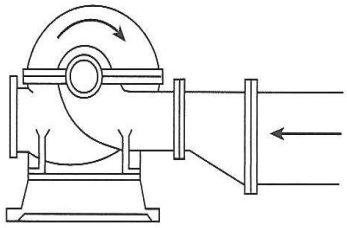
- Control valves, check valves and backflow
- Join pipe well to avoid water and air leaks (for bell & spigot joints)
  - Hydrostatic test will prove
- Reducers must be eccentric
- Protect pipe from freezing
- Screens (Open Water Source)

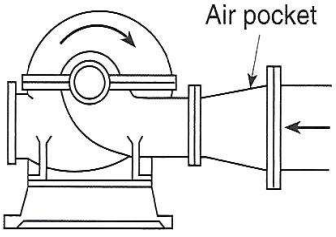
NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

43

Reducers







Correct
Eccentric Reducer

Not Correct
Concentric Reducer

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

44

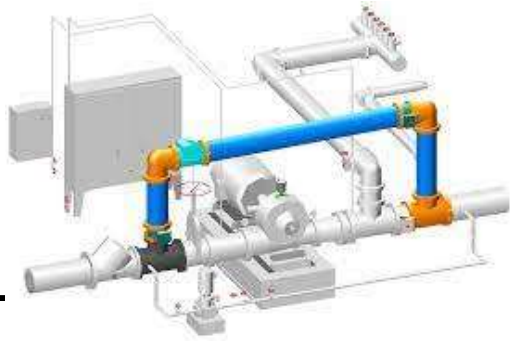
Devices in Suction Pipe

- Control Valves
  - Need one to isolate the pump
  - Don't add extras
  - Gate not butterfly
  - Slow close
- Check Valves and Backflow Preventers
  - Cause turbulence, which can damage pumps
  - Keep at least 10 times the pipe diameter away from the suction flange of the pump

45

Devices Required in the Suction Piping

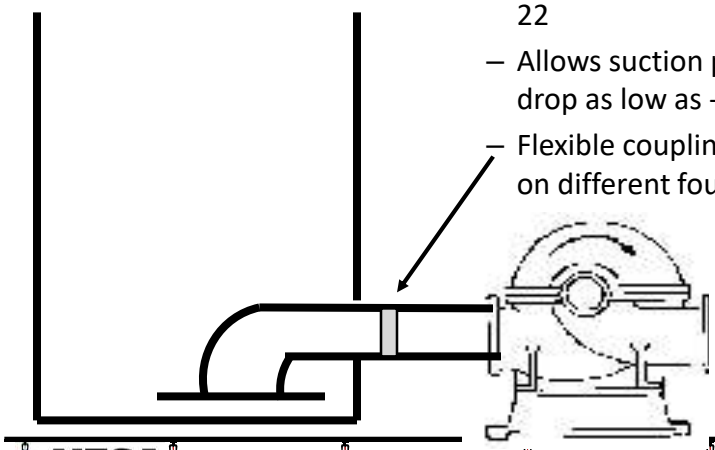
1. Bypass piping if water supply has material value
2. Listed OS&Y valve
   1. Any other type must be 50' away
3. Suction screening required if open body of water or wet pit
   a) Required size & number



46

Devices Required in the Suction Piping cont

- Anti Vortex plate
  - Must be installed by NFPA 22
  - Allows suction pressure to drop as low as -3psi
  - Flexible coupling required if on different foundations



47

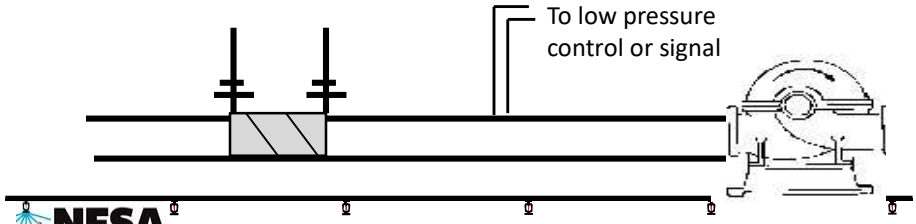
Anti Vortex Plate



48

Devices Allowed in the Suction Piping

1. Check valves & back flow devices where required (must be 10 pipe diameters away)
2. Sensing line for low pressure control or signal
   a) Just the sensing line- no requirement for 10 pipe diameters
3. Other devices specifically permitted or required by the AHJ
4. Suction diffusers
5. Section 4.16.9.2



NFSA

49

5. Equipment in Discharge Piping

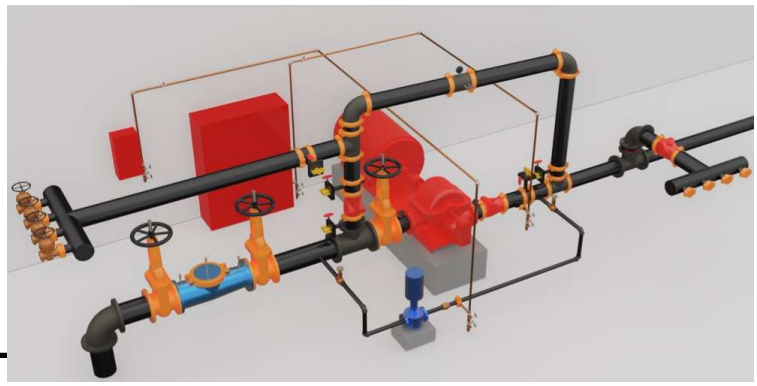
- Piping must be steel
  - Rated for Maximum Working Pressure
- Maximum Working Pressure = Static Pressure + (Net) Churn Pressure

NFSA

50

The Discharge Pipe

- Starts at the pump discharge flange
- Continues to the discharge control valve
- Must be sized according to Table 4.28(a)
- No pressure reducing valves allowed in discharge piping



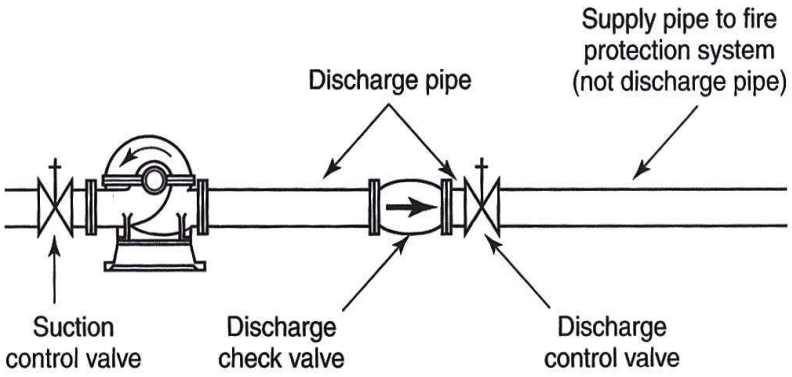
51

Devices in Discharge Piping

- Check valve and control valve
- Pressure Relief Valve (Section 4.20)
  - Only required if discharge pressure when turning 10% too fast exceeds component's rating
  - Under normal conditions, not needed
- Circulating Relief Valve
  - Required for electric driven pumps
  - Required for diesel driven pumps with radiator cooling

52

Discharge Pipe and Components



53

Fire Pump Pressure Relief Valve

Pressure Relief Valve



54

Fire Pump Circulation Relief Valve

Circulation relief valve



55

Testing Arrangements

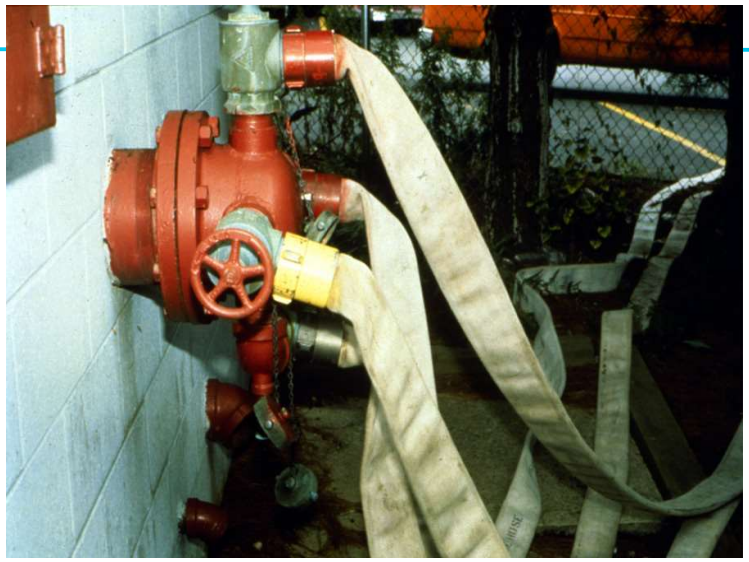
- Test Header to Open
- Flow to Reservoir
- Closed Loop Metering

56

Test Headers

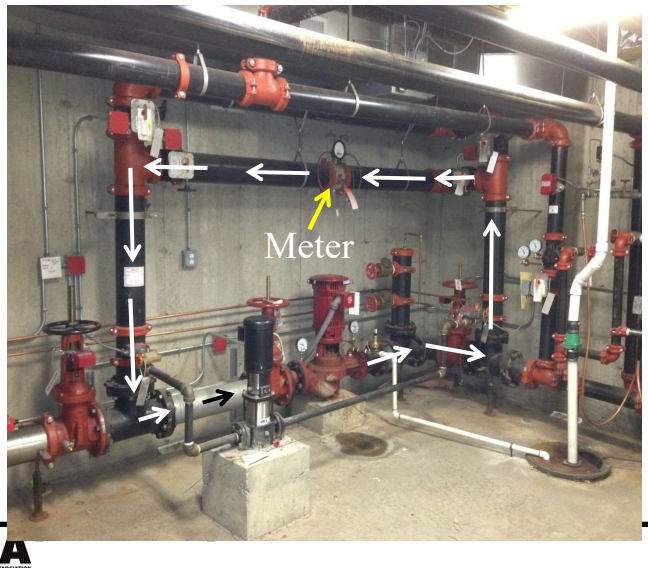
- Listed
- Number and size of outlets
- Location
- Shut-off Valve
- Drain
- Pipe Size (Table 4.28(a) or hydraulic calculations)

57



58

Closed Loop Metering



59

Determining Flow

- Pitot Gauge
- "Pitotless" Gauge

- Flow Meter
  - Listed
  - 175% of Rated Flow
  - Size - Table 4-28(a)

60

Pitot Gauge



61



62



63

"Pitotless" Gage



HOSE MONSTER COMPANY

1¾" PITOTLESS NOZZLE™
PN1.75THD–GPM FLOW CHART
FC-PN175THD.2021.09.21.MA

THIS DEVICE IS FM APPROVED

The pressure vs. flow rate data developed within this flow chart is based on the average K-factor measured during laboratory testing. This data has been determined to be within the acceptable limitations for accuracy. It is the user's responsibility to verify that the correct chart and column are being used.

HM2H | 2½" Hose Monster Model II or Flusher with flow splitter (HM2H, HM2HF) Use this column if the Pitotless Nozzle is connected to the 2½" Hose Monster or Flusher. The built-in pitot or flow splitter must be installed for accuracy.

PSI	HM2H GPM	OA GPM
5.2*		250
5.7*	250	
10	337	347
11	354	364
12	369	380
13	384	396
14	399	410
15	413	425
16	426	439
17	440	452
18	452	465
19	465	478
20	477	491
21	489	503
22	500	515
23	511	526

PSI	HM2H GPM	OA GPM
36	640	658
37	648	667
38	657	676
39	666	685
40	674	694
41	683	702
42	691	711
43	699	719
44	707	728
45	715	736
46	723	744
47	731	752
48	739	760
49	746	768
50	754	776
51	761	783

PSI	HM2H GPM	OA GPM
64	853	878
65	859	884
66	866	891
67	873	898
68	879	905
69	885	911
70	892	918
71	898	924
72	905	931
73	911	937
74	917	944
75	923	950
76	929	956
77	935	963
78	941	969
79	947	975

64

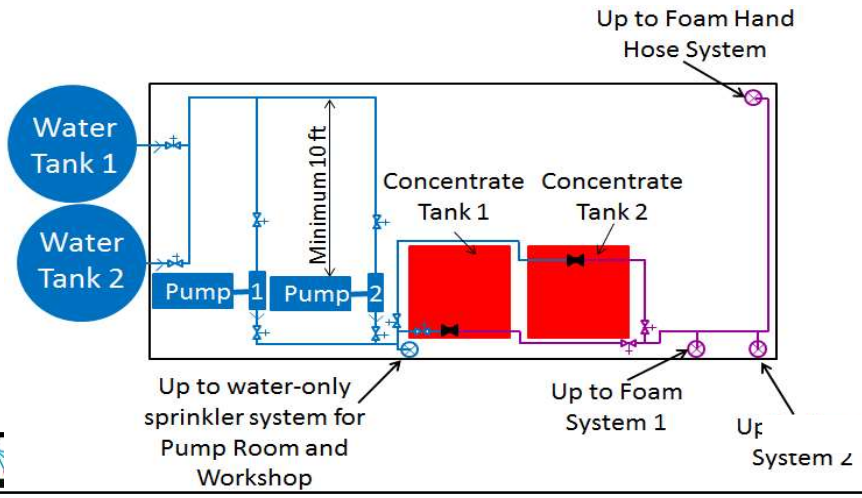
6. Pumps in Parallel and Series

- Pumps in Parallel
  - Multiple pumps in the same system where the water only goes through one pump on the way to the fire protection devices
- Pumps in Series
  - Multiple pumps in the same system where the water goes through one pump and then into another pump before going to the fire protection devices

65

Pumps in Parallel

- Redundant pumps (only one runs at a time)
- Parallel pump will start if needed



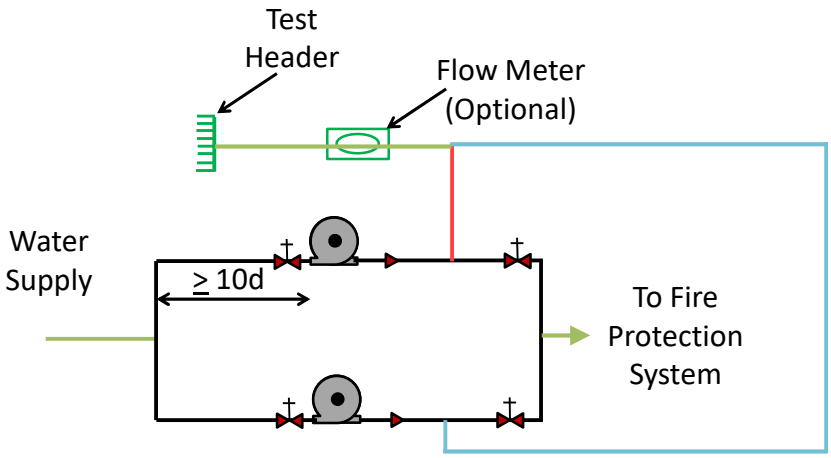
66

Pumps in Parallel

- Where multiple pumps arranged in parallel are required to operate simultaneously to meet the maximum fire protection system demand, the common piping, flow measuring device, and discharge shall be sized for the combined rated flow of all fire pumps required to operate simultaneously.
- The common flow measuring device shall be capable of providing accurate flow measurements when testing a single fire pump and when simultaneously testing all fire pumps required to operate simultaneously.

67

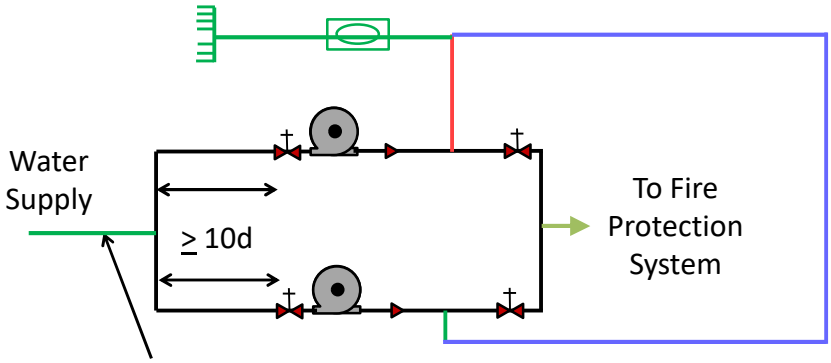
Testing Pumps in Parallel Designed to Operate Simultaneously



Piping to meter and test header needs to be sized for full flow of both pumps operating at the same time.

68

Pumps in Parallel Designed to Operate Simultaneously



Piping to multiple pumps needs to be sized for full flow of both pumps operating at the same time

69

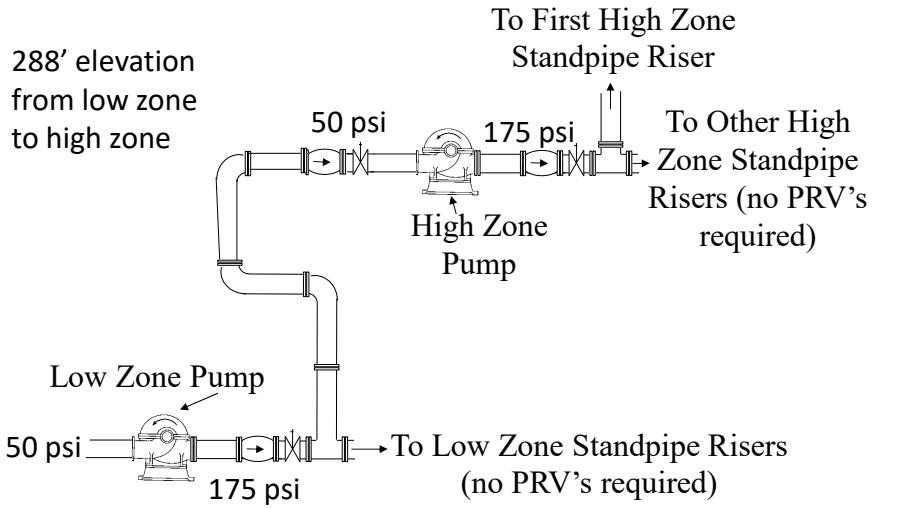
Pumps in Series

- Where high pressure can't be obtained by a single pump
- Where the building is divided into multiple vertical zones to control pressure

- Note: in the 2019 edition of NFPA 20, changes were made to allow multiple stage, multiple port pumps, which can substitute for pumps in series, but are beyond the scope of this class

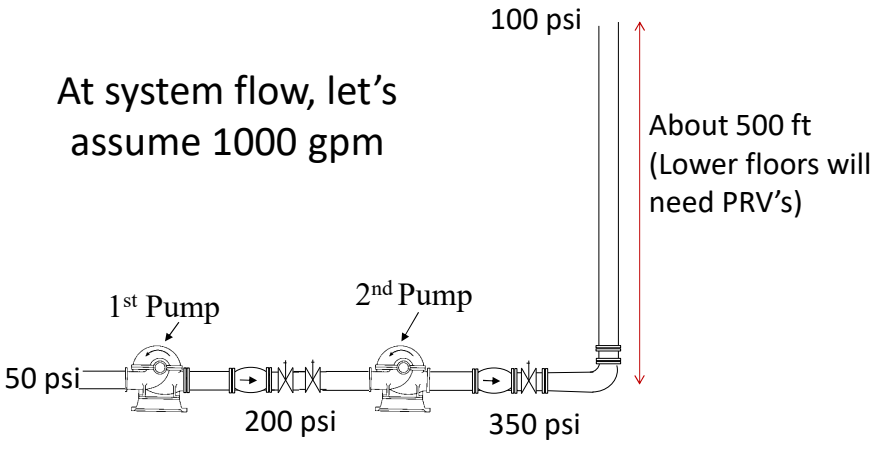
70

Control System Pressure at Lower Floors



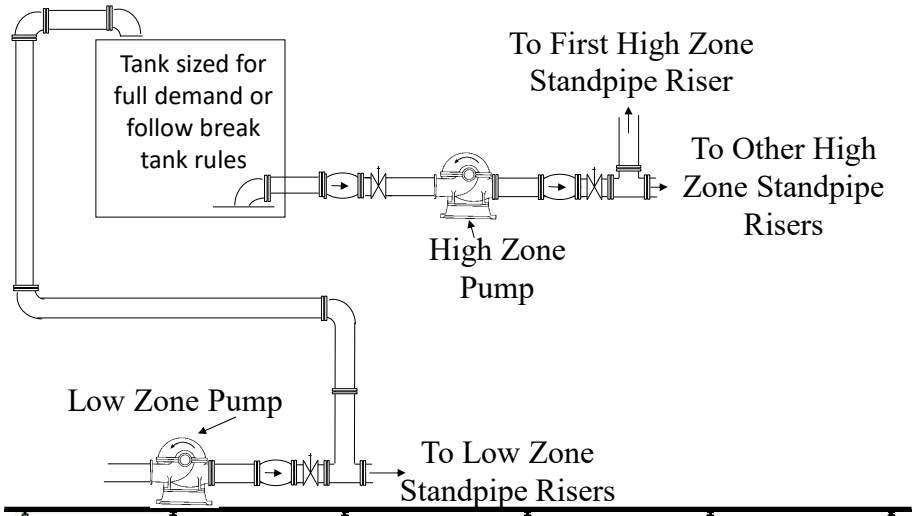
71

Meeting a High Demand Pressure



72

NOT Pumps in Series



73

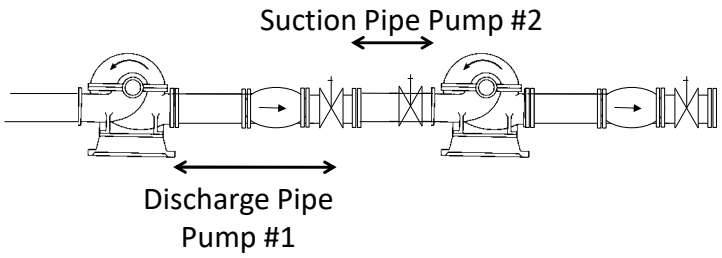
Pumps in Series Section 4.21

- Suction Pipe Definition
- Pumps in Series
- Sequence Starting of Electric Motor Driven Fire Pumps
- Sequence starting of Diesel Engine Driven Fire Pumps

74

Suction Pipe Definition for Pumps in Series

- Where pumps are installed in series, the suction pipe for the subsequent pump(s) shall begin at the system side of the discharge valve of the previous pump."



75

Pumps in Series

- All pumps in series are considered a unit
- No more than three pumps in series
- No more than two variable speed pumps in series
- No pump in a series pump unit shall be shut down automatically for any condition of suction pressure.
- No pressure-reducing or pressure-regulating valves between fire pumps in series
- The pressure at any point in any pump in a series fire pump unit, with all pumps running at shutoff and rated speed at the maximum static suction supply, shall not exceed the pressure rating.

76

Pumps in Series (cont)

- Pumps in series are required to be in the same pump room unless all of the following are met
  - All pumps in series can be manually stopped or started from all pump rooms with the series pumps
  - Suction and discharge pressures from all pumps are displayed in all pump rooms housing the series pumps
  - The alarms and signals shall be annunciated in the other pump rooms for all pumps that are in series
  - The interconnect control wiring between the controllers in different pump rooms shall be protected
  - Communication system between pump rooms

77

Pumps in Series (cont)

- Interconnected control wiring of fire pumps in series that are not located in the same room and that affect the starting of the supply (lower zone) pump(s) shall be protected against fire and physical damage in the same manner as power conductors described in NFPA 70, Article 695

78

Pumps in Series (cont)

- Audible and visual status signals shall be provided in each pump room indicating the status of the associated series pump(s) not located in the same pump room
- Electric Motor Driven Pumps
  - Pump running, phase loss, phase reversal, controller connected to alternative source, alternate circuit breaker open or tripped, low suction pressure (suction pressure more than 10 psi below the design suction pressure on any downstream pump)
- Diesel Engine Driven Pumps
  - Pump running, control switch in off or manual position, trouble on controller or engine, low suction pressure (suction pressure more than 10 psi below the design suction pressure on any downstream pump)

79

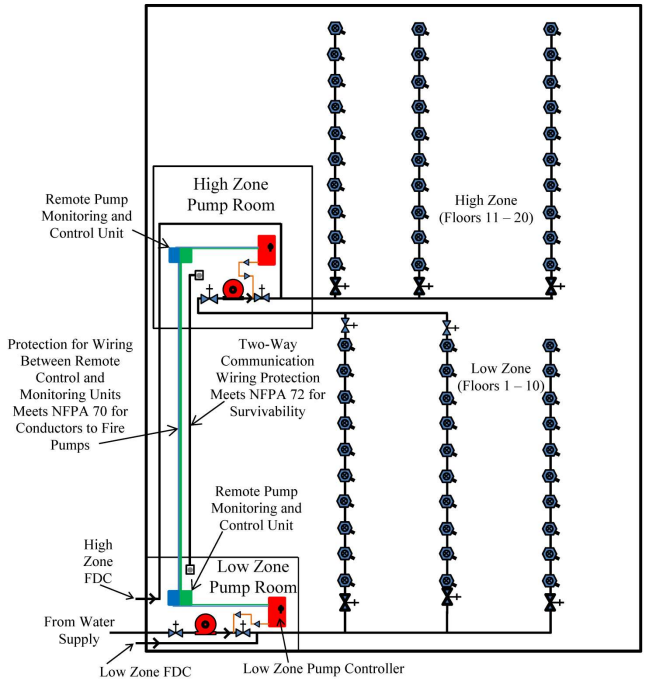
Pumps in Series (cont)

- A two-way, in-building emergency services communications system in accordance with NFPA 72 shall be provided in each pump room where pumps in series are not located in the same room
- The communication system shall meet the survivability requirements of NFPA 72

80

Pumps in Series Not in the Same Room

From *Standpipe Systems for Fire Protection* by Isman, used with permission of the author



81

Sequence Starting of Electric Motor Driven Pumps

- The controller for each unit of multiple pump units shall incorporate a sequential timing device to prevent any one driver from starting simultaneously with any other driver
- Each pump supplying suction pressure to another pump shall be arranged to start within 10 seconds before the pump it supplies
- Failure of a leading driver to start shall not prevent subsequent pumping units from starting

82

Sequence Starting of Diesel Engine Driven Pumps

- Same rules as electric motor driven pumps
- Additional statement, “The controllers for pumps arranged in series shall be interlocked to ensure the correct pump starting sequence.”

83

7. Controllers and Sensing Lines



84

Controllers

- "Brains" of the fire pump installation
- Monitor the conditions within the fire protection system
- Monitor the fire pump and its associated equipment
- Start the pump when needed
- Let people know what is happening

85

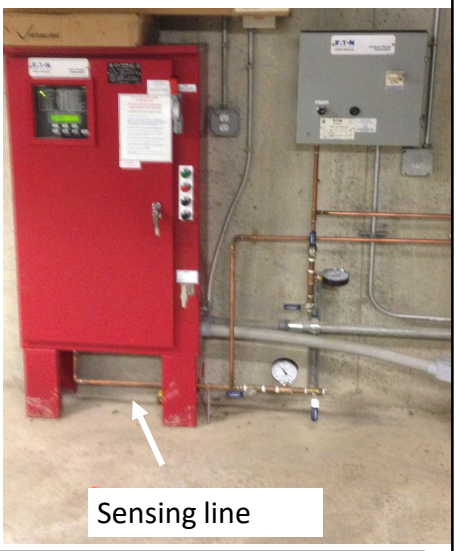
Controllers

- Controllers have to be listed for fire pump service
- Every fire pump needs its own controller
- Every jockey pump needs its own controller

86

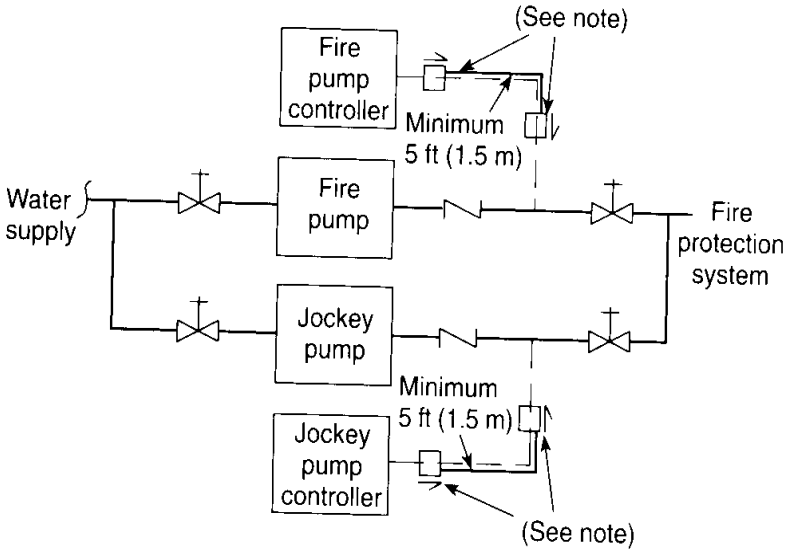
Sensing Lines

- Pipe that goes between controller and system
- Connected to system between discharge check valve and control valve
- Separate for each pump
- Minimum 1/2” corrosion resistant pipe
- Check valves/Ground Face Unions

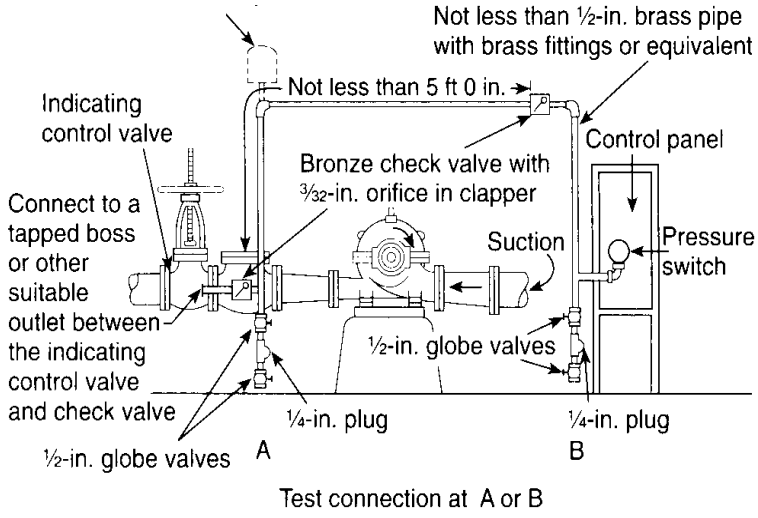


87

Pressure Sensing Line Connections



88



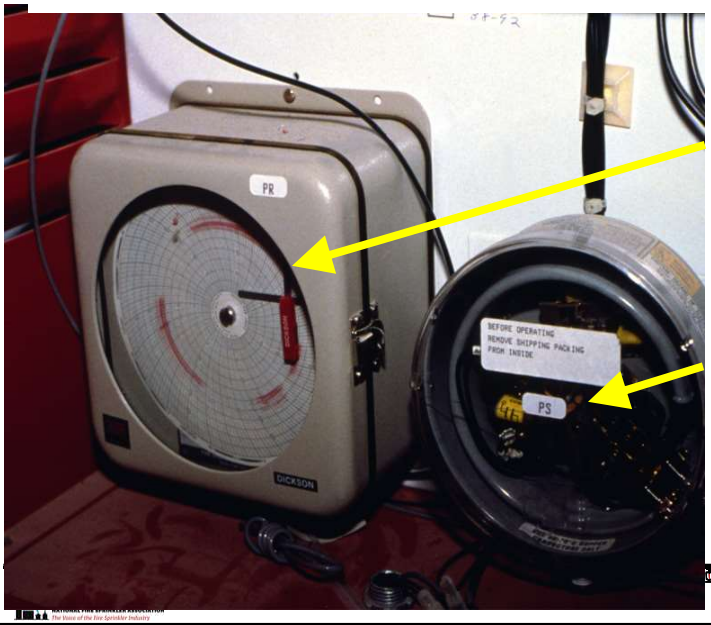
89

Pressure Recorder

- Required on the sensing line to all controllers
  - May be inside the controller
  - May be outside the controller on the sensing line
- Records pressure in fire protection system over 7 day period
- Analog or digital

90

Analog Pressure Recorder

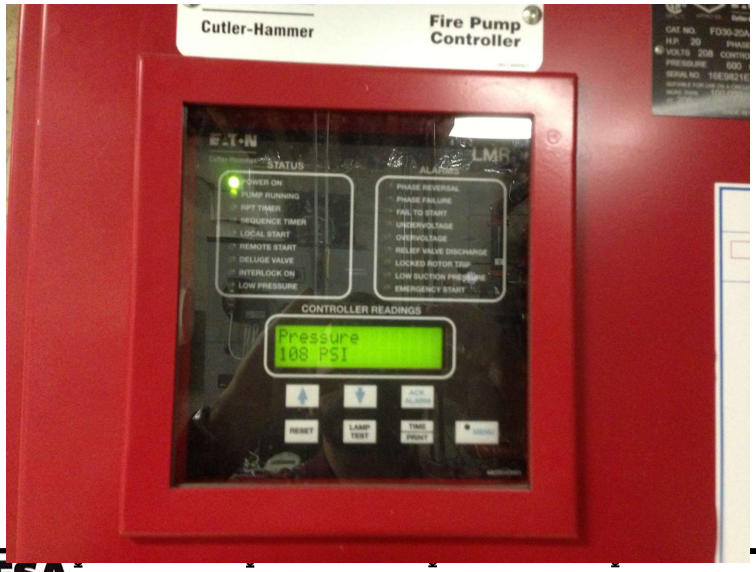


Pressure Recorder

Pressure Switch

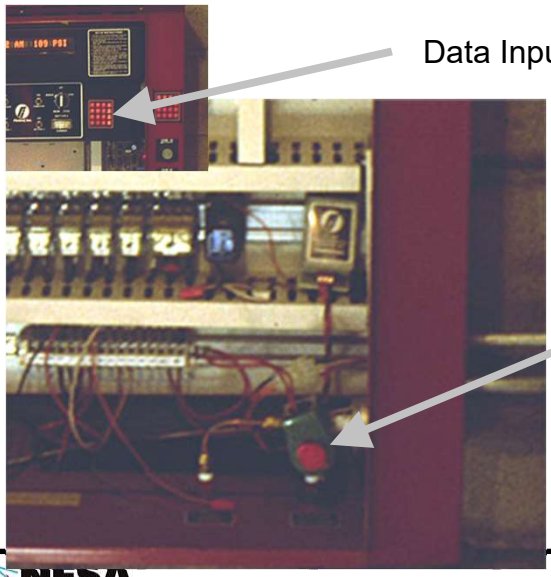
91

Digital Pressure Recorder/Switch



92

Digital Pressure Recorder/Switch



93

Starting the Pump

- Automatic & Manual
- Programmed Timer (Weekly Testing)

- Diesels Pumps Started By:
  - Batteries
    - 2 Sets
    - 15 Second Intervals
  - Hydraulic start
  - Air pressure start

94

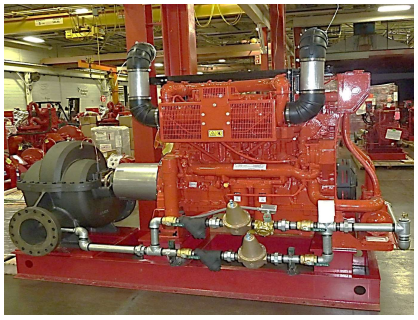
Stopping the Pump

- Manual - Main Switch and Stop Button
- Automatic - only allowed when all starting conditions have returned to normal
- Automatic Shutdown for Electric Motors only under two conditions
  - AHJ permits automatic shutdown
  - Automated testing meeting 5 parts of 10.5.2.7
- Automatic Shutdown for Diesel Engines only under three conditions
  - AHJ permits automatic shutdown
  - Overspeed condition occurs
  - Automated testing meeting 7 parts of 12.7.2.7

95

Controllers for Diesel Engine Driven Pumps





96

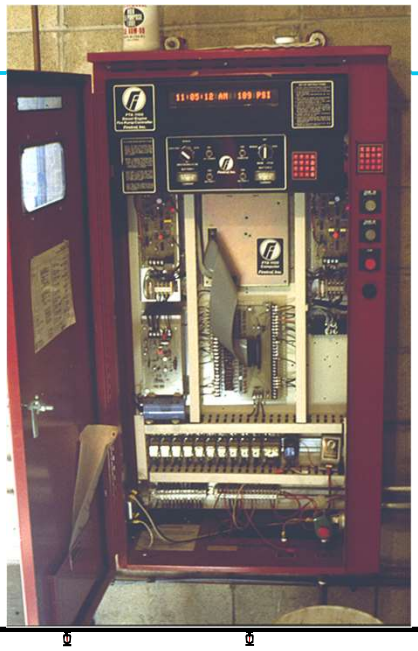
Diesel Engine Controllers

- Listed for diesel engines
- Within sight of engine
- Clearances - NFPA 70 Article 110
- Signage
- Grounding - NFPA 70 Article 250
- 1 per Pump

97



98



99

Alarms and Signals

- Alarms sent to a constantly attended location
  - Pump running
  - Controller has been turned to off or manual
  - Any of the other trouble signals

100

Mandatory Signals

- Visible indicator and common audible alarm
  - Critically Low Oil Pressure
  - High Engine Temperature
  - Failure of Automatic Start
  - Overspeed Shutdown
  - High Cooling Water Temperature

101

Mandatory Signals (cont)

- Visible indicator and common audible signal
  - Battery and Charger Failure
  - Low Air or Hydraulic Pressure (only if these starting mechanisms are present)
  - System Overpressure (variable speed drivers only)
  - For ECM Control Engines
    - Selector switch in alternate ECM position
    - Fuel injection malfunction

102

Battery Condition Monitoring on Controller



103

ECM Control Panel on Engine



104

Mandatory Signals (cont)

- Visible indicator and common audible signal
  - Low fuel level (less than 2/3 of a tank)
  - Low engine temperature
  - Liquid into interstitial space of double-wall tank
  - High cooling water temperature
  - Fuel maintenance required for those systems with fuel maintenance systems

105

Recommended Signals

- Low Pump Room Temperature
- Relief Valve Discharge
- Flow Meter bypass “on”
- Water Level or Pressure in Suction Pipe

106

Controller Panel



107

Signals

- Signal at the controller
- If the pump room is not a constantly attended location, send the signals to a constantly attended location

108

Controllers for Electric Motor Driven Pumps





109

Power for Fire Pumps- Electric

- Electric Motors & Controllers
  - All equipment must be installed according to NFPA 70
    - No phase converters
  - Provided with normal power from a continual source
    - Alternate power is required
      - High rise buildings
      - Where building height is beyond pumping capacity of the fire department
      - Where normal power is not reliable (A.9.3.2)
    - Must have an alternate power source if normal power is not reliable

110

Power for Fire Pumps- Electric cont

- Electric Motors cont
  - Must be listed for fire pump service
  - Motors with variable speed controllers must meet requirements of NEMA MG-1 & listed
  - Specific rules for generators used as standby power sources

111

Power for Fire Pumps- Electric cont

- Electric motor controllers
  - Must be listed for electric motor driven fire pumps
  - Must be within sight of the motor they control
  - Specific signal devices on the controller
    - Power available
    - Phase reversal
  - Specific signals remote from controller to a constantly attended location if pump room is not constantly attended
    - Pump or motor running
    - Loss of phase or phase reversal
    - Controller connected to alternate power

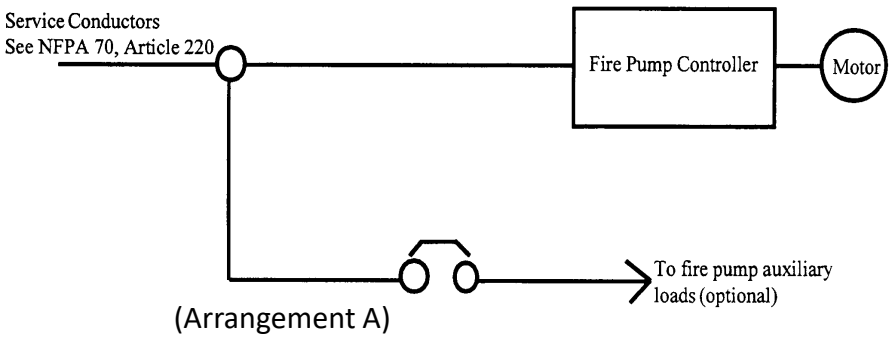
112

Power for Fire Pumps- Electric cont

- Electric motor controllers cont
  - Must be capable of starting both automatically & manually
  - Special rules for controllers in excess of 600V
  - Special rules for limited service controllers
    - ≤ 30hp, ≤ 600V, across the line starting
  - Separate rules for power transfer to alternate power
  - Specific rules for variable speed controllers

113

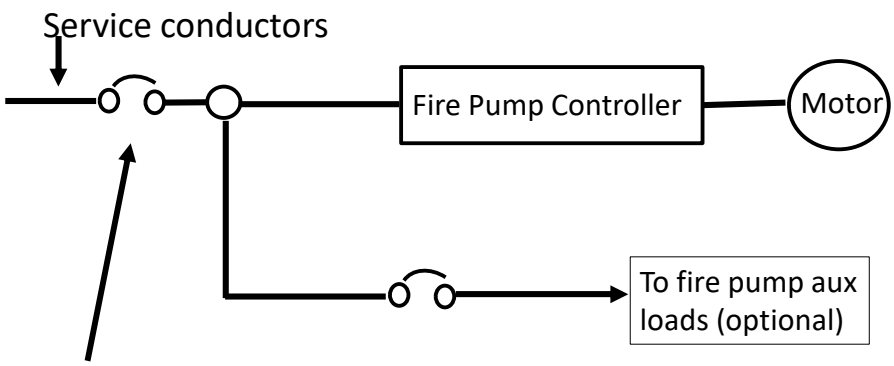
Electric Supply at Motor Voltage



(Arrangement A)

114

Electric Supply at Motor Voltage



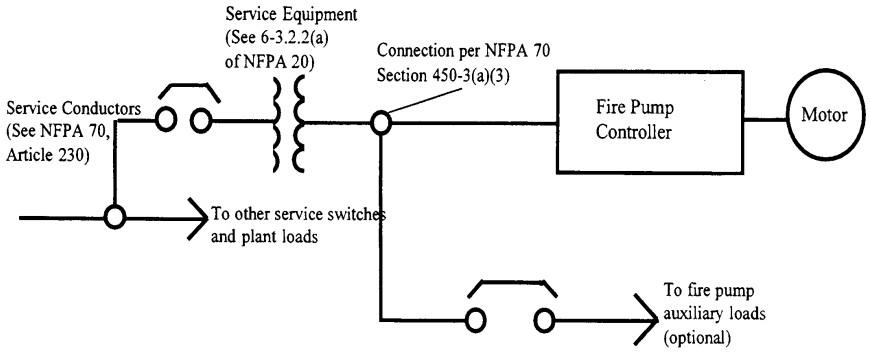
115

Power Supply Arrangements

- Power arrives at proper voltage; or
- Transformer installed to change voltage
  - Step-up Transformer increases voltage if supply is too low
  - Step-down Transformer decreases voltage if supply is too high

116

Electric Supply NOT at Motor Voltage



117

Isolating Switch & Breaker

- Isolation switch
  - Operable from outside the controller
  - Warning Label or Circuit Breaker Interlock



- Circuit breaker
  - Operable from Outside Controller
  - Labeled



118



Three position switch (outside controller) to make sure that shut-down occurs in correct order

Isolating Switch (inside controller)

Circuit Breaker (inside controller)

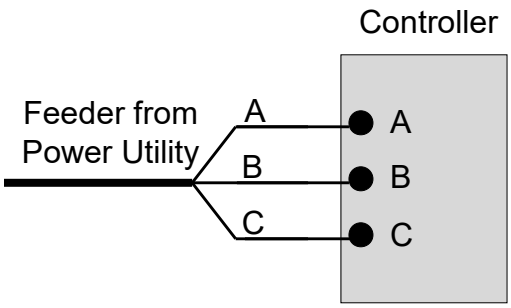
119

Three Phase Power

- In order to achieve the necessary horsepower, three-phase motors are needed for most pump situations
- Three-phase motors need three-phase electricity
- Three wires from power supply that each need to be connected to the correct terminal to get the electricity to flow correctly

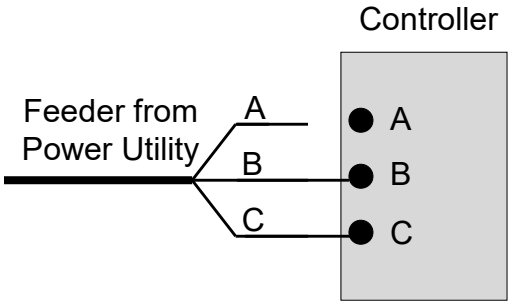
120

Three Phase Power (correctly wired)



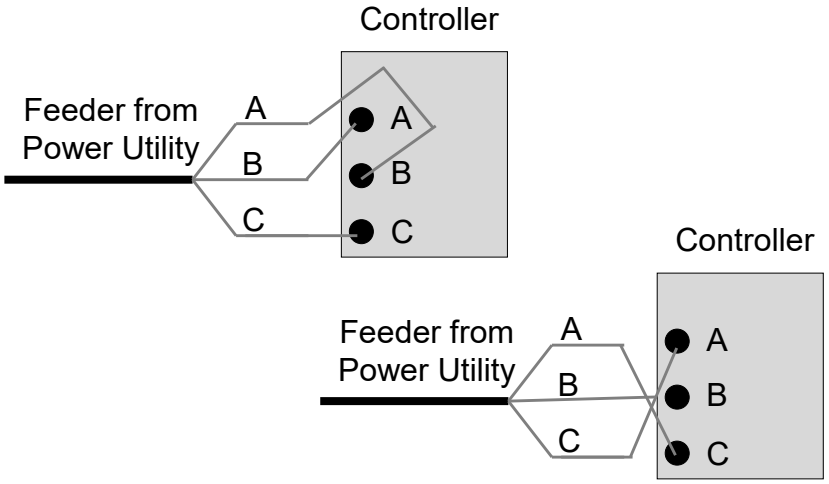
121

Three Phase Power (loss of phase)



122

Three Phase Power (phase reversal)



123

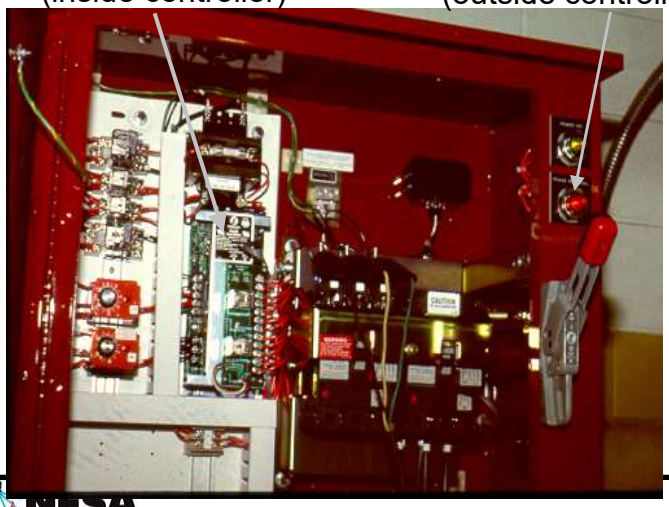
Signals

- Required signals
  - Power available
    - Individual phases
    - From all power sources
  - Phase reversal
- Required to sound at constantly attended location
  - Pump Running
  - Loss of Phase
  - Phase Reversal

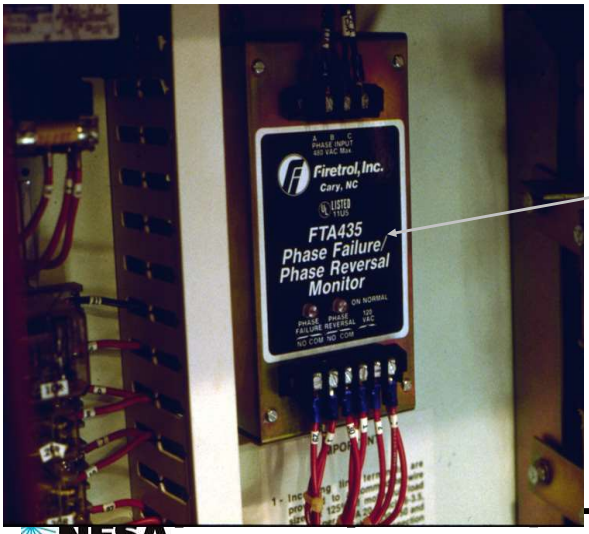
124

Normal Phase Monitor (inside controller)

Reverse Phase Indicator (outside controller)



125

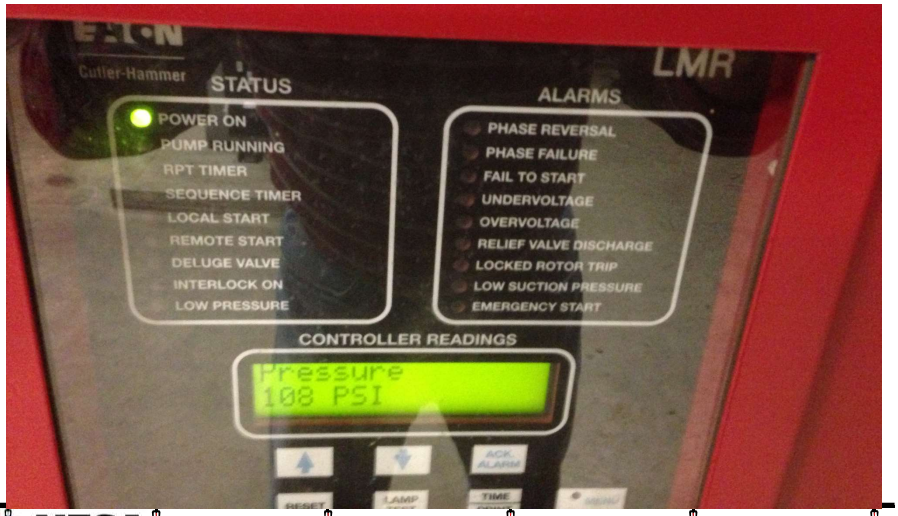


Phase Reversal Monitor

- Inside Controller
- "On" is normal

126

Indicators on Outside of Controller



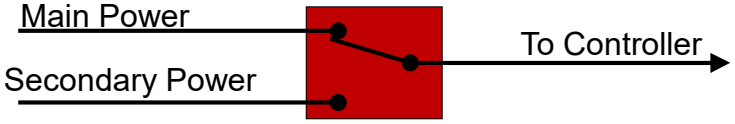
127

Transfer Switches

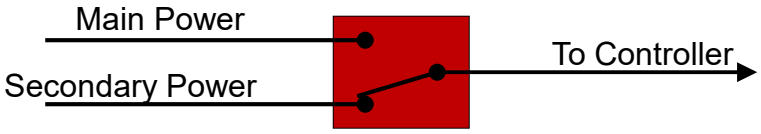
- A listed device
- Used when two power supplies
- Physically connects the controller to the main power supply unless power is lost, low voltage or phase reversal
- If activated, disconnects from the main power supply and connects the controller to the secondary supply

128

Transfer Switch

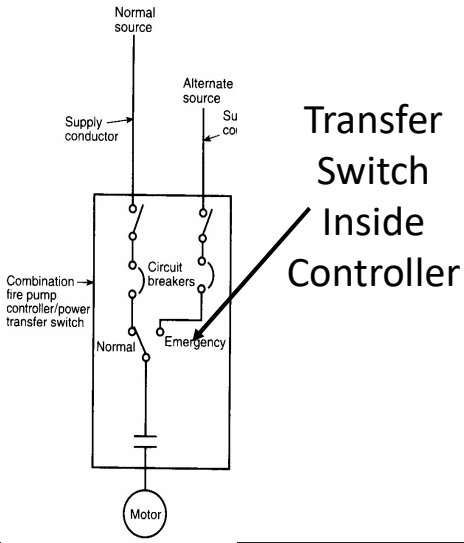


Transfer Switch Connected to Main Power Supply



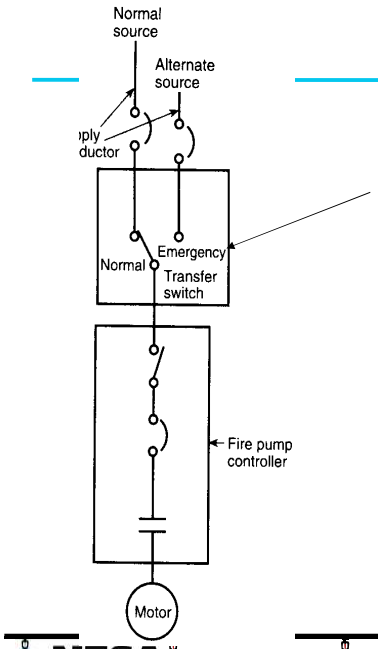
Transfer Switch Connected to Secondary Power Supply

129



Transfer Switch Inside Controller

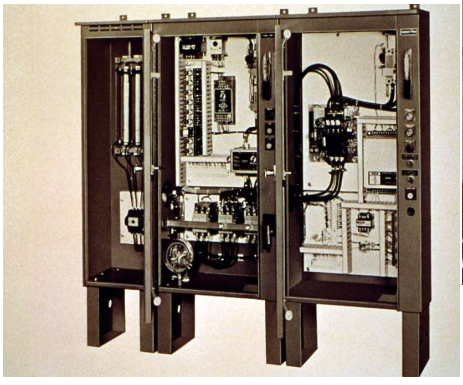
130



Transfer Switch Outside of Controller

131

Transfer Switch Outside Controller





132

Limited Service Controllers

- ≤ 30HP Motors and <600 Volts



133

8. Hydraulic Formulas

- Elevation Pressure Change
  - 0.433 x change in height (in feet)
  - Loss of energy going uphill
  - Gain of energy going downhill
- Friction Loss with Hazen-Williams formula
  - $P_f = \frac{4.52(Q)^{1.85}}{(C)^{1.85}d^{4.87}}$
  - $P_{fl} = P_f(L)$

P_f = Friction loss per ft of pipe
Q = flow in pipe in gpm
C = relative roughness of pipe
d = inside diameter of pipe
P_{fl} = Total friction loss in pipe
L = length of pipe

134

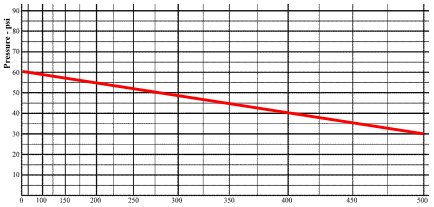
Pump Formulas

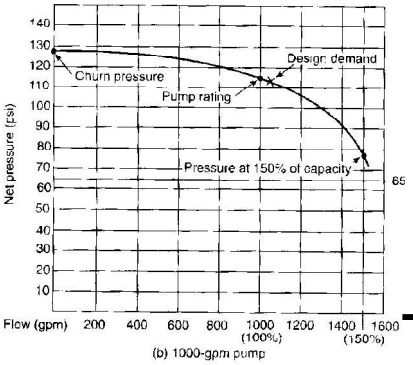
- Net Pressure formula: $P_N = P_D - P_S$
- Discharge Pressure formula: $P_D = P_S + P_N$
- P_N = The net pressure produced by the pump
- P_D = Pressure at the pump's discharge
- P_S = Pressure at the pump's suction
- Each of these pressures changes as the flow changes

135

Pump Pressures

- Suction Pressure – function of the water supply
- Net Pressure – function of the pump
- Discharge Pressure – function of water supply and pump





136

Terminology

- Water Supply
  - P_{Static} = Static Pressure = pressure from the water supply when there is no water flowing in the fire protection system
  - $P_{Residual}$ = Residual Pressure = pressure from the water supply when a specific flow is going into the fire protection system
- Pump
  - Churn – when the pump is running but no flow is going into the fire protection system
  - Rated Flow – the flow at which the pump is rated
  - Maximum Flow – 150% of the rated flow (there is an exception, but it is beyond the scope of this class)

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

137

Suction Pressure

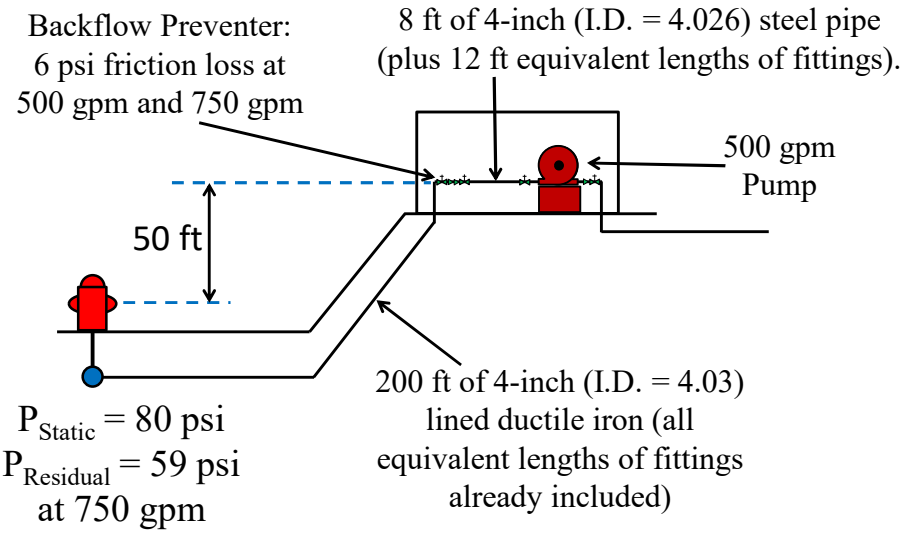
- $P_S = P_{Residual} - P_E - P_{fl}$

- This calculation needs to be done at several flows
  - At the flow demand for the fire protection system to make sure that the discharge pressure can meet the pressure demand
  - At maximum flow to make sure that the suction pressure is positive
  - At churn to make sure that the discharge pressure does not over-pressurize the system (note that at this flow, the Residual Pressure is the Static Pressure)

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

138

Example



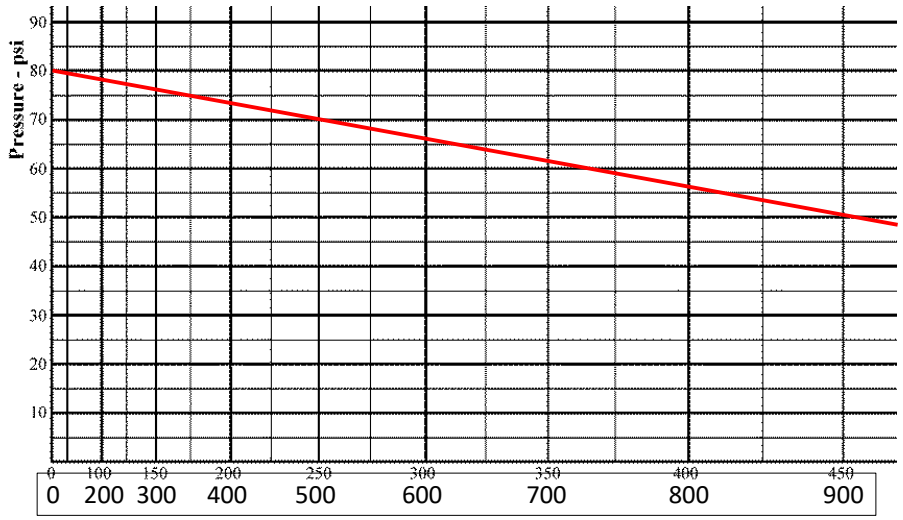
139

Example

- Pump
  - Rated at 500 gpm and 50 psi
  - 60 psi at churn
  - 34 psi at 750 gpm (maximum flow)
- Fire Protection System Demand
  - 520 gpm at 70 psi
  - Calculated to the pump discharge flange

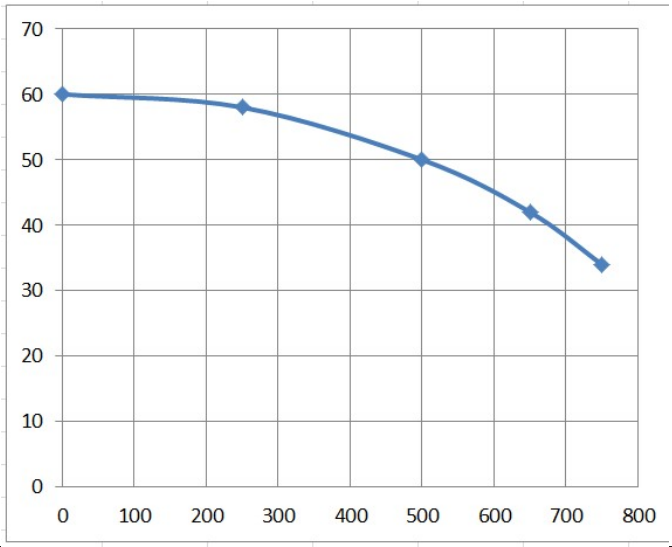
140

Water Supply Curve Measured at Fire Hydrant



141

Pump Performance (Net Pressure) Curve



142

Suction Pressure Summary at Demand Flow (520 gpm)

- $P_{residual}$ = 69 psi (from water supply curve)
- Friction Loss
  - Underground suction pipe: $\frac{4.52(520)^{1.85}}{(140)^{1.85}(4.03)^{4.87}} = 0.058$
    - 0.058 x 200 = 11.6 psi
  - Aboveground suction pipe: $\frac{4.52(520)^{1.85}}{(120)^{1.85}(4.026)^{4.87}} = 0.077$
    - 0.077 x (8 + 12) = 1.5 psi
  - 6 psi from friction loss in backflow
- Elevation Loss: 50 x 0.433 = 21.7 psi

143

Suction Pressure Summary at Demand Flow (520 gpm)

- $P_S = P_{residual} - P_{fl} - P_E$
- P_S = 69 – 11.6 – 1.5 – 6 – 21.7 = 28.2 psi
- P_N = 49 psi (from Pump Curve)
- $P_D = P_S + P_N$ = 28.2 + 49 = 77.2 psi
- Meets or exceed system demand (70 psi)

144

Suction Pressure Summary at Maximum Flow (750 gpm)

- $P_{residual}$ = 59 psi (from water supply curve)
- Friction Loss
  - Underground suction pipe: $\frac{4.52(750)^{1.85}}{(140)^{1.85}(4.03)^{4.87}} = 0.114$
    - 0.114 x 200 = 22.8 psi
  - Aboveground suction pipe: $\frac{4.52(750)^{1.85}}{(120)^{1.85}(4.026)^{4.87}} = 0.152$
    - 0.152 x (8 + 12) = 3 psi
  - 6 psi from friction loss in backflow
- Elevation Loss: 50 x 0.433 = 21.7 psi

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION

145

Suction Pressure Summary at Maximum Flow (750 gpm)

- $P_S = P_{residual} - P_{fl} - P_E$
- P_S = 59 – 22.8 – 3 – 6 – 21.7 = 5.5 psi
- Meets requirement of being a positive pressure

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION

146

Pressure Summary at Churn (0 gpm)

- P_{Static} = 80 psi (from water supply curve)
- Friction Loss
  - Underground suction pipe: $\frac{4.52(0)^{1.85}}{(140)^{1.85}(4.03)^{4.87}} = 0$
    - 0.114 x 200 = 22.8 psi
  - Aboveground suction pipe: $\frac{4.52(0)^{1.85}}{(120)^{1.85}(4.02\ \ )^{4.87}} = 0$
    - 0.152 x (8 + 12) = 3 psi
  - 6 psi from friction loss in backflow
- Elevation Loss: 50 x 0.433 = 21.7 psi

147

Maximum Pressure Summary at Churn (0 gpm)

- $P_S = P_{Static} - P_{fl} - P_E$
- P_S = 80 – 0 – 0 – 6 – 21.7 = 52.3 psi
- P_N = 60 psi (from Pump Curve)
- $P_D = P_S + P_N$ = 52.3 + 60 = 112.3 psi
- Does not exceed maximum pressure of fire protection system components of 175 psi

148

9. Pump Sizing

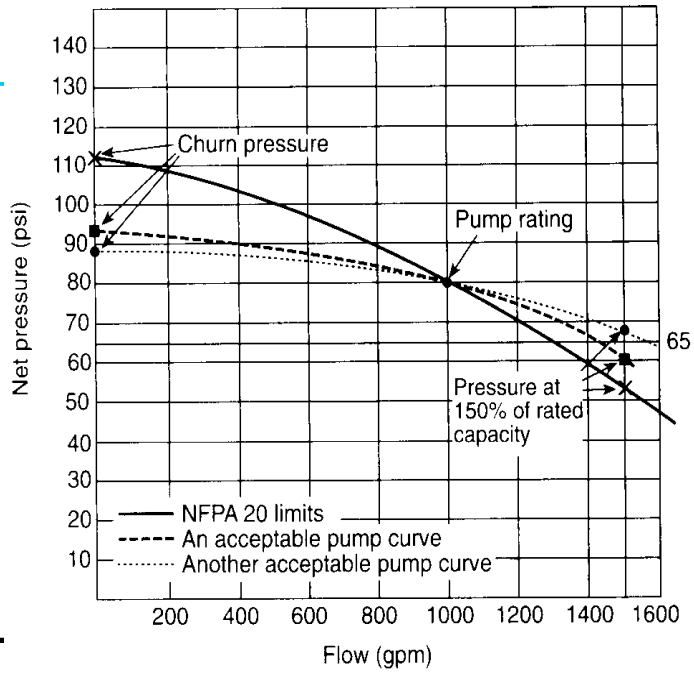
- Rated Flow (25-5000 gpm)
- Rated Pressure (40-200 net psi)
- Rated Speed

149

Permissible Performance Ranges

- Allows *maximum* 140% rated net pressure at churn (no flow)
- Requires a *minimum* of 65% rated net pressure at 150% of rated flow (max. flow)

150



151

Pump Sizing – 7 Step Procedure

1. Calculate system demand to pump discharge flange
2. Calculate suction pressure
3. Select pump so that the system flow demand is less than 150% (annex recommends 90-140%) of the rated flow of the pump. Section 4.10.
4. Using the Manufacturer's Pump Curve, find the pump's net pressure at the system demand flow

152

Pump Sizing – 7 Step Procedure

5. Add the suction pressure to the net pressure to get the discharge pressure (all at demand flow)

6. If the discharge pressure is greater than the demand, okay. If not, select new pump.

7. Check maximum pressure produced by pump and make sure that the pump does not create more pressure than the equipment can handle

153

Step 1-

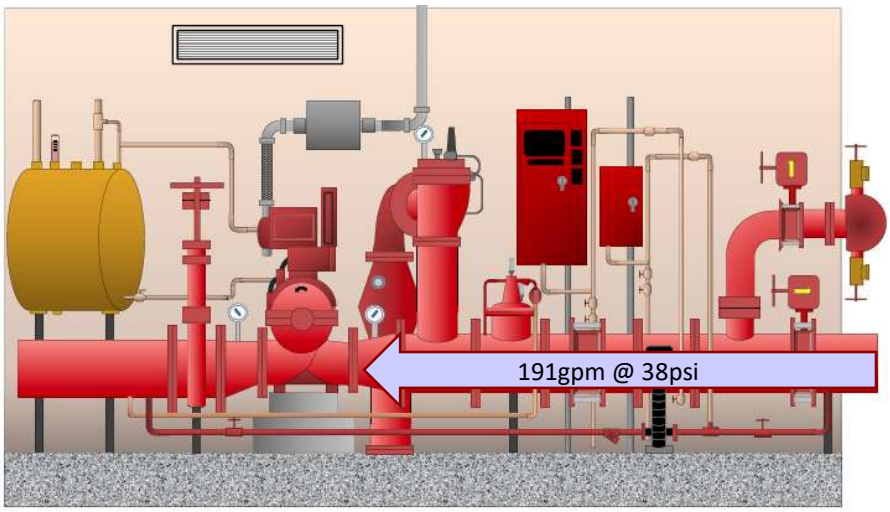
calculate system demand back to pump discharge flange

BL3	16	5.38	26.8	3"		183	C=120	24.8	Q_{BL3}=26.8 ;
						20.7		6	Adjust EL & GV to Sch 10; Pe= 14 * 0.433=6.5
BOR	2		190.8	3.26	ACV=10 EL=9.4 GV= 1.3	203.7	0.034	6.9	
BOR	1			4"		4	C=120	37.7	System demand = 191gpm @ 38psi
					EL=7 GV=1	8		0	
FP	1		190.8	4.24		12	0.009	0.1	
								37.81	

154

Step 1-

calculate system demand back to pump discharge flange



155

Step 2 – Water Supply



156

Step 2-

calculate the available flow & pressure from the water supply at the pump suction flange



157

Step 2-

calculate the available flow & pressure from the water supply at the pump suction flange

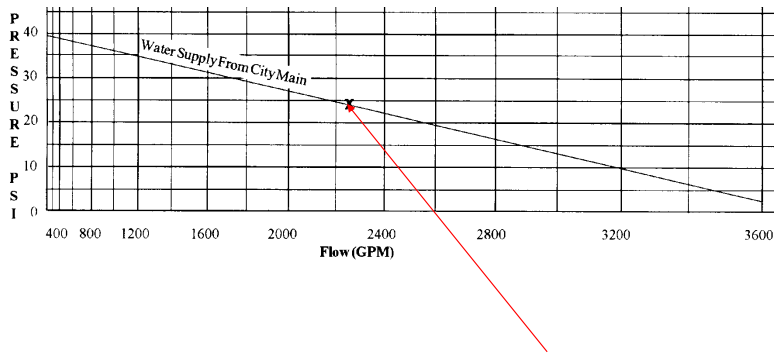
- Find the residual pressure of the water supply at the maximum flow for the pump at 150% of rated flow. Call this P_R
- Calculate all pressure loss for both friction and elevation between the water supply and the pump suction flange at the maximum flow for the pump. Call this P_L
- The suction pressure will be the residual pressure from the water supply minus the pressure losses.

$P_S = P_R - P_L$

158

Step 2-

calculate the available flow & pressure from the water supply at the pump suction flange



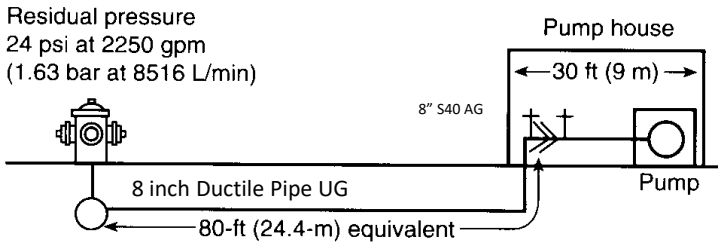
Supply curve indicates that there is 2250 GPM @ 24 PSI

159

Step 2-

calculate the available flow & pressure from the water supply at the pump suction flange

Example: 1500 gpm Pump



160

Step 2-

calculate the available flow & pressure from the water supply at the pump suction flange

Q = Flow / GPM
C = Coefficient
d = Inside Diameter

$$4.52xQ^{1.85} \div C^{1.85} \div d^{4.87}$$

Example:

1500 gpm @ 100% / Ductile Iron/Class 54 UG (C=140) / 8" Diam.

$$4.52x2250^{1.85} \div 140^{1.85} \div 8.15^{4.87}$$

FL/per ft. = .028 psi per ft of pipe

FL in Underground Pipe = .028 psi/ft x 80 ft. = 2.24 psi

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION

161

Step 2-

calculate the available flow & pressure from the water supply at the pump suction flange

Q = Flow / GPM
C = Coefficient
d = Inside Diameter

$$4.52xQ^{1.85} \div C^{1.85} \div d^{4.87}$$

Example:

1500 gpm @ 100% / S/40 AG (C=120) / 8 in. Diam.

$$4.52x2250^{1.85} \div 120^{1.85} \div 7.98^{4.87}$$

FL = 0.041 per ft of pipe
FL in Aboveground Pipe = .041 psi/ft x 30 ft. = 1.23 psi

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION

162

Step 2-

calculate the available flow & pressure from the water supply at the pump suction flange

- Analysis at 2250 gpm (150% of 1500)
- Residual pressure = 24 psi (from graph)
- Friction loss through underground (80 ft)= 2.24 psi
- Friction loss through backflow device = 8.0 psi (Provided by Manufacturer)
- Friction loss in pump room piping (30 ft) = 1.2 psi
- Elevation loss (Same Elevation) = 0.0

P_S = (24 psi Supply) – 2.24 – 1.2 – 8.0 – 0.0
P_S = 12.56 psi available at suction flange

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION

163

Step 3 –

select a pump that can make up the difference between the supply and what we need coming out of the pump



NFSA NATIONAL FIRE SPRINKLER ASSOCIATION

164

Step 3 –

select a pump that can make up the difference between the supply and what we need coming out of the pump

- Meets system demand
- Size selection normally varies from 90% to 140% pump capacity
- Must not over-pressurize the system

Step 3 –

select a pump that can make up the difference between the supply and what we need coming out of the pump

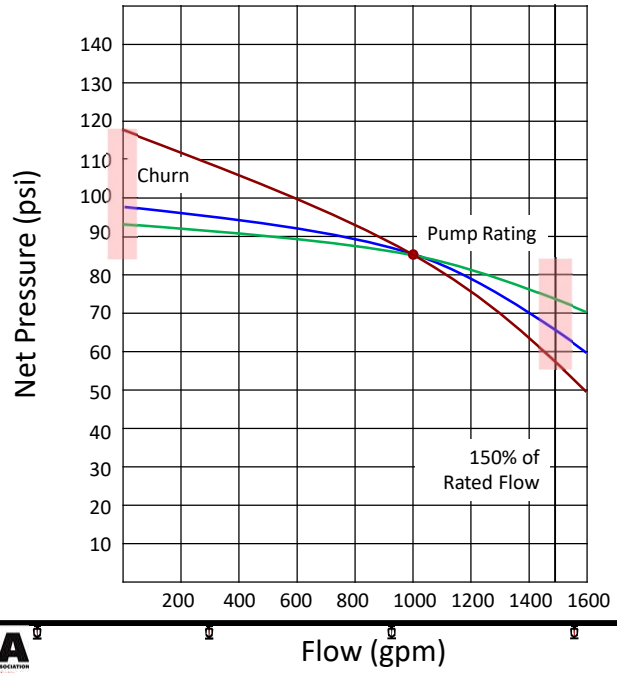
- Pump Capacities
  - Churn – (0%)
  - Capacity – (100%)
  - Peak – (150%) –Exception for supply limitations, but must be able to supply system demand.

Permissible Performance Ranges

- Allows maximum 140% rated net pressure at churn (no flow)
- Requires a minimum of 65% rated net pressure at 150% of rated flow (max. flow)

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

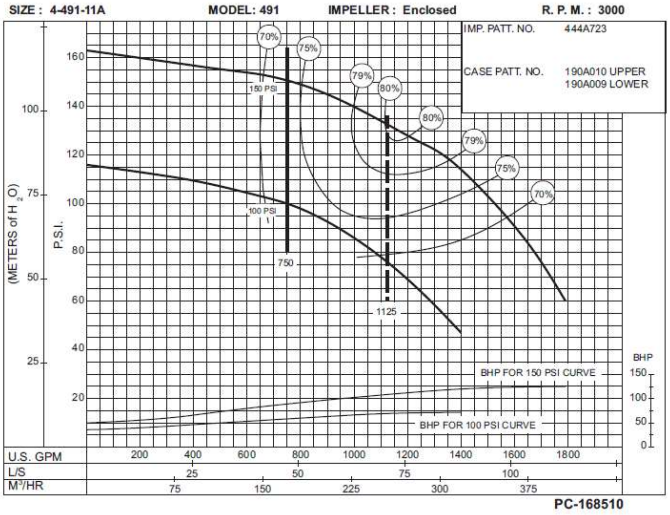
167



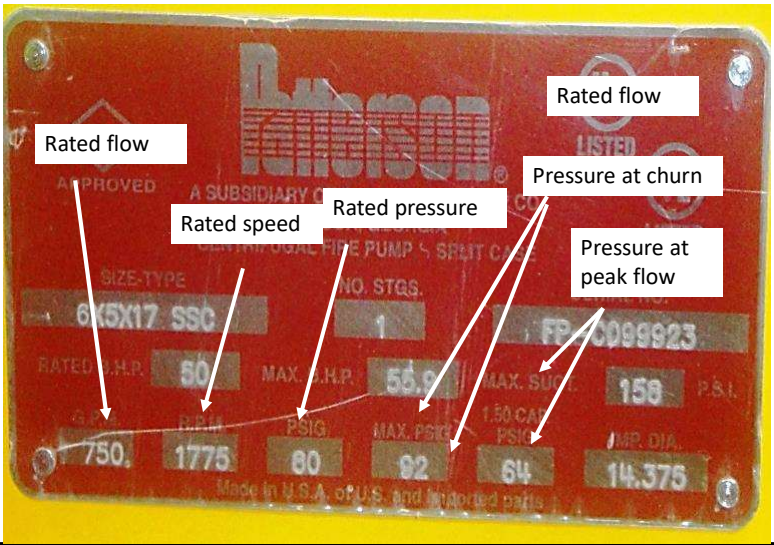
NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

168

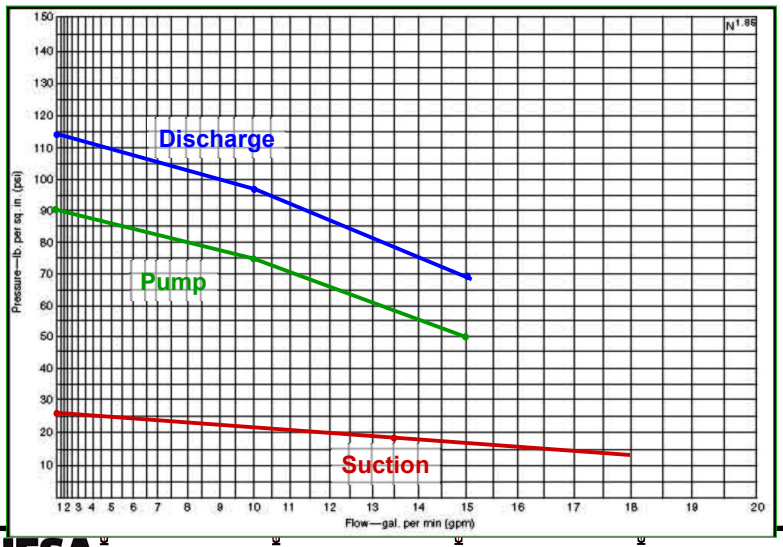
Step 4 – Manufacturer's Curve



Nameplate

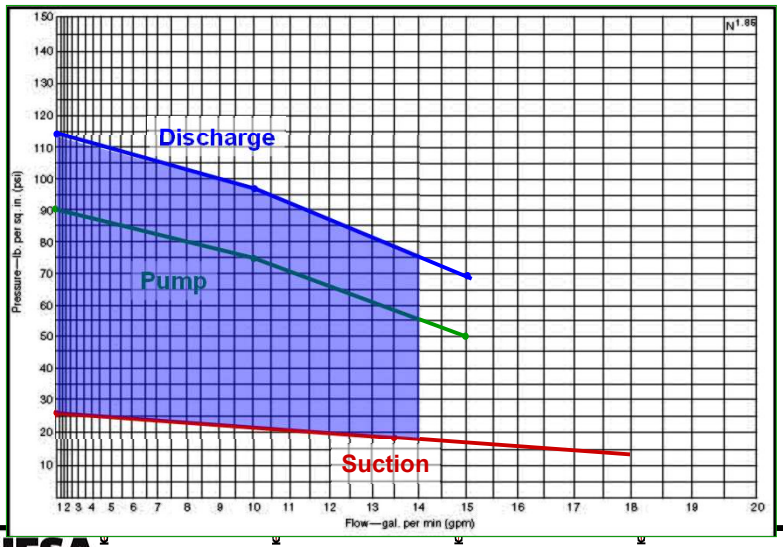


Step 5 – Combine Suction & Net



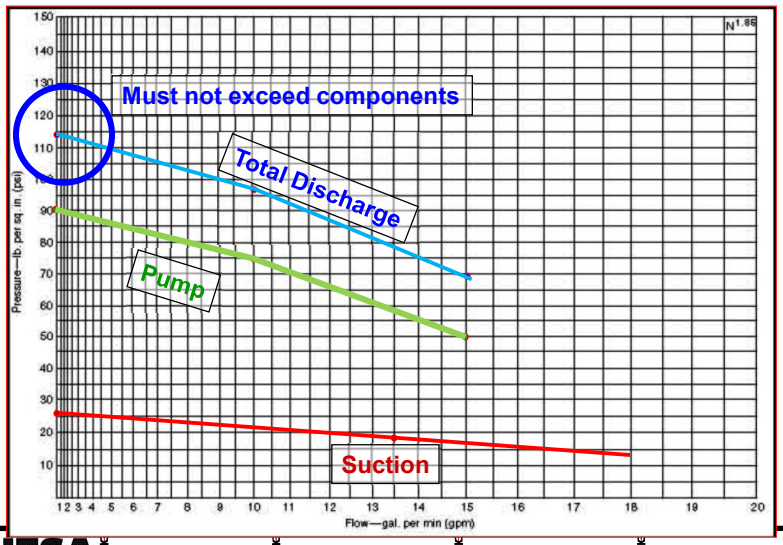
171

Step 6 – Compare System Demand



172

Step 7 – Check Maximum Pressure

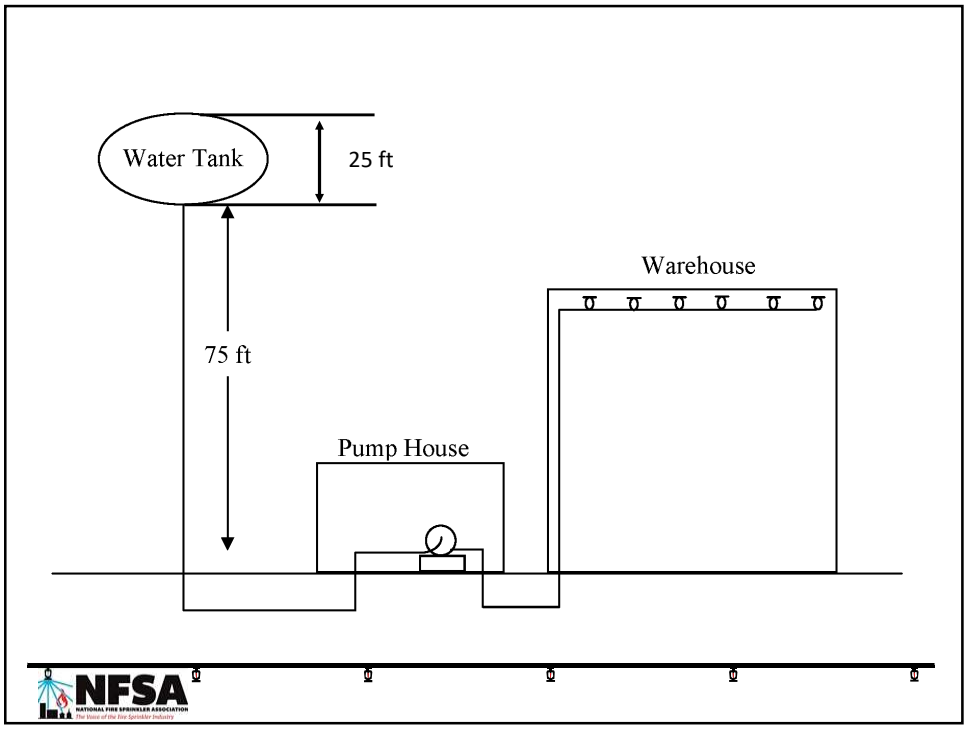


173

Pump Sizing Example

- Warehouse with a sprinkler demand (calculated back to the discharge flange of the pump) of 1010 gpm at 125 psi
- Water supply is a tank elevated 75 ft above the centerline of where the pump will be
- Friction loss in the suction piping is 1 psi from the water supply to the suction flange of the pump at 1010 gpm

174

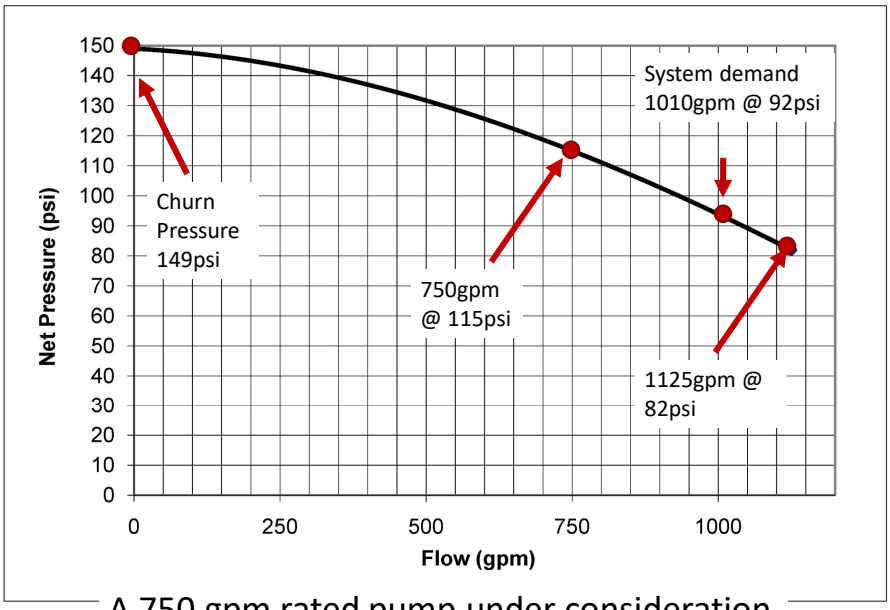


175

750 gpm Pump Under Consideration

- Churn pressure = 149 psi
- Rated pressure = 750 gpm @ 115psi
- Pressure at maximum flow = 1125 gpm @ 82psi
- Pressure at 1010 gpm = 92 psi
- Can we use this pump?

176



A 750 gpm rated pump under consideration

177

Can we use this pump?

- $P_D = P_S + P_N$
- P_N = 92 psi at 1010 gpm
- Suction Pressure
  - Elevation pressure = 75 x 0.433 = 32 psi
  - Friction loss in suction pipe = 1 psi
  - Suction pressure = 32 – 1 = 31 psi
- $P_D = P_S + P_N$ = 92 + 31 = 123 psi at 1010 gpm

178

Can we use this pump?

- No, pump does not produce enough pressure at 1010 gpm
  - System demand is 125 psi at 1010 gpm
  - Discharge pressure of pump is 123 psi at 1010 gpm

179

Alter the system to use this pump?

- Can the system be altered so that you could use this pump?
  - Could raise elevated tank 5 ft to get 2 psi more suction pressure; or
  - Could redesign sprinkler system to cut down on friction loss and reduce demand to 123 psi or less (lower the ceiling- not likely)
- Would you want to?

180

Alter the system to use this pump?

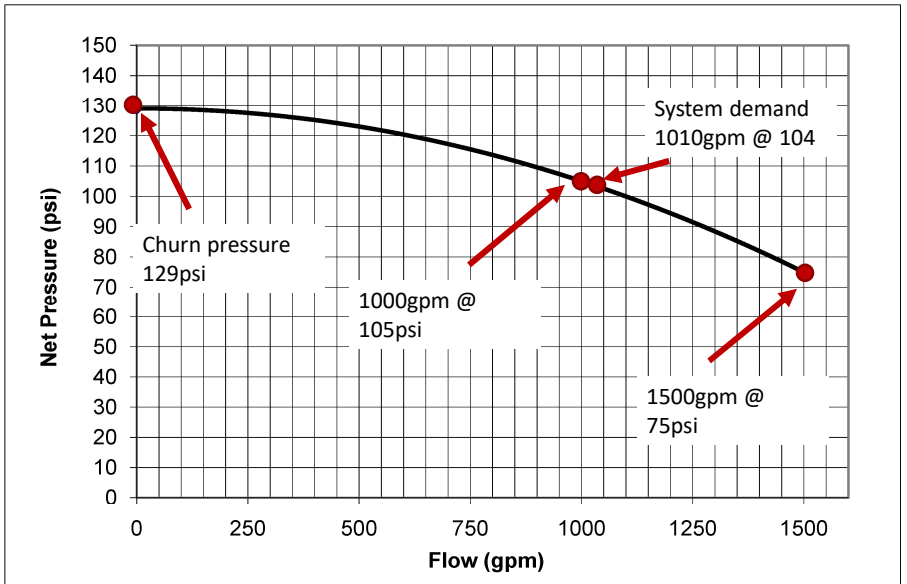
- Would you want to?
  - At churn, pump will produce 32 + 149 = 181 psi
  - This is at the LOW point of the tank.
- At the high point the pressure would be even greater
  - At churn, pump will produce 43 + 149 = 192 psi

181

1000 gpm Pump Under Consideration

- Churn pressure = 129 psi
- Rated pressure = 105 psi at 1000 gpm
- Pressure at maximum flow = 75 psi at 1500 gpm
- Pressure at 1010 gpm = 104 psi
- Can we use this pump?
- 31 + 104 = 135 psi

182



A 1000 gpm rated pump under consideration

183

Can we use this pump?

- Yes, pump produces enough pressure at 1010 gpm
  - System demand is 125 psi at 1010 gpm
  - Discharge pressure of pump is 135 psi at 1010 gpm

184

Can we use this pump?

- Yes, pump produces enough pressure at 1010 gpm
  - System demand is 125 psi at 1010 gpm
  - Discharge pressure of pump is 135 psi at 1010 gpm
- What is the maximum pressure produced by the pump?
  - 32 + 129 = 161 psi

185

10. Using a Pump with Multiple Water Supplies

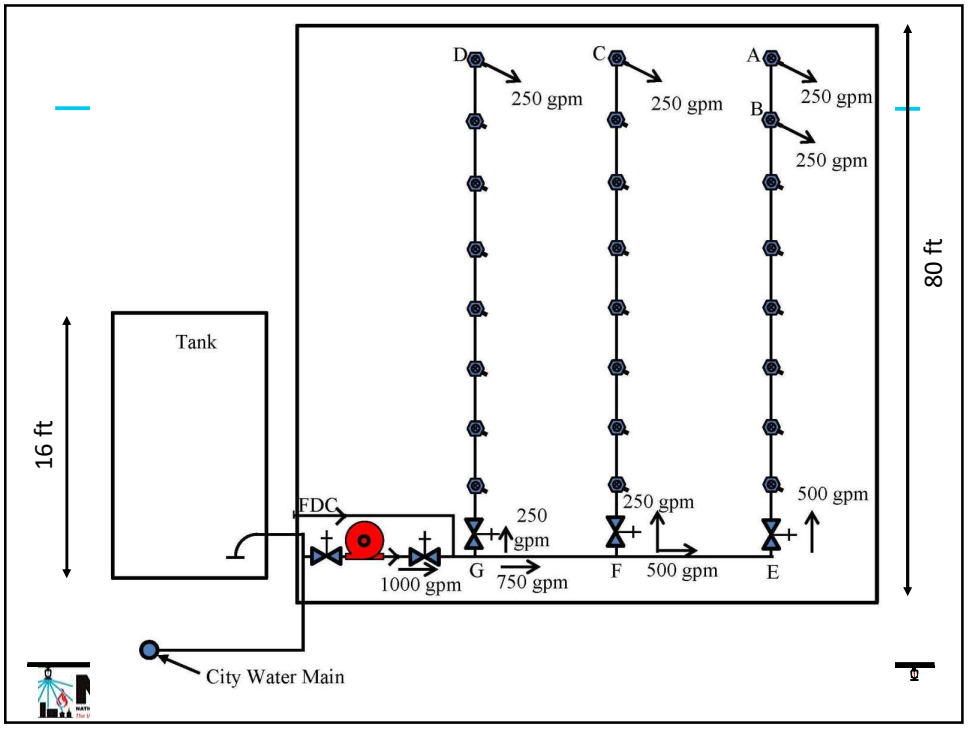
- Reasons why two water supplies are used
  - Single water supply does not meet flow demand
  - Secondary water supply for redundancy
  - Secondary water supply for seismic concerns

186

Design with Two Water Supplies

- Design Situations
  - If the water supplies are at the same pressure, no special considerations are needed
  - If one water supply is at a higher pressure than the other
    - Size the pump so that when the water comes from the lower pressure water supply, the system demand is still met
    - Make sure that when the water comes from the higher pressure water supply, the system is not over-pressurized

187



188

Tank as Water Supply

- Reasonable Worst Case
  - Water level in tank is at its lowest (end of a fire)
  - P_S approaches zero
  - At 1,000 gpm, barely meets system demand
    - $P_D = 0 + 160 = 160$, which is the system demand
- Best case, when tank is full
  - At churn: $P_D = (0.433 \times H) + 168$
  - $P_D = (0.433 \times 16) + 168 = 175$ psi
- No pressure reducing valves needed

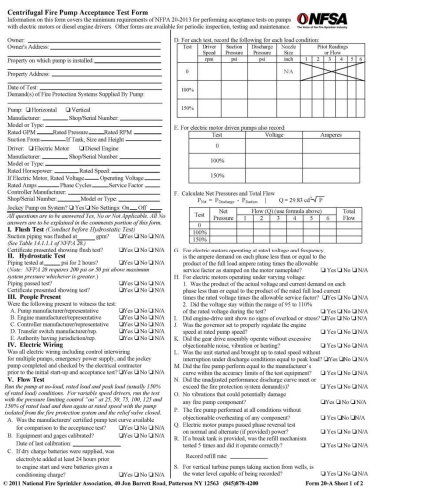
189

11. Acceptance Testing of Fire Pumps



190

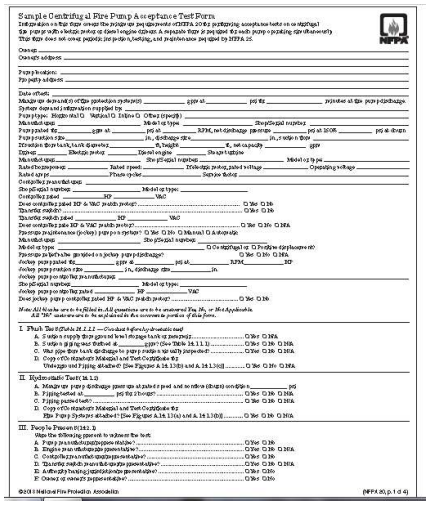
Acceptance Test Forms



Centrifugal Fire Pump Acceptance Test Form

Information on this form covers the minimum requirements of NFPA 20-2013 for performing acceptance tests on pumps with electric motors or diesel engine drivers. Other forms are available for periodic inspection, testing and maintenance.

NFSA Form



Sample Centrifugal Fire Pump Acceptance Test Form

NFPA Annex Form – A.14.1.3

Before the Testing Safety Concerns

- Survey the site, where will all the water go?
- Will your ears need protection?
- Will your eyes need protection?
- Will you need arc flash PPE?



Before the Testing

- Annually calibrate gauges, transducers and other devices used for measurement
  - Accuracy level of ± 1%
  - Factory calibrated voltage and current readings on controllers that are accurate to ±2% are permitted to be used instead of volt/ohm meters
- Visually inspect flow devices, discharge and sensing orifices to make sure they are free from damage and obstructions (not required to disassemble)
- If diesel engine with dry batteries, add electrolyte at least 24 hours before test and fully charge

193

Test Requirements

Chapter 14 of NFPA 20

- 14.1 Hydrostatic Tests & Flushing
- 14.2 Field Acceptance Tests
- 14.3 Record Drawings, Manuals, Special Tools and Spare Parts
- 14.4 ITM
- 14.5 Component Replacement

194

Flushing the Suction Pipe

- Flushing needs to be done prior to hydrostatic test
- Flow for flushing
  - Flow in table on next slide
  - Hydraulically calculated water demand if it is greater than the flow rate on the next slide
  - If the water supply can't provide either of the above, flow the larger of:
    - Fire protection system demand
    - Rated flow of the pump

195

Flush Test

- Flow is calculated to produce a velocity of 15 ft/sec
- This is greater than the other NFPA standards that use 10 ft/sec

Nominal Pipe Size (in.)	Flow Rate (gpm)
3	330
4	590
5	920
6	1360
8	2350
10	3670
12	5290

196

Hydrostatic Test

- Must be done before field test
- Test suction and discharge piping
- Pressure for test, higher of
  - 200 psi
  - 50 psi + maximum system pressure

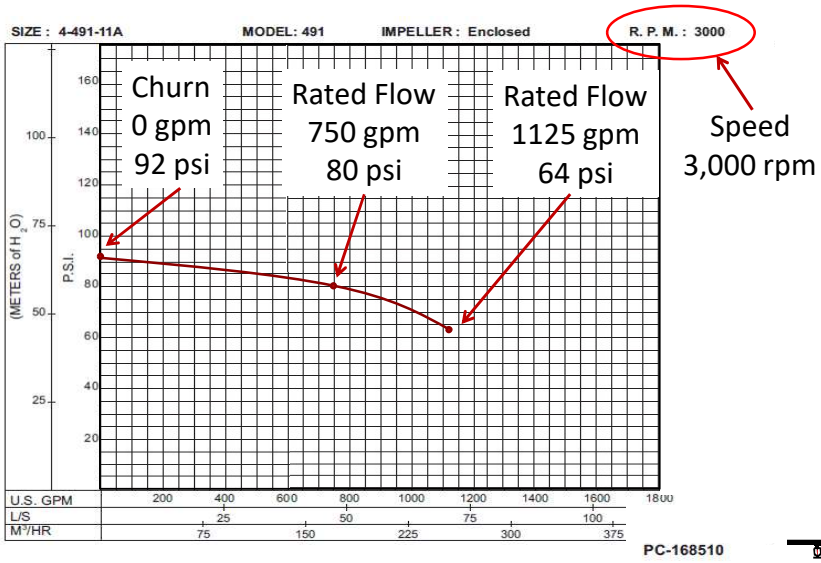
197

Before the Field Acceptance Tests

- Make sure all of the people that need to be there are assembled
  - Pump Manufacturer or their Rep.
  - Engine (if used) Manufacturer or their Rep.
  - Controller Manufacturer or their Rep.
  - Transfer Switch (if used) Manufacturer or their Rep.
  - Coordinate with all AHJ's
  - What about installing contractor, motor manufacturer, insurance company, and building owner?
- All electrical wiring must be completed (including jockey pump)
- Have a copy of the manufacturer's certified shop curve for the pump

198

Manufacturer's Certified Performance Curve



199

Pump Information



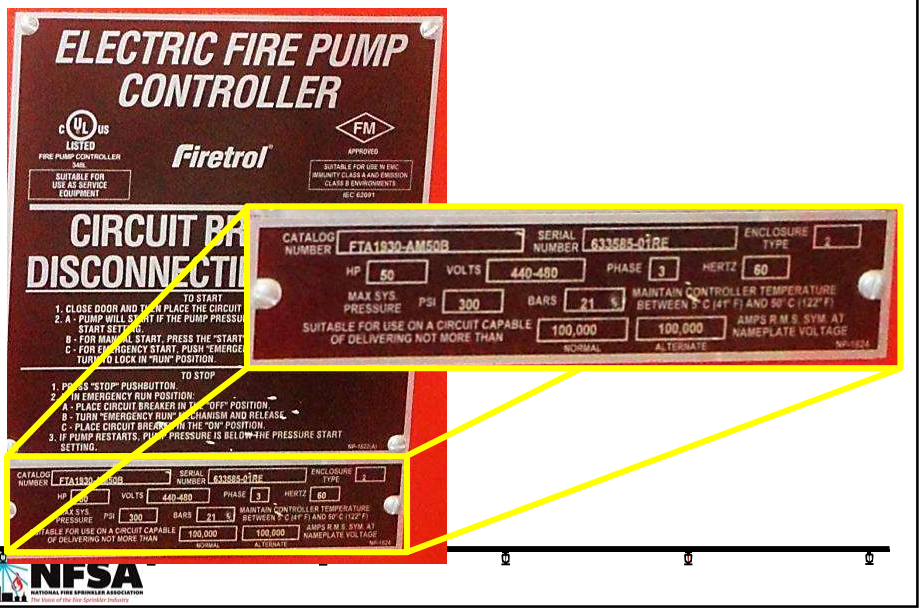
200

Driver Information



201

Controller Information



202

Field Acceptance Tests

- Pump Performance
- Drivers and Right Angle Gear Drives
- Controller Performance
  - Controllers for Electric Motor Driven Pumps
  - Controllers for Diesel Driven Pumps
- Transfer Switch and Alternate Power Supply
- Break Tank Refill (if break tank installed)
- Water Level Detection for Vertical Shaft Turbines

Additional Tests

- Beyond the scope of this class
  - Variable speed pumps
  - Multi-stage multi-port pumps
  - Positive displacement pumps

Pump Performance Test

- Flow Test at Minimum, Rated, and Peak Flow
  - Measured by Discharging Water or by Flow Meter
  - Need to match certified curve within accuracy of test equipment



205

Pump Performance Test

- Flow Conditions
  - Churn
  - Rated Flow
  - Peak Flow (150% of rated flow or the maximum flow available from the water supply)
- Pressure Readings
  - Discharge Pressure
  - Suction Pressure
  - Calculate Net Pressure from above

206

Measuring Flow

- If using a Pitot Gauge
  - $Q = 29.83cd^2\sqrt{P_{Pitot}}$
  - Q = flow in gpm
  - c = nozzle coefficient (0.97 for most straight open nozzles)
  - d = nozzle outlet diameter in inches
  - P = Pitot pressure in psi
- If using a flow meter, a control valve will allow specific flow conditions to be achieved

207

Test Procedure

1. Water at test header (priming the pump and getting all air out of the system)
2. Start the pump
3. General pump operation
   - No unusual vibrations, noises, oil or water leaks
   - If circulating relief valve is present, did it open?
4. Check packing gland (adjust if needed)
5. At churn (no flow into system), record:
   - Suction Pressure, Discharge Pressure, RPM
   - Amperes & Volts (if applicable)

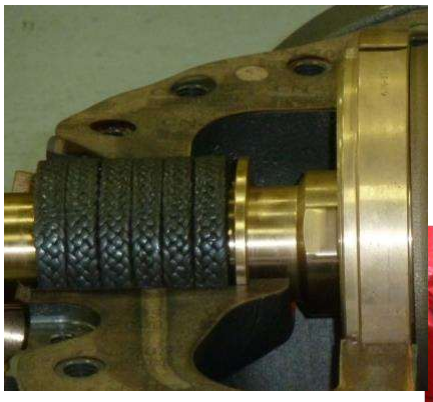
208

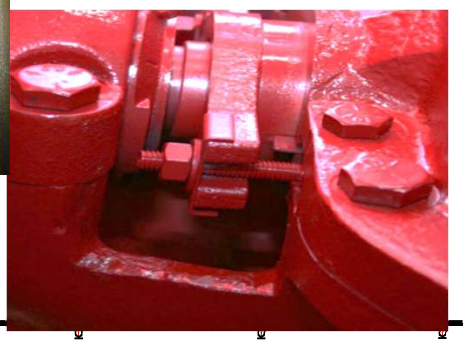
Field Acceptance Test



209

Packing Gland Adjustment





210

Test Procedure

6. Open test header valves or flow meter control valve to achieve 100% of rated flow

7. At rated flow, record:
   - Suction Pressure, Discharge Pressure, RPM
   - Pitot Gage Readings or Flow
   - Amperes & Volts (if applicable)

211

Pitot Tube



212

Outlet Meters



213

Flow Meter



214

Test Procedure

8. Open test header valves or flow meter control valve to achieve 150% of rated flow
9. Record data at 150% of rated flow
10. Calculate pump net pressures
11. Plot flow curve
12. Compare flow curve to manufacturers shop curve
13. Plot ampere curve (electric motor)
14. Compare ampere curve to manufacturers curve

215

Test Pump Speed

- Test results may need to be adjusted for variations in speed
- $P_{N1} = P_{N2}\left(\frac{S_1}{S_2}\right)^2$
- P_{N1} = Net pressure at speed condition 1
- P_{N2} = Net pressure at speed condition 2
- S_1 = Speed 1
- S_2 = Speed 2

216

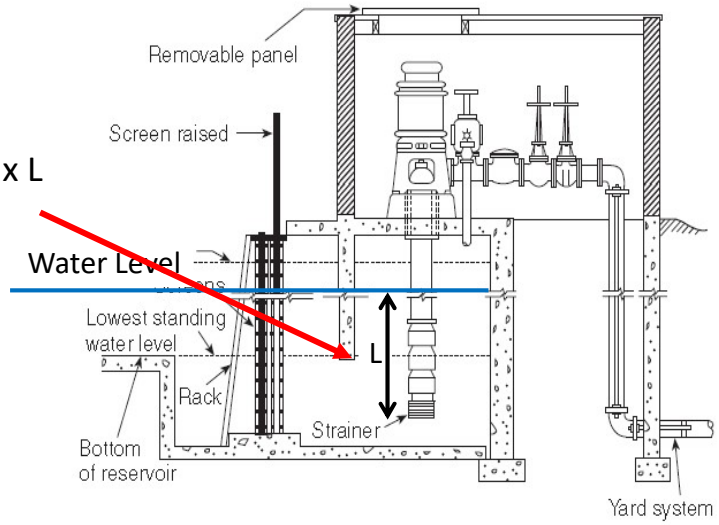
Water Level Detection for Vertical Shaft Turbines

- To get the suction pressure for vertical shaft turbine pumps, need to know the water level in the wet pit or sump
- Test at:
  - Churn (no-flow, or shutoff)
  - Rated Flow
  - Maximum Flow (Peak Flow)

217

Vertical Shaft Turbine Pump

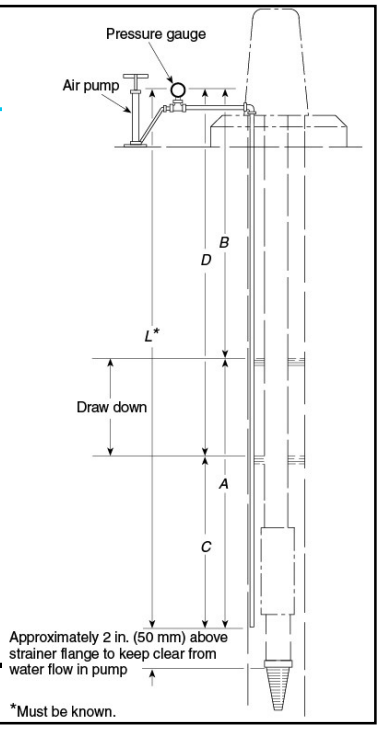
$P_S = 0.433 \times L$



218

One Method to Determine Water Level

- See A.7.3.5.3 of NFPA 20 for how to use this tube and a simple bicycle pump to determine the water level



219

Electric Motor

- If the motor operates at constant voltage and frequency, do the following on each phase
  - Multiply the full load amp rating times allowable service factor stamped on motor nameplate
  - Make sure the amp demand during the test did not exceed the number above
  - The voltage at the motor contactor does not vary more than 5% below or 10% above the voltage stamped on the nameplate

220

Diesel Engines

- During flow test, make sure that engine does not show signs of overload or stress
- Set governor to regulate engine speed
  - Rated speed at maximum flow (150% of rated flow)
  - Allowed to speed up as much as 10% when flowing less water (including churn)

221

Controller Acceptance Test

- 12 Starts
- 6 Automatic/6 Manual
  - Test each starting condition at least once
- Pump Runs 5 min @ Full Speed
  - Engines are not required to run for 5 minutes until the cumulative cranking time reaches 45 seconds
  - For engines, alternate the starts from different battery sets
- Check Overcurrent Devices

222

Controller Acceptance Test

- Full Load Test
  - With discharge equal to full load, start the pump and make sure it comes up to full speed without interruption
- Phase Reversal Test (Electric Motor Driven Pumps)
  - While the pump is running make sure that phase reversal has not occurred
  - While the pump is running from the alternate power source, make sure phase reversal has not occurred

223

Transfer Switch Test

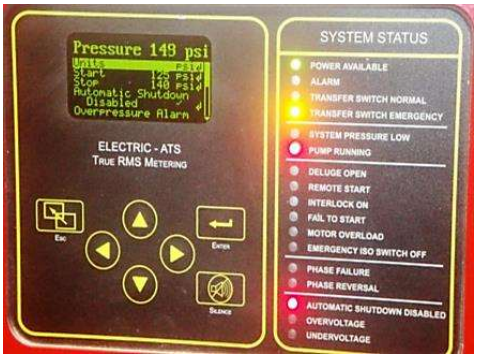
- With the pump running at maximum flow simulate power failure
- Transfer switch must sense loss of power and transfer to alternate power without tripping circuit breaker(s)
- Run half the manual and automatic starts from alternate power source
- Return normal power and see if the transfer switch reconnects to the normal source



224

Signals and Indicators

- During all of the tests described here, all signals and indicators that should have occurred need to have occurred
- All other signals need to be simulated to make sure they operate properly



225

Controller Test





226

Pump Running Duration

- During all of the testing, the pump shall run for a total of at least one hour

227

Generator Test

- Installed and tested in accordance with NFPA 110

228

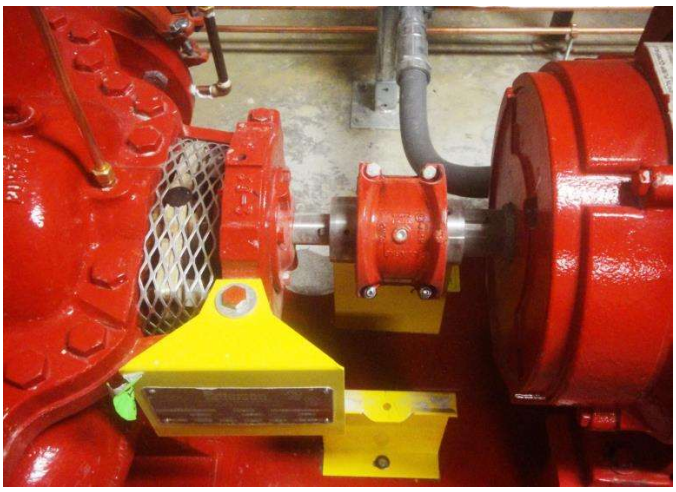
Break Tank

- Operate the refill device at least 5 times
  - Lower the water level in the tank
  - The automatic fill mechanism must operate before the water level drops more than 4 inches below the overflow outlet (see NFPA 22: 14.5.2.2.5)
- Test and record the refill rate
  - Must meet or exceed design refill rate

229

Section A.6.5 Recommends Alignment Test

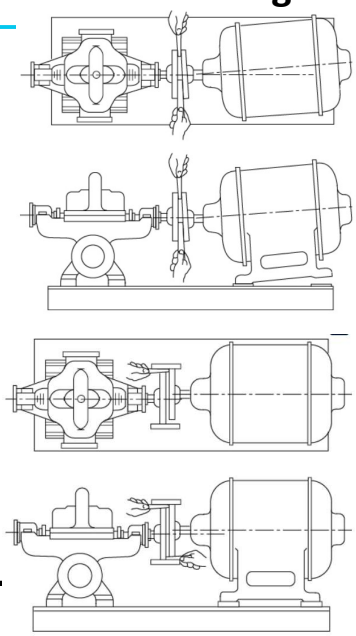
- Angular Alignment
- Parallel Alignment



230

Section A.6.5 Recommends Alignment Test

- Angular Alignment
- Parallel Alignment



231

Pressure Switch Settings

- Jockey Pump
  - Start : normal system pressure - 10 psi
  - Stop : churn pressure + static supply
- Fire Pump
  - Start : jockey pump start pressure - 5 psi
  - Stop : churn pressure + static supply

232

Information For Owner

- Operating Manuals
- Instructions for Routine Maintenance (NFPA 25)
- Parts List
- Electrical Schematics
- Manufacturers Certified Shop Curve

233



Join us for our Expo in Austin May 2-5!

Details

When	Where	Questions?	Hotel Information
May 2, 2023 – May 5, 2023 11:00 AM-10:00 PM CT	JW Marriott 110 E 2nd St Austin, TX 78701	NFSA Events events@nfsa.org	The NFSA room block is open! Room rate is $359/night
Add to Calendar	Register Now Already registered?	Contact Us	Book Your Room

NFSA.org

Events Tab

North American Fire Sprinkler Expo

234

CONCLUSION



Questions?



Contact: Michael Joanis
joanis@nfsa.org
410-983-9417

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION
The Voice of the Fire Sprinkler Industry

235

235

File Attachments for Item:

ER-2 Standpipe Systems and NFPA 14 (National Fire Protection Association)

All certifications (8 hours)

Staff Notes: This is a request for retroactive certification of a course presented on January 25. Caleb Armbrust of NFPA plans to attend. In spite of how the application is filled out, the course is just a single session.

Committee Recommendation:

NFSA
NATIONAL FIRE SPRINKLER ASSOCIATION
The Voice of the Fire Sprinkler Industry

STANDPIPE SYSTEMS & NFPA 14



CITY OF MASON
FIRE - RESCUE - EMS
OHIO



1

COPYRIGHT

This presentation is protected by US and international copyright laws. Any reproduction, recording, distribution, display, or use of the presentation without written permission of the

National Fire Sprinkler Association (NFSA) is prohibited.

©National Fire Sprinkler Association 2022

NFSA
NATIONAL FIRE SPRINKLER ASSOCIATION

2

INTRODUCTIONS



Michael Joanis, PE

- NFSA's Chief Engineer
- Responsible for delivery of technical services to our members
- University of Maryland, College Park
- Registered professional engineer
- NFPA 13 (discharge, hanging & bracing), 20, 200, 232, 241, 909/914
- NFSA Contractors and Manufacturers Councils
- Engineering & Standards, Quality Assurance, UL/FM Committees
- 28 years of experience as a sprinkler contractor and consulting engineer.
- Licensed sprinkler & special hazards contractor
- Fire Sprinkler Institute

- joanis@nfsa.org

3

3

MODULES

1. Introduction to Standpipe Systems
2. Referenced Standards, Definitions, System Components, and Hardware
3. System Requirements
4. Installation Requirements
5. Design
6. Plans, Calculations, & Water Supply Testing
7. Acceptance Testing & Inspection, Testing & Maintenance
8. Buildings Under Construction
9. Standpipe Design Exercise

4

4

MODULE 1

- Introduction to Standpipe Systems

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

5

5

2017 OHIO BUILDING CODE

4101:1-35-01 – Referenced Standards effective 11/01/2017

NFPA 14 – 2016 Edition Currently adopted in Ohio

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

6

6

LEARNING OBJECTIVES

At the end of this Module, participants will be able to:

1. **Explain the scope of NFPA 14**
2. **Discuss the history of standpipes**
3. **Recognize where standpipe systems are required**
4. **Discuss the hierarchy of codes and standards**

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION
The Voice of the Fire Sprinkler Industry

7

7

WHAT ARE STANDPIPES

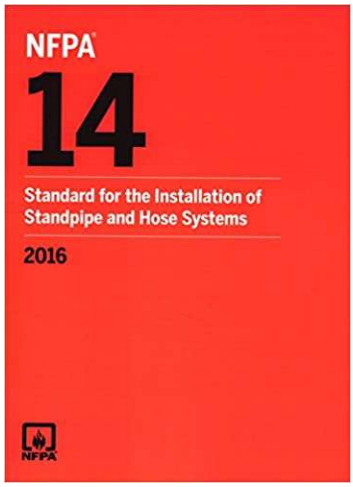
- System of piping that delivers the water supply for hose connections, and for sprinklers on combined systems.

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION
The Voice of the Fire Sprinkler Industry

8

8

NFPA 14



Scope and Layout of NFPA 14

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

9

9

HISTORY OF NFPA 14

- 1912
- 1993 changes to flows and pressures
- 1991 One Meridian Plaza, Philadelphia, PA (3 FF, PRV issues, 22-20 floors, 10 sprinklers)
- 2007 pressure regulating devices
- 2016 protection of piping
- 2019 distance monitoring, remote inspection, maximum pressure to 400 psi.

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

10

10

WHERE SYSTEMS ARE REQUIRED

- As per the building code
  - IBC
  - NFPA 5000
  - State and local building codes
- Tall buildings
- Large buildings

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

11

11

IBC

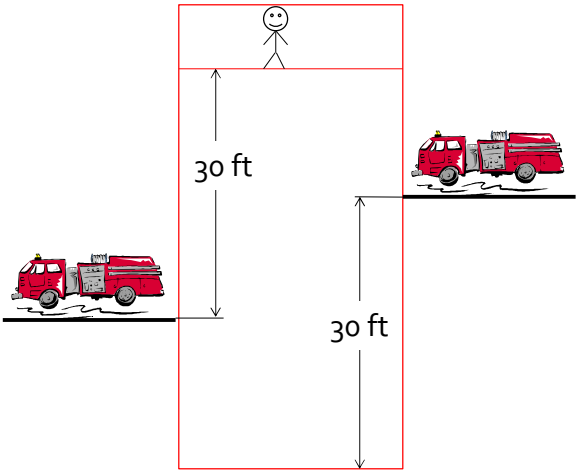
- A Class III Standpipe system shall be installed throughout the building where the floor level of the highest story is located more than 30 feet above the lowest level of fire department vehicle access or where the lowest story is located more than 30 feet below the highest level of fire department vehicle access

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

12

12

IBC



NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

13

13

EXCEPTIONS

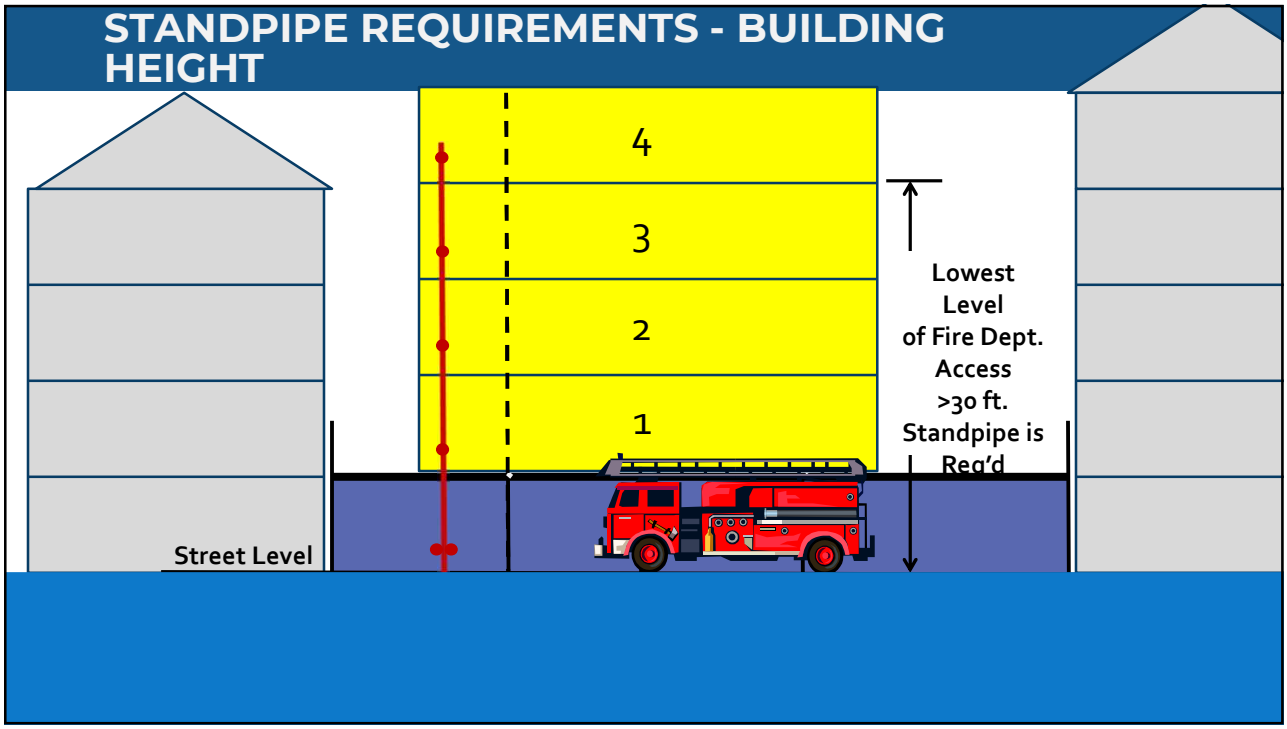
- Sprinklered buildings – Class I
- Open parking garages where the highest level is not more than 150 above lowest level of fire department access – Class I
- Open parking garages that are subject to freezing – Class I

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

14

14

STANDPIPE REQUIREMENTS - BUILDING HEIGHT



15

STANDPIPE REQUIREMENTS BUILDING HEIGHT – IBC 905.3.1

- When height of the building requires standpipes:
  - Class III
- When fully sprinklered per NFPA 13 or NFPA 13R:
  - Class I
- Open parking garages:
  - Class I

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION

16

16

STANDPIPE REQUIREMENTS OCCUPANCY OR USE

- Group A (Assembly Occupancies > 1,000 persons) – Class I
- Underground – Class I
- Helistops and Heliports – Class I or III
- Marinas & Boatyards – Class I
- Rooftop gardens and landscaped roofs (new 2012 IBC)
- Covered and open mall buildings…
- Stages…

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

17

17

STANDPIPE REQUIREMENTS - COVERED AND OPEN MALL BUILDINGS

- Covered and open mall buildings require standpipes: by height, or by 905.3.3:
  - Class I
  - Combined/Calculated with Sprinkler System
    - 250 gpm @ remote hose connection
      - Concurrent w/sprinkler calc
    - 50 psi loss max while flowing 250 gpm
  - Hose connection locations
    - Place outlet at entrance to each exit passageway/corridor
    - Place outlet at each floor landing of enclosed stairs opening directly into mall.
    - Place outlet on interior side of public entrances to the mall.
    - To reach into tenant space not exceeding 200 ft. from outlet.

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

18

18

STANDPIPE REQUIREMENTS - STAGES

- Stages > 1,000 sq. ft
  - Class III: 2 ½ in. & 1 ½ in. hose connection on each side of stage.
- When in Sprinklered Bldgs:
  - 1 ½ in. hose connection:
    - According to NFPA 13, or
    - NFPA 14 for Class II or III
  - 1 ½" hose connections must be equipped with hose and cabinet with adjustable fog nozzle

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

19

19

HIERARCHY OF CODES AND REFERENCED STANDARDS

- IBC Section 905.2: Standpipe systems shall be installed in accordance with this section (905) and NFPA 14.
- Building Code/Fire Code requirements
- NFPA 14

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

20

20

STANDPIPE REQUIREMENTS

- Building Code, Fire Code, Life Safety Code
- Based On:
  - Building Height (IBC 905.3)
  - Occupancy or Use (IBC 905.3.2 – 905.3.8)

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

21

21

MODULE 2

- Referenced Standards, Definitions, System Components, and Hardware

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

22

22

LEARNING OBJECTIVES

At the end of this Module, participants will be able to:

1. Review the referenced standards.
2. Explain the various definitions related to standpipe systems
3. Explain the various components used in standpipe systems
4. Discuss the similarity of system components with sprinkler systems

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

23

23

REFERENCED STANDARDS

2.1 General.

The documents or portions thereof listed in this chapter are referenced within this standard and shall be considered part of the requirements of this document.

2.2 NFPA Publications.

National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2019 edition.

NFPA 13R, *Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies*, 2019 edition.

NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*, 2019 edition.

NFPA 22, *Standard for Water Tanks for Private Fire Protection*, 2018 edition.

NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*, 2019 edition.

NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, 2017 edition.

NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work*, 2019 edition.

NFPA 72®, National Fire Alarm and Signaling Code®, 2019 edition.

NFPA *101®, Life Safety Code®*, 2018 edition.

NFPA 170, *Standard for Fire Safety and Emergency Symbols*, 2018 edition.

NFPA 1963, *Standard for Fire Hose Connections*, 2019 edition.

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

24

24

DEFINITIONS

3.1 General.

The definitions contained in this chapter shall apply to the terms used in this standard. Where terms are not defined in this chapter or within another chapter, they shall be defined using their ordinarily accepted meanings within the context in which they are used. *Merriam-Webster's Collegiate Dictionary*, 11th edition, shall be the source for the ordinarily accepted meaning.

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

25

25

NFPA OFFICIAL DEFINITIONS

- Approved
- Authority having jurisdiction
- Listed
- Shall
- Should
- Standard

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

26

26

GENERAL DEFINITIONS

- Auxiliary drain connection
  - Drain connection installed to permit draining water from a trapped section of pipe
- Main drain
  - Primary drain connection located on the system riser & utilized as a test connection

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

27

27

GENERAL DEFINITIONS

- Exit passageway
  - Hallways, corridors, passages or tunnels used as exit components & separated from other parts of the bldg.
- Horizontal exit
  - A way of passage from one bldg. to an area of refuge in another bldg. on approximately the same level

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

28

28

GENERAL DEFINITIONS CONT.

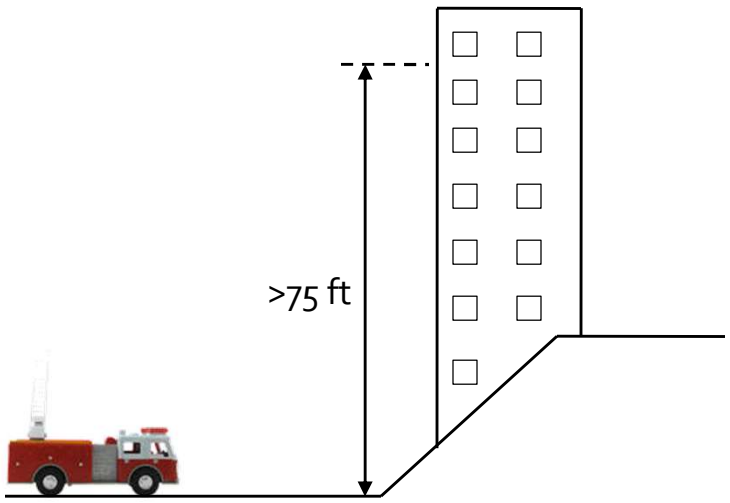
- High rise building
  - Where the floor of an occupiable story is > 75’ above the lowest level of fire department access
- Feed main
  - The portion of a standpipe system that provides water to one or more standpipes
- Express main
  - A type of feed main supplying the upper zone of a standpipe system & does not supply portion of a low zone standpipe system

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

29

29

HIGH-RISE BUILDING DEFINITION



NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

30

30

GENERAL DEFINITIONS CONT.

- Record drawing
  - A design, working drawing or as built drawing submitted as the final record of documentation for the project
- Standpipe
  - The system piping that delivers the water supply for hose connections, & for sprinklers on combined systems, vertically from floor to floor

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

31

31

GENERAL DEFINITIONS CONT.

- Horizontal standpipe
  - The horizontal portion of the system piping that delivers the water supply for TWO or more hose connections, and for sprinklers on combined systems
- Branch line
  - A piping system, generally in a horizontal plane, connecting not more than ONE hose connection with a standpipe

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

32

32

GENERAL DEFINITIONS CONT.

- Standpipe system zone
  - A vertical subdivision of a standpipe system limited or determined by the pressure limitations of the system components
- Travel distance
  - The length measured on the floor or other walking surface along the centerline of the natural path of travel, starting from the hose outlet, curving around any corners or obstructions with a 12” clearance.

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

33

33

SYSTEM COMPONENTS AND HARDWARE

- General rules
- Pipe & fittings
- Control valves
- Pressure-regulating devices
- Fire department connections
- Signs
- Hose stations/connections

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

34

34

SYSTEM COMPONENTS AND HARDWARE

- General rules
  - All devices & materials shall be listed
    - Except for components not affecting system performance
      - Drain piping, drain valves & signs
- Pipe & fittings
  - Selected from list in NFPA 14 or specifically listed
- Pressure regulating devices
  - Shall be listed

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

35

35

SYSTEM COMPONENTS AND HARDWARE

- Valves
  - All connections to water supplies & standpipes shall be listed indicating valves
  - Post indicating valves are permitted
  - Slow close feature
    - Non indicating valves permitted if acceptable to the AHJ
- Signs
  - Shall be permanently marked weather resistant metal or rigid plastic

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

36

36

SYSTEM COMPONENTS AND HARDWARE

- Hose stations
  - Cabinets & closets
    - 2” clearance from any part of the cabinet to the valve, except for the door
    - Break glass type must have device attached in the immediate vicinity
    - Must maintain fire resistive rating if penetrated
    - Marked to indicate contents
  - Hose
    - When supplied, no more than 100’ 1 ½” listed hose
    - If < 1 ½”, hose must be non collapsible

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

37

37

2” CLEARANCE FROM THE VALVE TO ANY PART OF THE CABINET



NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

38

38

SYSTEM COMPONENTS AND HARDWARE

- Hose racks
  - Each hose station shall be equipped with a rack or approved storage method
  - For hose < 1 ½", must be a continuous flow reel
  - Nozzles for Class II service shall be listed
  - Racks or storage facilities shall be labeled including "FIRE HOSE FOR USE BY TRAINED PERSONNEL" and operating instructions

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

39

39

SYSTEM COMPONENTS AND HARDWARE

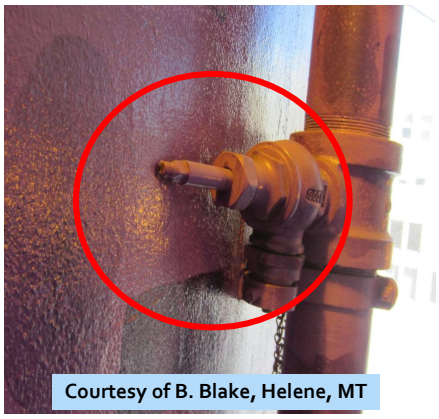
- Hose connections
  - All valves shall be listed with external NHS threads and caps
  - Local fire departments having different threads shall designate the hose threads used
  - Must be at least 3" clearance between the handle of the valve and any adjacent object when the valve is in any position

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

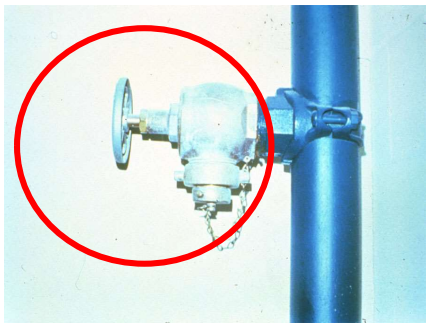
40

40

AT LEAST 3” CLEARANCE BETWEEN THE HANDLE OF THE VALVE AND ANY ADJACENT OBJECT WHEN THE VALVE IS IN ANY POSITION



Courtesy of B. Blake, Helene, MT



NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

41

41

SYSTEM COMPONENTS AND HARDWARE

- Fire department connections
  - Listed for system demand pressure or greater
  - Must have at least 2- 2 ½” internal threaded swivel fittings with NHS threads
    - Must be equipped with protective caps
    - Local fire departments having different threads shall have comparable fittings with minimum 2 ½” size

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

42

42

MODULE 3

- System Requirements

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

43

43

LEARNING OBJECTIVES

At the end of this Module, participants will be able to:

1. Identify the various types of standpipe systems
2. Identify the various classes of standpipe systems
3. Discuss specific rules for automatic/ semi-automatic dry systems
4. Discuss specific limits to the use of some systems
5. Explain the requirements for gauges & waterflow alarms

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

44

44

SYSTEM REQUIREMENTS

- General
- Types of standpipes
- Classes of standpipes
- Specific rules for Automatic/ semi-automatic dry systems
- Limits to the use of systems
- Gauges
- Waterflow alarms

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

45

45

THE ORIGINAL



NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

46

46

STANDPIPE SYSTEM CLASSIFICATION

- Types of Standpipes

47

47

TYPES OF STANDPIPE SYSTEMS

- Automatic-wet
- Automatic-dry
- Semi-automatic dry
- Combined system
- Manual wet
- Manual dry

48

48

TYPES OF STANDPIPE SYSTEMS

- Automatic-Wet Systems
  - Contain water at all times
  - Permanently attached to an automatic water supply that is capable of supplying the whole system
- Automatic-Dry Systems
  - Filled with air or nitrogen until a valve is opened
  - Permanently attached to an automatic water supply that is capable of supplying the whole system

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

49

49

TYPES OF STANDPIPE SYSTEMS

- Semiautomatic Dry Systems
  - Permanently attached to a water supply that is capable of supplying the whole system
  - Water supply must be remotely activated
- Manual Wet System
  - Contains water at all times
  - Required to be supplied through a fire department connection

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

50

50

TYPES OF STANDPIPE SYSTEMS

- Manual Dry System
  - No water in pipe
  - Required to be supplied through a fire department connection
- Combined System
  - A standpipe system that supplies both hose connections & automatic sprinklers

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

51

51

STANDPIPE SYSTEM CLASSIFICATION

- Classes of Standpipes

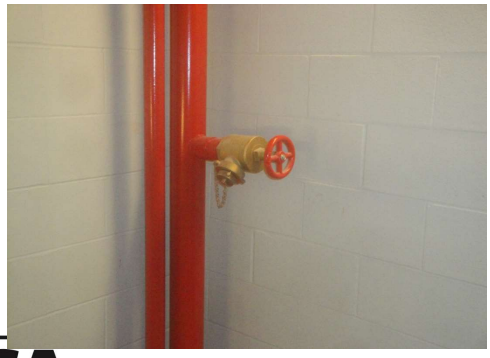
NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

52

52

CLASS I

- System that provides 2 ½ inch hose connections to supply water for fire department use only





NFSA NATIONAL FIRE SPRINKLER ASSOCIATION
The Voice of the Fire Sprinkler Industry

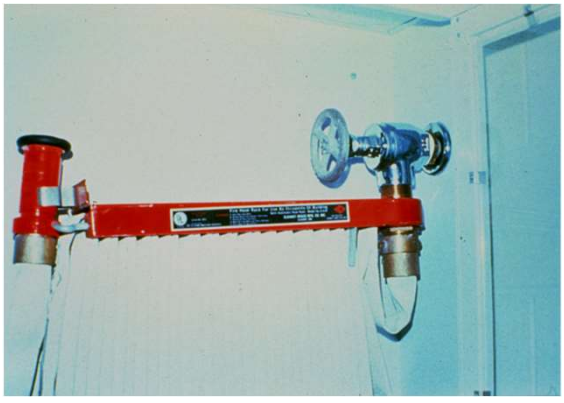
53

53

CLASS II

- System that provides 1 ½ inch hose stations for trained personnel or hose connections for fire department use during initial response

- Minimum of 1" may be allowed in light hazard where approved by the AHJ



NFSA NATIONAL FIRE SPRINKLER ASSOCIATION
The Voice of the Fire Sprinkler Industry

54

54

CLASS III

- 1 ½ inch hose stations for use by trained personnel
- 2 ½ inch hose connection for use by the fire department





NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

55

55

CLASS III CONT

- May use minimum 1" hose for light hazard where listed for such and approved by the AHJ
- Where fully protected by an approved automatic sprinkler system
  - Class II hose stations, upon AHJ approval, may be replaced with a 2 ½" x 1 ½" reducer with a cap and chain on each 2 ½" Class I hose connection
  - Do not have to meet the normal pressure & travel requirements for Class II systems

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

56

56

SYSTEM REQUIREMENTS

- General rules
  - The AHJ shall be consulted regarding the type & class of system and any special requirements
  - Standpipe & hose systems not required by the AHJ & not meeting the requirements of NFPA 14 shall be marked with a sign reading "FOR FIRE BRIGADE USE ONLY"

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

57

57

SYSTEM REQUIREMENTS AUTOMATIC & SEMIAUTOMATIC DRY SYSTEMS

- Automatic dry systems
  - Pressure gages
    - Water & air side of the dry pipe valve
    - At the air pump if one is provided
    - In each independent pipe from air supply to dry pipe system
    - At QOD's
  - Size limited to 750 gal. per dry pipe valve
    - Larger if water delivery is no more than 3 minutes
    - May use QOD's to meet the requirement

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

58

58

SYSTEM REQUIREMENTS AUTOMATIC & SEMIAUTOMATIC DRY SYSTEMS

- Dry valve & supply pipe shall be protected against freezing & mechanical injury
- Valve room must be lighted & heated
  - Heat must be a permanent type- no heat tape
- Protect against high water in clapper
- Air supply shall be capable of restoring pressure within 30 minutes

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

59

59

AIR COMPRESSORS

- An annex note states that the use of a single air compressor in multiple dry systems
  - Where a single compressor multiple dry pipe systems, the 30 minute fill time is based on the single largest system.

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

60

60

HIGH WATER LEVEL PROTECTION

- Where possible to reseat the dry valve after actuation without draining the system, it is permissible to protect against occurrence of water above the clapper by use of an automatic high water level signaling device or an automatic drain device

- This similar method is required for protection against accumulation of water above the clapper in Low Differential Dry Pipe Valves

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

61

61

SYSTEM REQUIREMENTS AUTOMATIC & SEMIAUTOMATIC DRY SYSTEMS

- Semiautomatic dry systems (single, double or non-interlock)
  - Remote control device must be within 3', visible & identified

  - Pressure gages
    - Above/below preaction valves & below deluge valves
    - On air supply to preaction & deluge valves

  - Valve room must be lighted & heated
    - Heat must be a permanent type- no heat tape

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

62

62

LIMITS TO THE USE OF SYSTEMS

- Class I systems
  - In non high rise buildings
    - Class 1 may be automatic wet, automatic dry, manual dry or manual wet
    - The Class 1 portion of a Class III system may be manual
  - In high rise buildings
    - All required standpipes shall be automatic or semi-automatic, including partial height & horizontal standpipes serving a limited number of floors or a portion of floors
  - All Class I's must be wet except where subject to freezing

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

63

63

LIMITS TO THE USE OF SYSTEMS CONT

- Class II & III systems
  - Shall be wet systems
    - May be automatic or semi automatic dry IF
      - Piping is subject to freezing
      - Fire brigade is trained to operate without FD help
      - The automatic portion of a Class III only has to supply the Class II portion unless the Class I portion requires an automatic water supply

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

64

64

SYSTEM REQUIREMENTS

- Gauges

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

65

65

GAUGES

- A listed pressure gauge with a minimum 3 ½" face is required:
  - At each discharge pipe from the fire pump
  - At the pressure tank
  - Air pump supplying a pressure tank
  - At the top of each standpipe
    - Where several standpipes are interconnected at the top, a single gage is permitted
  - At each main drain connection
  - Above & below each alarm check valve, dry, deluge valve, backflow preventer or system riser check valve where such devices are present

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

66

66

GAUGES

- Pressure regulating devices
  - A valved outlet for a pressure gauge shall be installed on the upstream side of every PRV
  - Pressure gauges shall be installed on the upstream & downstream side of master pressure regulating device assemblies

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

67

67

SYSTEM REQUIREMENTS

- Waterflow Alarms

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

68

68

WATERFLOW ALARMS

- Listed waterflow alarms are required on all systems
  - Not required on manual dry systems
- Shall utilize a sensing mechanism appropriate to the type of standpipe.
- Paddle-type waterflow alarms shall be used on wet standpipe systems only.

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

69

69

WATERFLOW ALARMS

- An annex note clarifies that it is acceptable to use a hose valve as a means to test a water flow device. This includes the use of a hose valve on the roof.
- Clarification was extended that this method was predicated on the hose valve discharging to an suitable location.

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

70

70

MODULE 4

- Installation Requirements

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

71

71

LEARNING OBJECTIVES

At the end of this Module, participants will be able to:

1. Explain & discuss the location and protection of both underground & above ground piping
2. Discuss the requirements for the installation & supervision of control valves & check valves
3. Explain the requirements for fire department connections
4. Discuss the various requirements for specific signs

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

72

72

LOCATION/ PROTECTION OF PIPING

- Location of Dry standpipes
  - Dry standpipes shall not be concealed without supervised air monitoring in the pipe in accordance with NFPA 72
- Above ground pipe
  - Protected from mechanical and fire damage
    - Protection based on Table for high rise or non high rise buildings
  - Feed mains, standpipes, horizontal standpipes & branch lines protected comparable to enclosed exit stairs

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

73

73

Location/ Protection of Piping cont.

- Above ground pipe cont.
  - Piping not requiring protection
    - Horizontal standpipes, feed mains & branch lines do not require protection if building is equipped with approved auto sprinkler system
    - Piping for 1 ½" connections
    - Standpipes where exit stairways are not required to be fire rated enclosures
    - Additional standpipes needed to meet travel distances in non high rise buildings

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

74

74

LOCATION/ PROTECTION OF PIPING CONT.

- Above ground pipe cont
  - Piping in areas subject to freezing shall maintain water temp. between 40-1200F
    - Anti freeze not allowed
  - May us heat tracing if:
    - Listed
    - Installed according to mfgr. specs.
    - Supervised by one of the following
      - Central station, proprietary or remote signaling service
      - Local signaling service to a constantly attended location

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

75

75

LOCATION/ PROTECTION OF PIPING CONT.

- Above ground pipe cont
  - Corrosion resistant types or coatings of pipe, tube fittings & hangars shall be used in corrosive atmospheres or where exposed to weather
  - Where subject to earthquakes, use requirements of NFPA 13
- Above ground pipe cont
  - All piping for dry standpipes, manual dry standpipes, & semi automatic standpipes shall be pitched at least ¼" per 10'
    - In refrigerated areas, must be ½" per 10'

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

76

76

UNDERGROUND PIPING

- Shall be in accordance with NFPA 24

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

77

77

GATE VALVES & CHECK VALVES

- Each connection to a automatic water supply shall have approved control valve & check valve
  - May be located in the building
  - Not required for auto & semi-auto systems supplied by fire pumps
  - Backflow preventers may meet this requirement
  - Valves not required on manual dry systems
  - Valves shall be required on all standpipes, including manual dry to allow isolation without interrupting flow to other standpipes from the same source of supply
  - Approved valves shall be provided in the water supply for manual wet systems

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

78

78

FIRE DEPARTMENT CONNECTIONS

- Clarifies that a listed check valve shall be installed in each fire department connection, including the connection in manual-dry systems.

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

79

79

GATE VALVES & CHECK VALVES CONT.

- FDC shall not be provided with isolation valves
- Valves shall be located at the standpipe for controlling branch lines for remote hose stations where the distance to the hose station exceeds 40’

- Control/check valves on combination systems
  - Each connection to a sprinkler system from a combined standpipe system shall have an additional control/check valve
  - Listed PRV’s shall be considered check valves

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

80

80

GATE VALVES & CHECK VALVES CONT.

- Valves on water supply connections
  - On each connection to a water supply (except in FDC)
  - Plainly marked to indicate the service they control
  - If not 40' from building, in an approved location (wall post indicators if approved by AHJ)
  - Where PI's can't be used, underground valves with an approved roadway box & T-wrench are permitted
  - Buildings served shall be marked to indicate the location of the valve that controls them
  - If supplied by a yard main or header in another building, standpipes shall have a valve at a safe distance or at the header

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

81

81

GATE VALVES & CHECK VALVES CONT.

- Valve supervision
  - Same as NFPA 13
  - Bypass valves for master PRV's shall be supervised in the closed position
    - Must be electrically supervised

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

82

82

GATE VALVES & CHECK VALVES CONT.

- Signs for rooms, valves & hose connections
  - Required for all main & sectional control valves indicating the portion of the system they control
  - All control, drain & test connections require signs
  - Where sprinkler system piping is fed by a dual feed design, signs indicating other valves needed to be shut off to isolate the system are required
  - Valves located in rooms or concealed spaces require signs at approved locations outside the space/ room
  - Hose connections not in stairways require signs posted in an approved manner
  - Valve cabinets must be marked (red on white min. 2 ½")

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

83

83

FIRE DEPARTMENT CONNECTIONS

- No shutoff valves between FDC & the system (except to isolate standpipes from others)
- Installed similar to the requirements for sprinkler systems
- Not connected to suction side of fire pump
- Drip valves required in areas subject to freezing

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

84

84

FIRE DEPARTMENT CONNECTIONS CONT.

- Location & Identification
  - Visible from street or FD access
  - Arranged to attach hose lines without obstruction
  - Each FDC shall have a sign at least 1" letters: "STANDPIPE" (if manual, shall also indicate wet or dry)
  - If also supplying automatic sprinklers, sign shall indicate: "STANDPIPE & AUTOSPKR" or "AUTOSPKR & STANDPIPE"

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

85

85

FIRE DEPARTMENT CONNECTIONS CONT.

- Location & Identification cont.
  - Sign shall indicate the pressure required at inlets
  - If multiple buildings, sign shall indicate buildings served
  - FDC shall be at within 100' to nearest hydrant
    - May exceed 100' if approved by AHJ
  - Located 18"-48" above level of adjoining grade surface

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

86

86

Signs

- Installation of signs
  - All shall be secured with corrosive resistant chain or wire
- Signs for water supply pumps
  - Where pumps are used, a sign shall be installed in the vicinity of the pump indicating pressure and flow needed at the pump flange to supply the system

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

87

87

HYDRAULIC DESIGN INFORMATION SIGN

- Installing contractor shall provide a sign indicating the basis of design
- Located at control valve for auto or semi-auto systems
  - At an approved location for manual systems
- Shall include the following:
  - Location of two most hydraulically remote connections
  - Design flow rate for the connections
  - Design residual inlet & outlet pressure for the connections
  - Design static pressure & design flow & residual pressure at the control valve or pump discharge & at each FDC

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

88

88

MODULE 5

- Design

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

89

89

LEARNING OBJECTIVES

At the end of this Module, participants will be able to:

1. Explain the general rules for standpipe piping
2. Explain the requirements for minimum pipe sizes
3. Describe required hose locations & number of standpipes
4. Explain minimum/maximum pressure limits in systems and how it is controlled

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

90

90

LEARNING OBJECTIVES CONT

At the end of this Module, participants will be able to:

5. Explain various pressure requirements for systems
6. Explain the concept of standpipe zones and their impact on design
7. Explain minimum flow rates in different systems
6. Explain the purpose & requirements for drains, test risers and FDC's

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

91

91

DESIGN

- General rules
- Pressure limitations
- Locations of hose connections
- Number of standpipes
- Interconnection of standpipes
- Minimum sizes for standpipes & branch lines
- System design & pipe sizing
- Standpipe system zones
- Flow rates
- Drain & test risers
- Fire department connections

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

92

92

GENERAL RULES

- Design shall be governed by
  - Building height
  - Area per floor occupancy
  - Classification
  - Egress system design
  - Required flow rate & residual pressure
  - Distance of hose connection to water supply
- When PRD's are used, they shall be approved for installation within the minimum/maximum anticipated flow conditions

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

93

93

MINIMUM PIPE SIZES

- Class I & II shall be a minimum of 4" in size
- Standpipes in combination systems must be a minimum of 6"
  - If building is protected throughout by a sprinkler system (either NFPA 13 or 13R), minimum size is 4"
- Branch shall be hydraulically calculated but a minimum of 2 ½"

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

94

94

PIPE SIZE FOR SYSTEM DEMAND

- For Class I & III, must be designed so the system demand can be supplied by each FDC
- Where auto or semi-auto water supply is required (based on class of system), must be designed to be independently supplied by the attached water supply & each FDC provided on the system

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

95

95

PIPE SIZE FOR SYSTEM DEMAND CONT.

- Attached water supply not required to supply the standpipe demand for manual wets or sprinkler standpipe combined manual wet systems
- When the system demand is to be supplied by the fire department connection, the fire department shall be consulted regarding the water supply available from their pumper

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

96

96

DESIGN

- Location of Hose Connections

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

97

97

LOCATIONS OF HOSE CONNECTIONS

- General
  - Connections & stations must be unobstructed & located 3-5’ above the floor
  - This dimension shall be measured from the floor to the center of the device
  - Shall not be obstructed by the closed or open stairwell door or other objects on the landing

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

98

98

HOSE CONNECTION LOCATIONS CLASS I (2 ½ INCH)

- Exit stairways
- Horizontal exits
- Exit passageways
- Covered mall buildings
- Highest landing of stairway or on roof
- Travel distance

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

99

99

CLASS I (2 ½ INCH) EXIT STAIRWAYS

- Outlets in every required exit stairwell
  - Most protected place in the building
  - Fire fighters protected before they get water into hose
  - Not required in non required stairs connecting two floors
- Put outlet at the main floor landing in exit stairwells
  - Intermediate landing previous editions IBC
- Allowed to put outlet at highest intermediate landing between floor levels if approved by AHJ

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

100

100

INTERMEDIATE FLOOR LEVEL LANDING

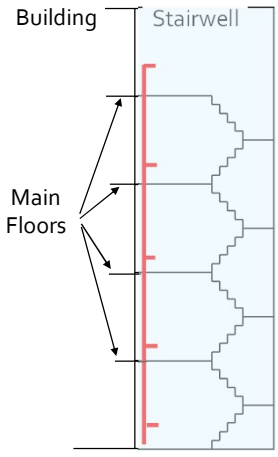
- NFPA 14/IBC floor landing differences
- Headroom
- Sweep of hose
- Area of refuge
- Hose kink

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

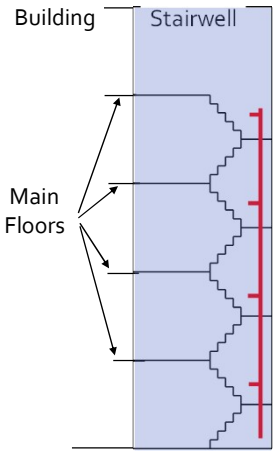
101

101

CLASS I (2 ½ INCH) EXIT STAIRWAYS



Hose Connections @ Floor Landings



Hose Connections @ Intermediate Landings

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

102

102

CLASS I (2 ½ INCH) HORIZONTAL EXITS

- A way of passage from one building to an area of refuge in another building on approximately the same level.
- Each side of the wall adjacent to exit openings of horizontal exits (unless the distance can be covered by one already in place)

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

103

103

CLASS I (2 ½ INCH) HORIZONTAL EXITS

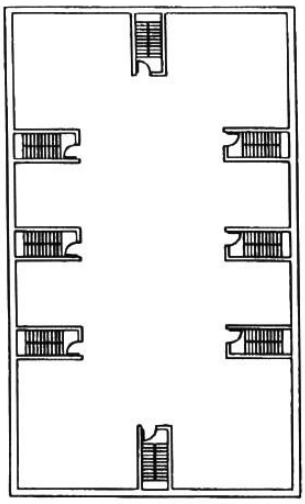


Figure 1

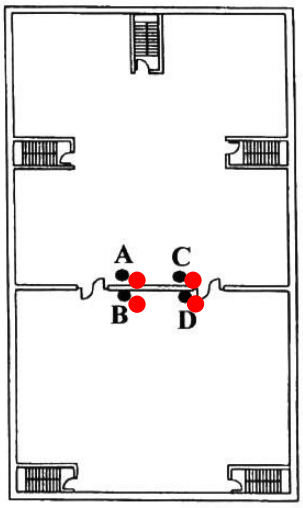


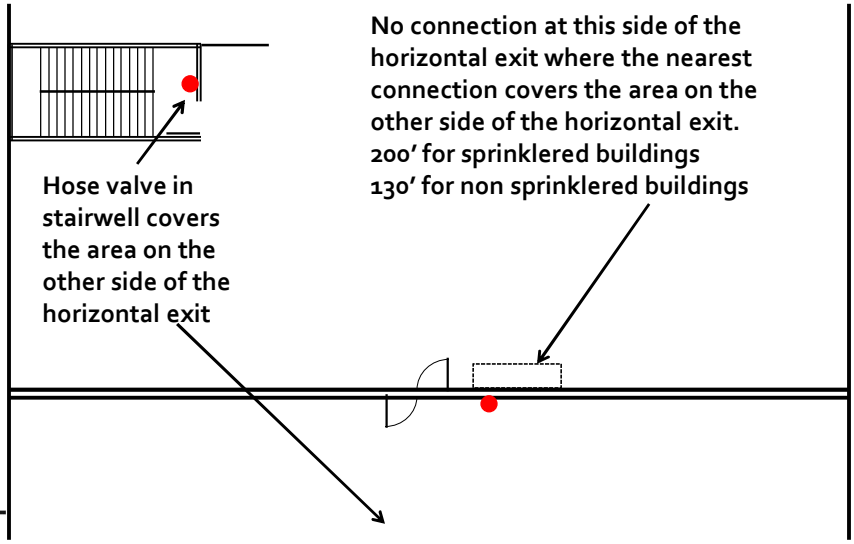
Figure 2

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

104

104

HORIZONTAL EXITS EXCEPTION



NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

105

105

CLASS I (2 ½ INCH) EXIT PASSAGEWAYS

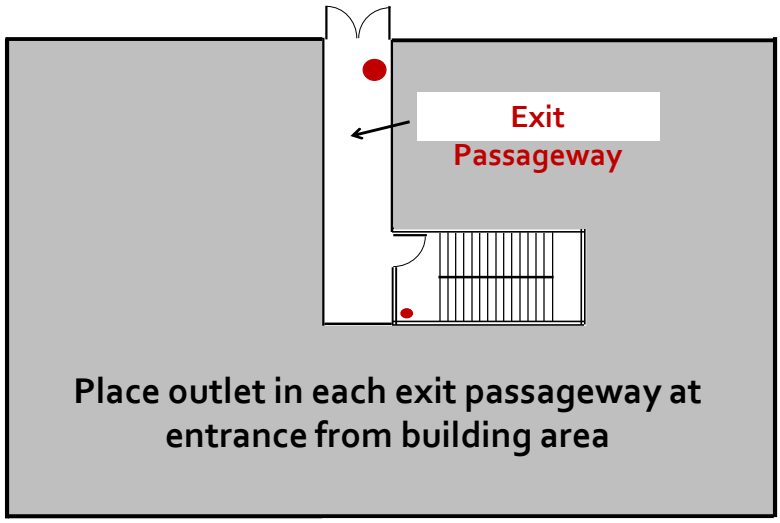
- Hallways, corridors, passages, or tunnels used as exit components and separated from other parts of the building in accordance with NFPA 101.

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

106

106

CLASS I (2 ½ INCH) EXIT PASSAGEWAYS



Place outlet in each exit passageway at entrance from building area

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

107

107

CLASS I (2 ½ INCH) COVERED MALL BUILDINGS

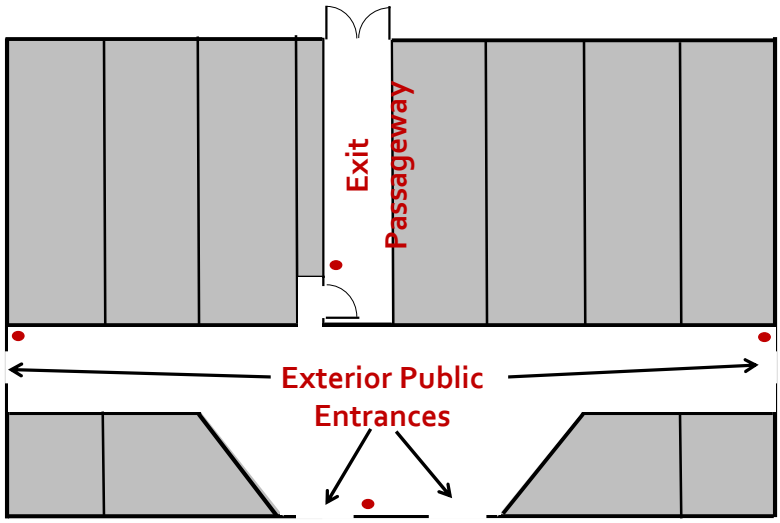
- Adjacent to each exterior public entrance
- Adjacent to each entrance from an exit passageway (or exit corridor) to the mall

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

108

108

CLASS I (2 ½ INCH) COVERED MALL BUILDINGS



NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

109

109

CLASS I LOCATIONS CONT. HIGHEST LANDING

- At the highest landing of stairways with roof access or on roofs (where slope is less than 4 in 12)
- See Section 7.3.2.7 thru 7.3.2.9

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

110

110

CLASS I LOCATIONS CONT.

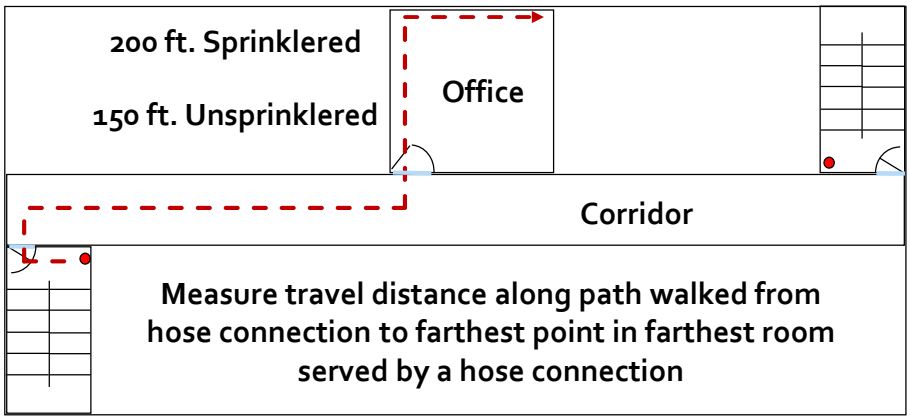
- Non sprinklered buildings
  - All portions of a floor must be within 150 feet of travel distance from a hose connection
- Sprinklered buildings
  - All portions of a floor must be within 200 feet of travel distance from a hose connection
- Distances do not apply to roofs if not occupied

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

111

111

CLASS I (2 ½ INCH) TRAVEL DISTANCE (DOES NOT APPLY TO THE ROOF IF NOT INTENDED FOR OCCUPANCY)



NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

112

112

CLASS II LOCATIONS

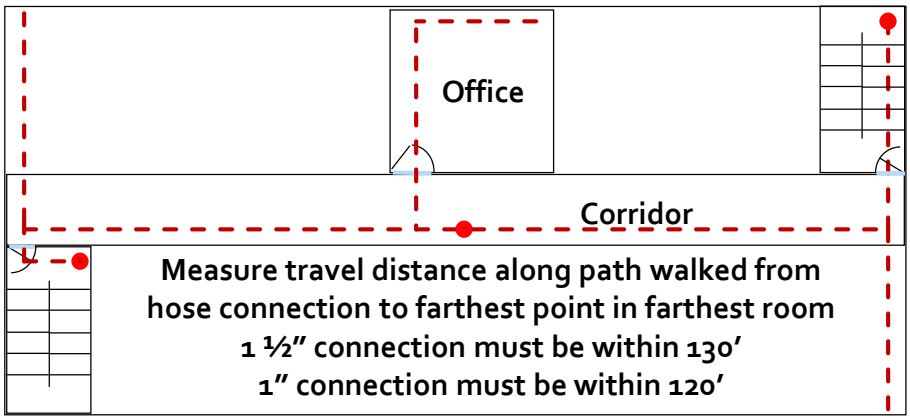
- 1 ½ inch hose stations
  - All portions of each floor level must be within 130 feet of a hose connection
- Less than 1 ½ inch hose stations
  - All portions of each floor level must be within 120 feet of a hose connection

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

113

113

CLASS II (1 ½ INCH) TRAVEL DISTANCE



NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

114

114

CLASS III LOCATIONS

- Class I and II requirements
  - Does not have to meet the 130' requirement for Class II systems
  - Where the building is completely sprinklered in accordance with NFPA 13, Class II hose stations are not required if
    - Approved by the AHJ & local Fire Department
    - Each Class I hose connection is equipped with 2 ½" x 1 ½" reducer with cap attached by a chain
    - Flow, pressure & duration according to Class I in buildings protected throughout with an approved automatic sprinkler system

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

115

115

NUMBER/INTERCONNECTION OF STANDPIPES

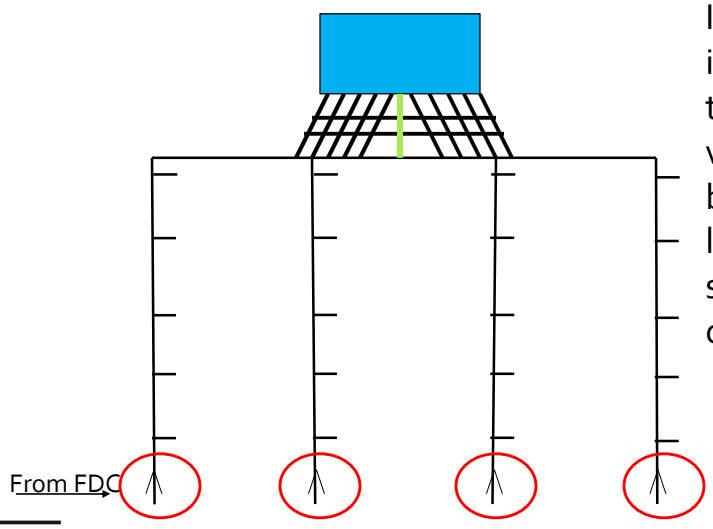
- Number of standpipes
  - Separate standpipes for each exit stairwell
- Interconnection of standpipes
  - Two or more in the same building or section of building must be interconnected
  - If supplied by tanks at the top of the building or zone, connect at the top
  - Where connected at the top & bottom, check valves are required at the base to prevent circulation
  - Dry standpipes only need a single level of interconnection

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

116

116

TANK FED STANDPIPE CONNECTED AT TOP & BOTTOM



It would be important for these check valves to be below the lowest standpipe connection

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

117

117

MINIMUM & MAXIMUM PRESSURE LIMITS

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

118

118

HISTORY BEHIND SYSTEM PRESSURE REQUIREMENTS

- The first edition of NFPA 14 was made in 1912
- The first requirements were in the 1950s due to increase in high-rise buildings
- 250 gpm at 50 psi at the nozzle
- 15 friction loss in the hose
- 65 psi total required

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

119

119

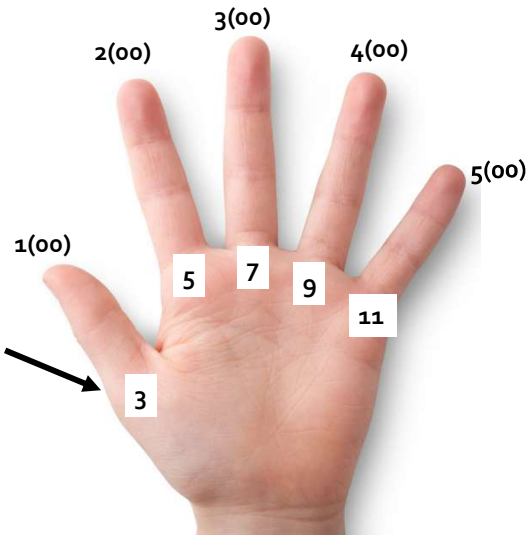
HISTORY BEHIND SYSTEM PRESSURE REQUIREMENTS CONT.

Friction loss in 2 ½" fire hose (per 100')

$$F_L = 2Q^2 + Q$$

Where Q = number of gallons ÷ 100

Conversion number



NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

120

120

HISTORY BEHIND SYSTEM PRESSURE REQUIREMENTS CONT.

- In the 1990s fire departments started using fog nozzles instead of solid tip nozzles
  - 100 psi to operate
- 65 psi was allowed for solid stream nozzles
- 100 psi was required for fog nozzles
- In 2007 the 65 psi allowance was removed

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

121

121

PRESSURE LIMITATIONS

- Maximum pressure anywhere in the system must not exceed 400 psi (was 350 psi in 2016 edition and earlier)
  - Does not apply to express mains according to their listing or approval by the AHJ
- No hose connections allowed on any portion of a system where the pressure exceeds 400 psi

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

122

122

PRESSURE LIMITATIONS CONT.

- Maximum pressure at hose connections
  - Pressure regulating devices must limit residual pressure to 100 psi for 1 ½-inch hose connections (does not apply to 2 ½" x 1 ½" reducer allowed in Class III systems)
  - Pressure regulating devices must limit static & residual pressure to 175 psi for 2 ½-inch hose connections
  - Pressure on the inlet side of the PRD shall not exceed the rated working pressure of the device

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

123

123

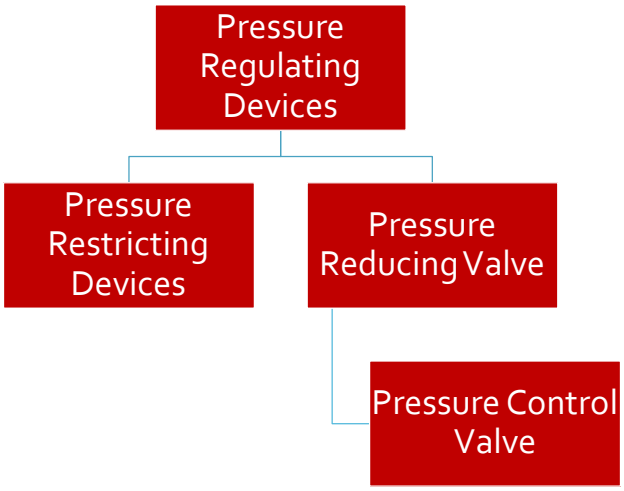
PRESSURE CONTROL

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

124

124

DEVICE HIERARCHY
ALL ARE REQUIRED TO BE LISTED



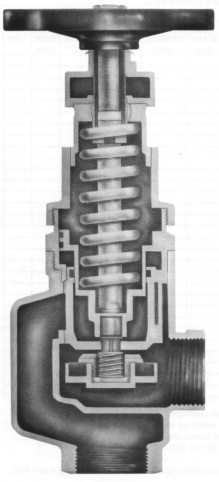
NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

125

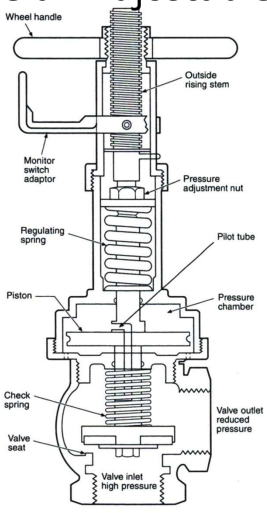
125

PRESSURE REDUCING VALVES

Preset



Field - Adjustable



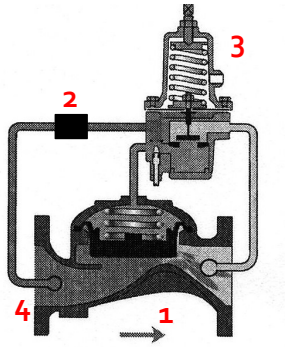
NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

126

126

PRESSURE REDUCING VALVES

- Pilot-Operated (Pressure Control Valves)



1. Pressure Reducing Valve
2. Restriction tube fitting
3. Pilot valve
4. Strainer

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

127

127

PRESSURE CONTROL

- Maximum pressure at hose connections
  - Where more than two hose connections are used downstream of a PRD, the following conditions must apply:

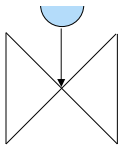
1. In systems w/ multiple zones, PRD's are permitted to control lower zone pressures as long as all other conditions are met	**6. PRD provided with inlet & outlet gauges**
2. Isolation method of the PRD for repair & maintenance must be provided	7. FDC on system side of outlet isolation valve
3. Regulating devices must be arranged so failure of one does not allow pressure > 175psi to any hose connections downstream	8. PRD provided with a pressure relief device according to mfgr. recommendations
4. Equally sized bypass, normally closed shall be installed	9. Remote monitoring & supervision for detecting high pressure failure of the PRD must be provided according to NFPA 72
5. PRD's installed no more than 7 ½' above floor	

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

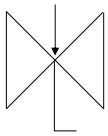
128

128

SYMBOLS



Pressure Regulating Valve
(Pressure Reducing Valve)



Pressure Relief Valve

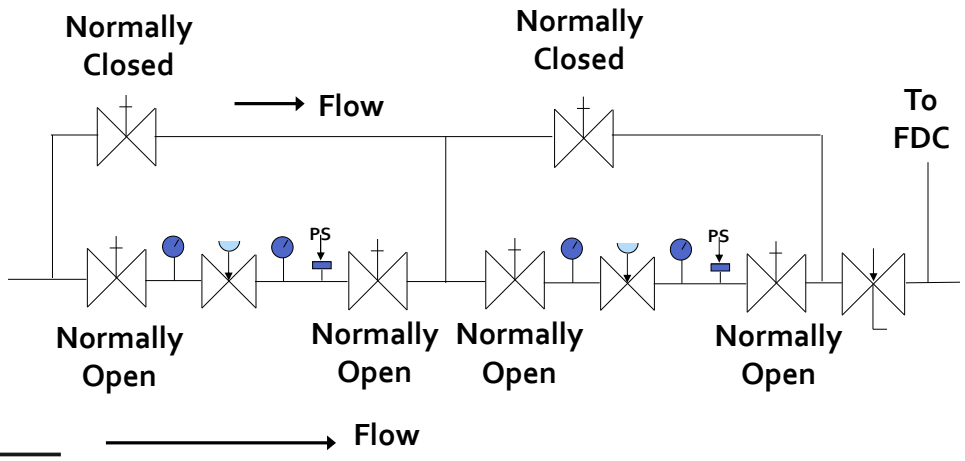
NFSA NATIONAL FIRE SPRINKLER ASSOCIATION
The Voice of the Fire Sprinkler Industry

129

129

MASTER PRD – NFPA 14

(2nd PRD must be pilot operated for this to work)



NFSA NATIONAL FIRE SPRINKLER ASSOCIATION
The Voice of the Fire Sprinkler Industry

130

130

PRESSURE REQUIREMENTS

- Minimum 100 psi residual pressure at the hydraulically most remote 2 ½" hose connection
  - Maximum 175 static or residual pressure
- Minimum 65 psi residual pressure at the hydraulically most remote 1 ½" hose station
  - Maximum 100psi residual
- Include loss in hose valve
- Minimum 100psi at top most outlet calc'd to FDC for manual systems

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

131

131

STANDPIPE SYSTEM ZONES

- Except where a master PRD is used, each zone must have a separate pump
  - Use of pumps in series is permitted
  - Allowed but not required to be on the same level
  - May have a separate discharge outlet from a multi port pump
- Each zone above the low zone shall have two or more separate & direct supply pipes sized to automatically & independently supply flow & pressure requirements
  - May use standpipes in the lower zone

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

132

132

STANDPIPE SYSTEM ZONES

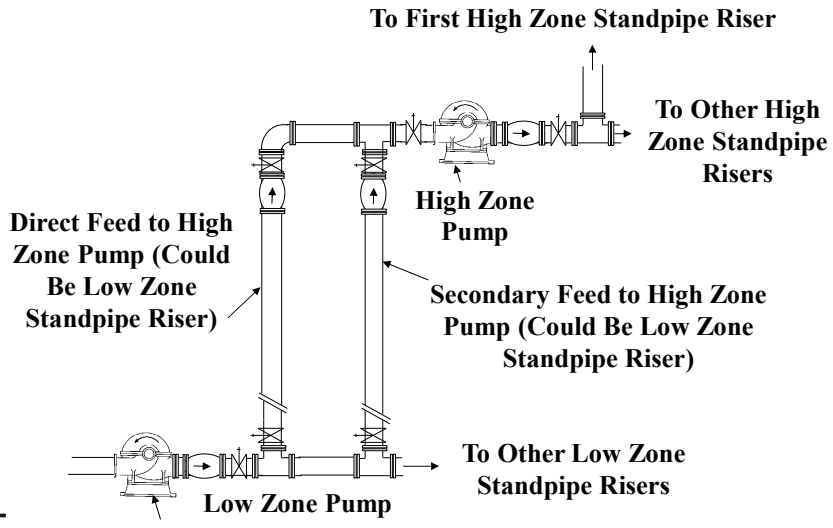
- An annex note to Section 7.9.2. further clarifies the position of the committee by use of an illustration.

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

133

133

STANDPIPE SYSTEM ZONES



NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

134

134

STANDPIPE SYSTEM ZONES CONT.

- For systems where 2 or more zones exceed the capacity of the fire department, hi level water storage is required with additional pumping equipment or other means acceptable to the AHJ
- NFPA 20 has an entire chapter dedicated to pumps in high rise buildings

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

135

135

FLOW RATES

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

136

136

FLOW RATES

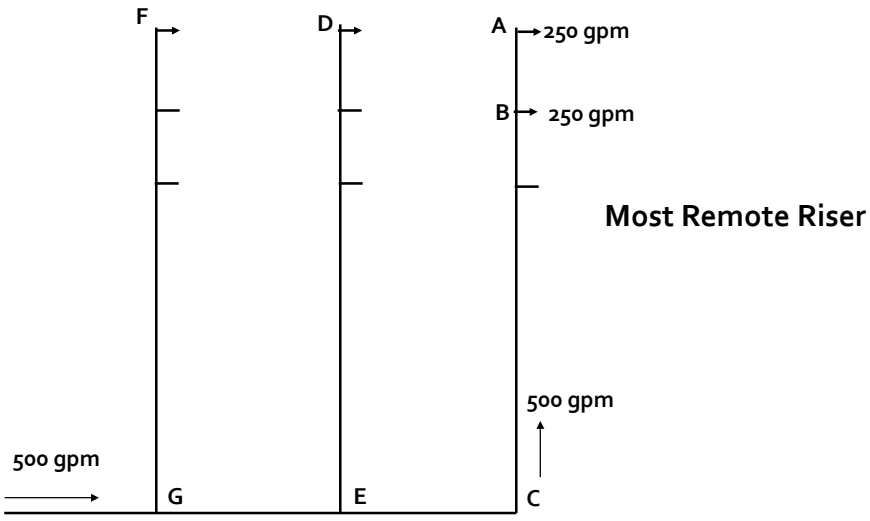
- Class I & III systems
  - Flow 500 gpm through the two most remote 2 ½" hose outlets
  - 250 gpm for each additional riser
  - Do not have to balance flows
  - Maximum flow rates
    - Sprinklered Building 1000 gpm
    - Unsprinklered Building 1250 gpm

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

137

137

CLASS I & III FLOW RATES

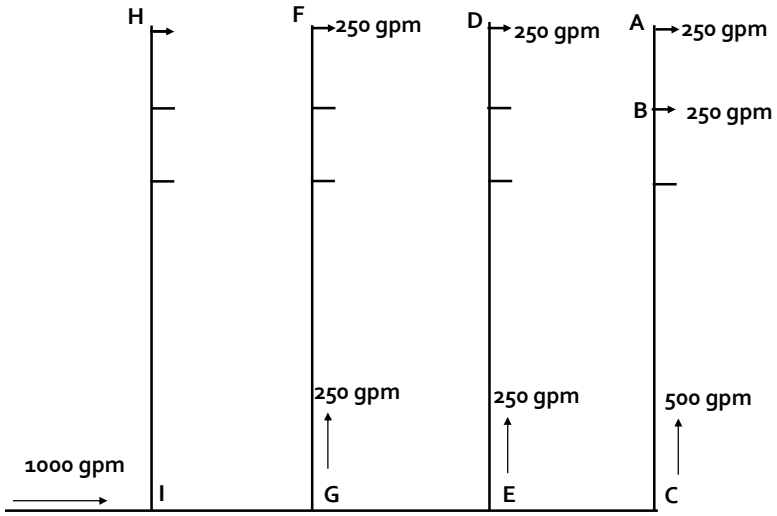


NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

138

138

SPRINKLERED BUILDING

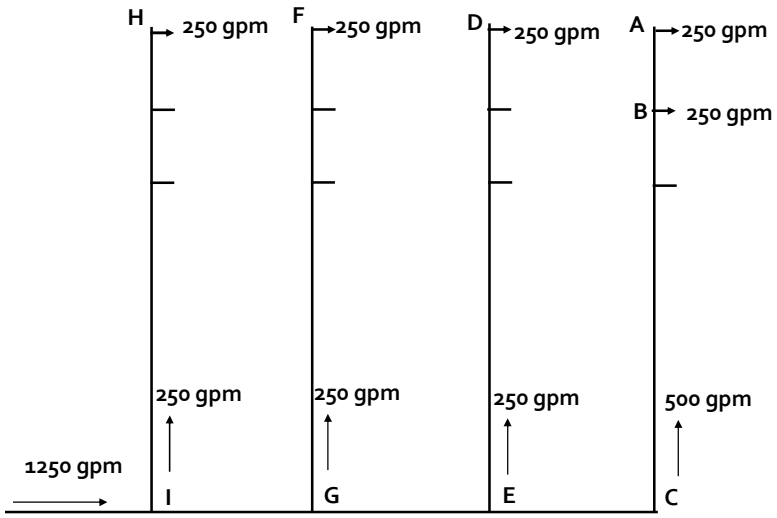


NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

139

139

UNSPRINKLERED BUILDING



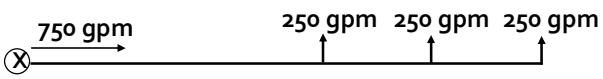
NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

140

140

HORIZONTAL STANDPIPE

- Horizontal Standpipe
  - The horizontal portion of the system piping that delivers the water supply for two or more hose connections, and for sprinklers on combined systems, on a single level



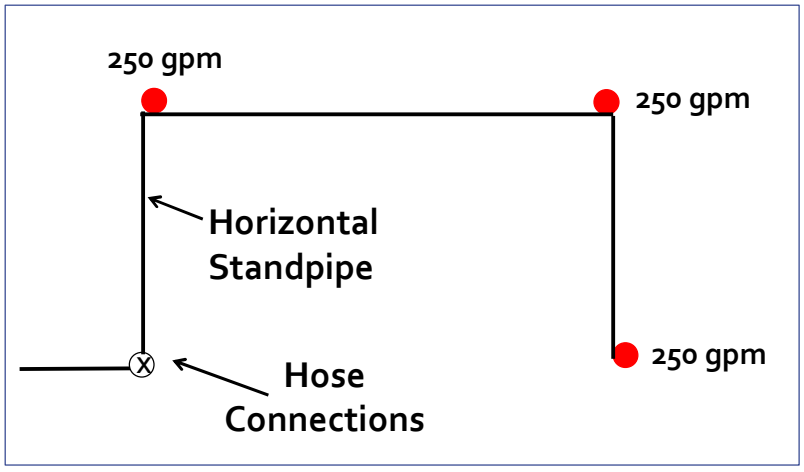
Plan view of horizontal standpipe

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

141

141

HORIZONTAL STANDPIPE
HORIZONTAL STANDPIPE, 750 GPM DEMAND



Plan View

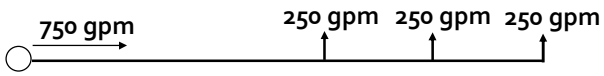
NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

142

142

HORIZONTAL STANDPIPE

- Class I & III systems
  - For horizontal standpipes that supply three or more hose connections on any floor
    - Flow 750 gpm through the three most hydraulically remote hose connections on the standpipe
  - 250 gpm for each additional riser to meet total requirements

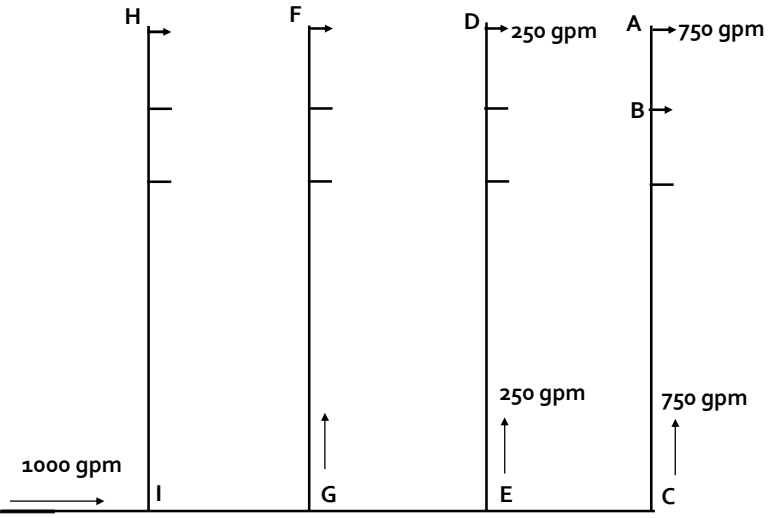


NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

143

143

SPRINKLERED BUILDING WITH HORIZONTAL STANDPIPE SERVING 3 OR MORE



NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

144

144

FLOW RATES CONT.

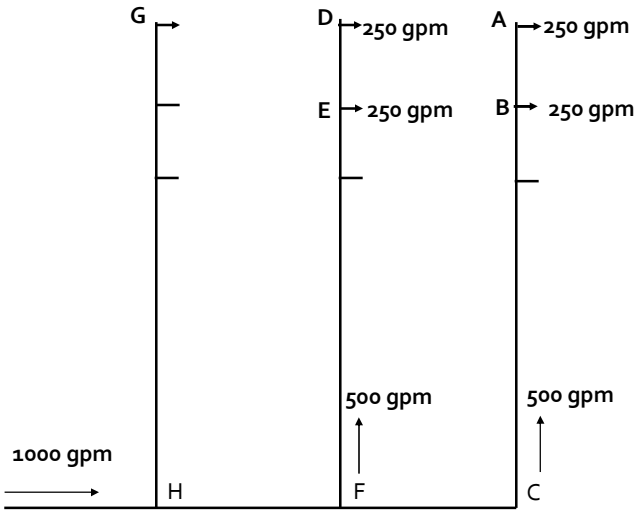
- Class I & III systems cont.
  - For large buildings (floor area > 80,000 ft2/floor)
    - 500 gpm from most remote standpipe
    - 500 gpm each for any additional standpipes needed for required flow
  - Do not have to balance flows
  - Maximum flow rates
    - Sprinklered Building 1000 gpm
    - Unsprinklered Building 1250 gpm

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

145

145

LARGE BUILDING SPRINKLERED

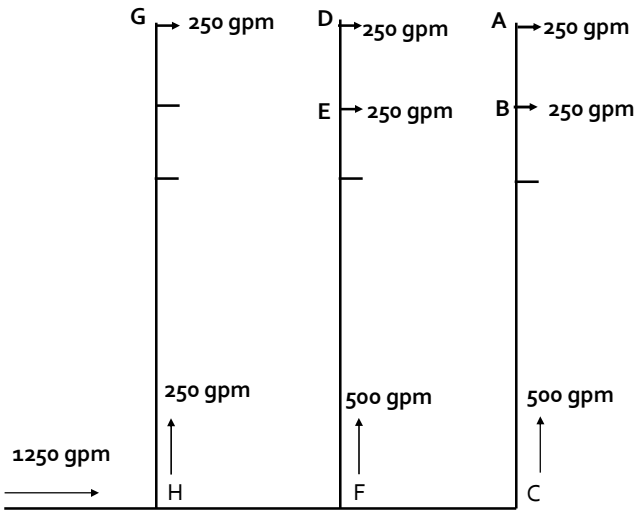


NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

146

146

LARGE BUILDING NON SPRINKLERED



NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

147

147

FLOW RATES CONT.

- Flow Rates for Single Outlets on Lateral Piping
  - Where lateral piping serves a single outlet, the minimum flow rate for the system shall be determined as if the outlet is being served from a separate standpipe

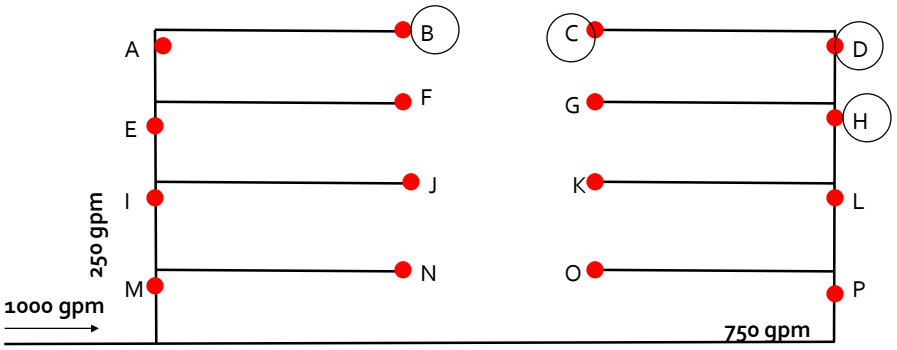
NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

148

148

SINGLE OUTLET ON LATERAL PIPING

For sprinklered building



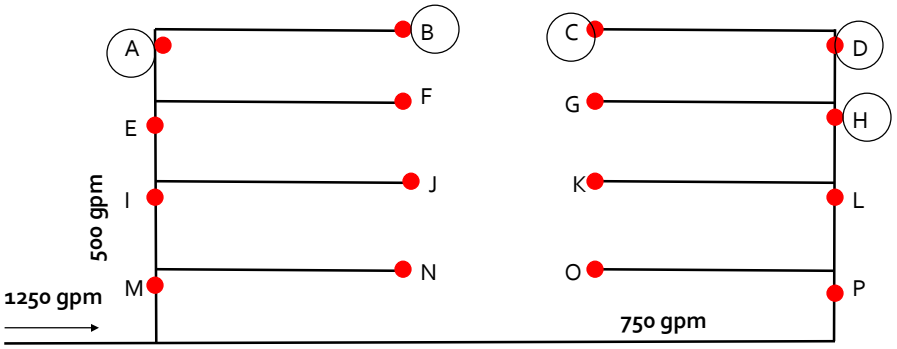
NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

149

149

SINGLE OUTLET ON LATERAL PIPING

For non sprinklered building



NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

150

150

FLOW RATES CONT.

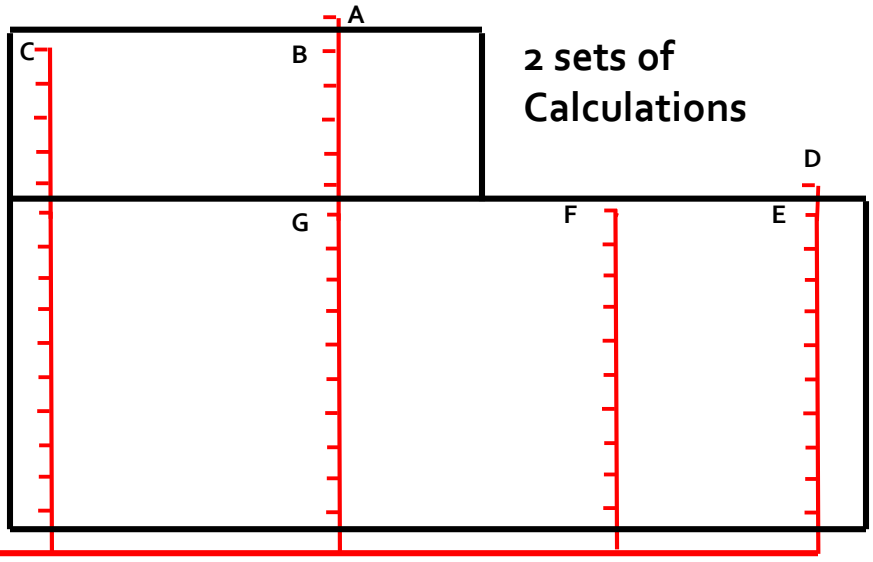
- Hydraulic calculation requirements
  - When standpipe systems have risers terminating at different floor levels, separate calculations are required for the standpipes that exist on each level.
  - In each case, flow shall be added only for standpipes that exist on the level of the calculations

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

151

151

STANDPIPE SYSTEMS WITH RISERS AT DIFFERENT HEIGHTS



NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

152

152

FLOW RATES CONT.

- Combined systems
  - A standpipe and sprinkler system sharing the same riser
  - Fully sprinklered buildings (either NFPA13 or 13R)
    - Provide the greater demand of the standpipe or sprinkler system
  - Partially sprinklered buildings
    - Standpipe demand plus
      - The lesser of Sprinkler demand or 150 gpm for LH
      - The lesser of Sprinkler demand or 500 gpm for OH

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

153

153

FLOW RATES CONT.

- Class II flow rates
  - Flow 100 gpm at the most remote hose connection
  - Additional flow is not required

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

154

154

DRAINS, TEST RISERS & FIRE DEPARTMENT CONNECTIONS

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION
The Voice of the Fire Sprinkler Industry

155

155

DRAIN AND TEST RISERS

- Test risers
  - Install a 3 inch drain riser adjacent to each standpipe with pressure regulating devices
  - Must handle flow from the largest PRD but not less than
    - Size of discharge outlet for those PRD's > 2 ½" in size
    - 3" for those PRD's that are 2 ½" in size
    - 2" for those PRD's that are 1 ½" in size
  - Drain risers shall be equipped with tees that are the same size as the discharge outlet of the PRD with internal threaded swivel fitting as specified with NFPA 1963, unless specified by the local fire department, located on at least every other floor.

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION
The Voice of the Fire Sprinkler Industry

156

156

DRAIN AND TEST RISERS CONT.

- Drains
  - Each standpipe systems must be equipped with drains
  - A main drain shall be provided on the standpipe system side of the system control valve
  - May use lowest hose connection if acceptable to the AHJ
  - Main drain shall be located to allow opening without damage

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

157

157

DRAIN AND TEST RISERS CONT.

- Drains
  - Trapped portions must have an auxiliary method of draining by one of the following:
    - An auxiliary drain according to NFPA 13
    - An auxiliary drain according to Table 7.11.2.3

Sizing for standpipe drain	
Standpipe size	Size of drain connection
Up to 2"	¾" or larger
2 ½", 3", or 3 ½"	1 ¼" or larger
4" or larger	2" or larger

  - A hose connection at a low point for use with an approved hose to drain water from the system

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

158

158

FIRE DEPARTMENT CONNECTIONS

- One or more FDC's required for each zone for Class I or Class III
  - Not required in high zone if beyond FD capability
  - Hi rise buildings shall have at least 2 remotely located FDC's for each zone
    - Single connection for each zone if AHJ approved
  - One 2 ½" connection for each 250 gpm demand
    - LDH connections are permitted
    - May be on multiple FDC's
    - May be located in multiple locations with AHJ approval

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

159

159

MODULE 6

- Plans, Calculations, & Water Supply Testing

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

160

160

LEARNING OBJECTIVES

At the end of this Module, participants will be able to:

1. Describe and explain the 27 items required on a set of plans and specifications
2. Explain the procedures to be followed for hydraulic calculations
3. Explain the requirements for water supplies and the required duration

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

161

161

PLANS AND CALCULATIONS

- Plans & Specs
  - Working plans must include pertinent items from a list of 27
- Hydraulic calculations
  - Piping shall be sized by hydraulic calculation
- Hydraulic calculation procedure
  - Shall begin at the outlet of each hose connection
  - Shall include the friction loss for the valve & any piping from the valve to the riser
  - Equivalent feet of valves & fittings similar to requirements of NFPA 13

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

162

162

MINIMUM DESIGN PRESSURES

- Pressure loss in the hose valve shall be calculated in accordance with the additions to the equivalent pipe length chart:

Fittings & Valves Expressed as Equivalent Feet of Pipe		
Fittings & Valves	1 ½"	2 ½"
Globe (straight) hose valve	46	70
Angle or hose valve	20	31

- When published, the valve manufacturer's most up-to-date data shall be used

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

163

163

WATER SUPPLIES & TESTING

- Auto & semi-auto systems shall be attached to an approved water supply capable of supplying demand
- Manual systems must have an approved supply accessible to the fire department
- Where the system demand cannot be supplied through the FDC, high water storage with additional pumping equipment is required
  - The auxiliary demand must meet the 30 minute supply

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

164

164

Water Supplies & Testing

- Acceptable water supplies
  - Public water works
  - Fire pumps connected to approved water source
  - Manually controlled fire pumps w/ pressure tanks
  - Pressure tanks
  - Manually controlled fire pumps operated by remote control devices at each hose station if supervised
  - Gravity tanks
- Minimum supply for standpipe systems
  - Class I & III- 30 minutes
  - Class II- 30 minutes

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

165

165

WATER SUPPLIES & TESTING

- Water supply evaluation
  - Water flow test is required to determine ability of the water system to provide the demand flow & pressure
  - Water flow test data must be no more than 12 months old unless approved by the AHJ

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

166

166

MODULE 7

- Acceptance Testing &
- Inspection, Testing & Maintenance

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

167

167

LEARNING OBJECTIVES CONT

At the end of this Module, participants will be able to:

- Discuss how baselines are established for future insp/test for NFPA 25
- Describe requirements for flushing UG pipe & calculate allowable leakage
- Describe requirements for hydrostatic testing for UG & AG pipe
- Describe the purpose & requirements for pneumatic testing
- Descibe & explain all of the operational tests required
- Describe and discuss signs required & materials required to be provided to owner & importance of NFPA 25

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

168

168

ACCEPTANCE TESTING

- Ensures that the system is completely installed and correctly functioning
- Establishes a baseline for future system tests
- Provides the owner with the means to maintain the system

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

169

169

CONTRACTORS MATERIAL AND TEST CERTIFICATES



Contractors Material and Test Certificate for Aboveground Piping

NFSA

A. Procedure Upon completion of work, inspection and tests shall be made by the contractor's representative and witnessed by an owner's representative. All defects shall be corrected and system left in service before contractor's personnel finally leave the job. A certificate shall be filled out and signed by both representatives. Copies shall be prepared for approving authorities, owners and contractor. It is understood the owner's representative's signature in no way prejudices any claim against contractor for faulty material, poor workmanship, or failure to comply with approving authority's requirements or local ordinances. All "No" answers shall be explained in the Comments portion of this form.

Property Name _____ Address: _____ Date: _____

B. Plans
1. Accepted by Approving Authorities (Names) _____
2. Address _____
3. Installation conforms to accepted plans ❑Yes ❑No
4. Equipment used is approved ❑Yes ❑No

C. Instructions
1. Has person in charge of fire equipment been instructed as to location of control valves and care and maintenance of this new equipment ❑Yes ❑No
2. Have copies of the following been left on the premises:
   a. System components instructions ❑Yes ❑No
   b. Care and maintenance instructions ❑Yes ❑No
   c. NFPA 25 ❑Yes ❑No

D. Location of system – Supplies building(s): _____

E. Sprinklers

Make	Model	Year Made	Orifice	Quantity	Temperature

F. Pipe and Fittings
1. Type of Pipe _____
2. Type of Fittings: _____

G. Alarm Valve or Flow Indicator

Type	Make	Model	Max. Time to Operate Through Insp. Test

O. Tests
1. All piping hydrostatically tested at ____ psi for ____hours
2. Dry piping pneumatically tested ❑Yes ❑No
3. Equipment operates properly ❑Yes ❑No
4. Do you certify as the sprinkler contractor that additives and corrosive chemicals, sodium silicate or derivatives of sodium silicate, brine, or other corrosive chemicals were not used for testing systems or stopping leaks? ❑Yes ❑No
5. Drain Test
   a. Static pressure reading of gage located near water supply connection _____ psi.
   b. Residual pressure with valve in test connection open wide: _____ psi.
6. Underground mains and lead-in connections to risers flushed before connection made to sprinkler piping and verified by copy of form No. 13-U ❑Yes ❑No
7. Flushed by installer of underground piping ❑Yes ❑No
8. If powder driven fasteners are used in concrete, has representative sample testing been satisfactorily completed? ❑Yes ❑No

P. Blank Testing Gaskets
1. Number used: _____
2. Locations: _____
3. Number removed: _____

Q. Welded Piping – If welded piping was used in the system, complete the following.
1. As the sprinkler contractor, were welding procedures in compliance with the requirements of at least AWS D2.1, ASME Section IX or other required standards ❑Yes ❑No
2. Was welding performed by welders qualified in

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

170

170

FLUSHING OF PIPING

- In accordance with NFPA 24
- Three Acceptable Flow Rates
  - Flow at system demand
  - Maximum flow available to the system under fire conditions
  - Flow at 10 ft/s (3 m/s) velocity

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

171

171

FLUSHING OF PIPING

Flow required to produce a velocity of 10 ft/sec in pipes	
Pipe size (in)	Flow rate (gpm)
4	390
6	880
8	1560
10	2440
12	3520

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

172

172

HYDROSTATIC TESTING

- Two hour long test pressure test at 200 psi or the system pressure plus 50 psi for systems over 150 psi. (may use an interim air test in inclement weather)
- Pressure is measured at the lowest point of the system
- Including the FDC

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

173

173

HYDROSTATIC TESTING – EXISTING SYSTEMS

- Same as for new installations
- For newly added piping only
- Testing in excess of static pressure not required if the piping cannot be isolated

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

174

174

SAMPLE PROBLEM #1

- City water pressure: 75 psi
- Pump static pressure: 100 psi

- What would the hydrostatic pressure be?

$$75\text{psi} + 100\text{psi} > 150\text{psi}$$

$$75\text{psi} + 100\text{psi} + 50\text{psi} = 225\text{psi}$$

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

175

175

SAMPLE PROBLEM #2

- City water pressure: 25 psi
- Pump pressure: 110 psi

- What would the hydrostatic pressure be?

$$25\text{psi} + 110\text{psi} < 150\text{psi}$$

$$25\text{psi} + 110\text{psi} = 200\text{psi}$$

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

176

176

LEAKAGE TEST – UNDERGROUND

- Underground piping shall be tested in accordance with NFPA 24
- Testing allowance is in gallons lost, not psi lost
- Testing results are measured from pumping from a calibrated container

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

177

177

LEAKAGE TEST – UNDERGROUND

- Make sure underground is ready to be tested
- Thrust blocks to be hardened before testing
- Backfill between joints to prevent movement of piping
- NFPA 24 annex recommends pre-stabilizing and 1-hour intermediate check for leakage

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

178

178

CALCULATING LEAKAGE

$$L = \frac{SD\sqrt{P}}{148{,}000}$$

- Where:
- L = makeup water (water that can be added to the system), gallons (or liters) per hour
- S = length of pipe, feet
- D = nominal diameter of the pipe, inches
- P = average test pressure during the hydrostatic test in psi

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

179

179

LEAKAGE TEST

NFPA 13 Table 10.10.2.2.6	
Hydrostatic Testing Allowance @ 200 psi per 100ft. of pipe	
2	0.019
4	0.038
6	0.057
8	0.076
10	0.096
12	0.115
14	0.134
16	0.153
18	0.172
20	0.191
24	0.229

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

180

180

SAMPLE PROBLEM 1

- Hydrostatic test pressure: 200 psi
- Pipe size: 8 inches
- Pipe length: 300 feet

- How many gallons can leak from the system?

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

181

181

SAMPLE PROBLEM 1

- Using the table: 100 ft. of 8" pipe can lose 0.076 gallons per hour

0.076 gallons x 3 x 2 = 0.456 gallons

- Using the formula:

$$L = \frac{SD\sqrt{P}}{148{,}000} = \frac{300x8x\sqrt{200}}{148{,}000} = \frac{33{,}941.13}{148{,}000}$$

$$L = 0.229x2 = 0.459gal$$

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

182

182

SAMPLE PROBLEM 2

- Hydrostatic test pressure: 250 psi
- Pipe size: 6 inches
- Pipe length: 450 feet

- How many gallons can leak from the system?

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

183

183

SAMPLE PROBLEM

- Using the formula:

$$L = \frac{SD\sqrt{P}}{148{,}000} = \frac{450x6x\sqrt{250}}{148{,}000} = 0.289$$

$$L = .289x2 = 0.58gal.$$

- Using the Table: 100ft. Of 6" pipe can lose 0.057 gallons per hour at 200 psi

$$L = 0.057x\left[\frac{250}{200}\right]x4.5x2 = 0.64gal$$

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

184

184

PNEUMATIC TESTING

- Interim test when a hydrostatic test cannot be performed on wet pipe systems
- Required for:
  - Automatic dry pipe systems
  - Semiautomatic systems

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

185

185

PNEUMATIC TESTING

- 40 psi
- Maintain pressure for 24 hours
  - Can lose up to 1.5 psi
  - No check for visible leakage is required

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

186

186

SYSTEM OPERATIONAL TESTS

- Flow test
- Automatic dry and semiautomatic systems trip test
- Pressure-regulating devices
- Alarm and supervision
- Main drain test
- Backflow test
- Manual valves

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

187

187

FLOW TESTS

- Flow 250 gpm from each hose connection as required
  - 250 gpm from two most remote locations
    - Additional standpipes may use flow from any connection on that standpipe
  - Maximum 3 (horizontal standpipe system)
  - Maximum 4 (sprinklered building)
  - Maximum 5 (unsprinklered or partially sprinklered building)

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

188

188

FLOW TEST

- Manual systems require a means of providing flow
  - Could use a fire department pumper
  - Could use a portable pump with required capacity
  - Test may be waived by the AHJ
- Suction tanks require verification that the supply valve operates as needed
  - Shut off all fill valves
  - Drain the tank to below designated low water level
  - Open supply valve to verify automatic operation

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

189

189

AUTOMATIC DRY AND SEMIAUTOMATIC SYSTEM TRIP TEST

- For systems larger than 750 gallons:
  - 250 gpm to the most remote hose connection
  - Within 3 minutes of opening the hose valve
- All remote control activation devices for semiautomatic systems tested in accordance with manufacturer's specifications

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

190

190

PRESSURE-REGULATING DEVICES

- Installed correctly
- Operating
  - Additional rules for devices in series
- Static Pressure
  - Inlet
  - Outlet
- Residual Pressure
  - Inlet
  - Outlet
- Annex suggests
  - Test at minimum & maximum anticipated flow rates
  - Test at sustained flow at minimum flow rates

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

191

191

ALARM AND SUPERVISION

- Each alarm & supervisory device shall be tested according to NFPA 72
  - Examples of components supervised by fire alarm system
    - Flow alarm
    - Supervisory switches
    - Semiautomatic actuation devices
    - Low temperature signal (dry pipe valve enclosures)

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

192

192

MAIN DRAIN TEST

- Static pressure
- Residual pressure
- Baseline strength of the water supply
- Not required for manual systems with no permanently attached water supply



NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

193

193

BACKFLOW PREVENTERS

- Forward flow test
- Full system demand must be capable of going through the backflow preventer
- Will occur during the system flow test



NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

194

194

MANUAL VALVES & HOSE THREADS

- All valves intended to be manually opened or closed shall be operated through their full range and returned to normal position
- Make sure hose caps are tight during the test
- Take hose caps off after the test to drain water and relieve any pressure
- ALL hose and FDC connections must be verified to be compatible with the fire department

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

195

195

RECORD DRAWINGS, TEST REPORTS & MANUALS PROVIDED TO THE OWNER

- Set of record drawings
- Copy of completed test report
- All literature & instructions from the manufacturer describing operation & maintenance of devices installed
- Set of instruction manuals for all major components containing
  - Explanation of the operation of the component
  - Routine maintenance instructions
  - Instructions concerning repairs
  - Parts list & identification for serviceable components
  - Copy of the current edition of NFPA 25

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

196

196

SIGNS

- The installation of all signs shall be verified
- Standpipes & hose systems not meeting the requirements of NFPA 14 & not required by the AHJ
- Signs for room identification, valves & hose connections
- Signs required on FDC's
- Signs required on pumps
- Hydraulic design information sign

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

197

197

SYSTEM INSPECTION, TESTING & MAINTENANCE

- Shall be performed by the property owner or an authorized representative in accordance with NFPA 25

Pin Header

Table 6.1.1.2 Summary of Standpipe and Hose Systems Inspection, Testing, and Maintenance

Item	Frequency	Reference
Inspection		
Cabinet	Annually	6.2.8
Control valves	–	Chapter 13
Gauges	–	Chapter 13
Hose	Annually	6.2.5
Hose connection	Annually	6.2.3
Hose nozzle	Annually and after each use	6.2.6
Hose storage device	Annually	6.2.7
Hydraulic design information sign	Annually	6.2.2
Hose valves	–	Chapter 13
Piping	Annually	6.2.4
Pressure-regulating devices	–	Chapter 13
Supervisory devices (except valve supervisory devices)	–	Chapter 13
Valve supervisory devices	–	Chapter 13
Test		
Control valves	–	Chapter 13
System valves	–	Chapter 13

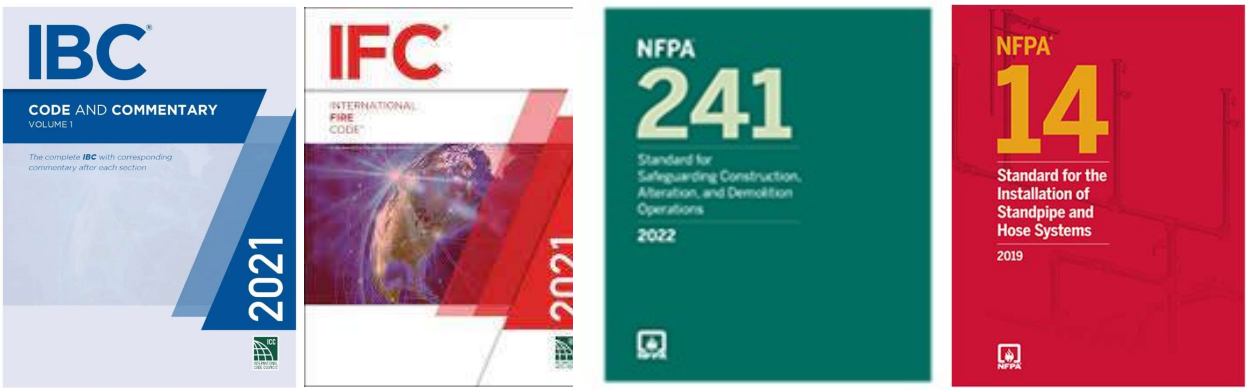
NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

198

198

MODULE 8

- Buildings Under Construction



NFSA NATIONAL FIRE SPRINKLER ASSOCIATION

199

199

LEARNING OBJECTIVES

At the end of this Module, participants will be able to:

- Describe and explain the requirements for the temporary installation of standpipe systems as buildings are being constructed

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION

200

200

BUILDINGS UNDER CONSTRUCTION

- In general, new buildings or buildings being renovated or demolished, standpipes are required to be maintained in accordance with the construction (or destruction) of the building to be always ready for use.

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

201

201

BUILDINGS UNDER CONSTRUCTION

- Standpipes shall be provided with readily accessible FDC's conspicuously marked at the street side
  - Location approved by the fire department
- All pipe sizes, connections, etc. shall conform to the standard
- Standpipes shall be supported & restrained at each floor

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

202

202

BUILDINGS UNDER CONSTRUCTION CONT.

- Hose connections
  - At least one at each floor level
    - Location approved by the fire department
    - Kept closed & guarded against mechanical injury
  - Standpipes shall be extended up with each story and capped at the top
  - Temporary standpipes are required to remain in service until permanent standpipe is complete
    - Those containing water shall be kept from freezing

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

203

203

BUILDINGS UNDER CONSTRUCTION CONT.

- Where construction height exceeds the capabilities of the water works system, fire pumps shall be installed for upper levels
  - May be temporary or permanent
  - Not required if AHJ allows fire department pumping apparatus to provide the pressure needed
- Threaded caps & plugs shall be installed on FDC's & hose connections
- FDC's & hose connections protected against damage

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

204

204

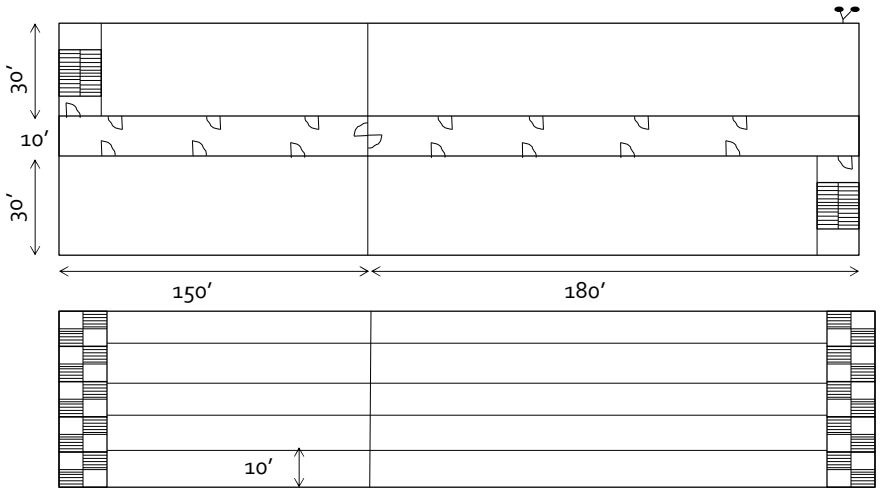
MODULE 9

- Standpipe Design Exercise

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

205

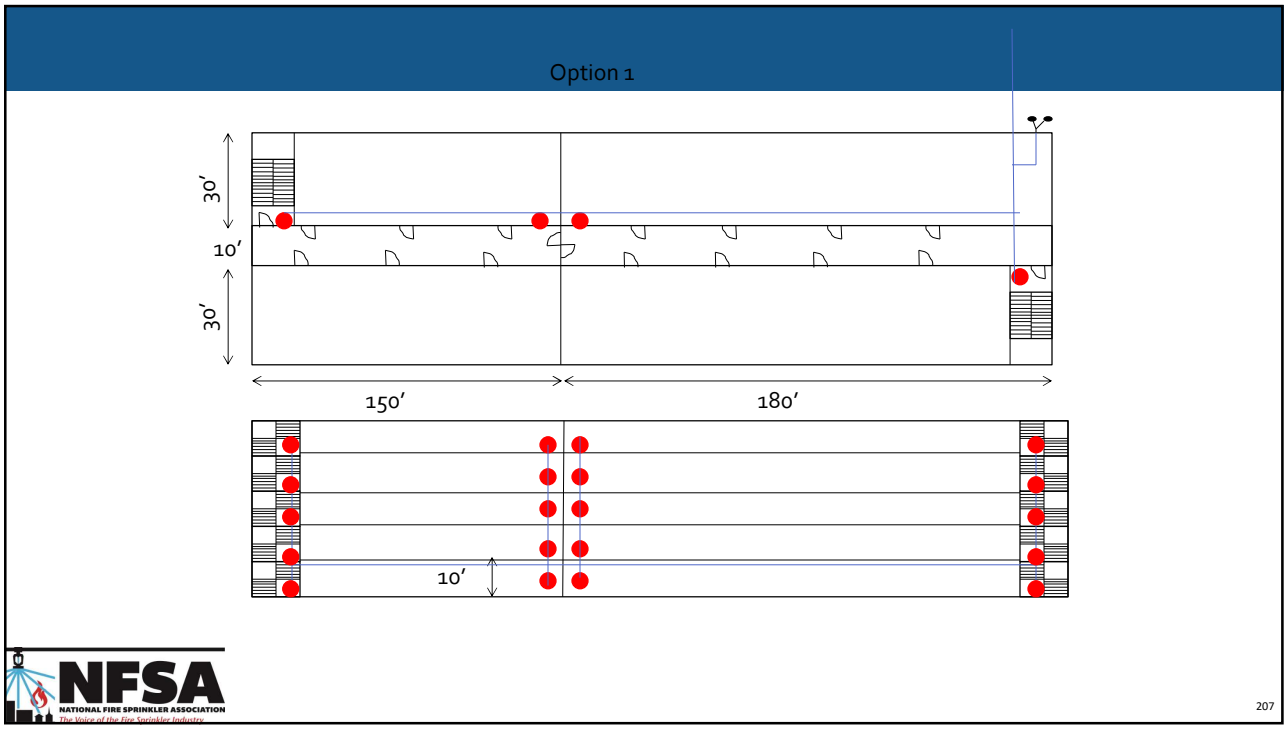
205



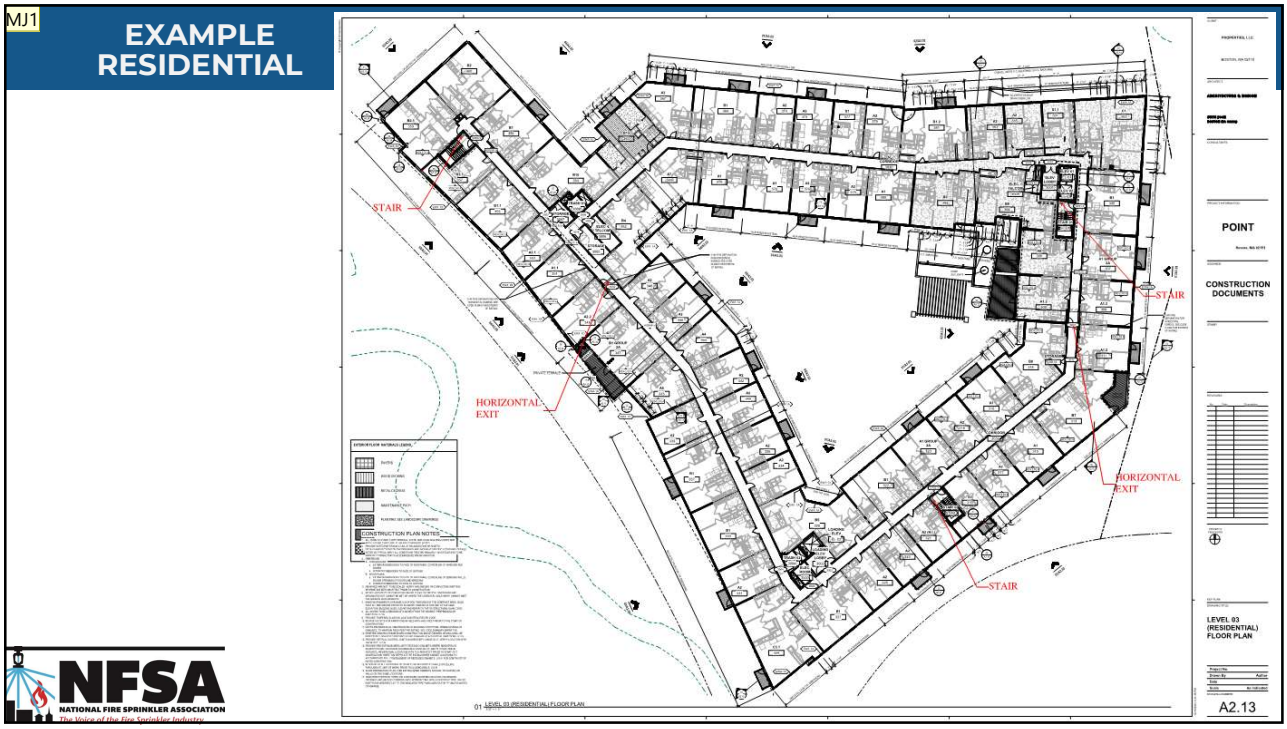
NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

206

206


Option 1
30′
10′
30′
150′
180′
10′
NFSA
NATIONAL FIRE SPRINKLER ASSOCIATION
The Voice of the Fire Sprinkler Industry
207

207


MJ1
EXAMPLE RESIDENTIAL
STAIR
HORIZONTAL EXIT
STAIR
HORIZONTAL EXIT
STAIR
POINT
CONSTRUCTION DOCUMENTS
LEVEL 03 (RESIDENTIAL) FLOOR PLAN
A2.13
NFSA
NATIONAL FIRE SPRINKLER ASSOCIATION
The Voice of the Fire Sprinkler Industry

208

Slide 208

MJ1 Michael Joanis, 1/18/2023



Join us for our Expo in Austin May 2-5!

NFSA.org
Events Tab
North American Fire Sprinkler Expo

Details

When	Where	Questions?	Hotel Information
May 2, 2023 – May 5, 2023 11:00 AM-10:00 PM CT	JW Marriott 110 E 2nd St Austin, TX 78701	NFSA Events events@nfsa.org	The NFSA room block is open! Room rate is $359/night
Add to Calendar	Register Now Already registered?	Contact Us	Book Your Room

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

209

CONCLUSION



Questions?



Contact: Michael Joanis
joanis@nfsa.org
410-983-9417

NFSA NATIONAL FIRE SPRINKLER ASSOCIATION The Voice of the Fire Sprinkler Industry

210

210

Ohio | Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: Ron Ritchey

Organization: National Fire Sprinkler Association (NFSA)

Address: 514 Progress Drive, Suite A - Linthicum Heights, MD

E-mail: ritchey@nfsa.org Telephone: 765-412-6707

Website: www.nfsa.org

Conference Sponsor (if applicable)_____ Conference Email:_____

Check here if Course Renewal:_____ Prior course number _____ *(i.e. BBS2018-429)*

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: Standpipe Systems & NFPA 14

Course instructor: Michael Joanis, PE

Course description: (see attached word document - Seminar Information Sheet)

Instructional hours per session: 8 hours Number of Sessions: 9 modules

Course Date(s) and Location: 1/24/23 - Mason Fire Dept Sta. 51
4420 Mason Montgomery Road
Mason, OH 45040

Special Content:

Code Administration:_____
Existing Buildings: _____
Electrical Instruction: _____
Plumbing Instruction:_____

Conference Course: _____
Conference Name: _____
Conference location:_____

Course to be offered online? NO **On Demand**_____ **Webinar**_____

Course Website: _____

Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation)*:

_____

Course applicable for the following certifications

Residential Certifications Only: _____ Commercial Certifications: X

Administrative Course, All Certifications: _____

Application materials included:

X Course Outline or Course Learning Objectives
X Presentation Materials/Slides (not required for roundtable courses)
_____ Assessment Materials (for online courses)
X Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

NFSA
NATIONAL FIRE SPRINKLER ASSOCIATION

Seminar Information Sheet

Seminar Title: Standpipe Systems & NFPA 14

Seminar Description: This one-day program provides the participant with the requirements for design, layout, installation and acceptance testing of standpipe systems using NFPA 14. Through discussion and activities, the seminar will address topics such as system pressures, the challenges of tall buildings, requirements for horizontal standpipes and the acceptance requirements for standpipe systems. The applicable codes for when standpipe systems are required and installations standards will be reviewed in detail to allow layout technicians to properly design and calculate standpipe systems. Total Instructional Time: 8 Contact Hours

Intended Audience: Sprinkler system layout technicians, sprinkler system contractors, Authorities Having Jurisdiction, Building Owners, Facilities Managers

Duration: 8 contact hours

Learning Outcomes:

At the conclusion of this program, the participant will be able to:

1. Introduction to Standpipe Systems
    a. Explain the scope of NFPA 14
    b. Discuss the history of standpipes
    c. Recognize where standpipe systems are required
    d. Discuss the hierarchy of codes and standards
2. Referenced Standards, Definitions, System Components, and Hardware
    a. Review the referenced standards.
    b. Explain the various definitions related to standpipe systems
    c. Explain the various components used in standpipe systems
    d. Discuss the similarity of system components with sprinkler systems
3. System Requirements
    a. Identify the various types of standpipe systems
    b. Identify the various classes of standpipe systems
    c. Discuss specific rules for automatic/ semi-automatic dry systems
    d. Discuss specific limits to the use of some systems
    e. Explain the requirements for gauges & waterflow alarms
4. Installation Requirements
    a. Explain & discuss the location and protection of both underground & above ground piping
    b. Discuss the requirements for the installation & supervision of control valves & check valves
    c. Explain the requirements for fire department connections
    d. Discuss the various requirements for specific signs
5. Design
    a. Explain the general rules for standpipe piping
    b. Explain the requirements for minimum pipe sizes
    c. Describe required hose locations & number of standpipes
    d. Explain minimum/maximum pressure limits in systems and how it is controlled
    e. Explain various pressure requirements for systems
    f. Explain the concept of standpipe zones and their impact on design
    g. Explain minimum flow rates in different systems
    h. Explain the purpose & requirements for drains, test risers and FDC's
6. Plans, Calculations, & Water Supply Testing
    a. Describe and explain the 27 items required on a set of plans and specifications
    b. Explain the procedures to be followed for hydraulic calculations

   c. Explain the requirements for water supplies and the required duration
7. Acceptance Testing & Inspection, Testing & Maintenance
   a. Discuss how baselines are established for future insp/test for NFPA 25
   b. Describe requirements for flushing UG pipe & calculate allowable leakage
   c. Describe requirements for hydrostatic testing for UG & AG pipe
   d. Describe the purpose & requirements for pneumatic testing
   e. Describe & explain all of the operational tests required
   f. Describe and discuss signs required & materials required to be provided to owner & importance of NFPA 25
8. Buildings Under Construction
   a. Describe and explain the requirements for the temporary installation of standpipe systems as buildings are being constructed
9. Standpipe Design Exercise
   a. Complete the layout of a standpipe system

Seminar Format(s): Lecture, case studies, code review and interactive exercises.

Participant Materials: Participant Guide.

Seminar Schedule:

Module 1 – Introduction to Standpipe Systems	.5 hour
Module 2 - Referenced Standards, Definitions, System Components, and Hardware	1 hour
Module 3 - System Requirements	1 hour
Module 4 - Installation Requirements	1 hour
Module 5 - Design	1 hour
Module 6 - Plans, Calculations, & Water Supply Testing	1 hour
Module 7 - Acceptance Testing & Inspection, Testing & Maintenance	1 hour
Module 8 - Buildings Under Construction	.5 hour
Module 9 - Standpipe Design Exercise	1 hour

Seminar Schedule

Module 1 – Introduction to Standpipe Systems	8:00 – 8:30
Module 2 - Referenced Standards, Definitions, System Components, and Hardware	8:30 – 9:30
Module 3 - System Requirements	9:30 – 10:30
Module 4 - Installation Requirements	10:30 – 11:30
Lunch	11:30 – 12:00
Module 5 - Design	12:00 – 1:00
Module 6 - Plans, Calculations, & Water Supply Testing	1:00 – 2:00
Module 7 - Acceptance Testing & Inspection, Testing & Maintenance	2:00 – 3:00
Module 8 - Buildings Under Construction	3:00 – 3:30
Module 9 - Standpipe Design Exercise	3:30 – 4:30

Michael Joanis, PE is the Chief Engineer at the NFSA. He obtained his Bachelor of Science degree in Fire Protection Engineering from the University of Maryland, College Park. He has been a registered professional engineer in several states since 1996. He is a member of NFPA and the Society of Fire Protection Engineers. He is currently a member of six NFPA technical committees including Sprinkler System Discharge Criteria and Hanging and Bracing. Michael is a licensed sprinkler contractor and serves as the NFSA staff liaison for the Contractors Council and Quality Assurance Committee.

Contact Information: Michael J. Joanis, PE
Director of Contractor Services
NFSA
514 Progress Drive, Suite A
Linthicum Heights, MD 21090
Tel: 410-983-9417
E-mail: joanis@nfsa.org

File Attachments for Item:

ER-3 Using Black and White Codes in a World of Grey (Fire Code Academy)

1 hour, all certifications

Staff Notes: Submitted after final agenda update released 2/15/23. Recommend approval.

Committee Recommendation:

Application for Continuing Education Course Approval

Provider Information:

Name: Randy Hormann

Organization: Fire Code Academy

Address: 81 Mill Street - Suite 300 Gahanna, Ohio 43230

E-mail: RandyH@FireCodeAcademy.com Telephone: 614-416-8077

Website: www.FireCodeAcademy.com

Conference Sponsor (if applicable)_____ Conference Email:_____

Check here if Course Renewal:_____Prior course number _____ (*i.e. BBS2018-429*)

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: Using Black and White Codes in a World of Grey

Course instructor: Leonard Belliveau, Jr., PE, and Steven E. Unger PE,

Course description:

Understanding the Code is not enough. Effective enforcement requires understanding the "whys" behind the codes and standards as well as using the Codes properly. You can't simply cherry-pick code sections without proper application in context. Codes addresses reasonably "normal" circumstances (the "norm" or what most people think of "the norm."). So, what happens when today's codes and standards need to be applied to those "out of the norm" situations?

Instructional hours per session: 1.0 Hours Number of Sessions:_____

Course Date(s) and Location:_____

Special Content:

Code Administration:_____ Conference Course: _____

Existing Buildings: _____ Conference Name: _____

Electrical Instruction: _____ Conference location:_____

Plumbing Instruction:_____

Course to be offered online? No **On Demand**_____ **Webinar**_____

Course Website: _____

Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation*):

_____

Course applicable for the following certifications

Residential Certifications Only: _____ Commercial Certifications: _____

Administrative Course, All Certifications: _____

Application materials included:

X Course Outline or Course Learning Objectives

X Presentation Materials/Slides (not required for roundtable courses)

_____ Assessment Materials (for online courses)

X Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

Using Black and White Codes in a World of Grey

Leonard Belliveau, Jr., PE, Senior Fire Protection Engineer, Protection Engineers LLC
Steven E. Unger, PE, Senior Fire Protection Engineer, Protection Engineers LLC

1.0 Hours

Understanding the Code is not enough. Effective enforcement requires understanding the "whys" behind the codes and standards as well as using the Codes properly. You can't simply cherry-pick code sections without proper application in context. Codes addresses reasonably "normal" circumstances (the "norm" or what most people think of "the norm."). So, what happens when today's codes and standards need to be applied to those "out of the norm" situations?

Learning Objectives: Through real world, select application examples participants will …

1) Learn the "hows" and "whys" behind specific code references.
2) Learn how to use the codes and standards properly.
3) Understand that codes and standards very often lag technology and other solutions not thought of in the Code may be as relevant and applicable as what's written in the requirements.

Leonard Belliveau, Jr., has over 20 years' experience managing fire protection engineering design and code consulting projects for government and commercial clients. He has successfully managed numerous large and complex contracts, with the U.S. DOT John A. Volpe National Transportation Systems Center, the Architect of the Capitol, Leidos Corporation, FedEx Ground and Emerson College. Mr. Belliveau has supported numerous other clients, including the Federal Aviation Administration, the Federal Railroad Administration, the Maritime Administration, the U.S. Department of Veterans Affairs, the U.S. Coast Guard, the U.S. Air Force, the Massachusetts Port Authority, the Port Authority of New York and New Jersey, and the Rhode Island Air National Guard. He has extensive experience in the areas of fire protection and life safety for mission critical facilities and fire alarm system evaluation, design, construction support and commissioning for both low-rise and high-rise buildings across all occupancy types.

Experience Summary

- Program Management and Program Development
- Fire Protection and Life Safety Inspections, Condition Assessments, and Evaluations
- Project Design and Construction Support
- Facilities Commissioning
- Code and Standards Consultation
- Quality Assurance and Control Activities
- Development / Implementation and Management of Training Programs

Education

- 2007, M.S., Marketing and Technological Innovation, WPI, Worcester, MA
- 1997, M.S., Fire Protection Engineering, WPI, Worcester, MA
- 1994, B.S., Mechanical Engineering, WPI, Worcester, MA

Employment

- Protection Engineers, L.L.C. (Sr. Fire Protection Engineer), Worcester, MA – April 2021 to Present
- Jensen Hughes, Westborough, MA – March 2001 to April 2021
- SimplexGrinnell, Westminster, MA – 1997 to 2001
- Custer Powell, Inc., Wrentham, MA – 1996 to 1997
- Rolf Jensen and Associates, Inc., Springfield, NJ – 1995

Certifications & Membership

- Professional Engineer (Registered in 11 states)
- National Council of Examiners for Engineering and Surveying (NCEES)
- National Institute for Certification in Engineering Technologies (NICET), FPE Technology / Fire Alarm Systems – Level IV
- NICET, FPE Technology / Inspection and Testing of Water-Based Systems – Level I
- Professional Member, Society of Fire Protection Engineers (SFPE)
- Member Society of Fire Protection Engineers (SFPE), New England Chapter
- Member, National Fire Protection Association (NFPA)
- (Former) Principal and Secretary, Technical Committee on Protected Premises Fire Alarm and Signaling Systems (SIG- PRO), NFPA 72
- (Former) Principal, Technical Committee on Telecommunications, NFPA 76

Project Experience

Federal Aviation Administration [FAA], Fire Life Safety [FLS] Program, Nationwide Program Support, Cambridge, MA
Responsible for supporting the National FLS program since 2002 under four consecutive multi-year IDIQ contracts, including serving as the Program Manager for many years under three of the contracts. Provided fire protection engineering and life safety code consulting support for FAA facilities throughout the U.S., including ATCTs, ARTCCs, TRACONs, ARSRs, CERAPs, and other FAA support buildings. Additional support included: fire protection and life safety inspections / evaluations, development of upgrade design packages, construction administration and commissioning for certification to the OSHA 1960.20 Compliance Program; participation in policy making activities such as assisting with revisions to master specifications, standard designs, FAA Order 6930, the Technical Implementation Guidance document, and the Consolidated Requirements for Existing Airport Traffic Control Towers; and developing, scheduling and hosting Maintenance of Fire Protection Systems training classes for FAA Technical Operations personnel.

National Airspace System Integration Support [NISC], FAA Nationwide Program Support, Washington, D.C.
Responsible for supporting the NISC FAA Program since 2011, under a 10-year contract, including serving as the Program Manager for many years. Work consisted of facility surveys of / testing of building FLS systems such as: means of egress components, fire barriers, automatic fire alarm systems, automatic fire suppression systems, smoke-proof enclosures, and a review of Emergency Action Plans, Fire Prevention Plans, evacuation / fire drill training documentation and records. Developed and presented courses and participated in National training on such subjects as: fire life safety compliance, codes and policy reviews, fire protection

passive / active systems, hazards identification, life cycle maintenance, emergency procedures, recognition of code violations, and standard designs and specifications.

Architect of the Capitol, Washington, D.C.
Conducted a complex wide fire alarm system false alarm study by evaluating the existing fire alarm systems installed in 20 of the buildings on Capitol Hill, including the U.S. Capitol Building, the Library of Congress Buildings, the Senate Office Buildings and the House Office Buildings. Evaluated the existing fire alarm systems, provided design packages for upgrades and / or replacement systems, and witnessed selective inspection, testing and commissioning of fire alarm systems in the U.S. Capitol Building, the Hart Senate Office Building, and the three Library of Congress Buildings.

Other Relevant Experience

- Evaluated and performed a code compliance and operational analysis of the existing fire alarm systems in 60 buildings in and around Logan International Airport in Boston, MA for Massport.
- Acted as the lead QA/QC reviewer of the fire protection system upgrade designs for the Port Authority Bus Terminal and the JFK International Airport ATCT in New York, NY.
- Evaluated existing fire protection systems, provided design packages for upgrades, and witnessed inspection, testing and commissioning of systems in multiple high-rise multi-use and residential buildings throughout Emerson College campus in Boston, MA.
- Managed a multi-year Master Services Agreement contract for fire protection system upgrades across the U.S. and Canada in package distribution facilities for FedEx Ground.

Publications

- Co-author, NFPA Fire Protection Handbook, Twenty-first Edition, Section 20, Chapter 20 “Occupancies in Special Structures” [to be released]
- Co-editor, NFPA 72 National Fire Alarm and Signaling Code Handbook, 2016 Edition (Chapters 12, 21, 23 and Annex C)
- Co-editor, NFPA 72 National Fire Alarm and Signaling Code Handbook, 2013 Edition (Chapters 12, 21, 23 and Annex C)
- Co-editor, NFPA 72 National Fire Alarm and Signaling Code Handbook, 2010 Edition (Chapter 14)
- Chapter author, NFPA Fire Protection Handbook, Eighteenth Edition, Appendix C “Organizations with Fire Protection Interests”

Mr. Unger is a licensed professional fire protection engineer with over 29 years serving in various roles throughout his career, including operating a successful fire protection consulting company, serving as the NISC team lead for fire life safety for the Federal Aviation Administration EOSH Fire Life Safety program, and managing fire protection projects of varying scopes. Mr. Unger's projects have included governmental agencies, commercial facilities, hospitality structures, university campuses, institutional complexes, airport terminals, research laboratories, and chemical/hazardous material plants. Mr. Unger possesses a B.S. degree in Fire Protection Engineering from the University of Maryland.

Experience Summary

- NISC Fire Life Safety Team Lead and Supervisor
- Former Owner/Operator of Consulting Firm
- Program Management and Project Devlopment
- Fire Protection Design and Construction Support
- Fire Protection Code Consulting and Interpretations
- System Analysis and Condition Assessments
- Fire Hazard Analysis
- Knowledge Transfer & Training

Education

1993, B.S., Fire Protection Engineering, Magna Cum Laude, University of Maryland

Employment

- Protection Engineers, LLC, Dallas, TX - September 2022 to present
- Leidos, Inc., Dallas, TX – October 2013 to August 2022
- Obsidian Fire Consulting, L.L.C., Dallas, TX – July 2013 to September 2022
- Hughes Associates, Inc., Dallas, TX – May 2000 to July 2013
- Schirmer Engineering Corp., Dallas, TX – March 1996 to May 2000
- Parsons Facility Services, NASA Goddard Space Flight Center, MD - February 1995 to March 1996
- AlliedSignal Technical Services, NASA Goddard Space Flight Center, MD – May 1993 to February 1995

Certifications & Membership

- Professional Engineer (Registered in multiple states)
- Professional Member, Society of Fire Protection Engineers (SFPE)

- Member, SFPE Dallas / Fort Worth Chapter (former President)
- Member, National Fire Protection Association (NFPA)
- Member, SFPE Subcommittee for Code and Standards Liaison (SCCSL)
- Member, SFPE Existing Building Task Group
- Former Member, SFPE ICC Working Group
- Former Member and Chair, McKinney Building and Standards Commission
- Salamander Honorary Fire Protection Engineering Society
- National Council of Examiners for Engineering and Surveying (NCEES)

Project Experience

FAA Fire Life Safety Condition Risk Assessment Program, Throughout US
Management and oversight of the Condition Risk Assessments (CRAs) conducted at the FAA ATO control facilities throughout the US. Developed the implementation plan and methodology for the completion of the CRA effort, as well as, oversaw the technical teams completing the CRAs. Reviewed completed assessments and provided out-briefings to FAA management regarding findings and recommended mitigations.

In addition, conducted FAA facility surveys building FLS systems such as: means of egress components, fire barriers, automatic fire alarm systems, automatic fire suppression systems, smokeproof enclosures, and review of emergency response documentation and records. Provide training of FLS maintenance courses.

Drury Hotels, Multiple Locations Throughout US
Oversaw fire protection designs and construction period services for hotel/hospitality buildings developed in multiple locations. Designs included sprinkler/ suppression systems, standpipe systems, fire pump assemblies, fire alarm and voice communication systems, stair pressurization systems, and smoke control systems. In Provided code consulting and third-party special inspection services.

Demilec, Arlington, Texas
Provided hazardous material consulting as related to the applicable building and fire codes. Services included hazardous material classification in accordance with the fire codes, development of mitigation strategies to address hazards, preparation of Hazard Analysis report to be provided to the AHJ, and completion of Hazardous Material Inventory Statements (HMIS) and Hazardous Materials Management Plans (HMMP).

University of Texas, Austin, Texas
Managed program to provide fire life safety services to various buildings throughout the campus. Performance of work included fire protection and life safety condition assessments (using building codes and evaluation systems), designs of fire protection systems, code consulting and review of new project design, and development of the emergency communication systems throughout the campus.

Using Black and White Codes in a World of Grey

Do we know what we are doing?

Lenny Belliveau, PE, SET
Senior Fire Protection Engineer
Protection Engineers, LLC
Worcester, MA

Steve Unger, PE
Senior Fire Protection Engineer
Protection Engineers, LLC
McKinney, TX

19th Annual Fire Code and Fire Protection Life Safety Forum
Columbus, OH • February 2023

Presentation Inspired by Jeffrey Moore, PE, FSFPE, CFEI, Firemark Consulting, LLC, Union, KY

Contact Information

Lenny Belliveau, PE, SET
Senior Fire Protection Engineer
Protection Engineers, LLC
Worcester, MA
Email: lbelliveau@protengineers.com
Tel: 401-338-3394

Steve Unger, PE
Senior Fire Protection Engineer
Protection Engineers, LLC
McKinney, TX
Email: seunger@protengineers.com
Tel: 469-667-8596



Presentation Road Map

- The Codes and Standards Process
- NFPA Codes and Standards
- How do we use these codes and standards
- How do we misuse these codes and standards
- Examples of code application and misapplication



Coming to Terms with Terms



- **CODE**
  - A “Code” tells you what you must do
  - Generally written in a format that can be adopted and enforced by a governmental jurisdiction as a statutory requirement
  - Examples: IBC, IFC, NFPA 101, NFPA 70, and ANSI/ASME A17.1
- **STANDARD**
  - A “Standard” tells you how to meet a “Code”
  - Provides the nuts, bolts, and details of “how to . . .”
  - Examples: NFPA 13, NFPA 20, NFPA 72, NFPA 2001

Babylonian Code of Hammurabi

1780 BC

“If a builder build a house for someone and does not construct it properly, and the house which he built fall in and kill its owner, then that builder shall be put to death.”



What is the purpose of a Code / Standard?

- Codes establish the minimum acceptable level of fire safety
- Generally refer to other standards for the “how to”
- Example: NFPA 101 and the IBC refer to NFPA 13 as the minimum requirements related to design and installation of automatic sprinkler systems
- The IBC / IFC protect the public from the building
- NFPA standards are minimums



Life Cycle of a Code / Standard

- It’s an idea
- It’s shaped into a technical document
- It’s modified through a committee process
- It’s modified by the political process
- What can’t be agreed upon is omitted
- The code/standard ends up as a political document





The NFPA Process

- Request for a new project submitted to NFPA
- NFPA standards council establishes a technical committee with representation from varied interest groups
  - Insurance
  - Consumer
  - Enforcing authorities
  - Labor
  - Installer / maintainer
  - Special expert
  - Applied research/testing laboratories
  - Users
  - Manufacturers





The NFPA Process (cont.)

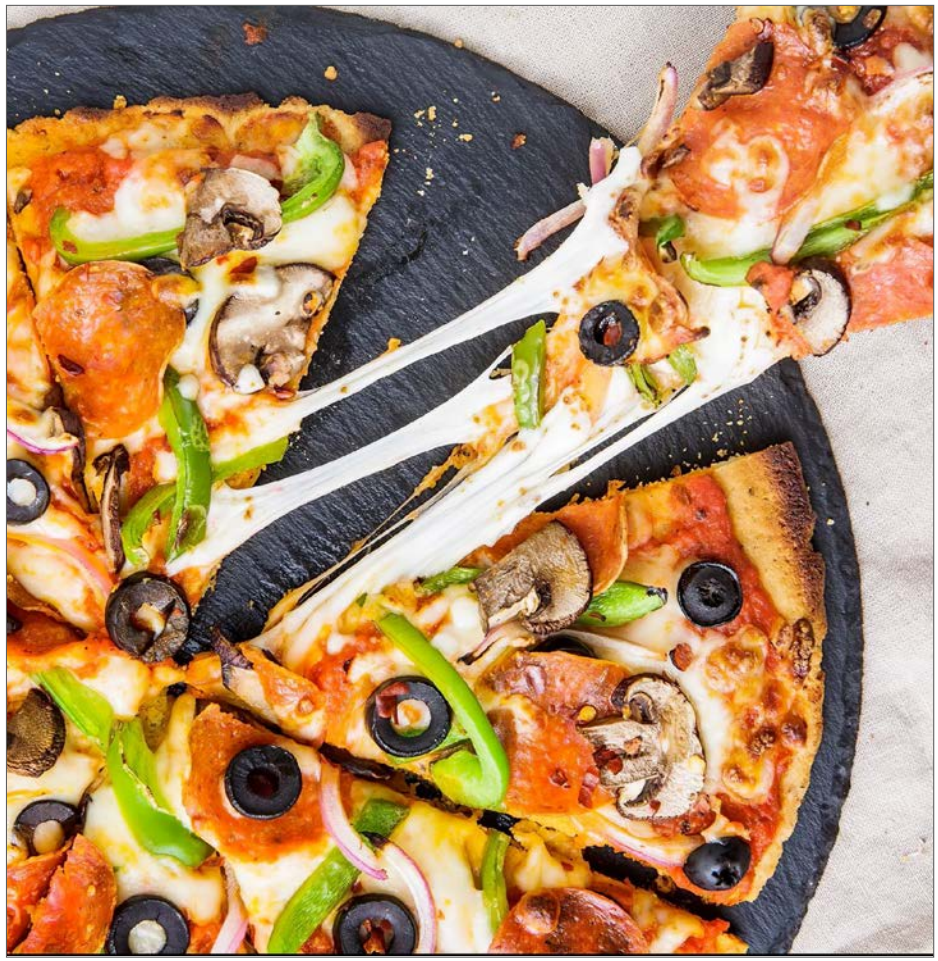
- **Public inputs accepted**
  - Suggestions from the public on what should be included in the document
  - Technical committee meets to act on each public input and ballot their actions
  - Committee actions published for public review as the “First Draft”
- **Public comments accepted**
  - Technical committee meets to act on each public comment and ballots their actions
  - Committee actions published for public review as the “Second Draft”
- **NFPA Technical Meeting**
  - Anyone not satisfied with the document as presented can propose an amendment
  - Members of NFPA vote on the final document (as amended if applicable)
- **NFPA Standards Council**
  - Accepts appeals related to the entire process
  - Issue the standard or return it to the technical committee





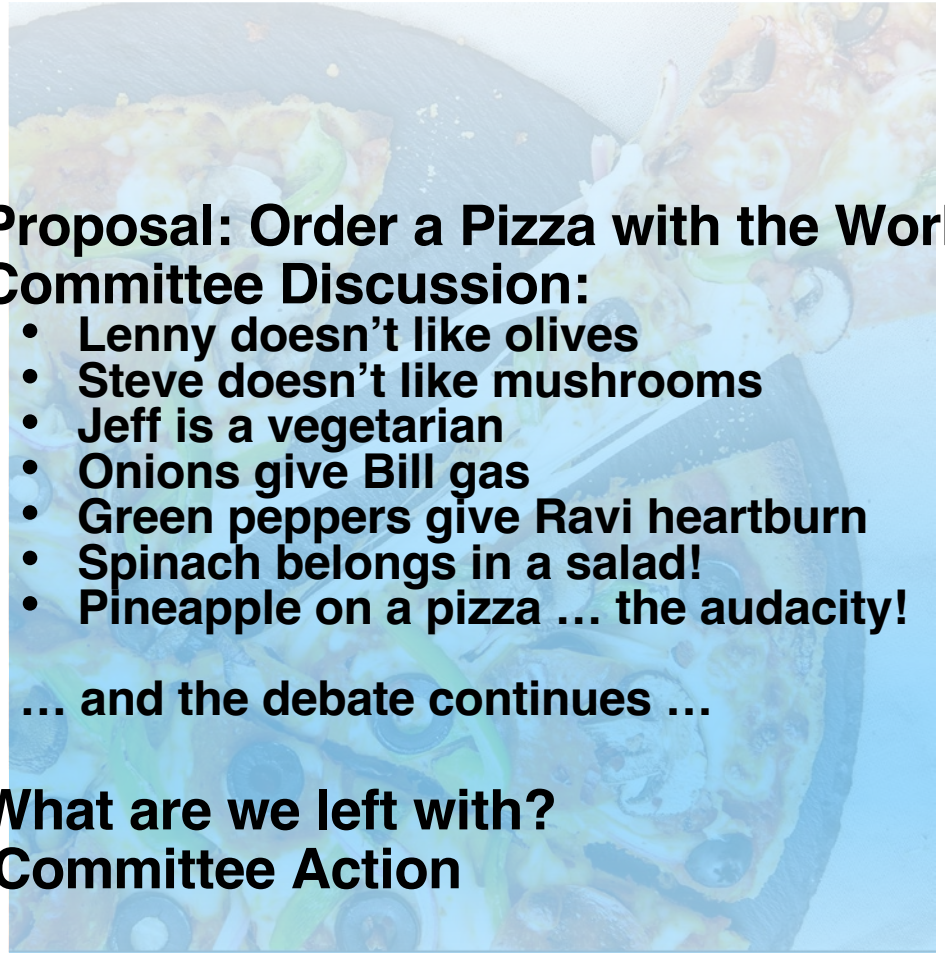
The NFPA Process Simplified

The NFPA Technical Committee on Pizzas



The NFPA Process Simplified

The NFPA Technical Committee on Pizzas



- **Proposal: Order a Pizza with the Works**
- **Committee Discussion:**
  - **Lenny doesn't like olives**
  - **Steve doesn't like mushrooms**
  - **Jeff is a vegetarian**
  - **Onions give Bill gas**
  - **Green peppers give Ravi heartburn**
  - **Spinach belongs in a salad!**
  - **Pineapple on a pizza … the audacity!**

  … and the debate continues …

- **What are we left with?**
  Committee Action

The NFPA Process Simplified

The NFPA Technical Committee on Pizzas

Committee Action - New Code Section: Plain Cheese Pizza



The NFPA Process Simplified

The NFPA Technical Committee on Pizzas

Committee Action - New Code Section: Plain Cheese Pizza

… unless we address Paul who is lactose intolerant and Gene who has allergies to tomatoes and gluten …



The NFPA Process Simplified

The NFPA Technical Committee on Pizzas

Committee Action - New Code Section: Plain Baked Gluten-Free Dough



The Fallacy of Code Compliance

My (choose one) complies with the "Code" so it is safe from fire.

- **building**
- **process**
- **equipment**
- **other (specify)**







The Titanic complied with all codes. Lawyers can make any device (*situation*) legal, only engineers can make them safe.

Prof. Vincent Brannigan
Department of Fire Protection Engineering
University of Maryland



Code Enforcement Problem

Enforcing a code without an understanding of the code

New diesel pumps failed the AHJ acceptance inspection because the installation did not include a circulation relief valve for each pump. Why?



One of the challenges in this world is knowing enough about a subject to think you are right but not knowing enough about it to know you are wrong.

Neil deGrasse Tyson
Astrophysicist/Director of
the Hayden Planetarium
New York

“One of the elements needed in solving a complex technical problem is to have the individuals who make the decisions trained in the technology involved. A concept widely accepted in some circles is that all you need is to get a college degree in management, and then, regardless of the technical subject, you can apply your management techniques to run any program; including the Presidency, Congress, or the Vatican. This has become a tenet of our modern society, but it is valid as the once widely held precept that the world is flat. **Properly running a sophisticated technical program requires a fundamental understanding of and commitment to the technical aspects of the job and a willingness to pay infinite attention to the technical details. This can only be done by one who understands the details and their implications.** The phrase “The devil is in the details” is especially true for technical work. If you ignore those details and attempt to rely on management techniques or gimmicks you will surely end up with a system that is unmanageable, and problems will be immensely more difficult to solve. At Naval Reactors, I take individuals who are good engineers and make them into managers. They do not manage by gimmicks but rather by knowledge, logic, common sense, and hard work.”

ADM H.G. Rickover
Before the Subcommittee on Energy Research and Production of the
Committee on Science and Technology
U.S House of Representatives
May 24, 1979

Knowing the “Whys” behind the “Whats”

Diesel Fire Pump Example

1. What is the purpose of a circulation relief valve?
2. How is a diesel fire pump driver cooled?
3. What would be the purpose of a circulation relief valve on a diesel fire pump?



Other Code Enforcement Problems

- The codes lag technology (sometimes significantly)
  - Ignitable liquids in plastic containers
  - Exterior combustible cladding
  - Hazards of EV batteries
  - Cybersecurity for control equipment







Other Code Enforcement Problems

- The available codes only address “normal” hazards
- Enforcement of “cherry picked” requirements
- Not knowing the scope of the “code/standard”





Other Code Enforcement Problems

- DBWA - Designing by Walking Around by code enforcement officials.
- DO NOT put yourself in the position of directing the design.
- If you “design” it. You own it.





Code Enforcement Problems Precision

- What is the intended level of precision for enforcement of the code?
- Most codes do a very poor job of specifying precision.
- What all codes should include, and how we should enforce them –
  - The values presented for measurements in this Code are expressed to the degree of precision appropriate for practical application and enforcement. It is not intended that the application or enforcement of these values be more precise than the precision expressed. - NFPA 72, *National Fire Alarm and Signaling Code.*
  - Close enough for . . .



Some Practical Examples - know the “why”

- Exit Signage
- Fire Extinguishers
- Visible Notification Appliance Heights
- Fire Detector Listed Spacing
- Manual Fire Alarm Box Heights

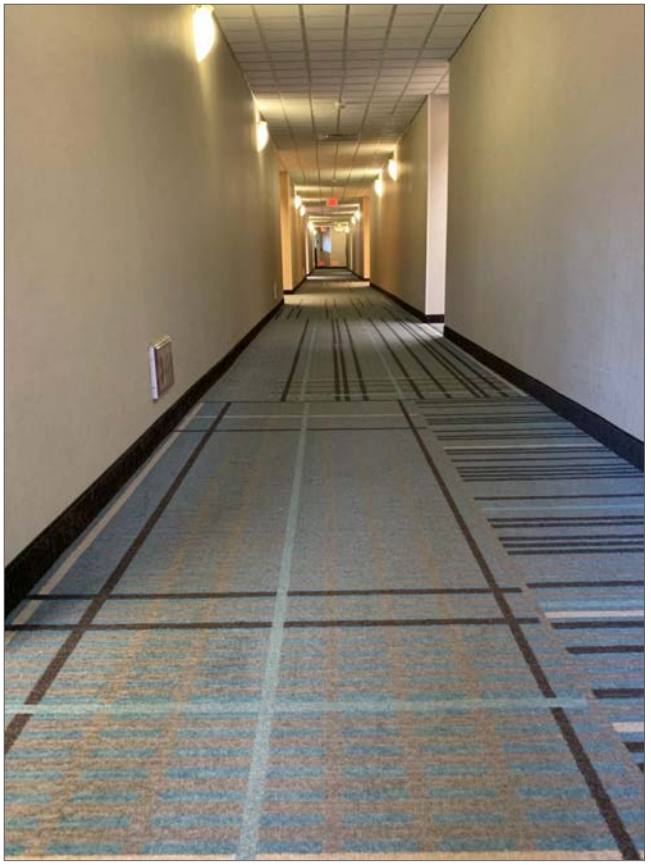
Exit Signage

- NFPA 101 – 2018, 7.10.1.2 Exits.
- 7.10.1.2.1* Exits, **other than main exterior exit doors that obviously and clearly are identifiable as exits**, shall be marked by an approved sign that is readily visible from any direction of exit access.
- 7.10.1.2.2* Horizontal components of the egress path **within an exit enclosure** shall be marked by approved exit or directional exit signs **where the continuation of the egress path is not obvious**.



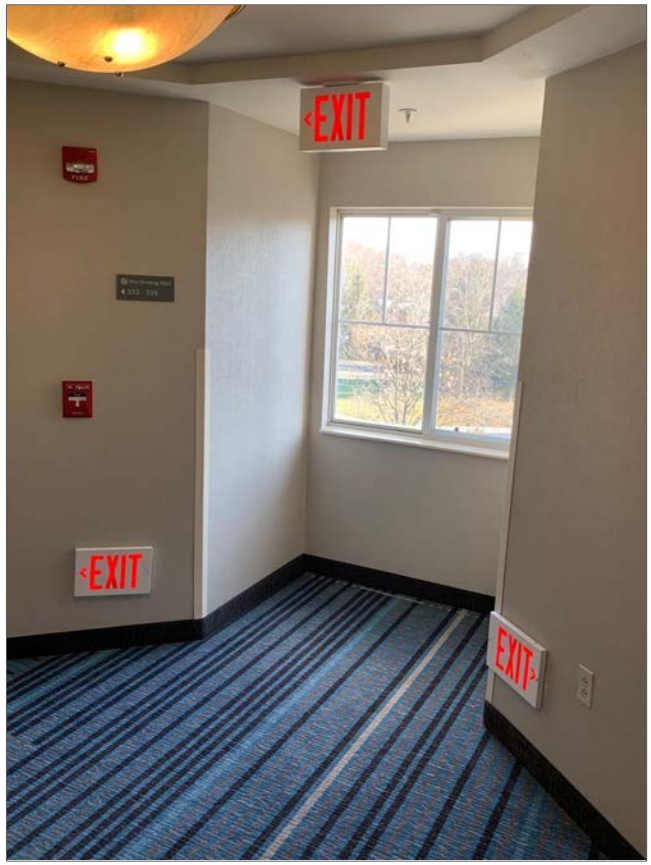
Exit Signage

- 7.10.1.5 Exit Access.
- 7.10.1.5.1 Access to exits shall be marked by approved, readily visible signs in all cases **where the exit or way to reach the exit is not readily apparent** to the occupants.
- 7.10.1.5.2* New sign placement shall be such that **no point** in an exit access corridor **is in excess of the rated viewing distance or 100 ft** (30 m), whichever is less, from the nearest sign.



Exit Signage

- 7.10.1.6* Floor Proximity Exit Signs. **Where** floor proximity exit signs are **required** … Such signs shall be **located near the floor level in addition to those signs required for doors or corridors**. The bottom of the sign shall be not less than 6 in. (150 mm), but not more than 18 in. (455 mm), above the floor. For exit doors, the sign shall be mounted on the door or adjacent to the door, with the nearest edge of the sign within 4 in. (100 mm) of the door frame.



Exit Signage … Some Extreme Examples



Exit Signage

- Is this Exit obvious? Does it need a sign?
- This Exit Sign needs some TLC.





Exit Signage

- More is better … isn't it?



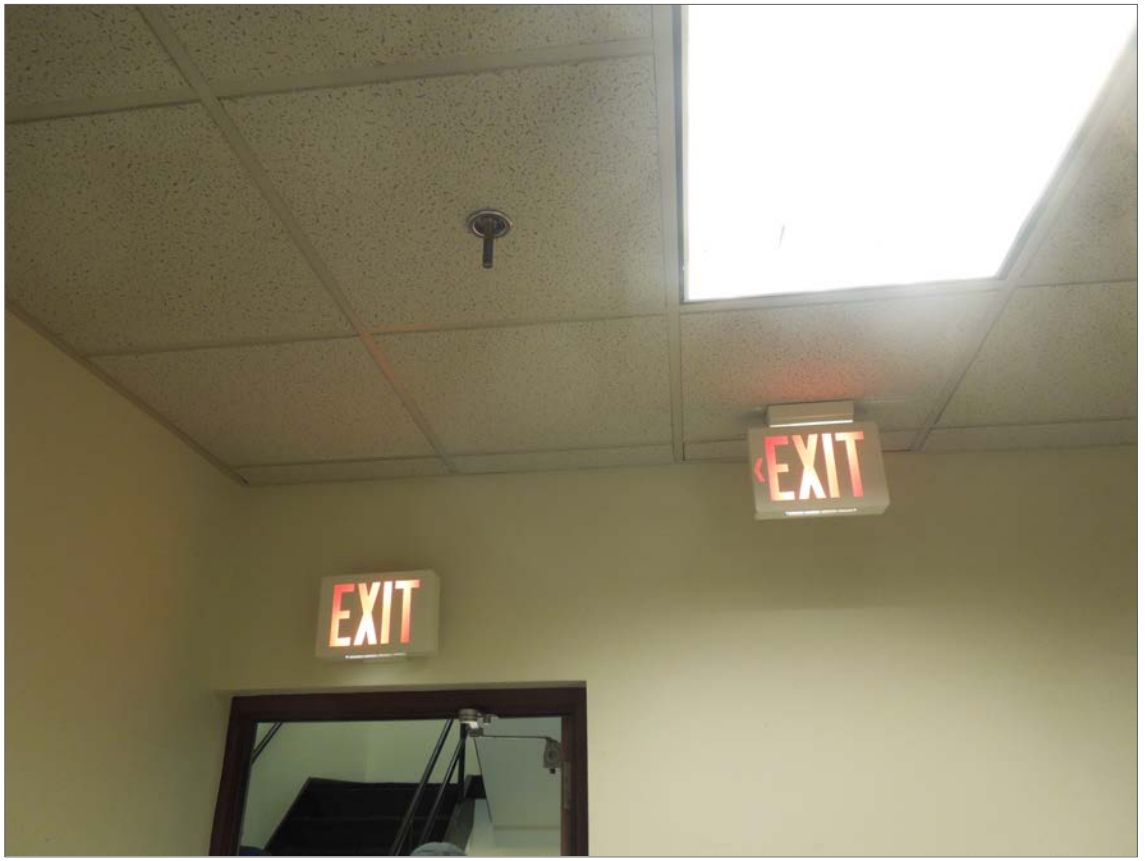




Exit Signage

- More is better … isn't it?



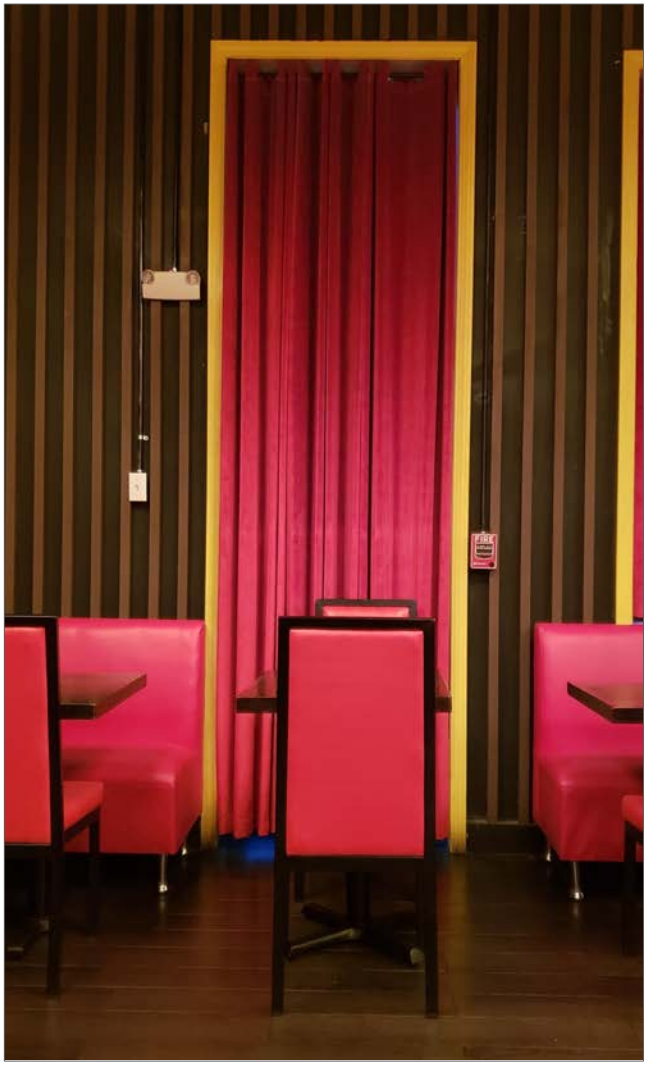


Exit Signage

- I’m confused!!







Exit Signage

- Well … is it or isn't is?!?!







Exit Signage

- Well … is it or isn't is?!?!







Exit Signage

- Where do I go now?







Exit Signage

- Even the Exit Discharge is not sacred!



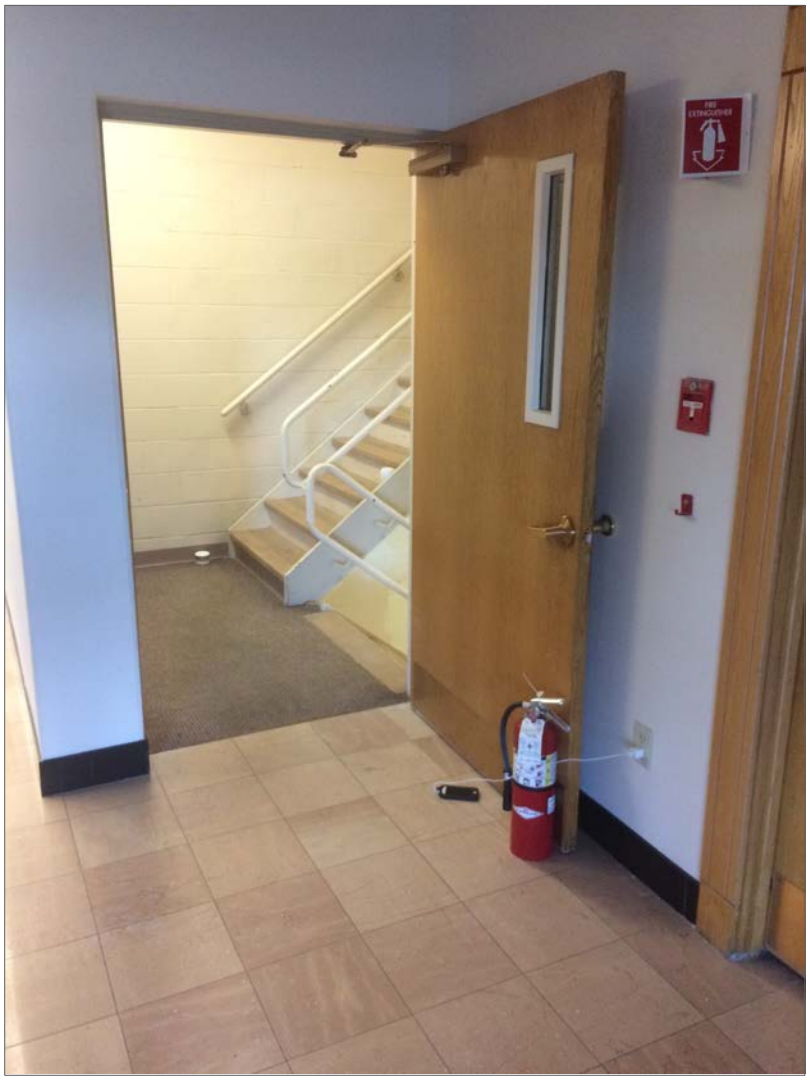
FIRE EXTINGUISHERS





FIRE EXTINGUISHERS





Visible Notification Appliance Height

- NFPA 72 – 2019, 18.5.5.1* Wall-mounted appliances shall be mounted such that the entire lens is **not less than 80 in.** (2.03 m) and **not greater than 96 in.** (2.44 m) **above the finished floor** or at the mounting height specified using the performance-based alternative of 18.5.5.7.
- What does this mean?
  - The “entire” lens must be within the range.
- Why?



Visible Notification Appliance Height

- … provides a minimum of **0.0375 lumens/ft2** (0.4036 lumens/m2) of illumination at any point within the covered area at all angles specified by the **polar dispersion planes** …as calculated for the maximum distance from the nearest visual notification appliance … (NFPA 72 – 2019, 18.5.5.7.1)
- What are **polar dispersion planes** ?



Visible Notification Appliance Height

$$I_e = d^2 \left[\frac{\int_{t_1}^{t_2} I dt}{0.2 + (t_2 - t_1)} \right]$$

Figure 27.1
Light output – horizontal dispersion

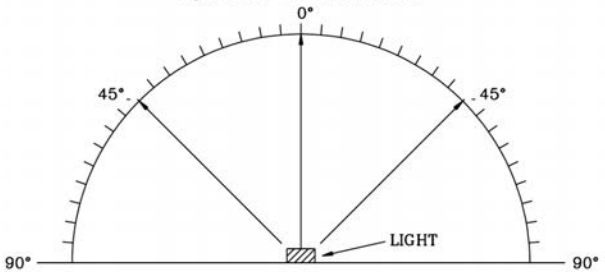


Figure 27.2
Light output – vertical dispersion, wall to floor

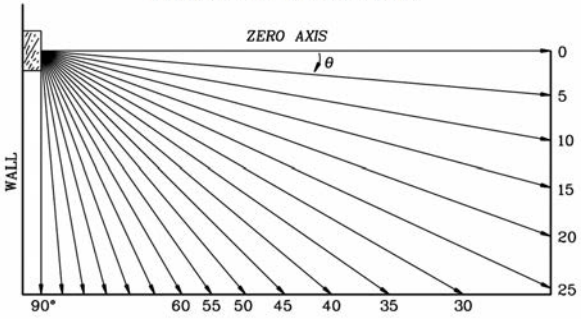


Figure 27.5
Light intensity black box

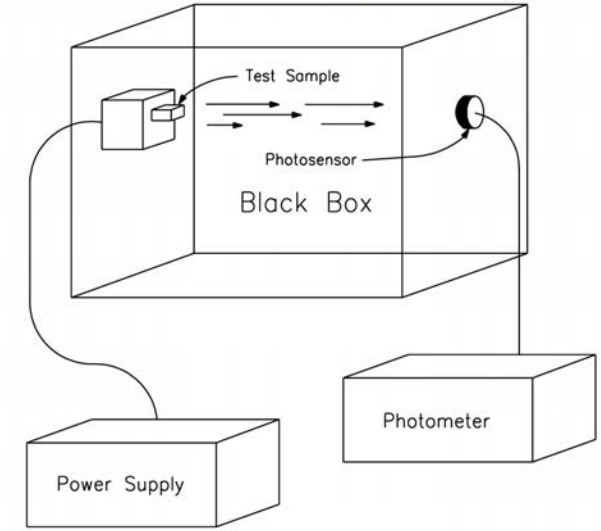


Figure 27.3
Light output – vertical dispersion, ceiling to walls and floor

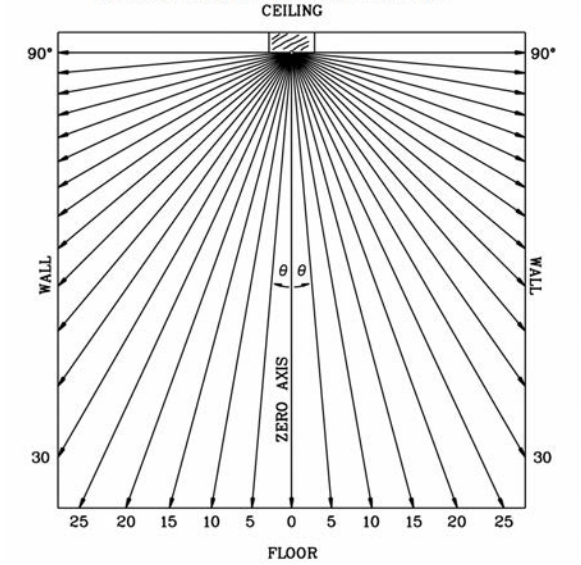


Table 27.1
Required minimum percentage for horizontal dispersion

Degrees[a]	Percent of rating
0	100
5 – 25	90
30 – 45	75
50	55
55	45
60	40
65	35
70	35
75	30
80	30
85	25
90	25
Compound 45 to the right	24
Compound 45 to the left	24

[a] Tolerance of ±1 degree is permitted.

Table 27.2
Required minimum percentage for vertical dispersion

Degrees[a]	Percent of rating
0	100
5 – 30	90
35	65
40	46
45	34
50	27
55	22
60	18
65	16
70	15
75	13
80	12
85	12
90	12

[a] Tolerance of ±1 degree is permitted.

Table 27.3
Required minimum percentage for vertical dispersion in both X and Y planes

Degrees[a]	Percent of rating
0	100
5 – 25	90
30 – 45	75
50	55
55	45
60	40
65	35
70	35
75	30
80	30
85	25
90	25

[a] Tolerance of ±1 degree is permitted.

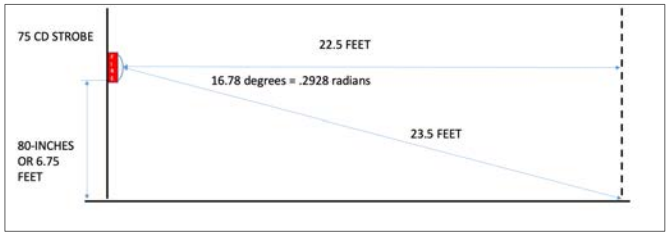
Visible Notification Appliance Height

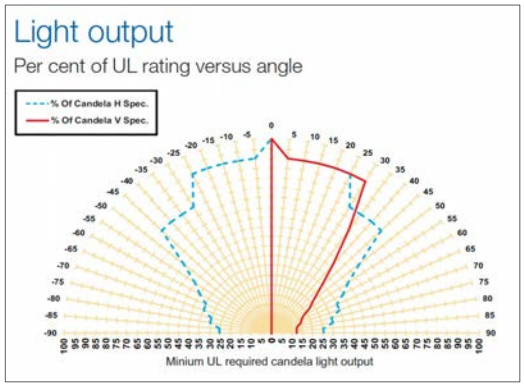
- … not less than 80 in. and not greater than 96 in. above the finished floor …
- What happens when it isn't?
- Are these installations an issue? Do they comply?
- How does this happen?
- What's the fix?

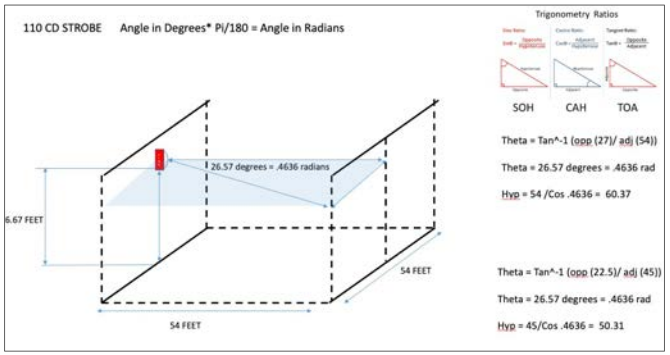


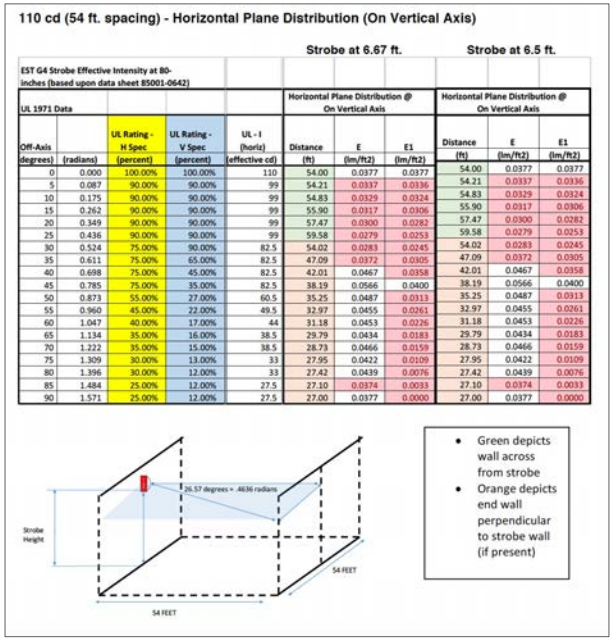
Visible Notification Appliance Height

- Possible fixes …
- Remove the appliance, electrical box, and re-pipe, reinstall the electrical box, re-pull wires, reinstall the notification appliance …
- Performance-Based Alternative - minimum of **0.0375 lumens/ft2** (0.4036 lumens/m2) of illumination …









110 cd (54 ft. spacing) - Horizontal Plane Distribution (On Vertical Axis)

					Strobe at 6.67 ft.			Strobe at 6.5 ft.		
EST G4 Strobe Effective Intensity at 80-inches (based upon data sheet 85001-0642)					Horizontal Plane Distribution @ On Vertical Axis			Horizontal Plane Distribution @ On Vertical Axis		
UL 1971 Data		UL Rating - H Spec	UL Rating - V Spec	UL - I (horiz)	Distance	E	E1	Distance	E	E1
Off-Axis degrees)	(radians)	(percent)	(percent)	effective cd)	(ft)	(lm/ft2)	(lm/ft2)	(ft)	(lm/ft2)	(lm/ft2)
0	0.000	100.00%	100.00%	110	54.00	0.0377	0.0377	54.00	0.0377	0.0377
5	0.087	90.00%	90.00%	99	54.21	0.0337	0.0336	54.21	0.0337	0.0336
10	0.175	90.00%	90.00%	99	54.83	0.0329	0.0324	54.83	0.0329	0.0324
15	0.262	90.00%	90.00%	99	55.90	0.0317	0.0306	55.90	0.0317	0.0306
20	0.349	90.00%	90.00%	99	57.47	0.0300	0.0282	57.47	0.0300	0.0282
25	0.436	90.00%	90.00%	99	59.58	0.0279	0.0253	59.58	0.0279	0.0253
30	0.524	75.00%	90.00%	82.5	54.02	0.0283	0.0245	54.02	0.0283	0.0245
35	0.611	75.00%	65.00%	82.5	47.09	0.0372	0.0305	47.09	0.0372	0.0305
40	0.698	75.00%	45.00%	82.5	42.01	0.0467	0.0358	42.01	0.0467	0.0358
45	0.785	75.00%	35.00%	82.5	38.19	0.0566	0.0400	38.19	0.0566	0.0400
50	0.873	55.00%	27.00%	60.5	35.25	0.0487	0.0313	35.25	0.0487	0.0313
55	0.960	45.00%	22.00%	49.5	32.97	0.0455	0.0261	32.97	0.0455	0.0261
60	1.047	40.00%	17.00%	44	31.18	0.0453	0.0226	31.18	0.0453	0.0226
65	1.134	35.00%	16.00%	38.5	29.79	0.0434	0.0183	29.79	0.0434	0.0183
70	1.222	35.00%	15.00%	38.5	28.73	0.0466	0.0159	28.73	0.0466	0.0159
75	1.309	30.00%	13.00%	33	27.95	0.0422	0.0109	27.95	0.0422	0.0109
80	1.396	30.00%	12.00%	33	27.42	0.0439	0.0076	27.42	0.0439	0.0076
85	1.484	25.00%	12.00%	27.5	27.10	0.0374	0.0033	27.10	0.0374	0.0033
90	1.571	25.00%	12.00%	27.5	27.00	0.0377	0.0000	27.00	0.0377	0.0000

Visible Notification Appliance Height

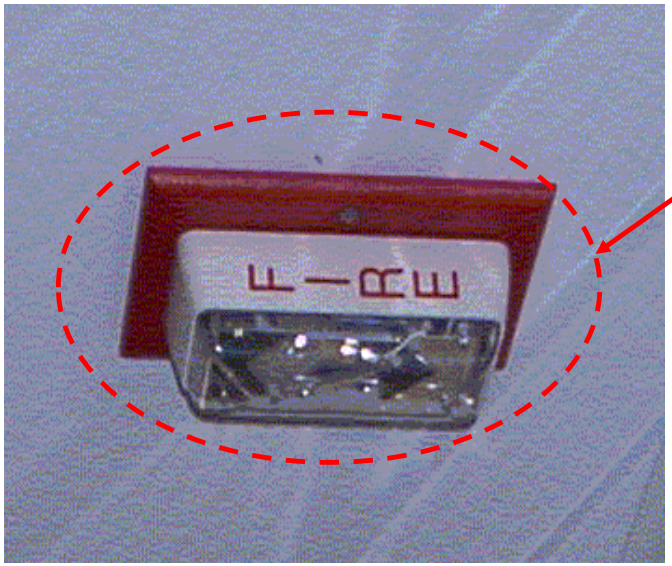
- DOES ANY OF THIS INCREASE FIRE PROTECTION OR LIFE SAFETY?



Visible Notification Appliance Height

- Is this installation an issue?
- The word “FIRE” is sideways … so what.

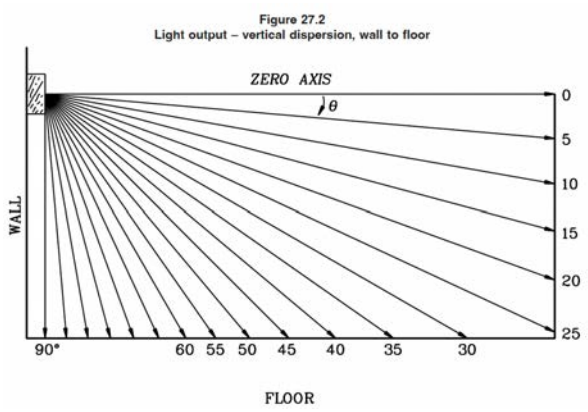


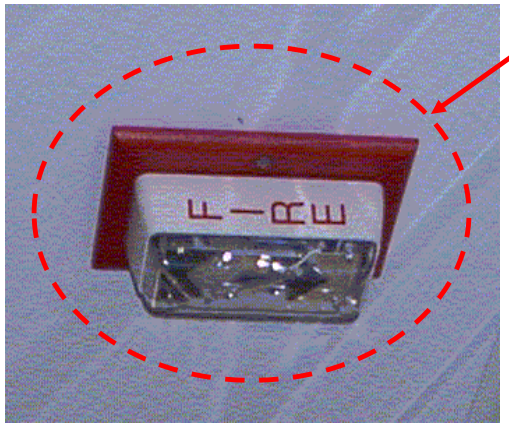




Visible Notification Appliance Height

- Is this installation an issue?
- The word “FIRE” is sideways … so what.
- Think back to the polar dispersion planes.

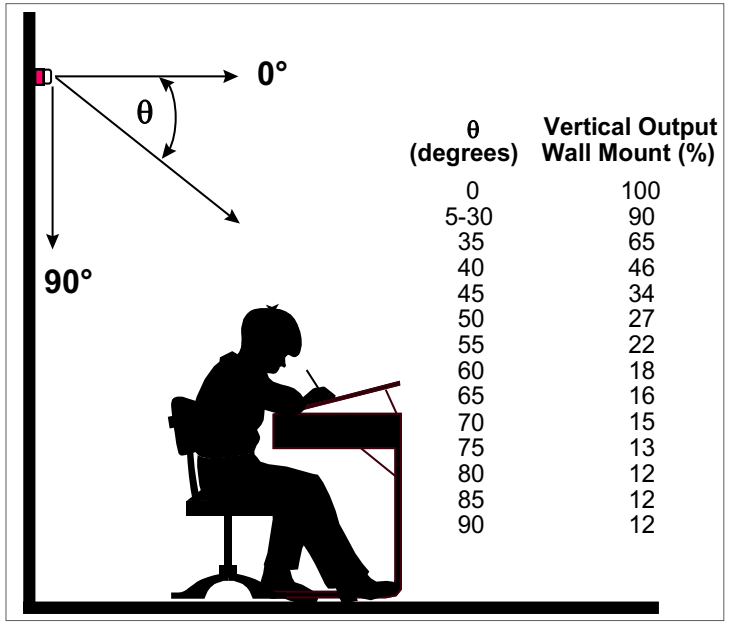




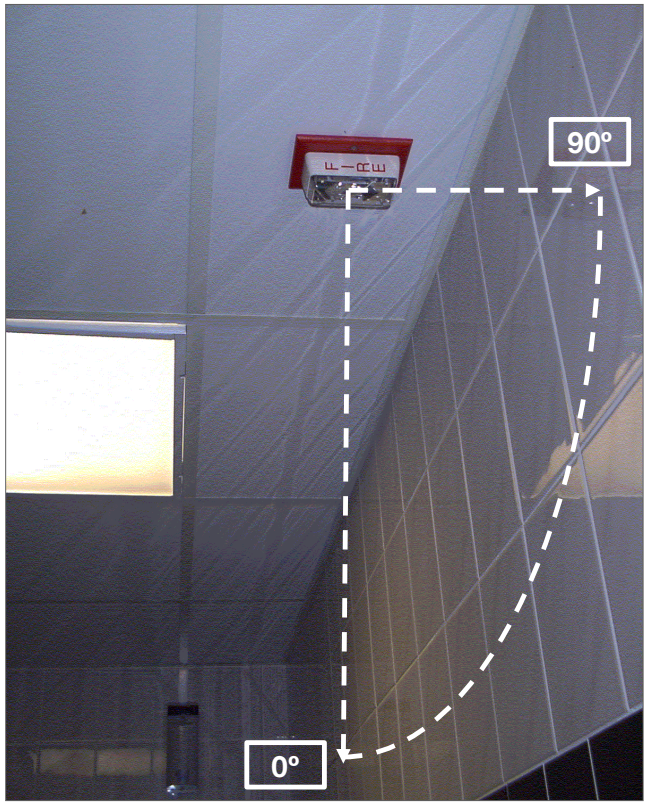


Visible Notification Appliance Height

- Wall mount strobe lenses are designed to optimize illuminance in 0 to 90 degrees.



θ (degrees)	Vertical Output Wall Mount (%)
0	100
5-30	90
35	65
40	46
45	34
50	27
55	22
60	18
65	16
70	15
75	13
80	12
85	12
90	12



- Therefore, in this case it matters!

Fire Detector Listed Spacing

- True or false … smoke detectors are listed to be spaced at 30 feet on-center?



Fire Detector Listed Spacing

- True or false … smoke detectors are listed to be spaced at 30 feet on-center?

FALSE!



Fire Detector Listed Spacing

- True or false … smoke detectors are listed to be spaced at 30 feet on-center?

FALSE!

well kinda …

sorta …



Fire Detector Listed Spacing

- True or false … smoke detectors are listed to be spaced at 30 feet on-center?
- Up until the 2007 Edition of NFPA 72, 30 foot spacing was always **“a guide”**.
- NFPA 72E – 1974:

4-4 Spacing.

***4-4.1 General.** Spacing of smoke detectors shall result from an evaluation based upon engineering judgment supplemented, if feasible, by field tests. Ceiling shape and surfaces, ceiling height, configuration of contents, burning characteristics of the stored combustibles, and ventilation are some of the parameters that shall be considered.

4-4.2 Smooth Ceilings. On smooth ceilings, with no forced air flow, spacing of 30 feet may be used as a guide. In all cases, the manufacturer's recommendations shall be followed. Other spacing may be used depending on ceiling height, different conditions or response requirements.



Fire Detector Listed Spacing

- Through the years the Editions have changed the “requirement”:
- NFPA 72 – 2007 revised the language introducing the concept of performance-based design:

5.7.3.2.3.1* In the absence of specific performance-based design criteria, smoke detectors shall be permitted to be located using 9.1 m (30 ft) spacing.



Fire Detector Listed Spacing

- Through the years the Editions have changed the “requirement”:
- NFPA 72 – 2010 revised the language introducing the concept of “nominal” 30 ft:

17.7.3.2.3.1* In the absence of specific performance-based design criteria, smooth ceiling smoke detector spacing shall be a nominal 30 ft (9.1 m).

- … with an explanation in the Annex:

For the purposes of this section, “nominal 30 ft (9.1 m)” should be determined to be 30 ft (9.1 m) +/–5 percent [+/–18 in. (460 mm)].



Fire Detector Listed Spacing

- Through the years the Editions have changed the “requirement”:
- NFPA 72 – 2013 revised the language introducing the concept of effects walls and partitions have on spacing:

17.7.3.2.3.1* In the absence of specific performance-based design criteria, one of the following requirements shall apply:

(1) The distance between smoke detectors shall not exceed a nominal spacing of 30 ft (9.1 m) and there shall be detectors within a distance of one-half the nominal spacing, measured at right angles from all walls or partitions extending upward to within the top 15 percent of the ceiling height.

- This is the current language in 2022 Edition



Fire Detector Listed Spacing

- Why 30 ft on center?
- Where did 30 ft on center come from?



Fire Detector Listed Spacing

- Why 30 ft on center?
- Where did 30 ft on center come from?
- Remember back to the NFPA Code Making Process discussion / slides …





Fire Detector Listed Spacing

- Why 30 ft on center? Where did 30 ft on center come from?
- Remember back to the NFPA Code Making Process discussion / slides …
- Anecdotally, as we understand it … A proposal for smoke detector spacing was at the committee for detector 60 foot spacing
- There was much debate that 60 was too far
- Someone proposed “cutting that in half”
- The Solution …






CHEESE PIZZA!
This was a time before lactose, tomato and gluten allergies were widely known …

Manual Fire Alarm Box Height

- NFPA 72 – 2007, 5.13.4 The operable part of each manual fire alarm box shall be **not less than 1.1 m (3½ ft)** and **not more than 1.37 m (4½ ft)** above floor level.
- NFPA 72 – 2010, 17.14.4 The operable part of each manual fire alarm box shall be **not less than 42 in.** (1.07 m) and **not more than 48 in.** (1.22 m) above floor level.
- Changed in 2010; same requirement through current 2022 edition (section 17.15.2).
- Why?



Manual Fire Alarm Box Height

- Many accessibility standards / requirements identify the forward reach and side reach for persons that are mobility impaired.

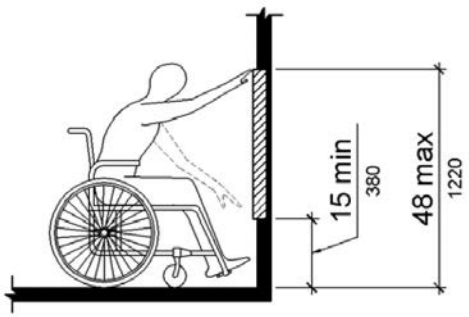


Figure 308.2.1
Unobstructed Forward Reach

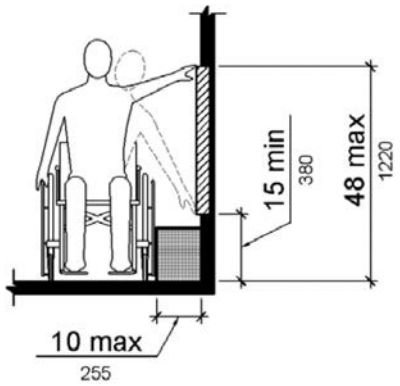


Figure 308.3.1
Unobstructed Side Reach



Manual Fire Alarm Box Height

- Some companies carry a Manual Pull Station Relocator to retrofit incorrect mounting heights.

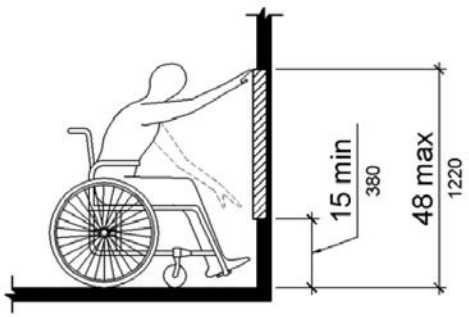


Figure 308.2.1
Unobstructed Forward Reach

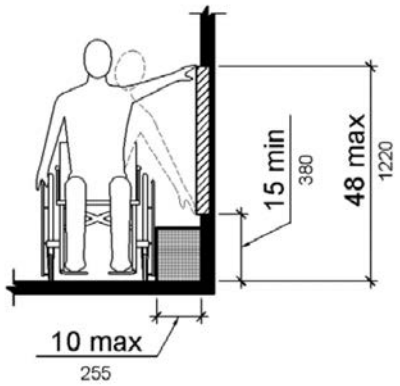
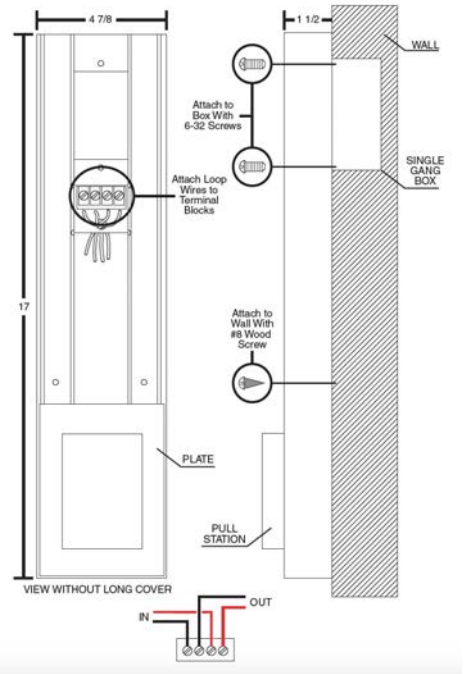
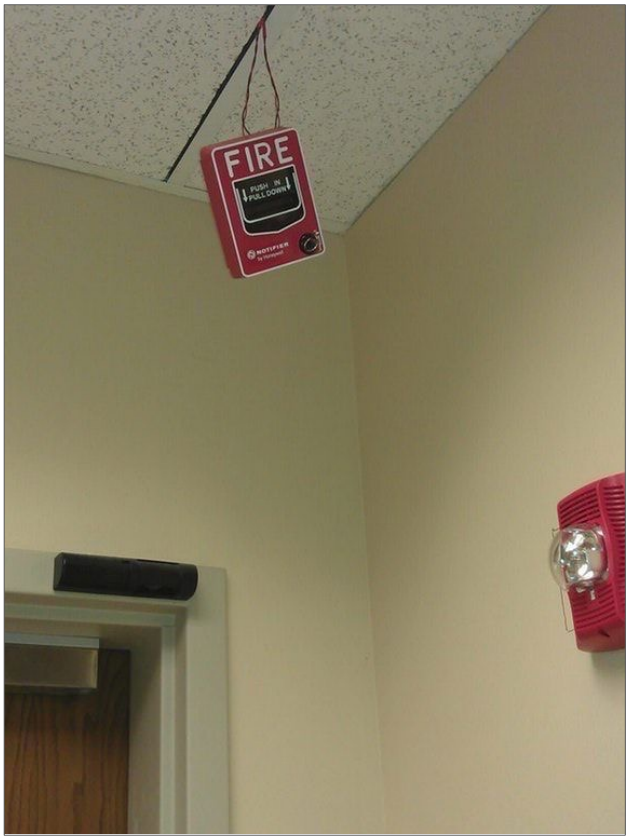


Figure 308.3.1
Unobstructed Side Reach





Manual Fire Alarm Boxes … Some Extreme Examples



Manual Fire Alarm Boxes

- WHAT ARE WE EVEN DOING HERE?







Manual Fire Alarm Boxes

- WHAT ARE WE EVEN DOING HERE?

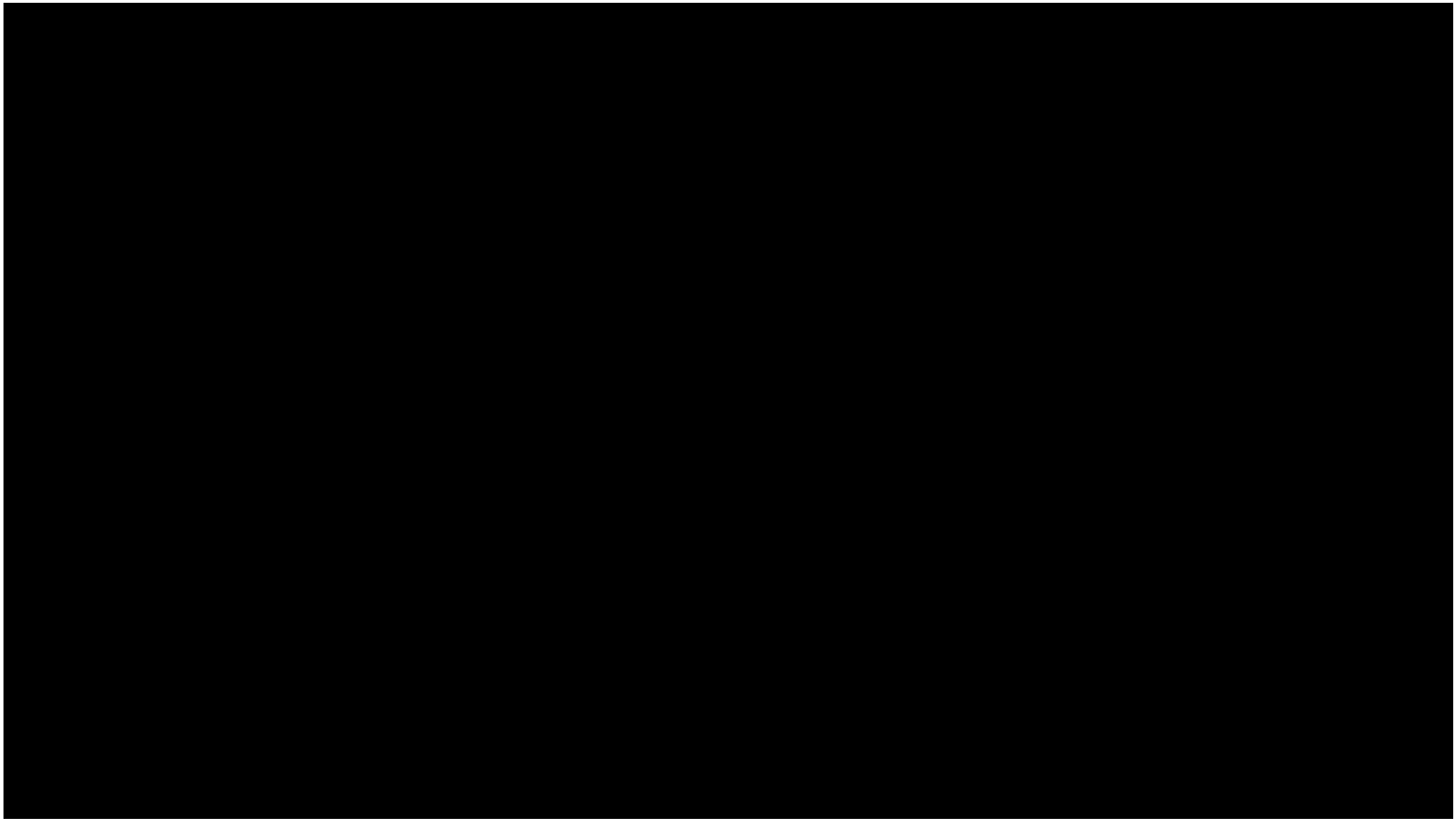




Summary



Questions



File Attachments for Item:

EC-1 Special Waste Piping Systems (Ohio Association of Plumbing Inspectors)

All certifications (1 hour)

APPLICATION FOR CONTINUING EDUCATION APPROVAL
COURSE CONDITIONS AND GUIDELINES

The Ohio Board of Building Standards is committed to the ongoing education and professional development of board-certified personnel through the delivery of high-quality, accurate and engaging professional continuing education content. To this end, the Board reviews and approves Continuing Education Courses for building department personnel.

Board approval is granted for course instruction on current codes and standards, including the OBC, OMC, OPC, and RCO, and any other content areas directly related to the responsibilities of the certification for which credit is being requested.

Promotion: Any person or organization promoting an approved course is required to make full and accurate disclosure regarding course title, course approval number, number of credit hours, categories for which the BBS has approved the class, and fees in promotion materials and advertising. ***The Board does not grant retroactive approval. It is recommended that courses be submitted for approval well in advance of any scheduling of classes and advertising***. Advertising may not falsely state BBS approval before approval is granted. Course providers may state that BBS approval is pending.

Application Submission: All Applications and associated materials shall be submitted by email in .pdf format. Instructions for completing the application are attached.

Certificate of Completion: Course providers shall provide participants a certificate of completion containing the following information:

- Name of participant
- Title of approved courses
- BBS approval #
- BBS approved certifications
- Date of the continuing education program
- Number of approved credit hours awarded, and
- Signature of authorized sponsor or instructor.

Any person or organization administering an approved course shall return a completed BBS Course Attendance form by email.

Participants: Participants must attend the complete course as presented by the instructor to receive credit hours approved by the Board. The organization or instructor of online courses shall plan and execute methods to verify the individual's attendance and completion of the course. No partial credit will be given to any participant who failed to complete the entire course as approved.

Board approval: All courses are approved for the calendar year in which application is made. Courses may be renewed so long as the referenced code is in effect, and the CEUs, certification and content remain unchanged. When the referenced code is updated, courses must be updated, and new approvals obtained.

Facility/training area: BBS Course may be delivered in person or online, or both, at the sponsor's option.
Course facilities shall include the following:

In Person Classes:
Sufficient seating capacity
ADA accessible facilities
Appropriate Audio/Visual devices for delivery
Writing surfaces for participants

Online Classes:
Web-accessible
ADA accessible delivery
Tech support available
Live and recorded courses permitted

In-person facilities shall comfortably and safely seat at least the number of attendees present in the room and shall be climate controlled, non-smoking, and sound controlled so that outside noise will not interfere with the training.

Ohio Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: James A. Richardson Jr.
Organization: City of Columbus
Address:
E-mail: jarichardson@columbus.gov Telephone: 6147744855
Website: www.columbus.gov/bzs
Conference Sponsor (if applicable) OAPI Conference Email:

Check here if Course Renewal: ☐ Prior course number _____ (*i.e. BBS2018-429*)
Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: SPECIAL WASTE PIPING SYSTEMS
Course instructor: CAMERON BAUCOM
Course description:
A comprehensive discussion/presentation on special waste and information required to selct the proper piping system for the waste.

Instructional hours per session: 1 Number of Sessions: 1
Course Date(s) and Location: OAPI annual Training Conference

Special Content:

Code Administration ☐
Existing Buildings: ☐
Electrical Instruction: ☐
Plumbing Instruction: ✔

Conference Course: _____
Conference Name: _____
Conference location: _____

Course to be offered online? ✔ **On Demand** ✔ **Webinar** ✔
Course Website: www.oapi.org
Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation)*:
Online/On Demand - exit questions, Webinar - monitored by IT proctor - exit questions developed by the Board after in-person conference prior to offing online.

Course applicable for the following certifications

Residential Certifications Only: ☐ Commercial Certifications: ✔
Administrative Course, All Certifications: ☐

Application materials included:

✔ Course Outline or Course Learning Objectives
✔ Presentation Materials/Slides (not required for roundtable courses)
✔ Assessment Materials (for online courses)
✔ Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

Instructions for new Continuing Education Approval form

Provider Information

1. Please include all contact information.
2. If course is not part of a conference, leave conference sponsor and email blank.

Course Renewal

1. Indicate if the course is being submitted for renewal. Include prior approval letter and write in prior course number.
2. Certification approval for courses has now changed: all existing courses being renewed will be approved within the new classification system.
    a. Courses previously approved for only residential certifications will be approved for all residential certifications.
    b. Courses previously approved for at least on commercial certification will now be approved for all commercial certifications and all residential certifications.
    c. Courses on required instruction topics, Ohio Ethics, Code Administration and Existing Buildings, will be noted as Administrative Courses and be approved for all certifications.
3. Courses being renewed should skip the New Course information section and are not required to submit outline, agenda, slides or other instructional materials for review. Skip to Special Content, and mark any item that applies to the course.

New Course Information

1. Enter course title, name of instructor, and a brief description of the course content. Learning objectives may be substituted for course description, if desired.
2. Number of instructional hours per session is the length of instructional time.
3. Number of sessions: can be 1 or the number of sessions planned.
4. Course date(s) and location: not necessary at this time, enter if known.

Special Content

1. Indicate if the course will meet instructional time in Code Administration or Existing Buildings.
2. Indicate if the course is a plumbing or electrical course, for ESIAC review and trainee course tracking.
3. If the course is associated with a conference, indicate the conference name and location, as this will allow BBS to coordinate approvals with the conference provider.
4. If the course will be offered online, specify whether it will be on demand or offered as a virtual webinar, or both. Include website where the course will be provided.

Course applicable for the following certifications

This section represents a major change from previous BBS course approval forms.

1. If the course is only for residential certifications, check 'Residential Certifications Only'. The course, if approved, will be approved for all residential certifications.
2. If the course is appropriate for any commercial certifications, check Commercial Certifications. The course, if approved, will be approved for all commercial certification **AND** all residential certifications.
3. If the course is intended to meet required instruction in Code Administration (Chapter 1) or Existing Buildings (commercial or residential) check 'Administrative Course, All Certifications'.

Application Materials Included

This is a checklist for the course submitter's use, to be sure all materials necessary for review are included with the application. All materials should be submitted in .pdf format, along with the application, via email to Michael.Lane@com.ohio.gov or BBS@com.ohio.gov



CAMERON BAUCOM

Field Technical Representative

Charlotte

Cameron Baucom is a Field Technical Representative for Charlotte Pipe and Foundry Company. Cameron has been in the plumbing industry for four years and worked in the foundry at Charlotte Pipe before coming in to the Technical Department. In his current position, his primary focus is educating engineers, designers, contractors, and code officials on products, industry trends and issues, as well as resolving job site issues. Cameron is based in the Charlotte area and covers Arkansas, Mississippi, Alabama, The Panhandle, Ohio, Kentucky, Indiana, Western Pennsylvania and West Virgina.

CONTACT

PHONE:
O:704-348-2242
C:980-425-9127

WEBSITE:
https://www.charlottepipe.com/

EMAIL:
cbaucom@charlottepipe.com

OAPI Special Waste Piping Systems Learning Objectives

1. Familiarize participants with the various types of special waste.
2. Enable participants to identify proper special waste piping materials.
3. Familiarize participants with referenced standards for the various special waste piping materials.
4. Familiarize participants with applicable designs for the various special waste piping materials.
5. Familiarize participants with limitations for the various special waste piping materials.

CHARLOTTE
PIPE AND FOUNDRY COMPANY

COMPLIANT USES OF PLASTIC PIPING IN THE OPC

& SPECIAL WASTE PIPING SYSTEMS



LEARNING OBJECTIVES

At the end of our conversation, participants will have a working knowledge of:

1. **What constitutes special or chemical waste and how are code requirements changing?**
2. **The different types of special waste systems**
3. **The capabilities, limitations and installation requirements of the available piping systems**

WHAT IS SPECIAL WASTE?

Acid Waste?

Corrosive Waste?

Laboratory Waste?

Yes

WHAT IS SPECIAL WASTE?

Could be:



Corrosive



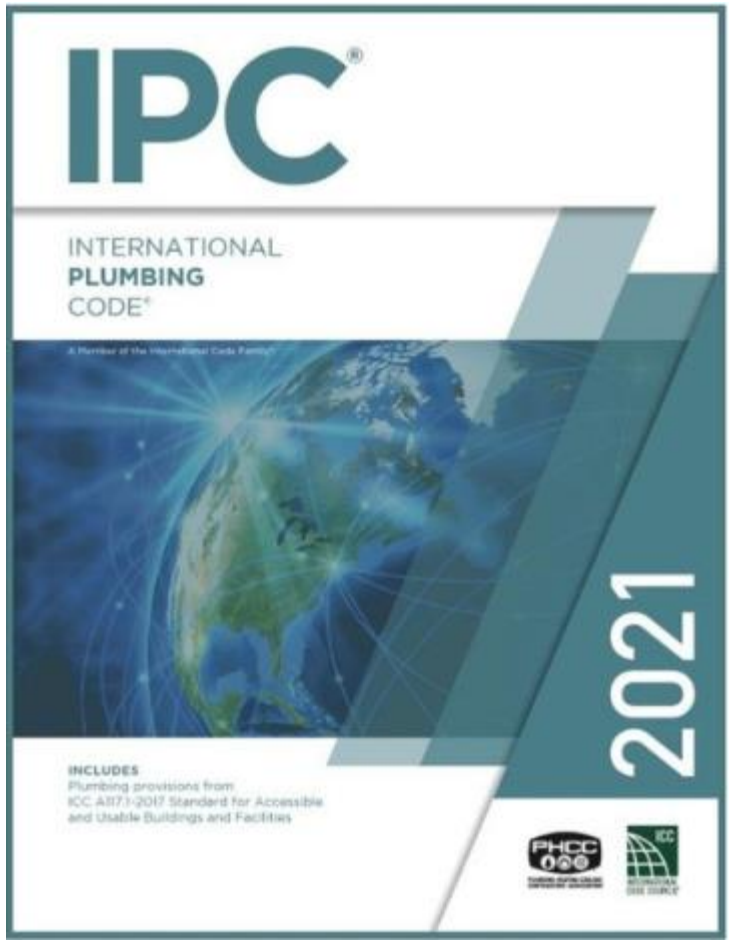


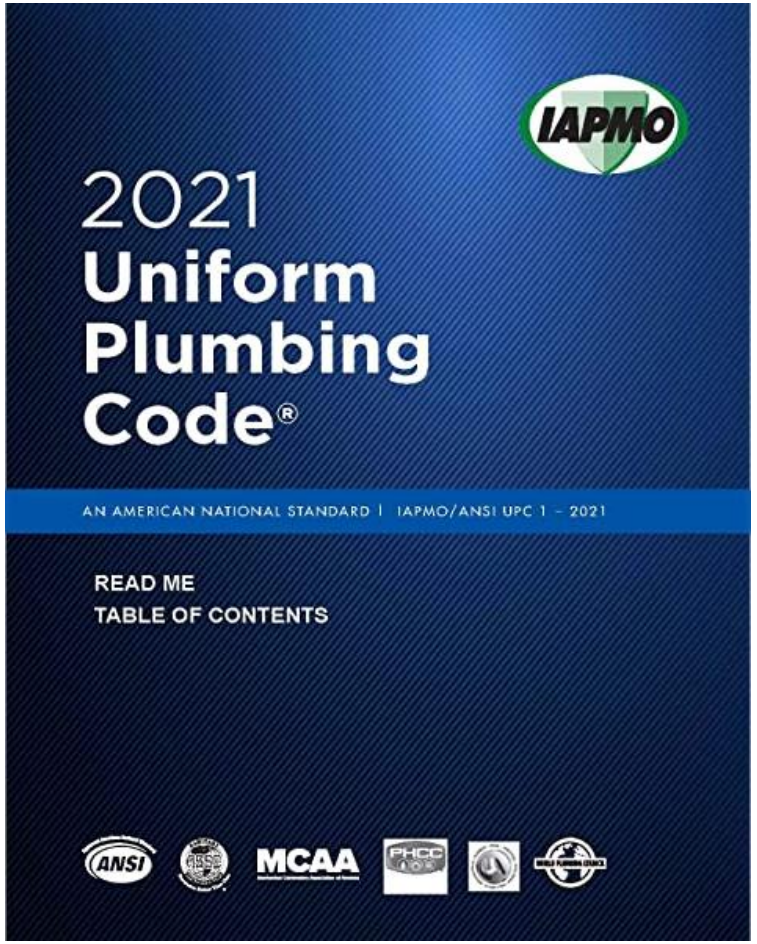
WHAT IS SPECIAL WASTE?



Corrosive

WHAT IS SPECIAL WASTE?

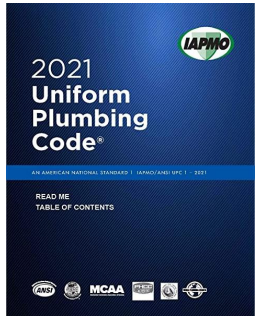




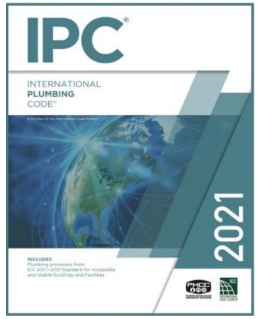
Generally, the Model Plumbing Codes describe these systems as

“Special Waste” or Chemical Waste”

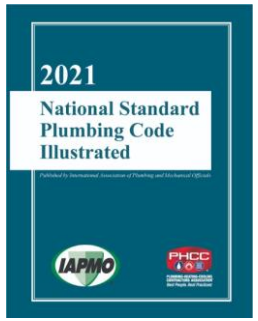
WHAT IS SPECIAL WASTE?



UPC 811.0 – Requires special waste and vent system to convey any waste likely to "damage or contaminate" the sanitary sewer

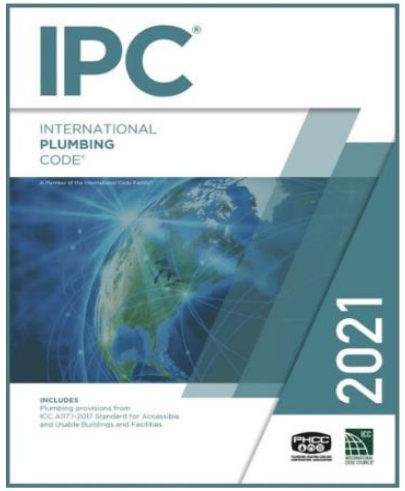


IPC 803.2, 803.3 – Requires special waste and vent system to convey any "harmful or corrosive" waste



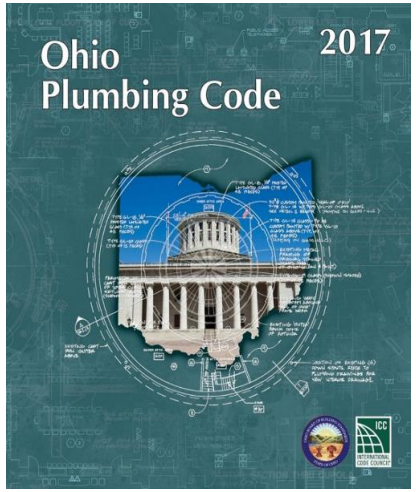
NSPC 9.4.1 – Requires "corrosive liquids, spent acids or other harmful chemicals not be discharged into the plumbing system until neutralized or treated"

CURRENT CODE CONSIDERATIONS



702.6 Chemical waste system. CDP

A chemical waste system shall be completely separated from the sanitary drainage system. The chemical waste shall be treated in accordance with Section 803.2 before discharging to the sanitary drainage system. Separate drainage systems for chemical wastes and vent pipes shall be of an *approved* material that is resistant to corrosion and degradation for the concentrations of chemicals involved.



803.2 System design.

A chemical drainage and vent system shall be designed and installed in accordance with this code. Chemical drainage and vent systems shall be completely separated from the sanitary systems. Chemical waste shall not discharge to a sanitary drainage system until such waste has been treated in accordance with Section 803.1.

FUTURE CODE CONSIDERATIONS



702.6

Chemical waste drainage system

A chemical waste drainage system, including its vent system, shall be completely independent from the sanitary drainage system. Separate drainage systems for chemical waste and vent pipes shall conform to one of the standards indicated in Table 702.6. The chemical waste shall be treated in accordance with Section 803.2 before discharging to the sanitary drainage system. Chemical waste drainage system pipe and fitting materials shall be resistant to ~~temperature,~~ corrosion and degradation for the concentrations of chemicals involved per manufacturer recommendations.

TABLE 702.6 CHEMICAL WASTE DRAINAGE SYSTEM PIPE AND FITTINGS

MATERIAL	STANDARD
Chlorinated polyvinyl chloride (CPVC)	ASTM F2618
Borosilicate glass	ASTM C1053
High silicon iron	ASTM A518/A518M
~~Polypropylene (PP)~~ Polyolefin	ASTM F1412, CSA B181.3
Polyvinylidene fluoride (PVDF)	ASTM F1673, CSA B181.3

FUTURE CODE CONSIDERATIONS



901.3

Chemical waste drainage vent systems

The vent system for a chemical waste drainage system shall be independent of any sanitary drainage vent system. The termination of a chemical waste drainage vent system shall be through the roof to the outdoors or to an air admittance valve that complies with ASSE 1049. Air admittance valves for chemical waste drainage systems shall be constructed of one of the materials listed in table 702.6 and shall be tested for chemical resistance in accordance with ASTM F1412.

902.1.1 Chemical waste drainage system vents.

The pipe and fitting materials for a chemical waste drainage vent system shall be in accordance with Section 702.6. The methods utilized for construction and installation of such venting system shall be in accordance with the pipe and fitting manufacturers' instructions.

TYPES OF SPECIAL WASTE SYSTEMS

Overview of Applications

TYPES OF SPECIAL WASTE SYSTEMS











LABORATORY VS. CONTINUOUS WASTE





TYPES OF SPECIAL WASTE SYSTEMS

- **Special waste piping systems can be used for both intermittent (laboratory) and continuous (process) drainage applications**
- **There are different design considerations for intermittent and continuous drainage**
- **Always follow the manufacturer's chemical resistance recommendations specific to the type of system for which you are designing**



LABORATORY DESIGN OVERVIEW



Examples of Types of Labs

- **Chemistry:**
  - **K-12**
  - **College and University**
- **Biology**
  - **Hospitals /Medical**
  - **College and University**
- **Microbiological**
  - **Biosafety Levels: BSL-1. BSL-2, BSL-3, BSL-4**

    (Enhanced, Ag, Autoclaves)
- **Industrial (Plants and Facilities)**

LABORATORY DESIGN OVERVIEW

Each Type of Lab will have different requirements for special waste drainage

Chemistry:

- K-12 typically uses few truly “harsh” chemicals. Relatively easy application.

- College/Univ will have more demanding requirements with broader range of reagents used and strengths/concentrations of chemicals

Biology/Medical:

- Biology, Medical Research may use different reagents and higher percentage of sanitizers after experiments



LABORATORY DESIGN OVERVIEW

Biosafety/Microbiological:

- Specific specialized systems required dependent on BSL Level:

- Biosafety Levels: BSL-1. BSL-2, BSL-3, BSL-4, Ag, Autoclaves

Each level requires increasingly more rigorous protection against possible harm to personnel and to the environment. Containment of harmful contaminants is critical.

Industrial (Plants and Facilities):

- Wide range of applications and requirements
- May involve high temps



TYPES OF SPECIAL WASTE SYSTEMS

Today, we'll be focusing on Laboratory Chemical Waste drainage systems in:

K-12, College & Universities and Hospitals







CHEMICAL WASTE LABORATORIES

Laboratory Applications

- **Small quantities of chemicals followed by flushing**
- **Resistance to a huge range of chemicals and reagents**
- **Resistance to elevated temperatures**



COMPETITIVE OVERVIEW OF AVAILABLE SYSTEMS

Laboratory Chemical Waste Material Selection

CHEMICAL WASTE MATERIAL SELECTION

Engineers and facility owners select materials partially based on:

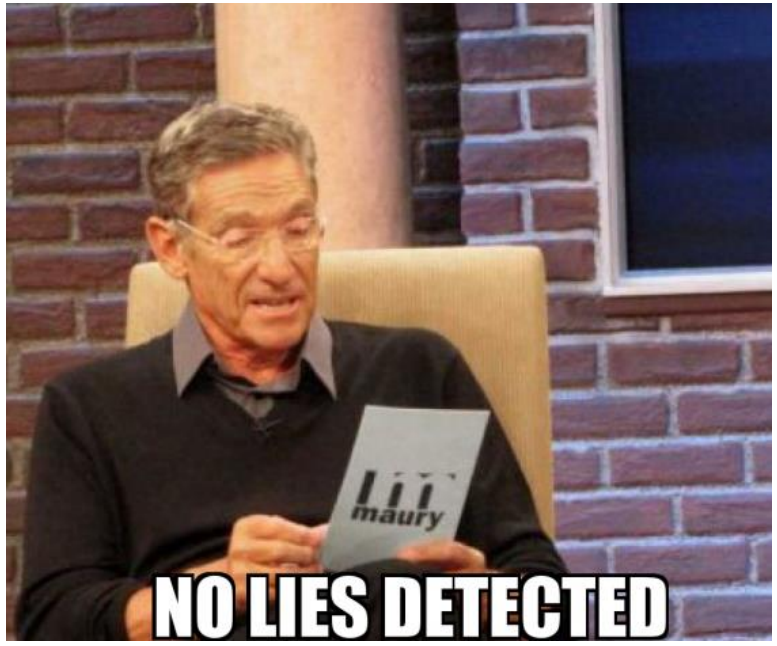
- **Past experience**
- **Application parameters including chemicals and concentrations to be disposed, temperatures expected, plenum or ducted returns, buried?**
- **Ease of maintenance; possible future alts & adds**
- **Installed cost**



CHEMICAL WASTE MATERIAL SELECTION

Is there one perfect piping system for all applications?





If there was, only one material would be produced and specified

CHEMICAL WASTE MATERIAL SELECTION

"Traditional Systems": they make a great system, but....

- **Borosilicate Glass (Kimax®)**
- **High Silicon Iron (Duriron®)**

"Newer Systems": Thermoplastics

- **Polypropylene (PPL or FRPP)**
- ***Polyvinylidene Fluoride (PVDF)***
- **Chlorinated Poly Vinyl Chloride (CPVC)**

CHEMICAL WASTE MATERIAL SELECTION



Borosilicate Glass

- Kimax®

Pros

- Excellent chemical resistance
- High temp

Cons

- Fragile
- Non-combustible
- Expensive to buy and install

CHEMICAL WASTE MATERIAL SELECTION



High-Silicon Iron

- Duriron
- No longer available
- Discontinued in 2016, but the standard is active

CHEMICAL WASTE MATERIAL SELECTION

Polypropylene

- **Polypropylene (PP) for below ground (brown)**
- **Flame Retardant Polypropylene (FRPP) for above ground (blue)**

Pros

- **Broad Chemical Resistance**
- **Installation Options (fusion or mechanical joint)**

Cons

- **Moderate Temps (140º F to 180º F)**
- **Low Tensile**
- **Poor flame and smoke ratings**



CHEMICAL WASTE MATERIAL SELECTION

Polyvinylidene Flouride (PVDF)

Pros

- **Broad Chemical Resistance**
- **High temperature rating**
- **Excellent flame and smoke properties**

Cons

- **Fabulously Expensive**
- **Often used with PP and the two materials have different properties that could complicate design, installation and maintenance**



CHEMICAL WASTE MATERIAL SELECTION

Chloronated Polyvinyl Chloride (CPVC)

Pros

- **Broad Chemical Resistance**
- **High temperature rating (220° F)**
- **Excellent flame and smoke properties**
- **Easy installation**

Cons

- **Limited resistance to Fats Oils and Greases (FOGs) and chlorinated hydrocarbons**



CHEMICAL RESISTANCE

Laboratory Chemical Waste Material Selection

CHEMICAL RESISTANCE

- **In Chemical Waste Systems obviously chemical resistance <u>may be the single most important selection criteria</u>**
- **Industrial process applications may be tough but parameters are easy to identify due to the limited number of chemicals involved**
- **Laboratory chemical waste drainage involves a variety of chemicals and reagents**
- **Laboratory applications require *<u>Versatility</u>***



CHEMICAL RESISTANCE

Glass & High Silicon Iron

- **Broadest chemical resistance of available systems**
- **Resistant to most chemicals except those in the hydrofluoric acid family and a few hot caustics**
- **Able to handle corrosives at high temperature**



CHEMICAL RESISTANCE

Polypropylene

- **Broad chemical resistance to acids, bases, and water-soluble solvents**
- **Not an optimal choice for continuous drainage of strong oxidizers such as bleach and peroxide**



CHEMICAL RESISTANCE

Polyvinylidene Flouride (PVDF)

- Good, broad chemical resistance to strong acids, weaker alkalis, solvents and oxidizers
- Excellent with high temperature wastes
- Limited resistance to some concentrated alkalis





CHEMICAL RESISTANCE

Chlorinated PolyVinyl Chloride (CPVC)

- Good, broad chemical resistance to strong acids, bases and oxidizers
- Excellent with high temperature wastes
- Limited resistance to solvents, FOGs, and chlorinated hydrocarbons



FLAME, SMOKE AND COMBUSTIBILITY

Laboratory Chemical Waste Material Selection

FLAME, SMOKE AND COMBUSTIBILITY

- **Glass is “non-combustible” per ASTM E136**
- **All plastics are combustible and will burn**
- **The question is, what happens *when* they burn?**



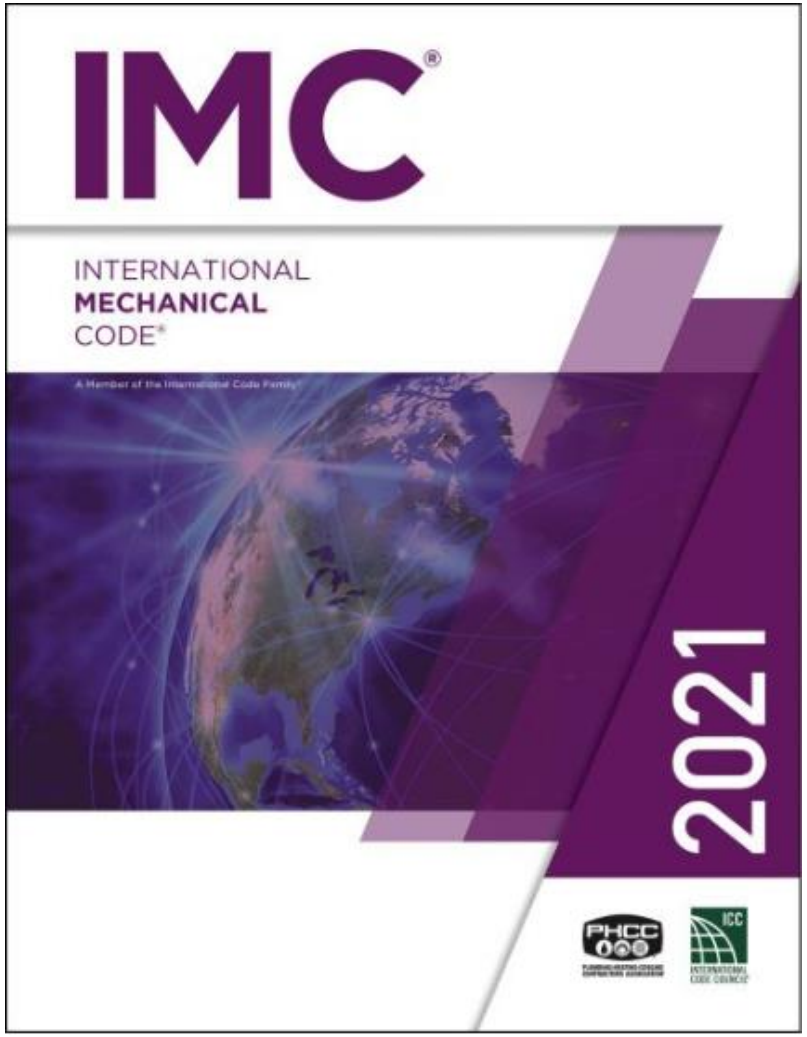
FLAME, SMOKE AND COMBUSTIBILITY

ASTM E84 (UL723) and ULCS 102.2

- **Measures “surface burning characteristics”; flame spread and smoke developed ratings**
- **Performed in a “Steiner Tunnel”**
- **Model Mechanical Codes require all combustible materials within plenum areas exhibit a flame spread rating of less than 25 and a smoke developed rating of less than 50.**



CODE CONSIDERATIONS



602.2.1 Materials within plenums. CDP

Except as required by Sections 602.2.1.1 through 602.2.1.8, materials within *plenums* shall be noncombustible or shall be *listed* and *labeled* as having a flame spread index of not more than 25 and a smoke-developed index of not more than 50 when tested in accordance with ASTM E84 or UL 723.

Exceptions:

1. Rigid and flexible ducts and connectors shall conform to Section 603.
2. Duct coverings, linings, tape and connectors shall conform to Sections 603 and 604.
3. This section shall not apply to materials exposed within *plenums* in one- and two-family dwellings.
4. This section shall not apply to smoke detectors.
5. Combustible materials fully enclosed within one of the following:
   - 5.1. Continuous noncombustible raceways or enclosures.
   - 5.2. Approved gypsum board assemblies.
   - 5.3. Materials *listed* and *labeled* for installation within a *plenum* and listed for the application.
6. Materials in Group H, Division 5 fabrication areas and the areas above and below the fabrication area that share a common air recirculation path with the fabrication area.

FLAME, SMOKE AND COMBUSTIBILITY

ASTM E84 (UL723) and ULCS 102.2

PVDF

- **Listed and labeled as E84 25/50 Rated**

PP / FRPP

- **Does not meet the 25/50 flame and smoke requirement for plenum application**

CPVC

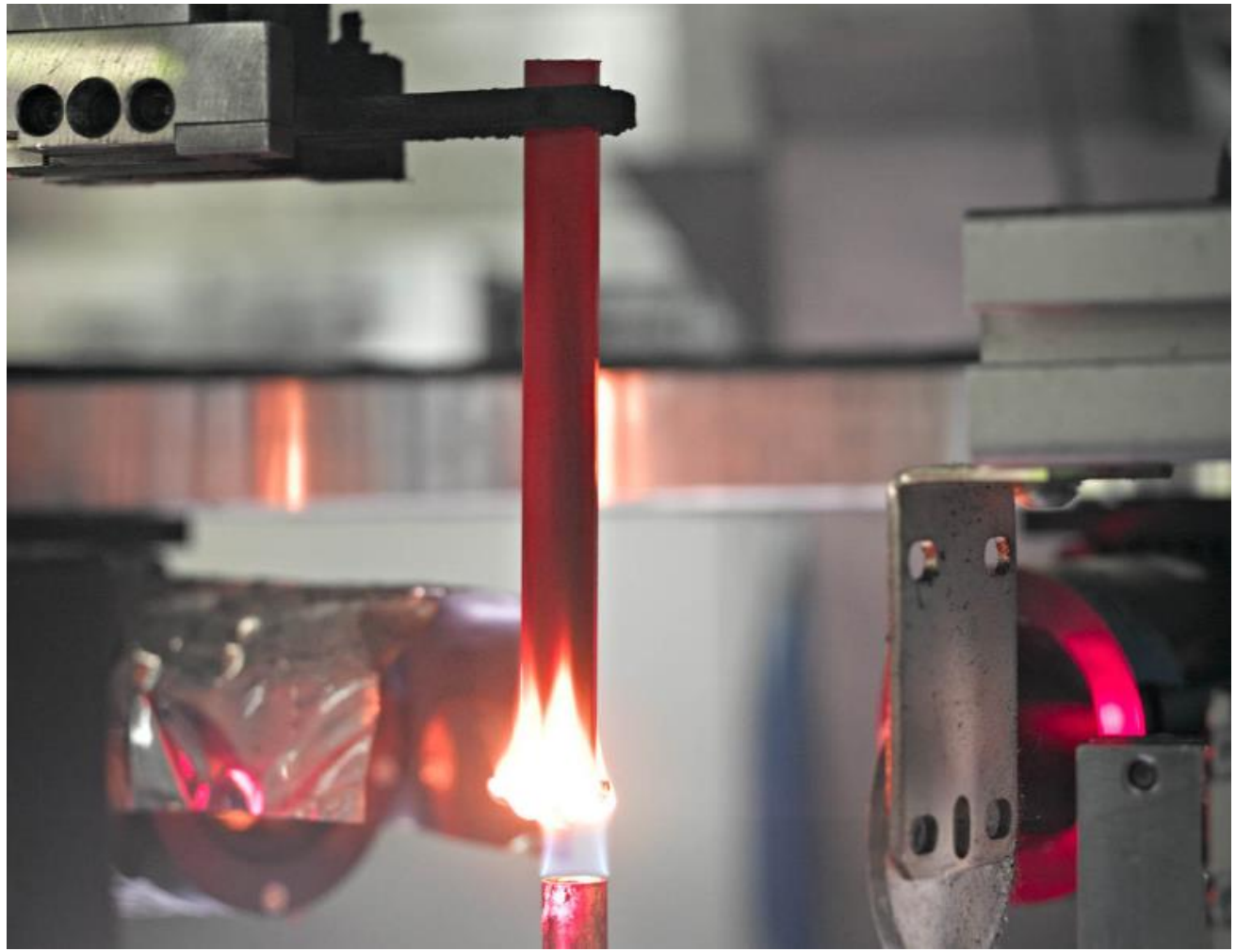
- **Consult the manufacturer for the ASTM E84 or ULC S102.2 test report from the certifying lab**
- **Test report will describe exactly how the test was conducted (number of pipes, how pipe was supported, etc.)**



FLAME, SMOKE AND COMBUSTIBILITY

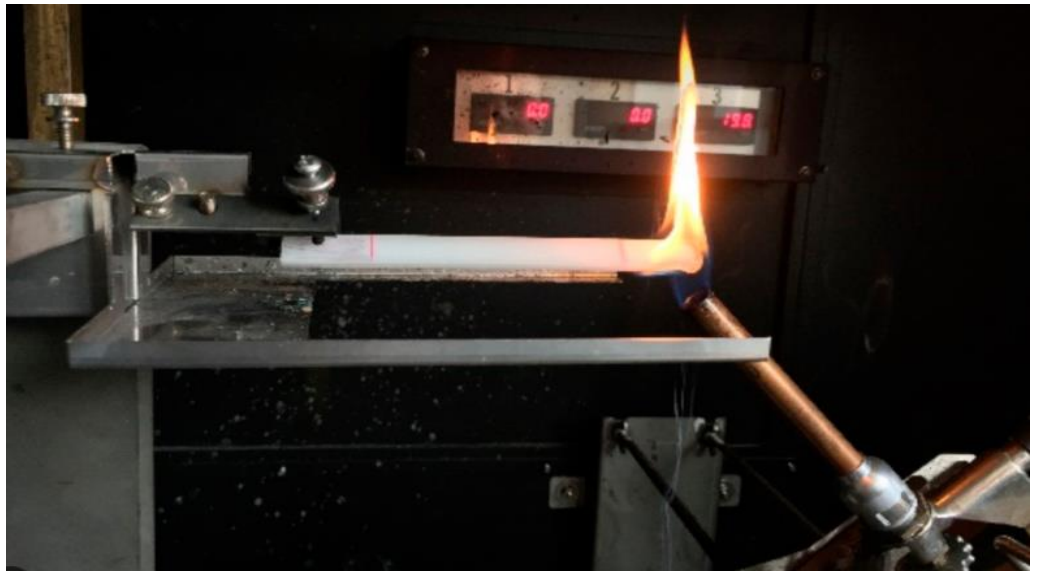
UL94

- **Test for Flammability of Plastic Materials**
- **Determines the material's tendency to either extinguish or spread the flame once the specimen has been ignited**



FLAME, SMOKE AND COMBUSTIBILITY

Piping Material	UL 94 Rating
PP	HB
FRPP	V-2
PVDF	V-0
CPVC	V-0



From lowest (least flame-retardant) to highest (most flame-retardant):

- **HB: slow burning continues**
- **V-2: burning stops within 30 seconds; drips of flaming particles are allowed**
- **V-1: burning stops within 30 seconds; drips of particles allowed as long as they are not inflamed**
- **V-0: burning stops within 10 seconds; drips of particles allowed as long as they are not inflamed**

FLAME, SMOKE AND COMBUSTIBILITY

Primary products of combustion:

FRPP: carbon monoxide (CO), carbon dioxide (CO_2)

PVDF: carbon monoxide (CO), carbon dioxide (CO_2), and hydrogen fluoride (HF)

CPVC: carbon monoxide (CO) carbon dioxide (CO_2) and hydrogen chloride (HCl)



FLAME, SMOKE AND COMBUSTIBILITY

Flash Ignition Temperature

- **Temperature at which the material will begin to burn**

Piping Material	Flash Ignition Temperature
PP	650°F
FRPP	650°F
PVDF	700°F
CPVC	900°F



FLAME, SMOKE AND COMBUSTIBILITY

Limiting Oxygen Index (LOI)

- **Minimum concentration of oxygen necessary to sustain combustion**





Piping Material	Limiting Oxygen Index
PP	17
FRPP	27
PVDF	44
CPVC	60

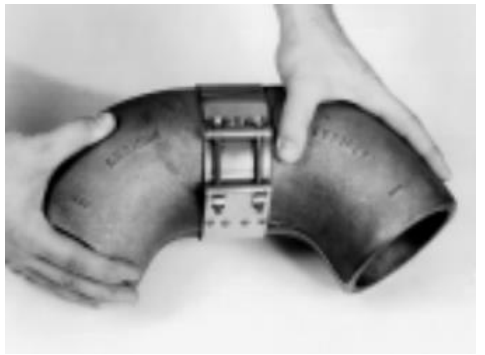
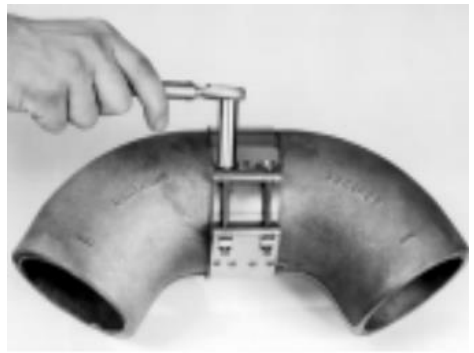
INSTALLATION REQUIREMENTS

Laboratory Chemical Waste Material Selection

INSTALLATION REQUIREMENTS

Glass & High Silicon Iron

- **High Silicon Iron**
  - **Mechanical or Caulked Joint**

- **Borosilicate Glass**
  - **Mechanical joint (MJ) with TFE lined couplings**
  - **When buried, should be encased in expanded polystyrene (EPS)**



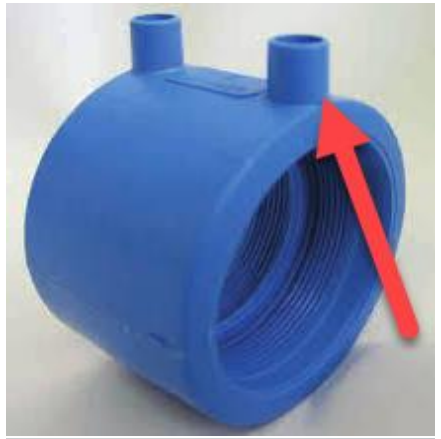


INSTALLATION REQUIREMENTS

Polypropylene and PVDF

Electro Fusion Joints

- Fusion coil in fitting hub
- Fusion machine supplies power
- Proprietary equipment
- 180 Degrees F







INSTALLATION REQUIREMENTS

Polypropylene and PVDF - Mechanical Joint







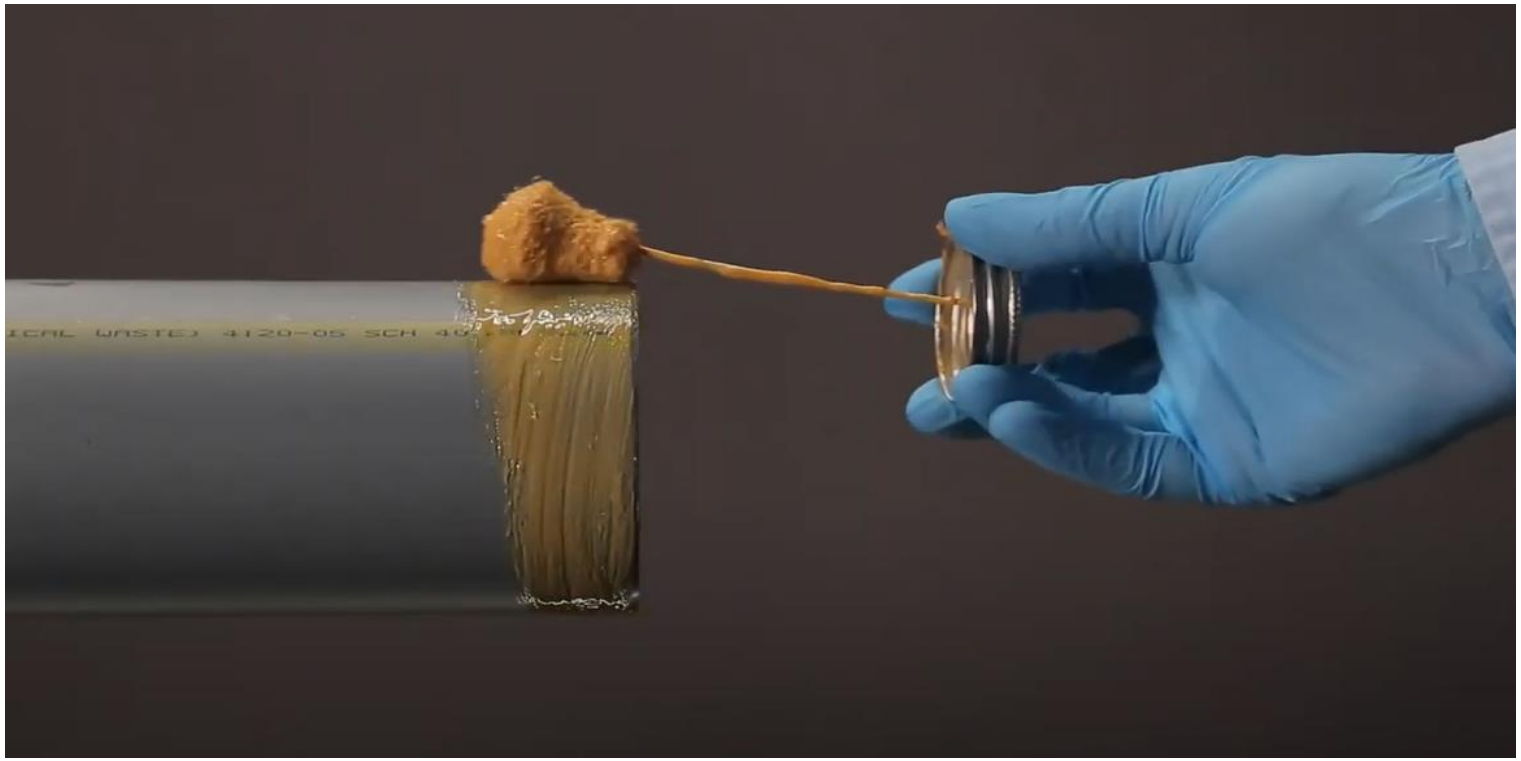
- **Rarely used concealed or buried**
- **Different tool-sets for different manufacturers.**
- **140 degrees F**

INSTALLATION REQUIREMENTS

CPVC

- **Single step solvent cement specifically formulated for chemical waste applications**

- **Pipe, fittings and cement must be a system**



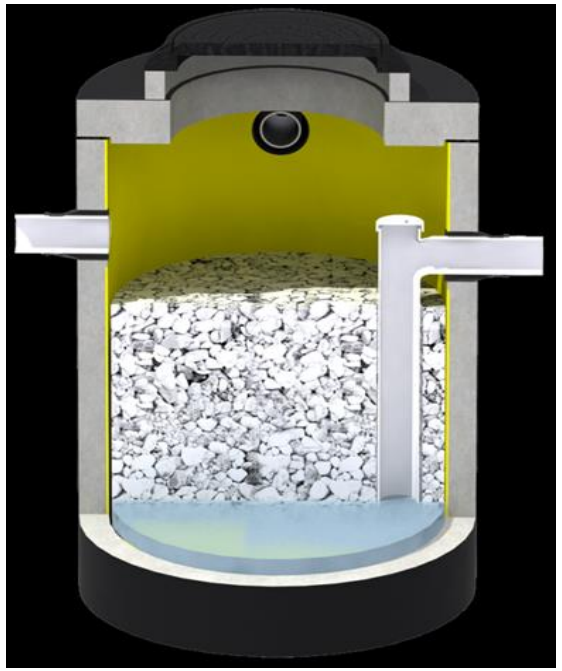
INSTALLATION REQUIREMENTS

- **Remember the traps, accessories, floor drains and cleanouts to ensure a complete system**



INSTALLATION REQUIREMENTS

- **Special waste systems require dilution or neutralization tanks prior to discharge into the sanitary system**





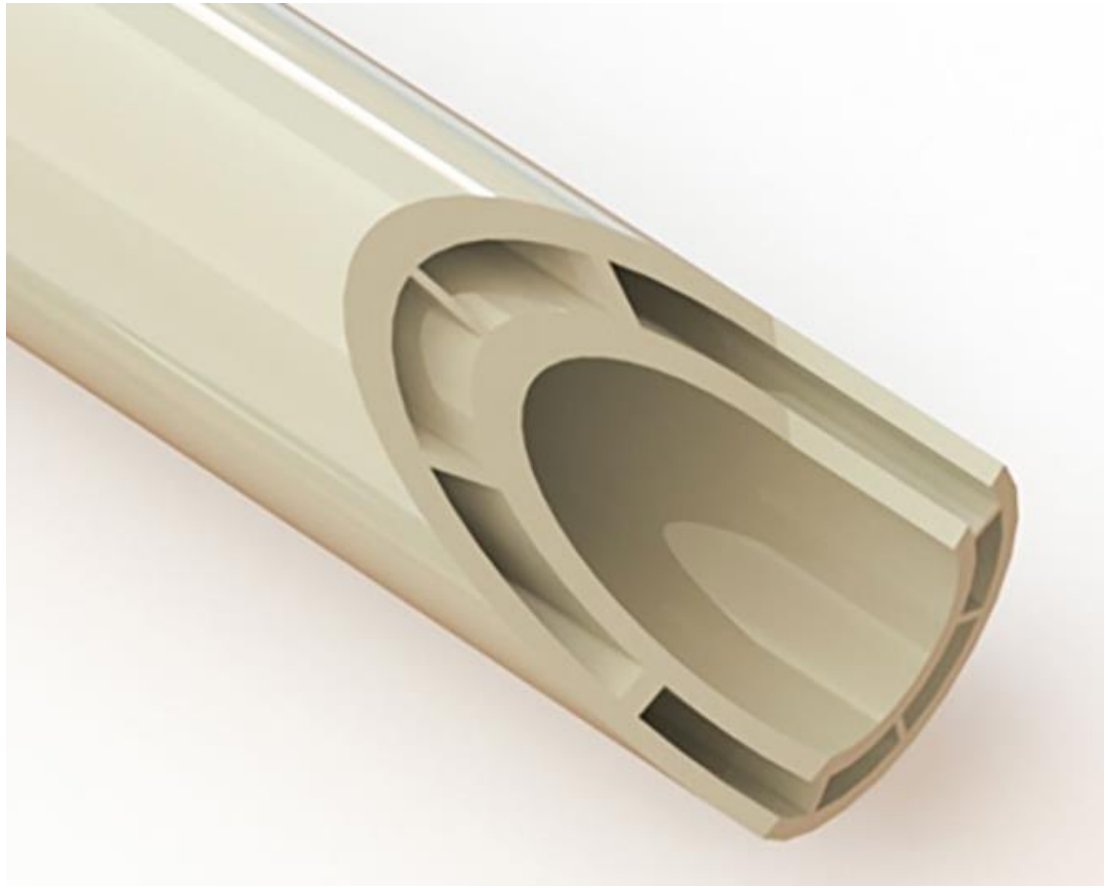


INSTALLATION REQUIREMENTS

Double/Dual or Secondary Containment

- **May be required due to severity of application based on local requirements, EPA requirements or at discretion of building owner/institution**





APPRECIATION

Thank you for the opportunity to meet with you today.

Ohio Association of Plumbing Inspectors

CHARLOTTE PIPE AND FOUNDRY COMPANY

File Attachments for Item:

EC-2 Replacement Water Heaters (Ohio Association of Plumbing Inspectors)

All certifications (1 hour)

Existing Building instruction

OAPI Replacement Water Heaters Learning Objectives

1. Familiarize participants with requirements associated with water heater replacements and “existing buildings” rules.
2. Enable participants to identify when a replacement water heater approval application may require additional information
3. Enable participants to identify when a replacement water heater could result in an unsafe/serious condition if additional questions are not asked as part of the plan approval process.

APPLICATION FOR CONTINUING EDUCATION APPROVAL
COURSE CONDITIONS AND GUIDELINES

The Ohio Board of Building Standards is committed to the ongoing education and professional development of board-certified personnel through the delivery of high-quality, accurate and engaging professional continuing education content. To this end, the Board reviews and approves Continuing Education Courses for building department personnel.

Board approval is granted for course instruction on current codes and standards, including the OBC, OMC, OPC, and RCO, and any other content areas directly related to the responsibilities of the certification for which credit is being requested.

Promotion: Any person or organization promoting an approved course is required to make full and accurate disclosure regarding course title, course approval number, number of credit hours, categories for which the BBS has approved the class, and fees in promotion materials and advertising. ***The Board does not grant retroactive approval. It is recommended that courses be submitted for approval well in advance of any scheduling of classes and advertising***. Advertising may not falsely state BBS approval before approval is granted. Course providers may state that BBS approval is pending.

Application Submission: All Applications and associated materials shall be submitted by email in .pdf format. Instructions for completing the application are attached.

Certificate of Completion: Course providers shall provide participants a certificate of completion containing the following information:

- Name of participant
- Title of approved courses
- BBS approval #
- BBS approved certifications
- Date of the continuing education program
- Number of approved credit hours awarded, and
- Signature of authorized sponsor or instructor.

Any person or organization administering an approved course shall return a completed BBS Course Attendance form by email.

Participants: Participants must attend the complete course as presented by the instructor to receive credit hours approved by the Board. The organization or instructor of online courses shall plan and execute methods to verify the individual's attendance and completion of the course. No partial credit will be given to any participant who failed to complete the entire course as approved.

Board approval: All courses are approved for the calendar year in which application is made. Courses may be renewed so long as the referenced code is in effect, and the CEUs, certification and content remain unchanged. When the referenced code is updated, courses must be updated, and new approvals obtained.

Facility/training area: BBS Course may be delivered in person or online, or both, at the sponsor's option.
Course facilities shall include the following:

In Person Classes:
Sufficient seating capacity
ADA accessible facilities
Appropriate Audio/Visual devices for delivery
Writing surfaces for participants

Online Classes:
Web-accessible
ADA accessible delivery
Tech support available
Live and recorded courses permitted

In-person facilities shall comfortably and safely seat at least the number of attendees present in the room and shall be climate controlled, non-smoking, and sound controlled so that outside noise will not interfere with the training.

Application for Continuing Education Course Approval

Provider Information:

Name: James A. Richardson Jr.
Organization: City of Columbus
Address:
E-mail: jarichardson@columbus.gov Telephone: 6147744855
Website: www.columbus.gov/bzs
Conference Sponsor (if applicable) OAPI Conference Email:

Check here if Course Renewal: ☐ Prior course number _____ (*i.e. BBS2018-429*)
Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: Replacement Water Heaters
Course instructor:
Course description:
A comprehensive discussion/presentation regarding water heater replacements. Discussion will be centered on plan approval and "existing" building rules.

Instructional hours per session: 1 Number of Sessions: 1
Course Date(s) and Location: OAPI annual Training Conference

Special Content:

Code Administration ☐
Existing Buildings: ✔
Electrical Instruction: ☐
Plumbing Instruction: ✔

Conference Course:
Conference Name:
Conference location:

Course to be offered online? ✔ **On Demand** ✔ **Webinar** ✔
Course Website: www.oapi.org
Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation)*:
Online/On Demand - exit questions, Webinar - monitored by IT proctor - exit questions developed by the Board after in-person conference prior to offering online.

Course applicable for the following certifications

Residential Certifications Only: ☐ Commercial Certifications: ✔
Administrative Course, All Certifications: ☐

Application materials included:

✔ Course Outline or Course Learning Objectives
✔ Presentation Materials/Slides (not required for roundtable courses)
✔ Assessment Materials (for online courses)
✔ Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

James A. Richardson Jr.

Instructions for new Continuing Education Approval form

Provider Information

1. Please include all contact information.
2. If course is not part of a conference, leave conference sponsor and email blank.

Course Renewal

1. Indicate if the course is being submitted for renewal. Include prior approval letter and write in prior course number.
2. Certification approval for courses has now changed: all existing courses being renewed will be approved within the new classification system.
    a. Courses previously approved for only residential certifications will be approved for all residential certifications.
    b. Courses previously approved for at least on commercial certification will now be approved for all commercial certifications and all residential certifications.
    c. Courses on required instruction topics, Ohio Ethics, Code Administration and Existing Buildings, will be noted as Administrative Courses and be approved for all certifications.
3. Courses being renewed should skip the New Course information section and are not required to submit outline, agenda, slides or other instructional materials for review. Skip to Special Content, and mark any item that applies to the course.

New Course Information

1. Enter course title, name of instructor, and a brief description of the course content. Learning objectives may be substituted for course description, if desired.
2. Number of instructional hours per session is the length of instructional time.
3. Number of sessions: can be 1 or the number of sessions planned.
4. Course date(s) and location: not necessary at this time, enter if known.

Special Content

1. Indicate if the course will meet instructional time in Code Administration or Existing Buildings.
2. Indicate if the course is a plumbing or electrical course, for ESIAC review and trainee course tracking.
3. If the course is associated with a conference, indicate the conference name and location, as this will allow BBS to coordinate approvals with the conference provider.
4. If the course will be offered online, specify whether it will be on demand or offered as a virtual webinar, or both. Include website where the course will be provided.

Course applicable for the following certifications

This section represents a major change from previous BBS course approval forms.

1. If the course is only for residential certifications, check 'Residential Certifications Only'. The course, if approved, will be approved for all residential certifications.
2. If the course is appropriate for any commercial certifications, check Commercial Certifications. The course, if approved, will be approved for all commercial certification **AND** all residential certifications.
3. If the course is intended to meet required instruction in Code Administration (Chapter 1) or Existing Buildings (commercial or residential) check 'Administrative Course, All Certifications'.

Application Materials Included

This is a checklist for the course submitter's use, to be sure all materials necessary for review are included with the application. All materials should be submitted in .pdf format, along with the application, via email to Michael.Lane@com.ohio.gov or BBS@com.ohio.gov

REPLACEMENT WATER HEATERS

ARE REPLACEMENT WATER HEATERS JUST SIMPLY REPLACEMENTS OF “EXISTING” DEFECTIVE EQUIPMENT?

IF YOU ARE LOOKING FOR A SIMPLE ANSWER THERE REALLY ISN’T ONE, BUT IF YOU WANT ONE THEN THE ANSWER IS . . .

MAYBE

ARE REPLACEMENT WATER HEATERS JUST SIMPLY REPLACEMENTS OF “EXISTING” DEFECTIVE EQUIPMENT?

TO REALLY ANSWER THIS, WE MUST FIRST LOOK TO THE RESIDENTIAL CODE AND THE COMMERCIAL BUILDING CODE RULES FOR “EXISTING BUILDINGS”

RESIDENTIAL

SECTION 113 EXISTING BUILDINGS AND STRUCTURES

113.1 GENERAL

PROVISIONS WITHIN THIS SECTION SHALL CONTROL THE ALTERATION, REPAIR, ADDITION AND CHANGE OF OCCUPANCY IF EXISTING RESIDENTIAL BUILDINGS.

RESIDENTIAL

SECTION 113 EXISTING BUILDINGS AND STRUCTURES

113.2 MAINTENANCE

RESIDENTIAL BUILDINGS, STRUCTURES AND THE BUILDING EQUIPMENT SHALL BE MAINTAINED IN A SAFE AND SANITARY CONDITION AND IN ACCORDANCE WITH THE CONDITION(S) ESTABLISHED IN CURRENT AND ANY PREVIOUS PLAN APPROVALS AND CERTIFICATES OF OCCUPANCY. DEVICES OR SAFEGUARDS WHICH ARE REQUIRED BY THIS CODE SHALL BE MAINTAINED IN CONFORMANCE WITH THE CODE EDITION UNDER WHICH INSTALLED. THE OWNER OR THE OWNER'S DESIGNATED AGENT SHALL BE RESPONSIBLE FOR THE MAINTENANCE.

RESIDENTIAL

SECTION 113 EXISTING BUILDINGS AND STRUCTURES

113.5 REPLACEMENT OF SYSTEMS, COMPONENTS AND MATERIALS

REPLACEMENTS OF AN EXISTING SYSTEM (EGRESS, FIRE PROTECTION, MECHANICAL, PLUMBING, ETC.) AND MATERIALS OR BUILDING COMPONENTS NOT OTHERWISE PROVIDED FOR IN THIS SECTION, SHALL CONFORM TO THAT REQUIRED FOR NEW CONSTRUCTION TO THE EXTENT OF THE ALTERATION. THE EXISTING SYSTEMS, MATERIALS, OR COMPONENTS SHALL NOT BE REQUIRED TO COMPLY WITH ALL OF THE REQUIREMENTS OF THIS CODE FOR NEW CONSTRUCTION **EXCEPT TO THE EXTENT THAT THEY ARE AFFECTED BY THE ALTERATION**. REPLACEMENT OF EXISTING SYSTEMS, MATERIALS, OR COMPONENTS **SHALL NOT CAUSE THEM TO BECOME UNSAFE, HAZARDOUS, OVERLOADED, OR BECOME LESS EFFECTIVE THAN WHEN ORIGINALLY INSTALLED, CONSTRUCTED, AND/OR APPROVED**.

COMMERCIAL

CHAPTER 34 EXISTING BUILDINGS AND STRUCTURES

Section 3401 General

3401.1 Scope

The provisions of this chapter shall control the **maintenance**, alteration, repair, addition and change of occupancy of existing structures.

COMMERCIAL

CHAPTER 34 EXISTING BUILDINGS AND STRUCTURES

3401.1.1 Compliance

Compliance shall be demonstrated by meeting the requirements of one of the following options:

1. Chapters 2 through 33 of this code; or
2. Sections 3403 through 3411; or
3. Section 3412 Compliance Alternatives.

COMMERCIAL

CHAPTER 34 EXISTING BUILDINGS AND STRUCTURES

3401.2 Maintenance

Buildings, structures, equipment and parts thereof, **shall be maintained in a safe and sanitary condition and in accordance with the condition(s) established in current and any previous plan approvals and certificates of occupancy**. Devices or safeguards which are required by this code shall be maintained in conformance with the code edition under which installed. The owner or the owner's designated agent shall be responsible for the maintenance of buildings and structures.

COMMERCIAL

CHAPTER 34 EXISTING BUILDINGS AND STRUCTURES

3401.3.1 EXISTING MATERIALS

MATERIALS ALREADY IN USE IN A BUILDING IN COMPLIANCE WITH REQUIREMENTS OR APPROVALS IN EFFECT AT THE TIME OF THEIR ERECTION OR INSTALLATION SHALL BE PERMITTED TO REMAIN IN USE UNLESS DETERMINED BY THE BUILDING CODE OFFICIAL TO BE DANGEROUS TO LIFE, HEALTH OR SAFETY PER SECTION 109. WHERE SUCH CONDITIONS ARE DETERMINED TO BE DANGEROUS TO LIFE, HEALTH OR SAFETY, THEY SHALL BE MITIGATED OR MADE SAFE.

COMMERCIAL

CHAPTER 34 EXISTING BUILDINGS AND STRUCTURES

3401.3.2 NEW AND REPLACEMENT MATERIALS

EXCEPT AS OTHERWISE REQUIRED OR PERMITTED BY THIS CODE, MATERIALS PERMITTED BY THE APPLICABLE CODE FOR NEW CONSTRUCTION SHALL BE USED. LIKE MATERIALS SHALL BE PERMITTED FOR REPAIRS AND ALTERATIONS, PROVIDED NO HAZARD TO LIFE, HEALTH OR PROPERTY IS CREATED. HAZARDOUS MATERIALS SHALL NOT BE USED WHERE THE CODE FOR NEW CONSTRUCTION WOULD NOT PERMIT THEIR USE IN BUILDINGS OF SIMILAR OCCUPANCY, PURPOSE AND LOCATION.

ARE REPLACEMENT WATER HEATERS JUST SIMPLY REPLACEMENTS OF “EXISTING” DEFECTIVE EQUIPMENT?

NOW, LET’S LOOK AT WHY THIS ANSWER IS

“MAYBE”

SCENARIO 1

EXISTING CONDITIONS:

1. BUILDING HAS A 40,000 BTU 40 GALLON NATURAL GAS ATMOSPHERIC VENT STORAGE TYPE WATER HEATER.
2. OWNER/CONTRACTOR IS PROPOSING TO REPLACE THE WATER HEATER WITH A 40,000 BTU 40 GALLON NATURAL GAS ATMOSPHERIC VENT STORAGE TYPE WATER HEATER

IS SCENARIO 1 A SIMPLE REPLACEMENT OF "EXISTING" DEFECTIVE EQUIPMENT?

YES

SCENARIO 2

EXISTING CONDITIONS:

1. BUILDING HAS A 40,000 BTU 40 GALLON NATURAL GAS ATMOSPHERIC VENT STORAGE TYPE WATER HEATER.
2. OWNER/CONTRACTOR IS PROPOSING TO REPLACE THE WATER HEATER WITH A 50,000 BTU 50 GALLON NATURAL ATMOSPHERIC VENT STORAGE TYPE WATER HEATER

IS SCENARIO 2 A SIMPLE REPLACEMENT OF "EXISTING" DEFECTIVE EQUIPMENT?

NOT EXACTLY, IT MAY BE FINE

BUT…

IS SCENARIO 2 A SIMPLE REPLACEMENT OF "EXISTING" DEFECTIVE EQUIPMENT?

THE AHJ SHOULD ASK FOR ADDITIONAL INFORMATION TO ENSURE THE ADDITIONAL 10,000 BTU'S WILL NOT NEGATIVELY AFFECT THE ABILITY OF THE EXISTING FUEL GAS DISTRIBUTION SYSTEM TO PROVIDE ADEQUATE FUEL GAS FOR COMBUSTION. ADDITIONALLY, THE SIZE OF THE EXISTING FLUE SHOULD BE VERIFIED IT IS ADEQUATELY SIZED.

SCENARIO 3

EXISTING CONDITIONS:

1. BUILDING HAS A 40,000 BTU 40 GALLON NATURAL GAS ATMOSPHERIC VENT STORAGE TYPE WATER HEATER.
2. OWNER/CONTRACTOR IS PROPOSING TO REPLACE THE WATER HEATER WITH A 40,000 BTU 40 GALLON NATURAL GAS POWER VENT STORAGE TYPE WATER HEATER

IS SCENARIO 3 A SIMPLE REPLACEMENT OF "EXISTING" DEFECTIVE EQUIPMENT?

NO

IS SCENARIO 3 A SIMPLE REPLACEMENT OF "EXISTING" DEFECTIVE EQUIPMENT?

THE EXISTING FUEL GAS DISTRIBUTION SYSTEM WILL ADEQUATELY PROVIDE FUEL GAS FOR COMBUSTION, HOWEVER, THE AHJ SHOULD ASK FOR ADDITIONAL INFORMATION ON THE FOLLOWING ISSUES -

IS SCENARIO 3 A SIMPLE REPLACEMENT OF "EXISTING" DEFECTIVE EQUIPMENT?

1. DID THE FLUE FOR THE EXISTING WATER HEATER CONNECT TO A COMMON FLUE THAT ALSO SERVED THE FURNACE?
2. HOW WILL THE EXISTING WATER HEATER FLUE BE TERMINATED?
3. WILL REMOVING THE EXISTING WATER HEATER FLUE BTU DISCHARGE FROM THE COMMON FLUE RESULT IN THE FLUE NOW BEING OVERSIZED FOR THE OTHER CONNECTED APPLIANCE(S) WHICH WILL RESULT IN CONDENSATION TAKING PLACE IN THE FLUE?

IS SCENARIO 3 A SIMPLE REPLACEMENT OF "EXISTING" DEFECTIVE EQUIPMENT?

4. WERE DETAILS PROVIDED FOR THE ROUTING AND TERMINATION OF THE POWER VENT?
5. HOW WILL CONDENSATION IN THE POWER VENT PIPING BE DEALT WITH, IS THERE A FLOOR DRAIN OR OTHER WASTE RECEPTOR TO DISCHARGE TO, OR WILL A CONDENSATE PUMP NEED TO BE PROVIDED?
6. IF A CONDENSATE PUMP IS REQUIRED, IS THERE EXISTING ELECTRIC OR WILL AN ADDITIONAL CIRCUIT NEED TO BE PROVIDED, AND WHERE WILL THE ELECTRIC FOR THE POWER VENT BE PROVIDED FROM, NEW CIRCUIT OR "EXISTING"?

SCENARIO 4

EXISTING CONDITIONS:

1. BUILDING HAS A 40,000 BTU 40 GALLON NATURAL GAS ATMOSPHERIC VENT STORAGE TYPE WATER HEATER.
2. OWNER/CONTRACTOR IS PROPOSING TO REPLACE THE WATER HEATER WITH A 199,000 BTU NATURAL GAS TANKLESS TYPE WATER HEATER.

IS SCENARIO 4 A SIMPLE REPLACEMENT OF "EXISTING" DEFECTIVE EQUIPMENT?

NO

IS SCENARIO 4 A SIMPLE REPLACEMENT OF "EXISTING" DEFECTIVE EQUIPMENT?

THE AHJ SHOULD ASK FOR ADDITIONAL INFORMATION ON THE FOLLOWING ISSUES –

1. IS THE EXISTING BRANCH PIPE THAT SERVED THE EXISTING WATER HEATER ADEQUATELY SIZED FOR THE ADDITIONAL BTU'S?
2. IS THE EXISTING FUEL GAS SYSTEM ADEQUATELY SIZED FOR THE ADDITIONAL BTU'S?

IS SCENARIO 4 A SIMPLE REPLACEMENT OF "EXISTING" DEFECTIVE EQUIPMENT?

3. DID THE FLUE FOR THE EXISTING WATER HEATER CONNECT TO A COMMON FLUE THAT ALSO SERVED THE FURNACE?
4. HOW WILL THE EXISTING WATER HEATER FLUE BE TERMINATED?
5. WILL REMOVING THE EXISTING WATER HEATER FLUE BTU DISCHARGE FROM THE COMMON FLUE RESULT IN THE FLUE NOW BEING OVERSIZED FOR THE OTHER CONNECTED APPLIANCE(S) WHICH WILL RESULT IN CONDENSATION TAKING PLACE IN THE FLUE?

IS SCENARIO 4 A SIMPLE REPLACEMENT OF "EXISTING" DEFECTIVE EQUIPMENT?

6. WILL THE NEW WATER HEATER BE DIRECT VENT OR POWER VENT?
7. WERE DETAILS PROVIDED FOR THE ROUTING AND TERMINATION OF THE VENT?
8. HOW WILL CONDENSATION IN THE POWER VENT PIPING BE DEALT WITH, IS THERE A FLOOR DRAIN OR OTHER WASTE RECEPTOR TO DISCHARGE TO, OR WILL A CONDENSATE PUMP NEED TO BE PROVIDED?
9. IF A CONDENSATE PUMP IS REQUIRED, IS THERE EXISTING ELECTRIC OR WILL AN ADDITIONAL CIRCUIT NEED TO BE PROVIDED, AND WHERE WILL THE ELECTRIC FOR THE POWER VENT BE PROVIDED FROM, NEW CIRCUIT OR "EXISTING"?

THE BOTTOM LINE

ASKING AND ANSWERING THESE QUESTIONS WILL RESULT IN

1. COMPLYING WITH THE REQUIREMENTS FOR EXISTING BUILDINGS APPROVALS
2. ENSURING PROPER APPROVALS ARE ACQUIRED FOR THE SCOPE OF WORK AND INSPECTIONS ARE PERFORMED
3. ENSURING THERE ARE NO UNSAFE/SERIOUS CONDITIONS THAT WOULD RESULT FROM AN IMPROPER INSTALLATION.

QUESTIONS?

THANK YOU

File Attachments for Item:

EC-3 Valves 101 (Ohio Association of Plumbing Inspectors)

All certifications (1 hour)

OAPI Valves Learning Objectives

1. Familiarize participants with the various types of valves.
2. Enable participants to identify proper connection methods for valves.
3. Familiarize participants with proper uses for the various types of valves.
4. Familiarize participants with design features associated with each valve type.



AMANDA JOST

Area Sales Manager

Amanda Jost is the Area Sales Manager for NIBCO in Ohio and West Virginia. She's been with NIBCO for 6+ years and is responsible for calling on engineers, contractors, and distributors to in her territory. She conducts training sessions for customers on new and existing products. Amanda is a graduate of Ball State University in Muncie, IN and resides in Columbus, OH. She's the WOA Liaison for the Central Ohio ASPE Chapter. Amanda provide continuing education for engineers, certified inspectors, and contractors as part of her functions with the Nibco Corporation.

CONTACT

PHONE:
614-634-2516

WEBSITE:
www.nibco.com

EMAIL:
josta@nibco.com

Valve 101

Presented by Aaron Kilburg & Amanda Jost

Commercial Sales Manager / Area Sales Manager

Ohio Association of Plumbing Inspectors

NIBCO®

AHEAD OF THE FLOW®

ASPE American Society of Plumbing Engineers CEU PROVIDER



Agenda

- Introductions/NIBCO Company Overview
- Valve 101 Presentation
- Points of contact and resources

ASPE American Society of Plumbing Engineers CEU PROVID

NIBCO – An American Company

- Founded in 1904
- Headquartered in Elkhart, Indiana
- Privately owned & controlled for four generations by the Martin family
- Positioned to grow for a 5th generation of family leadership



NIBCO®
AHEAD OF THE FLOW®

ASPE American Society of Plumbing Engineers CEU PROVID

Purpose of Valves in a Piping System

Valves serve the purpose of controlling flow in piping systems. Valves are produced in a variety of design types and materials. Proper selection is important to ensure efficient, cost effective and long lasting systems.





ASPE American Society of Plumbing Engineers CEU PROVID

Valve Selection Considerations

Principal Function

- Starting and stopping
- Regulating (throttling) flow
- Preventing reversal of flow
- Regulating or relieving the pressure of flow

Service Considerations

- Pressure
- Temperature
- Type of media (liquid, gas, semi-solid)
- Flow (what is the volume and velocity of media?)
- Operating conditions
  - Location
  - Environment
  - Frequency of operation
  - Accessibility of operation
  - Overall size/space available



ASPE American Society of Plumbing Engineers CEU PROVID

Topics of Discussion

Valves

- Ball Valves
- Butterfly Valves
- Bronze and Iron Valves
- Industrial Valves
- Fire Protection Valves
- Press Valves
- Comparisons



LEAD-FREE: Weighted average lead content <0.25%

ASPE American Society of Plumbing Engineers CEU PROVID


Ball Valves
NIBCO
HydraPure

Ball Valve

What is a Ball Valve?

- A ball valve is a 1/4 turn valve whose closure member is a rotating ball that turns within the valve body a total of 90 degrees from closed to opened



Applications

- Commercial
- Residential
- Industrial
- Used to isolate pumps
- Strainer blow-off
- Used in air lines
- Medical gas valve box



Ball Valves

Features and Benefits

- Commercial, industrial and residential applications
- Available materials
  - Bronze
  - Brass
  - Lead-Free
  - Carbon steel
  - Stainless steel
  - Lead-free available
- Body types
  - One-piece
  - Two-piece
  - Three-piece
  - Full port
  - Conventional port valves
- Wide Range of handles



LEAD-FREE: Weighted average lead content <0.25%

ASPE American Society of Plumbing Engineers CEU PROVID

Look to NIBCO

What is Dezincification? Why Should It Be Important to You?

Bronze and brass are not the same materials! Brass alloys can have a 35-40% zinc content. De-alloying corrosion, also known as dezincification, occurs in valve components containing more than 15% zinc. The leeching of zinc from the brass alloy creates porous copper which results in the loss of physical strength in the brass alloy material, subjecting valves to potential failure.



Dezincified ball valve

The Problem

Dezincification was effectively eradicated from valve products in the 1950s. Today, however, this problem has returned due to:

- Increased use of high-zinc alloys in forged and cast ball and gate valves produced outside the United States.
- Increased aggressiveness of today's water supplies and water treatment technologies.



Know the Signs of Dezincification

- Presence of zinc oxide, a loose adhering white deposit on outside of valve
- Presence of mineral stains on outer surface of valve
- Water weeping from valve body, stem/bonnet seal or threaded end





Why Choose Ball Valves?

Features

- Low pressure drop
- More compact
- Bubble tight shut-off feature

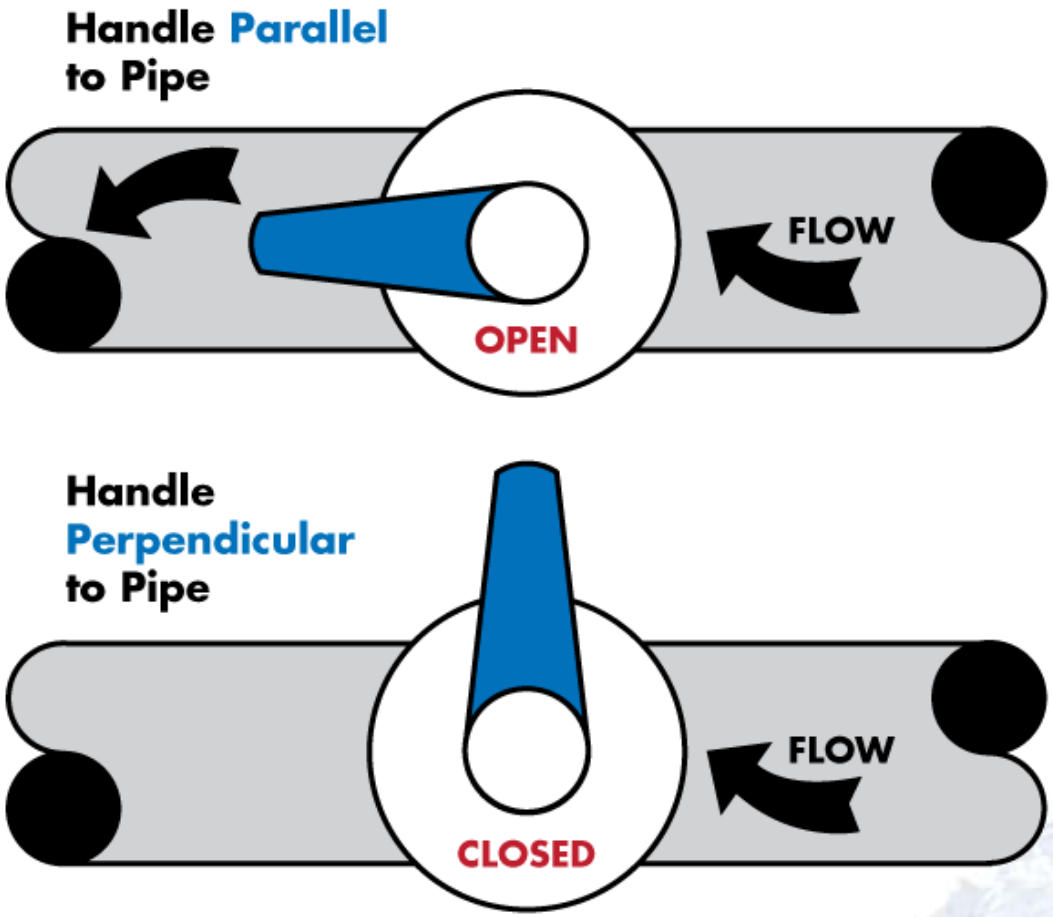
Benefits

- Versatility
- Less weight than gate and globe valves
- Ease of operation
- Many handle options
- Wide range of sizes



Ball Valve: Position Indication

Handle Illustration



Ball Valves: Design and Construction

Materials

- Brass
- Bronze
- Carbon steel
- Plastic
- Stainless steel

Ball Port Sizes

- Standard and reduced port (next smaller pipe size)
- Full port (pipe size)

End Connection Options

- Press-to-connect
- Threaded
- Solder
- Flanged

Seating Materials

- Virgin PTFE (most popular)
- 15% glass reinforced PTFE
- 25% glass reinforced PTFE
- Carbon-filled PTFE

- Temperature range
  - -20°F to 500°F
- Pressure range
  - 0 to 2000 PSI



ASPE American Society of Plumbing Engineers CEU PROVID

Ball Valves: Design and Construction
Handle Options

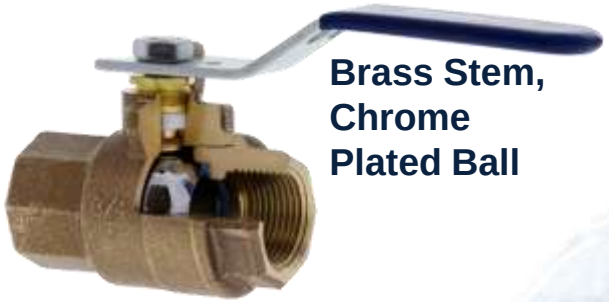
Handle Options

- Standard lever handle
- Extended lever handle with memory stop
- Locking lever handle
- Round handle
- Insulated handles
- Wing handle
- Chain lever



What Does Trim Refer To?

- Trim refers to the ball and stem
  - Options include Brass, Stainless Steel

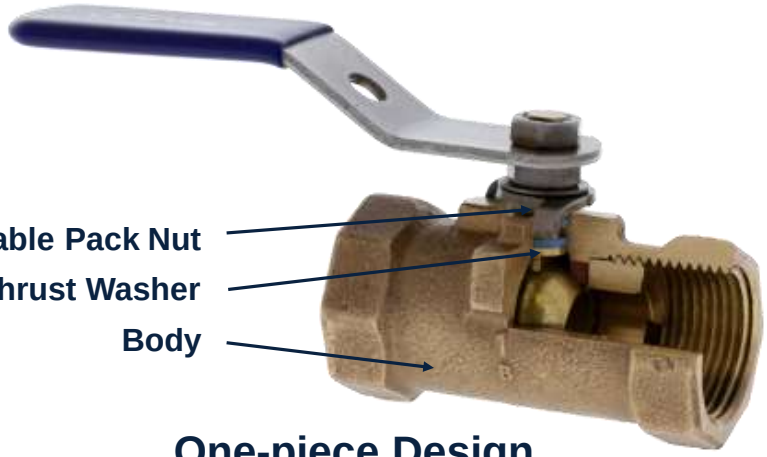


Brass Stem, Chrome Plated Ball

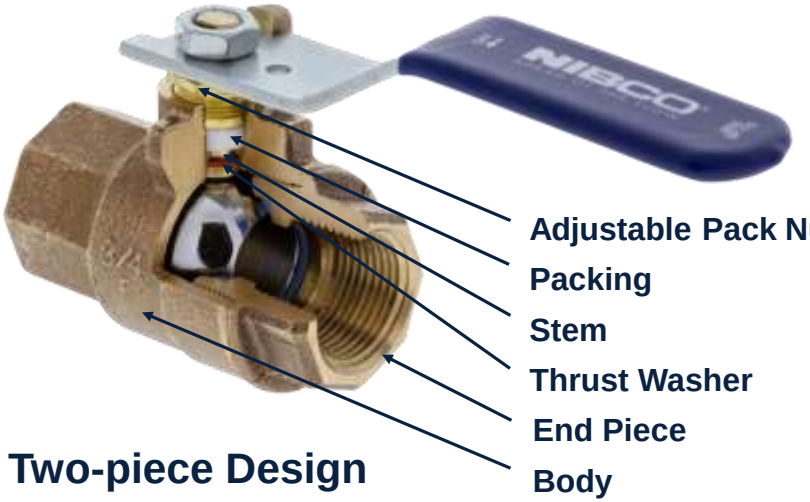
Silicon Bronze Ball and Stem



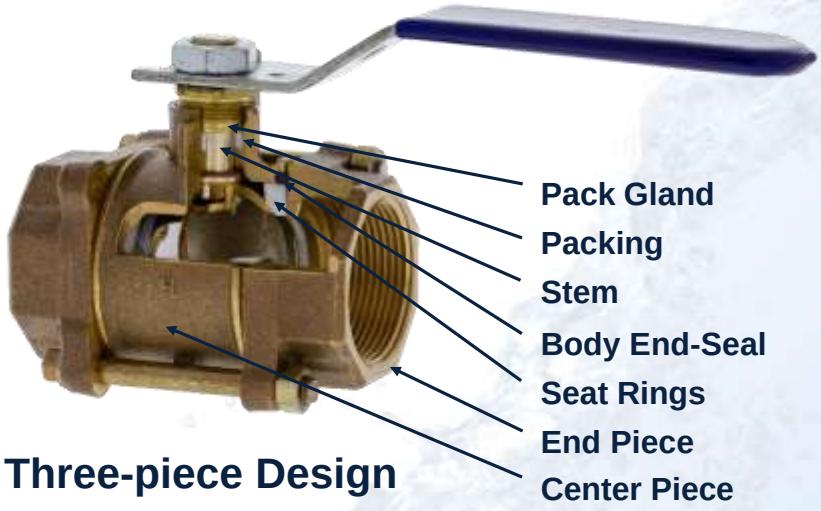
Ball Valves



One-piece Design



Two-piece Design



Three-piece Design

One Piece Ball Valve

One piece body design

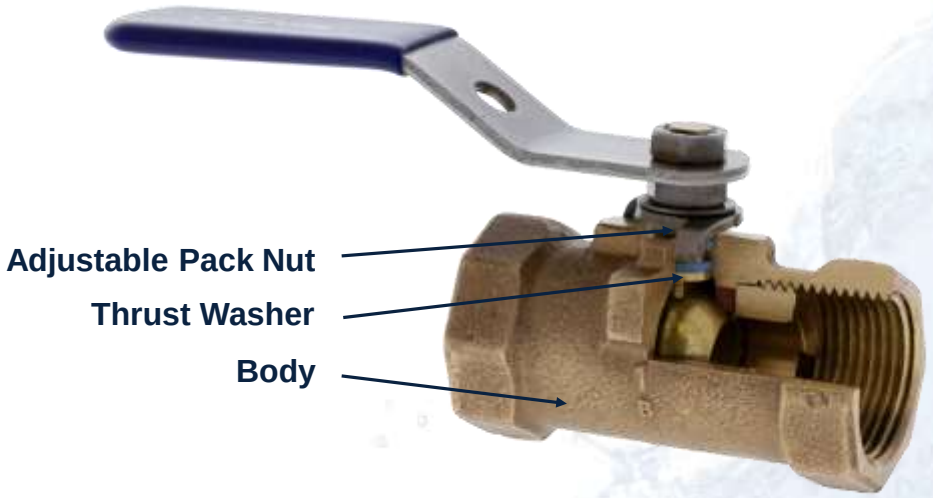
- No potential leak path
- Port size reduced or double reduced
- Materials Include Bronze, Carbon, and Stainless Steel

Typical Application

- Industrial
  - Chemical
  - High pressure
  - Steam
  - Corrosive materials

End Connection Options

- Threaded



ASPE American Society of Plumbing Engineers CEU PROVID

Two Piece Ball Valve

Two piece body design

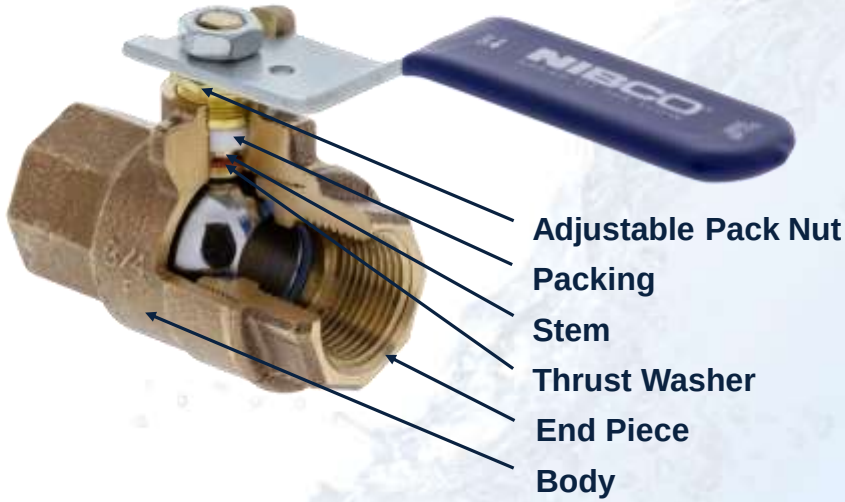
- Threaded end piece galled into body of valve
- Port size full or conventional
- Materials Include Bronze (LF), Carbon, and Stainless Steel
- Most popular type of ball valve with many options and configurations
- Cannot be brazed

Typical Application

- Commercial and Lite Industrial
  - Potable Water
  - HVAC
  - Steam (150 & 250 SWP)
  - Gas
  - Fire protection
  - Limited Chemical

End Connection Options

- Threaded, Solder, Press



ASPE American Society of Plumbing Engineers CEU PROVID

Three Piece Ball Valve

Three piece body design

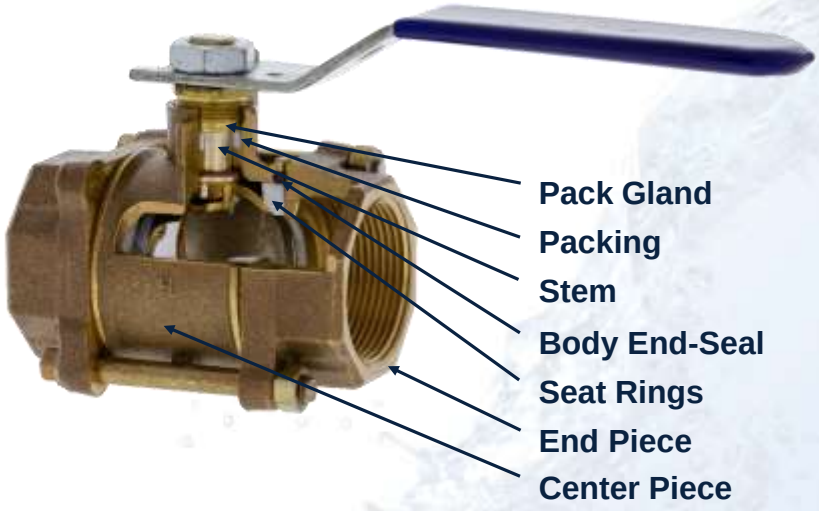
- 3 components - body and two end pieces (held in place with bolts)
- Port size full or conventional
- Materials Include Bronze (LF), Carbon, and Stainless Steel
- Removable seats and seals allows for brazing or welding
- Allows for inline maintenance
- Most costly ball valve body type

Typical Application

- Med Gas
- HVAC
- Potable Water
- Industrial process
- Fluids requiring frequent cleaning

End Connection Options

- Threaded, Solder, Press



ASPE American Society of Plumbing Engineers CEU PROVID

Ball Valves Summary

Advantages

- Versatile
- Low pressure drop
- Compact design
- Bi-directional
- Bubble tight shut off with resilient seating



Disadvantages

- Not recommended for throttling, low accuracy
- Not good choice for slurry systems or with abrasives.
- Temperature range limited by seating material
- Not a good choice for steam control due to “quick opening” feature.

ASPE American Society of Plumbing Engineers CEU PROVID

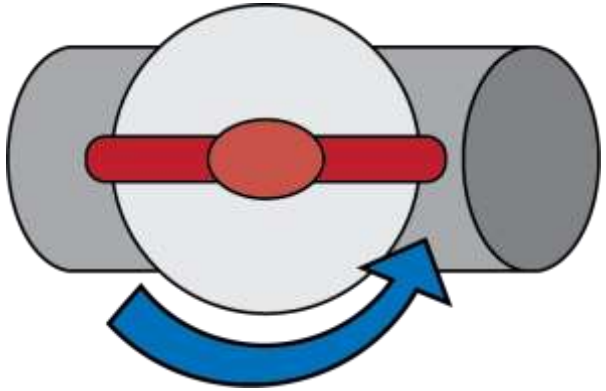


Butterfly Valves

Butterfly Valves: Design Features

Butterfly Valves Design Highlights

- Quarter-turn valve
- Rotary type valve
- Rigid body
- Disc that rotates on an axis
- Disc seals against an elastomer seat
  - Generally this lines the bore of the body
- Valve disc remains a waterway





ASPE American Society of Plumbing Engineers CEU PROVID

Butterfly Valves

Features and Benefits

- Commercial and industrial applications
  - Bi-directional dead-end service
- Available materials and selections
  - Cast iron
  - Cast ductile iron
  - CPVC materials
  - Lead-free available
  - Fire protection
  - High performance
- End connections
  - Wafer
  - Lug
  - Grooved
  - Press



LEAD-FREE: Weighted average lead content <0.25%

ASPE American Society of Plumbing Engineers CEU PROVID

Strength

MATERIAL	YIELD PSI	ELONGATION %	TENSILE PSI
BRONZE	16,000	22	34,000
IRON	0	0	31,000
DUCTILE IRON	40,000	18	60,000
STEEL WCB	36,000	22	70,000

ASPE American Society of Plumbing Engineers CEU PROVID

Butterfly Valves: Design Features



Lug Type

- Compatible with ANSI Class 125 (flat face) or ANSI Class 150 (raised face) flanges
- May be used as an isolation valve
- Available in 150, 200, 250, 285 pressure ratings
- HPBFV (dual offset) available in 285 - 740 PSI

Grooved Type

- Different type of disc, seal, and body construction
- Disc is contained in a sleeve type body
- Liner material encapsulates the disc which interferes with interior of the body to make the seal
- Compression molded disc available in 300 and 350 PSI

Wafer Type

- Also mounted between ANSI Class 125 and 150 flanges
- May be used in applications where quick valve replacement is necessary
  - Fewer flange bolts required

ASPE American Society of Plumbing Engineers CEU PROVID

Butterfly Valves: Design Features

Disc Types

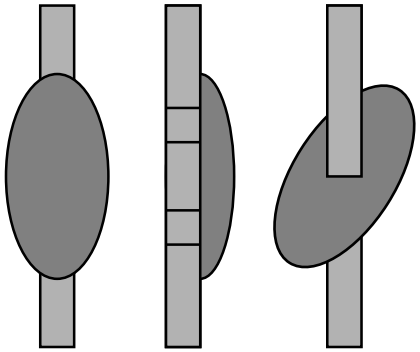
- Symmetrical/on center (most common)
- Single offset (uninterrupted seating)
- Angle disc (uninterrupted seating)

Types of Liners

- Boot liner
- Molded liner
- Cartridge liner

Disk Materials

- Aluminum bronze
- Nickel-plated ductile iron
- Stainless steel
- Nylon-coated disc



Liner Material Options

- EPDM
- Buna-N
- Fluorocarbon (Viton)



ASPE American Society of Plumbing Engineers CEU PROVID

Injection-Molded Liner

- Rubber Liner Injection Molded Directly onto the Body
- No Additional Assembly Required
- Rated for End of Line Service without Down Stream Flange



Boot
Liner

- Molded Rubber Liner
- No Hard Backing Ring
- Snaps into Body
- Not Rated for End of Line Service



Cartridge
Liner

- Molded Rubber Liner
- Hard Phenolic or Metal Backing Ring
- Slips into Body
- Not Rated for End of Line Service
  - (NIBCO's Dead-End Rated w/DS Flange)



Liners

- EPDM
  - EPDM has good abrasion and tear resistance and offers excellent chemical resistance to a variety of ***mild*** acids and alkalines but it is susceptible to attack by oils. It has good ozone resistance and is fairly good with ketones and alcohols with a temperature range from -20°F to 250°F. ***The primary choice for commercial and potable water applications.***
- NBR (Nitrile Buna-N)
  - NBR is a general purpose oil-resistant polymer known as nitrile rubber. It has a moderate temperature range of -20°F to 180°F and has good solvent, oil, water, and hydraulic fluid resistance. It displays good compression set, abrasion resistance and tensile strength.
- Fluorocarbon (Not available in LD-7000 or LD-3000)
  - Fluoroelastomers (FKM/FPM) are fluorinated synthetic polymers designed for harsh environments including aggressive chemical and temperature applications.



Liner Temperature Ratings

Liner Material	Temperature
EPDM**	-20°F to + 250°F
Nitrile (Buna-N)	-20°F to + 180°F
Fluoroelastomer	-20°F to + 300°F

** EPDM is rated at 250°F intermittent service and 225°F continuous service.

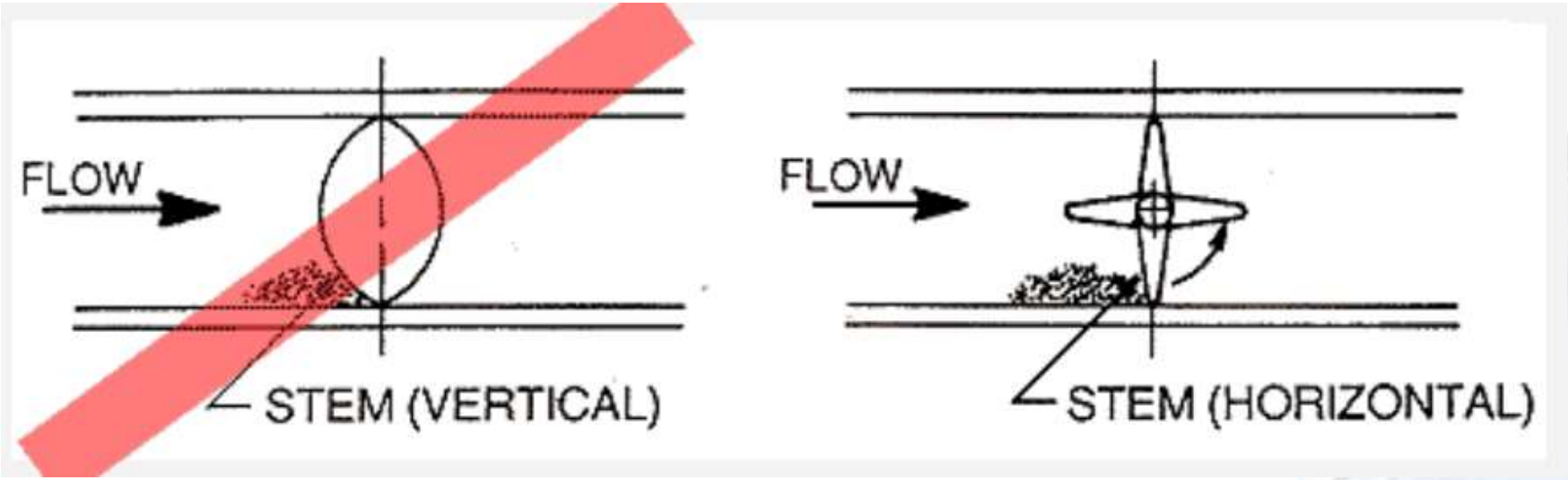
NOTE – The NIBCO® Chemical Resistance Guide should be referenced for liner material compatibility for each application.

Discs

- Nylon coated DI
  - Nylon 11 is a non-biodegradable, polyamide bioplastic which is derived from vegetable oil. It's used in metal coatings for noise reduction and protection against UV exposure as well as resistance to chemicals, abrasion, and corrosion. It's an economical option to aluminum bronze and stainless steel for lightly treated water applications.
- Aluminum Bronze
  - Aluminum bronze is a strong, corrosion resistant alloy but not recommended for high pH wet systems. **It is the primary choice for commercial and potable water applications.**
- 316 Stainless Steel
  - 316 SS has very good corrosion resistance to a wide range of environments, is not susceptible to stress corrosion cracking and is not affected by heat treatment. It works better than aluminum bronze in acidic acids and is commonly used in treated water applications. Particularly those where issues have developed with aluminum bronze due to water treatment mismanagement.



Semi-Solid/Solids Systems



Butterfly Valves: Features and Benefits

Features

- Operating life provides maintenance free cycles
- Lower pressure drop helps keep energy costs down
- Lightweight design which helps save installation dollars
- Bubble tight shut-off by design



Benefits

- Much more versatile compared to gate or globe
- Ease of operation offers a quarter turn open to close
- Self-cleaning maintenance when installed properly
- Takes up approximately a sixth of the space of gate valves
- Generally 40% the cost of iron gate valves
- Can be installed in any orientation



Bronze and Iron Valves

Multi-Turn Valves

Features and Benefits

- Commercial and industrial applications
  - Check
  - Gate
  - Globe
- Available materials
  - Bronze
  - Cast iron
  - Lead-free available
  - Cast ductile iron
- End connections
  - Threaded
  - Solder
  - Flanged
- Dezincification-resistant bronze selection
- IBBM (iron body, bronze mount) and/or OS&Y (outside stem and yoke) selection



LEAD-FREE: Weighted average lead content <0.25%

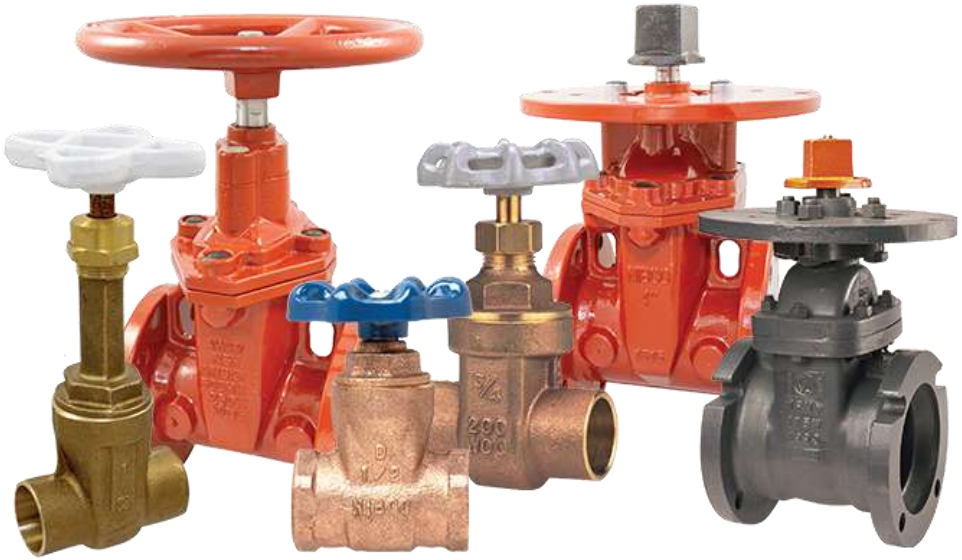
ASPE American Society of Plumbing Engineers CEU PROVID

448

Gate Valves

Overview

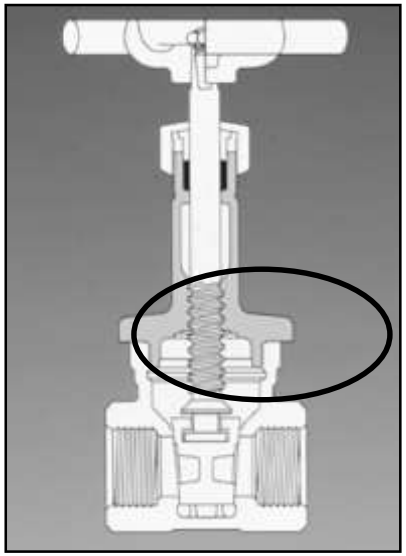
- Gate valves are distinguished by the use of a wedge or “gate” that lowers into or rises out of the waterway to control flow
- Used in either the completely open or closed position



Gate valve used in hot tapping application

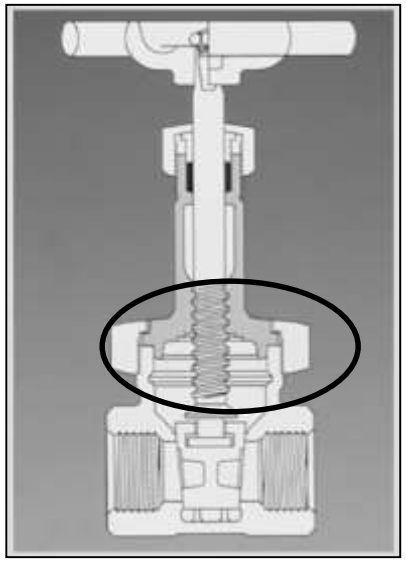


Gate Valves-Bonnet Types



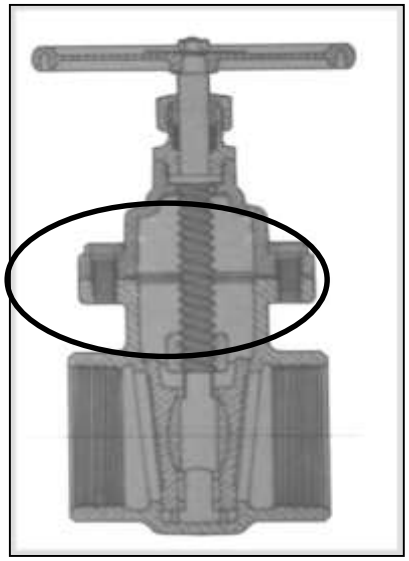
Threaded (screw-in)

- Lowest cost bonnet design
- Avoid temperature swings
- Primarily for Plumbing & HVAC
- Frequent dis-assembly difficult



Union Bonnet

- Ease of disassembly for maintenance
- Ideal for critical service
- Designed for building services piping



Bolted Bonnet

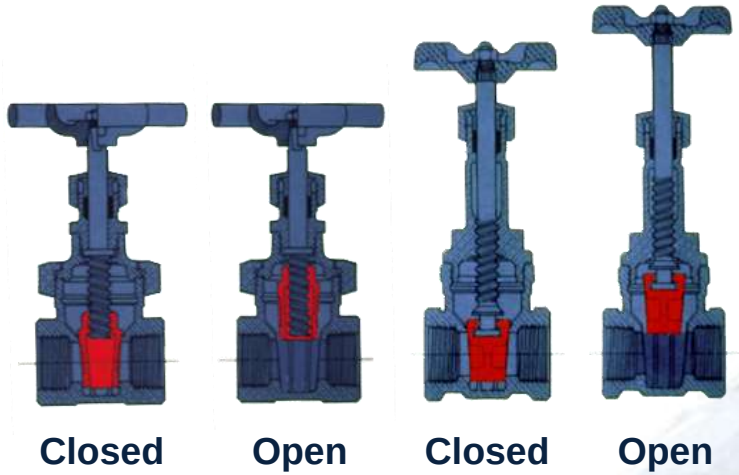
- Primarily for iron multi-turn valves
- Gasket joint
- Easy to maintain
- Plumbing & HVAC service

Gate Valve Design Features

Stem Design / Configuration

Non-Rising

- Less installation space required
- Less packing wear
- No visible position indicator
- Lowest cost
- Stem subjected to media



Rising (Inside Screw)

- Space needed for stem movement
- On-off position indicated
- Stem subjected to media, although not to the same degree as NRS



Rising (Outside Screw & Yoke - OS&Y)

- On/Off position indicated
- Threads not exposed to corrosive media, high temperature or solids
- Design allows for lubrication of threads

ASPE American Society of Plumbing Engineers CEU PROVID

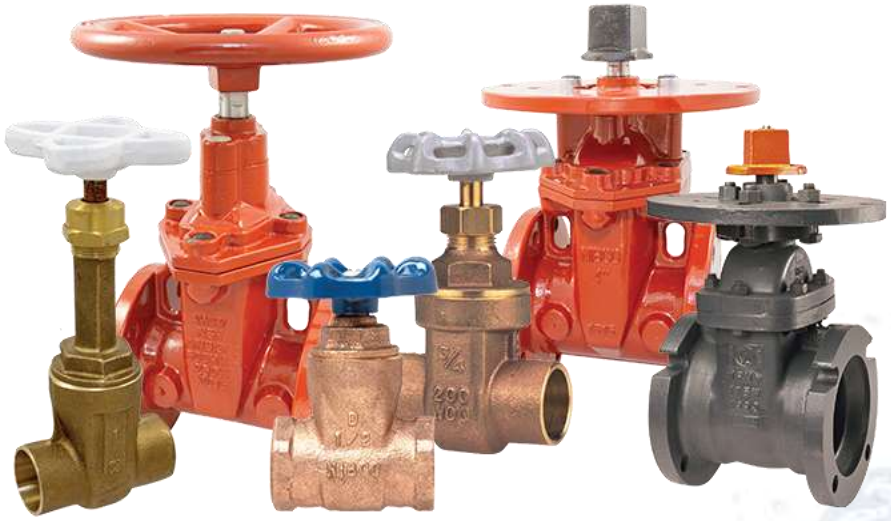
Gate Valves Summary

Advantages

- Good choice for on/off service
- Full flow (low pressure drop)
- Bi-directional
- Metal-to-metal seats can service high temperatures

Disadvantages

- Not for throttling; use fully opened or fully closed
- Metal-to-metal seating means not best choice for frequent operation
- Seating is not bubble-tight, allowable leakage rate
- Multi-turn is difficult to automate



ASPE American Society of Plumbing Engineers CEU PROVID

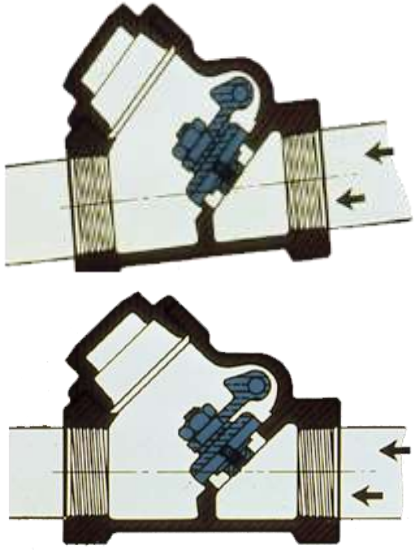
Check Valves

Types of Check Valves

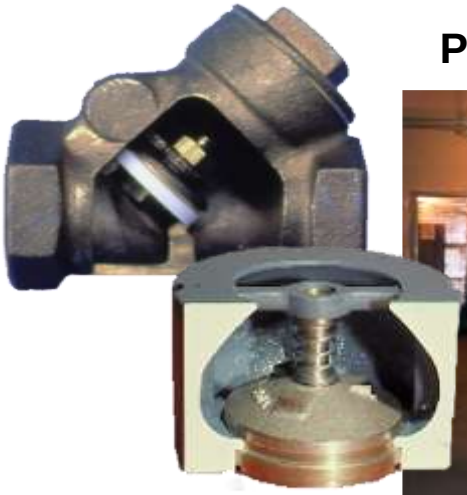
- Swing check
- Center guided, silent check
- Double door, silent check







Used in Typical Pump Application

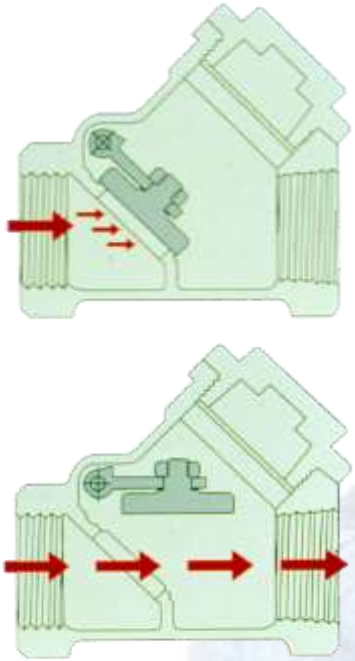




Check Valve Design Features

Backflow Prevention Features

- The check valve consists of a body, flapper (disc) and a seat
- Opens by upstream pressure and flow
- When flow stops and begins to reverse, the flapper shuts
- Sole purpose of the check valve is to prevent the medium from flowing backwards in the system when pressure is lost
- Design/Install minimum 5 pipe diameters from pump discharge to avoid flow turbulence.



Bronze Check Valves

- Oxygen service

Iron Check Valves

- Lever and weight (L&W)
- Lever and spring (L&S)





ASPE American Society of Plumbing Engineers CEU PROVID

Check Valves Summary

Advantages

- Swing checks have the least pressure drop
- Center guided, double door, and L&W/L&S are best for preventing water hammer
- Metal-to-metal seats can service high temperatures

Disadvantages

- Center guided and double door checks may have significant pressure drop due to flow path
- Swing checks may produce hydraulic shock (commonly referred to as water hammer)
- Must install in correct orientation
- No bubble tight seating, allowable leakage rate

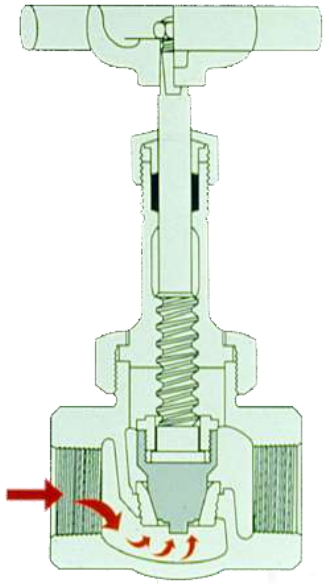


ASPE American Society of Plumbing Engineers CEU PROVID

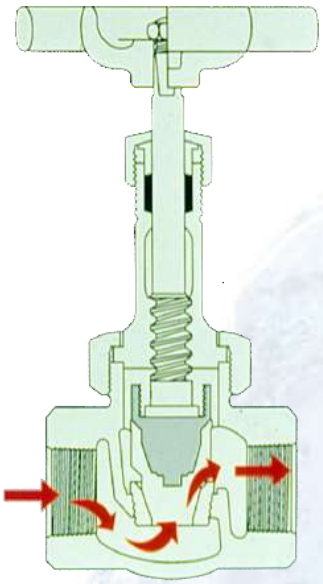
Globe Valves

Overview

- Used to regulate the amount of flow (referred to as “throttling”)
- Used in commercial and industrial applications
- Applications
  - Hot and cold water
  - HVAC
  - Steam
  - Gas
  - Other utility services for specific globe valves material types
    - Compressed air
    - Oil and gas
    - Limited chemical
    - Petroleum refining and production



Closed



Partially Open

Design Features

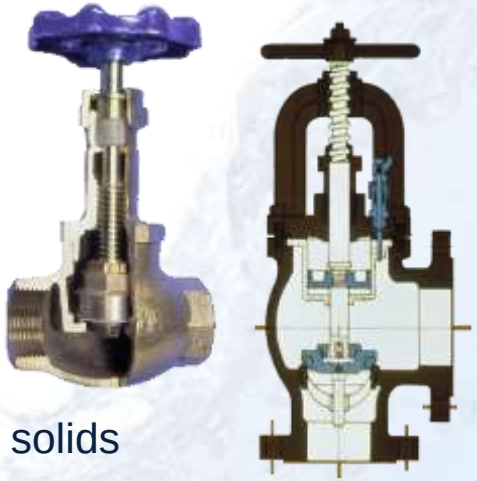


End Connection Options

- Threaded
- Solder
- Flanged
- Welded

Bonnet to Body Connection Options

- Threaded
- Union
- Bolted



Rising (Inside Screw)

- Space needed for stem movement
- On-off position indicated
- Stem partially subjected to media

Rising (Outside Screw & Yoke - OS&Y)

- On/Off position indicated
- Threads not exposed to corrosive media, high temperature or solids

Design Allows for Lubrication of Threads

ASPE American Society of Plumbing Engineers CEU PROVID

Globe Valves Summary

Advantages

- Recommended for throttling applications
- Positive bubble-tight shut off when equipped with resilient seating
- Good for frequent operation
- Metal-to-metal seats can service high temperatures

Disadvantages

- Flow path produces significant pressure drop
- Can be more costly than alternative valves



ASPE American Society of Plumbing Engineers CEU PROVID



Press Valves

Press Valves

Feature and Benefits

- Applications
  - Hydronic heating
  - Dry compressed air
  - Vacuum
  - Cooling water
  - Hot and cold water
  - Non-medical gases
  - Rain or gray water
  - Chilled water
- Flame-free press joining method
- Quick, reliable and convenient
- Dezincification-resistant (DZR) bronze available
- Requires pressing tool and jaw for assembly
- Leak detection feature

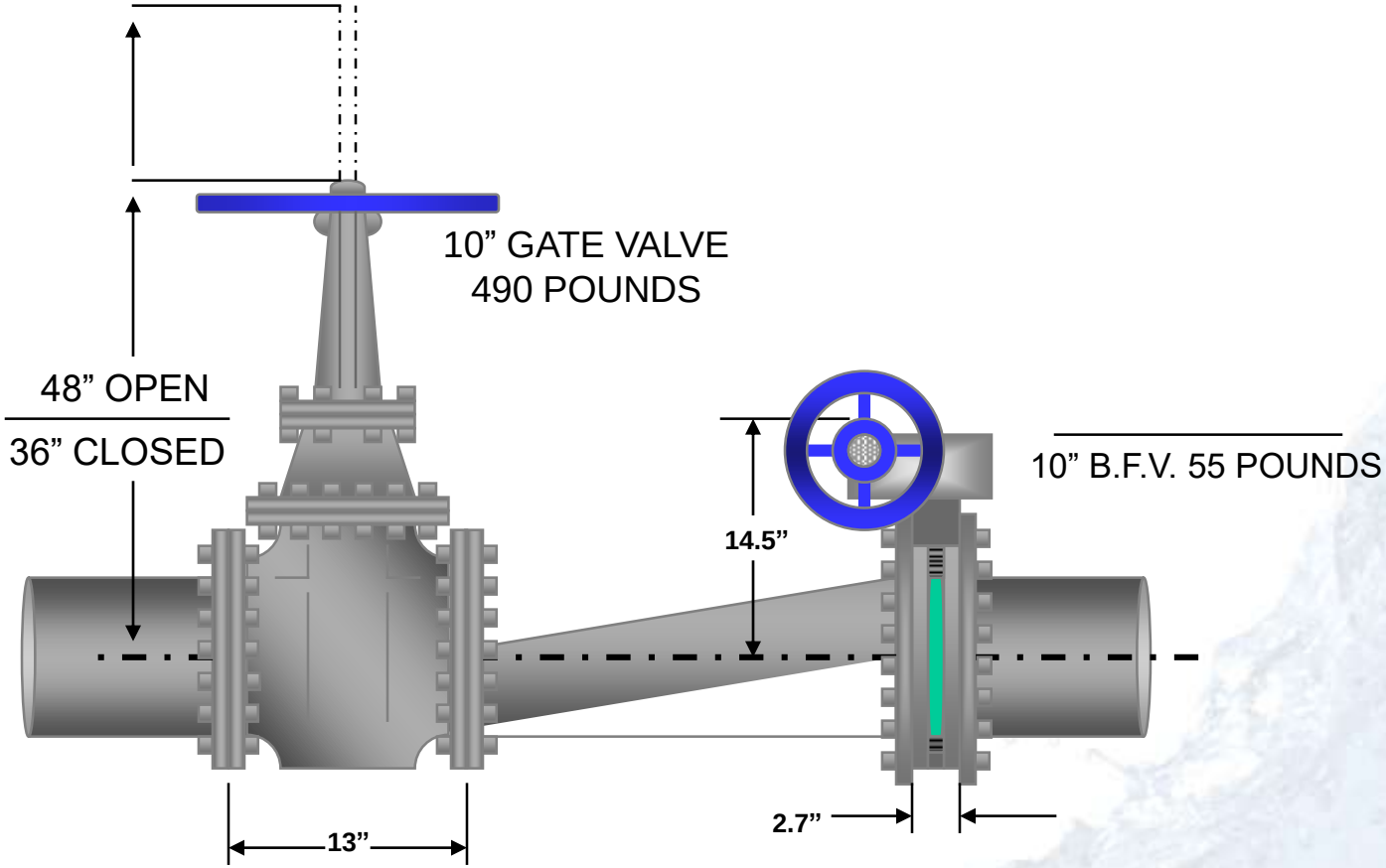


ASPE American Society of Plumbing Engineers CEU PROVID

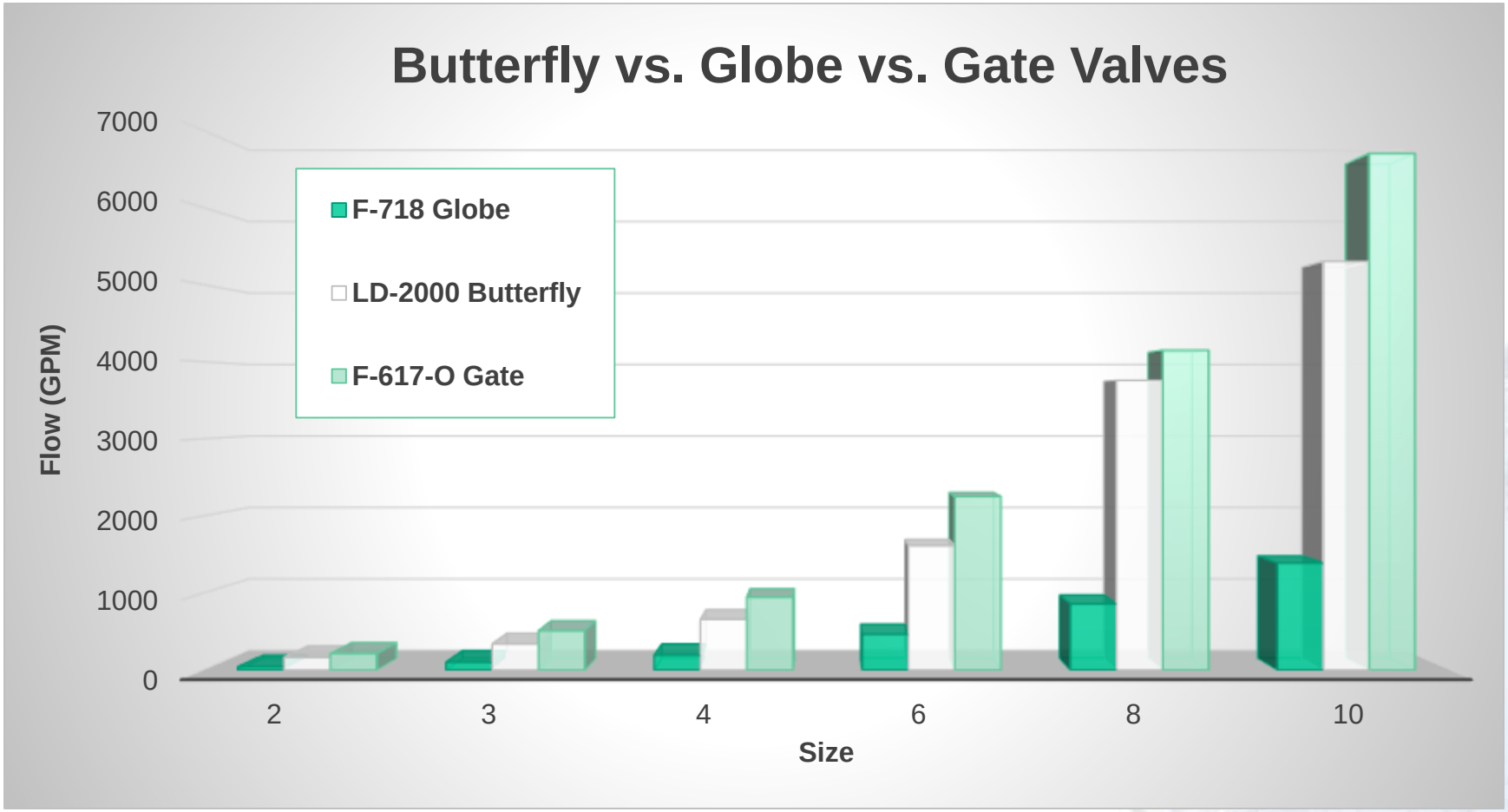
Comparisons

Comparison

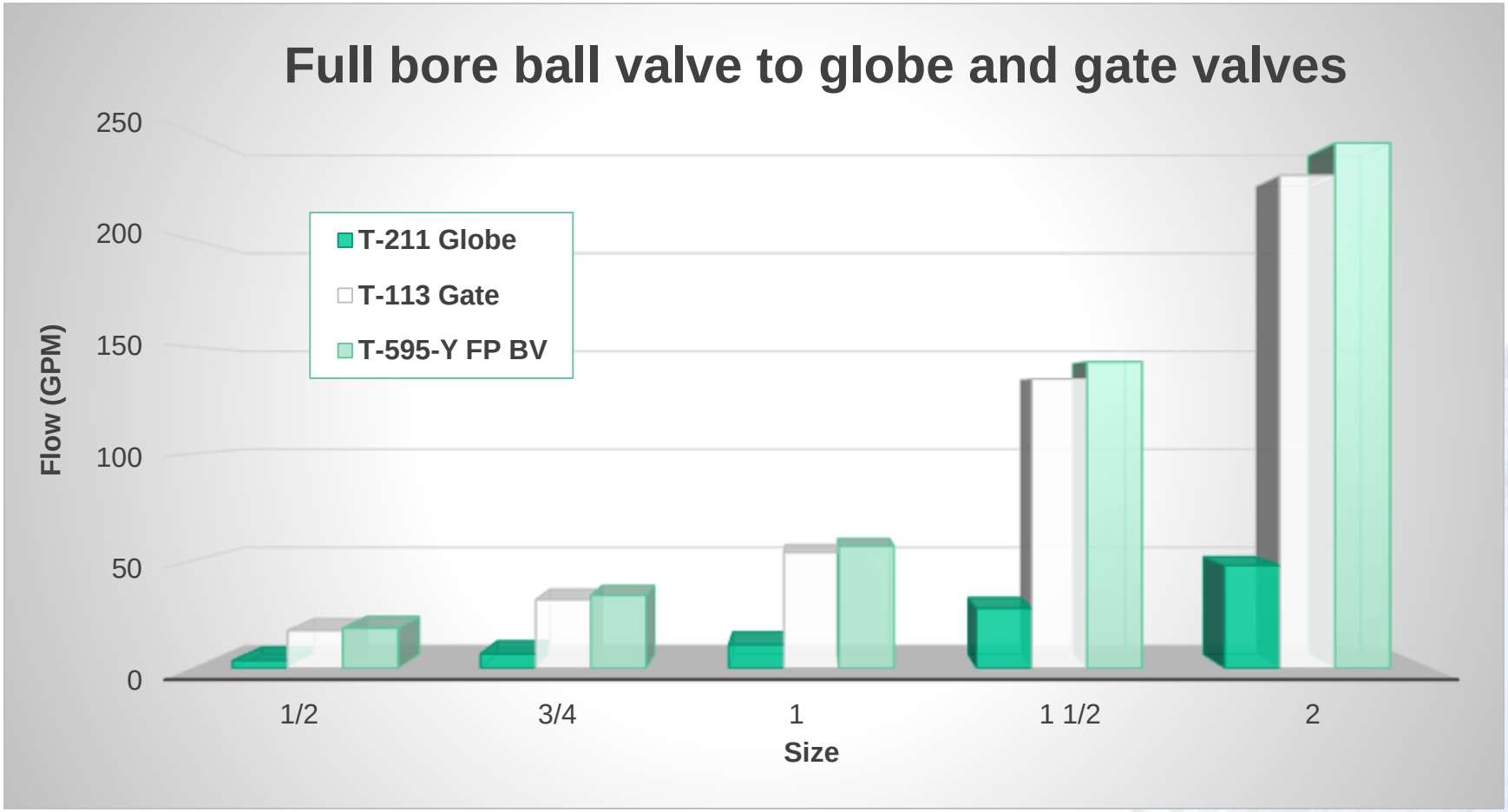
Gate and Butterfly Valves



Comparison – Flow (Cv)



Comparison – Flow (Cv)



Points of Contact

Amanda Jost
Area Manager
JostA@nibco.com
614-634-2516

Aaron Kilburg
Commercial Sales Manager
KilburgA@nibco.com
331-262-0868

NIBCO Customer Service	**NIBCO Technical Services**
csteam1@nibco.com	cs-technicalservices@nibco.com
800.234.0227	888.446.4226

Who should I call when. . . ?

Technical Questions Specification Work Aaron Kilburg Amanda Jost Technical Services team Rick Newbill- BDM	Checking Product Availability Amanda Jost Rick Newbill- BDM Customer Service Team
	Direct all other questions to Aaron Kilburg or Rick Newbill

nibcoinc @nibcoinc nibco inc. nibcoinc NIBCOVideos

NIBCO®

AHEAD OF THE FLOW®

www.nibco.com

ASPE American Society of Plumbing Engineers CEU PROVIDER



APPLICATION FOR CONTINUING EDUCATION APPROVAL
COURSE CONDITIONS AND GUIDELINES

The Ohio Board of Building Standards is committed to the ongoing education and professional development of board-certified personnel through the delivery of high-quality, accurate and engaging professional continuing education content. To this end, the Board reviews and approves Continuing Education Courses for building department personnel.

Board approval is granted for course instruction on current codes and standards, including the OBC, OMC, OPC, and RCO, and any other content areas directly related to the responsibilities of the certification for which credit is being requested.

Promotion: Any person or organization promoting an approved course is required to make full and accurate disclosure regarding course title, course approval number, number of credit hours, categories for which the BBS has approved the class, and fees in promotion materials and advertising. ***The Board does not grant retroactive approval. It is recommended that courses be submitted for approval well in advance of any scheduling of classes and advertising***. Advertising may not falsely state BBS approval before approval is granted. Course providers may state that BBS approval is pending.

Application Submission: All Applications and associated materials shall be submitted by email in .pdf format. Instructions for completing the application are attached.

Certificate of Completion: Course providers shall provide participants a certificate of completion containing the following information:

- Name of participant
- Title of approved courses
- BBS approval #
- BBS approved certifications
- Date of the continuing education program
- Number of approved credit hours awarded, and
- Signature of authorized sponsor or instructor.

Any person or organization administering an approved course shall return a completed BBS Course Attendance form by email.

Participants: Participants must attend the complete course as presented by the instructor to receive credit hours approved by the Board. The organization or instructor of online courses shall plan and execute methods to verify the individual's attendance and completion of the course. No partial credit will be given to any participant who failed to complete the entire course as approved.

Board approval: All courses are approved for the calendar year in which application is made. Courses may be renewed so long as the referenced code is in effect, and the CEUs, certification and content remain unchanged. When the referenced code is updated, courses must be updated, and new approvals obtained.

Facility/training area: BBS Course may be delivered in person or online, or both, at the sponsor's option.
Course facilities shall include the following:

In Person Classes:
Sufficient seating capacity
ADA accessible facilities
Appropriate Audio/Visual devices for delivery
Writing surfaces for participants

Online Classes:
Web-accessible
ADA accessible delivery
Tech support available
Live and recorded courses permitted

In-person facilities shall comfortably and safely seat at least the number of attendees present in the room and shall be climate controlled, non-smoking, and sound controlled so that outside noise will not interfere with the training.

Ohio Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: James A. Richardson Jr.

Organization: City of Columbus

Address:

E-mail: jarichardson@columbus.gov Telephone: 6147744855

Website: www.columbus.gov/bzs

Conference Sponsor (if applicable) OAPI Conference Email:

Check here if Course Renewal: ☐ Prior course number _____ (*i.e. BBS2018-429*)

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: Valves 101

Course instructor:

Course description:

A comprehensive discussion/presentation on valve design and application with plumbing systems.

Instructional hours per session: 1 Number of Sessions: 1

Course Date(s) and Location: OAPI annual Training Conference

Special Content:

Code Administration ☐ Conference Course:

Existing Buildings: ☐ Conference Name:

Electrical Instruction: ☐ Conference location:

Plumbing Instruction: ✔

Course to be offered online? ✔ **On Demand** ✔ **Webinar** ✔

Course Website: www.oapi.org

Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation)*:

Online/On Demand - exit questions, Webinar - monitored by IT proctor - exit questions developed by the Board after in-person conference prior to offing online.

Course applicable for the following certifications

Residential Certifications Only: ☐ Commercial Certifications: ✔

Administrative Course, All Certifications: ☐

Application materials included:

✔ Course Outline or Course Learning Objectives

✔ Presentation Materials/Slides (not required for roundtable courses)

✔ Assessment Materials (for online courses)

✔ Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

Instructions for new Continuing Education Approval form

Provider Information

1. Please include all contact information.
2. If course is not part of a conference, leave conference sponsor and email blank.

Course Renewal

1. Indicate if the course is being submitted for renewal. Include prior approval letter and write in prior course number.
2. Certification approval for courses has now changed: all existing courses being renewed will be approved within the new classification system.
    a. Courses previously approved for only residential certifications will be approved for all residential certifications.
    b. Courses previously approved for at least on commercial certification will now be approved for all commercial certifications and all residential certifications.
    c. Courses on required instruction topics, Ohio Ethics, Code Administration and Existing Buildings, will be noted as Administrative Courses and be approved for all certifications.
3. Courses being renewed should skip the New Course information section and are not required to submit outline, agenda, slides or other instructional materials for review. Skip to Special Content, and mark any item that applies to the course.

New Course Information

1. Enter course title, name of instructor, and a brief description of the course content. Learning objectives may be substituted for course description, if desired.
2. Number of instructional hours per session is the length of instructional time.
3. Number of sessions: can be 1 or the number of sessions planned.
4. Course date(s) and location: not necessary at this time, enter if known.

Special Content

1. Indicate if the course will meet instructional time in Code Administration or Existing Buildings.
2. Indicate if the course is a plumbing or electrical course, for ESIAC review and trainee course tracking.
3. If the course is associated with a conference, indicate the conference name and location, as this will allow BBS to coordinate approvals with the conference provider.
4. If the course will be offered online, specify whether it will be on demand or offered as a virtual webinar, or both. Include website where the course will be provided.

Course applicable for the following certifications

This section represents a major change from previous BBS course approval forms.

1. If the course is only for residential certifications, check 'Residential Certifications Only'. The course, if approved, will be approved for all residential certifications.
2. If the course is appropriate for any commercial certifications, check Commercial Certifications. The course, if approved, will be approved for all commercial certification **AND** all residential certifications.
3. If the course is intended to meet required instruction in Code Administration (Chapter 1) or Existing Buildings (commercial or residential) check 'Administrative Course, All Certifications'.

Application Materials Included

This is a checklist for the course submitter's use, to be sure all materials necessary for review are included with the application. All materials should be submitted in .pdf format, along with the application, via email to Michael.Lane@com.ohio.gov or BBS@com.ohio.gov

File Attachments for Item:

EC-4 Water and Fuel Gas Press Fit Connections (Ohio Association of Plumbing Inspectors)

All certifications (1 hour)

OAPI Press Fit for Water and Fuel Gas Piping Systems Learning Objectives

1. Familiarize participants with reference standards associated to Press Fit fittings.
2. Familiarize participants with the various applicable sealing elements for Press Fit fittings.
3. Familiarize participants with proper installation practices for Press Fit fittings.
4. Familiarize participants with proper testing procedures for Press Fit fittings.
5. Familiarize participants with operational pressure limitations for Press Fit fittings.

APPLICATION FOR CONTINUING EDUCATION APPROVAL
COURSE CONDITIONS AND GUIDELINES

The Ohio Board of Building Standards is committed to the ongoing education and professional development of board-certified personnel through the delivery of high-quality, accurate and engaging professional continuing education content. To this end, the Board reviews and approves Continuing Education Courses for building department personnel.

Board approval is granted for course instruction on current codes and standards, including the OBC, OMC, OPC, and RCO, and any other content areas directly related to the responsibilities of the certification for which credit is being requested.

Promotion: Any person or organization promoting an approved course is required to make full and accurate disclosure regarding course title, course approval number, number of credit hours, categories for which the BBS has approved the class, and fees in promotion materials and advertising. ***The Board does not grant retroactive approval. It is recommended that courses be submitted for approval well in advance of any scheduling of classes and advertising***. Advertising may not falsely state BBS approval before approval is granted. Course providers may state that BBS approval is pending.

Application Submission: All Applications and associated materials shall be submitted by email in .pdf format. Instructions for completing the application are attached.

Certificate of Completion: Course providers shall provide participants a certificate of completion containing the following information:

- Name of participant
- Title of approved courses
- BBS approval #
- BBS approved certifications
- Date of the continuing education program
- Number of approved credit hours awarded, and
- Signature of authorized sponsor or instructor.

Any person or organization administering an approved course shall return a completed BBS Course Attendance form by email.

Participants: Participants must attend the complete course as presented by the instructor to receive credit hours approved by the Board. The organization or instructor of online courses shall plan and execute methods to verify the individual's attendance and completion of the course. No partial credit will be given to any participant who failed to complete the entire course as approved.

Board approval: All courses are approved for the calendar year in which application is made. Courses may be renewed so long as the referenced code is in effect, and the CEUs, certification and content remain unchanged. When the referenced code is updated, courses must be updated, and new approvals obtained.

Facility/training area: BBS Course may be delivered in person or online, or both, at the sponsor's option.
Course facilities shall include the following:

In Person Classes:
Sufficient seating capacity
ADA accessible facilities
Appropriate Audio/Visual devices for delivery
Writing surfaces for participants

Online Classes:
Web-accessible
ADA accessible delivery
Tech support available
Live and recorded courses permitted

In-person facilities shall comfortably and safely seat at least the number of attendees present in the room and shall be climate controlled, non-smoking, and sound controlled so that outside noise will not interfere with the training.

Ohio | Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: James A. Richardson Jr.
Organization: City of Columbus
Address:
E-mail: jarichardson@columbus.gov Telephone: 6147744855
Website: www.columbus.gov/bzs
Conference Sponsor (if applicable) OAPI Conference Email:

Check here if Course Renewal: ☐ Prior course number _____ (*i.e. BBS2018-429*)
Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: Water and Fuel Gas Press Fit Connections
Course instructor: Dan Sabetta
Course description:
A comprehensive discussion/presentation Press Fit applications for potable water and fuel gas piping systems.

Instructional hours per session: 1 Number of Sessions: 1
Course Date(s) and Location: OAPI annual Training Conference

Special Content:

Code Administration ☐
Existing Buildings: ☐
Electrical Instruction: ☐
Plumbing Instruction: ✔

Conference Course: _____
Conference Name: _____
Conference location: _____

Course to be offered online? ✔ **On Demand** ✔ **Webinar** ✔
Course Website: www.oapi.org
Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation)*:
Online/On Demand - exit questions, Webinar - monitored by IT proctor - exit questions developed by the Board after in-person conference prior to offing online.

Course applicable for the following certifications

Residential Certifications Only: ☐ Commercial Certifications: ✔
Administrative Course, All Certifications: ☐

Application materials included:

✔ Course Outline or Course Learning Objectives
✔ Presentation Materials/Slides (not required for roundtable courses)
✔ Assessment Materials (for online courses)
✔ Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

Instructions for new Continuing Education Approval form

Provider Information

1. Please include all contact information.
2. If course is not part of a conference, leave conference sponsor and email blank.

Course Renewal

1. Indicate if the course is being submitted for renewal. Include prior approval letter and write in prior course number.
2. Certification approval for courses has now changed: all existing courses being renewed will be approved within the new classification system.
    a. Courses previously approved for only residential certifications will be approved for all residential certifications.
    b. Courses previously approved for at least on commercial certification will now be approved for all commercial certifications and all residential certifications.
    c. Courses on required instruction topics, Ohio Ethics, Code Administration and Existing Buildings, will be noted as Administrative Courses and be approved for all certifications.
3. Courses being renewed should skip the New Course information section and are not required to submit outline, agenda, slides or other instructional materials for review. Skip to Special Content, and mark any item that applies to the course.

New Course Information

1. Enter course title, name of instructor, and a brief description of the course content. Learning objectives may be substituted for course description, if desired.
2. Number of instructional hours per session is the length of instructional time.
3. Number of sessions: can be 1 or the number of sessions planned.
4. Course date(s) and location: not necessary at this time, enter if known.

Special Content

1. Indicate if the course will meet instructional time in Code Administration or Existing Buildings.
2. Indicate if the course is a plumbing or electrical course, for ESIAC review and trainee course tracking.
3. If the course is associated with a conference, indicate the conference name and location, as this will allow BBS to coordinate approvals with the conference provider.
4. If the course will be offered online, specify whether it will be on demand or offered as a virtual webinar, or both. Include website where the course will be provided.

Course applicable for the following certifications

This section represents a major change from previous BBS course approval forms.

1. If the course is only for residential certifications, check 'Residential Certifications Only'. The course, if approved, will be approved for all residential certifications.
2. If the course is appropriate for any commercial certifications, check Commercial Certifications. The course, if approved, will be approved for all commercial certification **AND** all residential certifications.
3. If the course is intended to meet required instruction in Code Administration (Chapter 1) or Existing Buildings (commercial or residential) check 'Administrative Course, All Certifications'.

Application Materials Included

This is a checklist for the course submitter's use, to be sure all materials necessary for review are included with the application. All materials should be submitted in .pdf format, along with the application, via email to Michael.Lane@com.ohio.gov or BBS@com.ohio.gov

MegaPress – Features & Benefits

- Carbon steel fitting with Zinc/Nickel coating
  - Corrosion Resistance
- EPDM, HNBR, & FKM sealing elements
  - Hydronics, fire protection, natural gas, vacuum, air, etc.
- Smart Connect® Technology
  - Ensures all connections are pressed prior to commissioning!
- 450+ fitting configurations
  - Couplings, elbows, tees, reducers, adapters, etc.
- MegaPress jaws fit all Ridgid, Milwaukee, and other standard press tool manufacturers
- MegaPress XL fittings require either a booster (Ridgid) or long throw tool.
- Refer to tool manufacturer for compatibility of Megapress Jaws and/or Ring Kits with their respective tool.





Property of Viega LLC

MegaPress – Features & Benefits

- For use with black or galvanized steel pipe
- Retains structural integrity of pipe
- No threading equipment or accessories
- Piping systems install using the same means and methods; *only the connection method changes!*
- No welding or fire watch
- Installation under flow conditions
- Clean - No oils or debris
- Reduced installation time
  - More jobs done in less time
  - 30% - 60% time savings over threading
  - Up to 70% time savings over welding
- Reliable
- Consistent connection every time
- Proven press technology







Property of Viega LLC

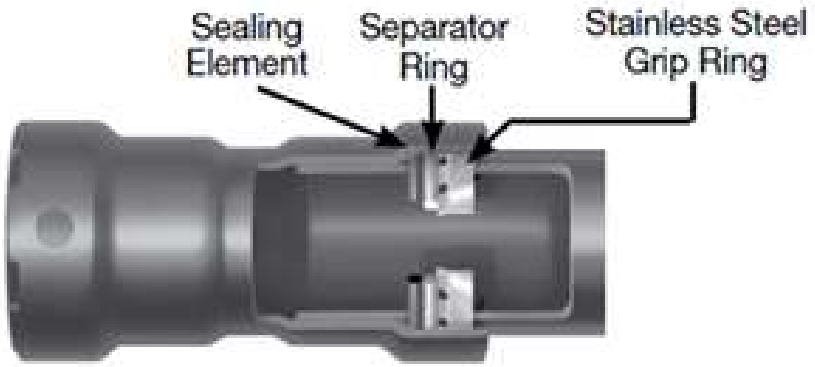
MegaPress & MegaPressG ½” to 2” – Technical Information



Fitting Components

- 420 stainless steel grip ring
  - Bi-directional teeth grip the pipe and ensure that the fitting is locked securely to the piping.

- 304 stainless steel separator ring
  - Protects sealing element by providing positive physical separation





Property of Viega LLC

MegaPress & MegaPressG ½” to 2” – Technical Information

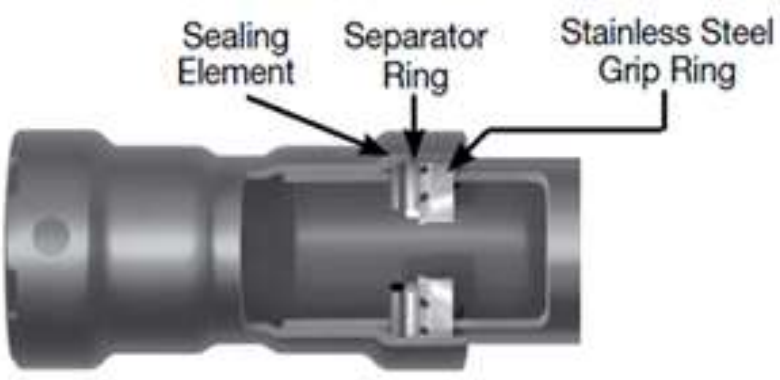


Sealing Elements on ½” – 2” fittings

- EPDM (shiny black)
- FKM (dull black)
- HNBR (yellow)

- Ribbed at the pipe contact surface.
  - Differs from a standard ProPress sealing element due to small irregularities of the pipe surface.

- **Sealing Elements are never interchangeable within MegaPress Systems!**



Property of Viega LLC

MegaPress EPDM & FKM 1/2” to 4”– Technical Information



Fitting Components

- 420 stainless steel grip ring
  - Provides mechanical strength
- 304 SS separator ring (1/2” – 2”)
- PBT separator ring (2-1/2” – 4”)
  - Protects sealing element from grip ring
- FKM sealing element
  - Broad selection of applications, temperatures, and pressures

Sealing Elements are never interchangeable within MegaPress Systems!

Property of Viega LLC

MegaPressG 2 ½” to 4”– Technical Information



Fitting Components

- 420 stainless steel grip ring
  - Provides mechanical strength
- 304 SS separator ring (1/2” – 2”)
- Black graphite separator ring (2-1/2” – 4”)
  - Protects sealing element from grip ring
- HNBR sealing element
  - Broad selection of applications, temperatures, and pressures

Sealing Elements are never interchangeable within MegaPress Systems!

Property of Viega LLC

MegaPress System – Technical Information

Pipe Compatibility: ½” – 2” sizes

- **MegaPress:** Green dot, EPDM sealing element
  - Schedule **5 - 40**
- **MegaPress FKM:** White dot, FKM sealing element
  - Schedule **5 - 40**
- **MegaPressG:** Yellow dot, HNBR sealing element
  - Schedule **5 - 40**
  - **Schedule 40** only in fuel gas applications
  - 2018 NFPA 54 allows Sch.10 in fuel gas, only with MegaPressG fittings. (Press Connect Fittings)





Property of Viega LLC

MegaPress System – Technical Information





Pipe Compatibility 2 ½" – 4" sizes

- **MegaPress:** Green dot, EPDM sealing element
  - Schedule **10 - 40**
- **MegaPress FKM:** White dot, FKM sealing element
  - Schedule **10 - 40**
- **MegaPressG:** Yellow dot, HNBR sealing element
  - Schedule **10 - 40**
  - **Schedule 40** only in fuel gas applications
  - 2018 NFPA 54 allows Sch.10 in fuel gas, only with MegaPressG fittings. (Press Connect Fittings)

Property of Viega LLC

MegaPress System – Technical Information

Pipe Compatibility

Fuel Gas Applications:

ASTM A 53

- Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless

Non-Fuel Gas Applications:

ASTM A 135

- Specification for Electric Resistance Welded Steel Pipe

ASTM A 795

- Specification for Black and hot-dipped, Zinc-coated (Galvanized), Welded and Seamless Steel Pipe for Fire Protection Use

ASTM A 106

- Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service

Property of Viega LLC

MegaPressG System – Approved Locations

Underground Installations

- MegaPressG fitting systems are approved for underground installations. However, any installations must meet all state and local codes, including those for underground

Concealed Spaces

- MegaPress G has been examined to the construction and performance criteria in the CSA requirement LC-4 and was found acceptable. Specific performance tests were conducted to evaluate the fittings for use in concealed locations

Property of Viega LLC

Approved applications

Media[1]	System Operating Conditions			Product Line, Material, and Sealing Element[2]								
				ProPress			ProPress and MegaPress Stainless			MegaPress		MegaPressG
				Copper			304	316		Carbon Steel		
	Comments	Max Pressure (psig)	Temperature Range (°F)	EPDM	FKM	HNBR	FKM	EPDM	FKM	EPDM	FKM	HNBR
Water/Liquids												
Hot and Cold Potable Water	Test pressure 600 psi	300 ProPress Copper 250 ProPress Valves 200 ProPress Stainless and all MegaPress	See note [3]	✓				✓				
Rainwater / Graywater				✓	✓		✓	✓	✓			
Chilled Water	≤50% Ethylene / Propylene glycol			✓	✓		✓	✓	✓	✓	✓	
Hydronic Heating Water	≤50% Ethylene / Propylene glycol			✓	✓		✓	✓	✓	✓	✓	
Treated Water	Fully desalinated, deionized, demineralized, distilled (open system)		32° to 250°				✓	✓	✓			
Reverse Osmosis Water	<1 MΩ						✓	✓	✓			
Paraffin Wax		200	Max 100°				✓		✓			
Methyl Ethyl Ketone								✓				
Isopropyl Alcohol			Ambient[5]				✓	✓	✓	✓	✓	
Nitric Acid	Concentration ≤10%						✓	✓	✓			
Phosphoric Acid	Concentration ≤25%							✓	✓			
Fire Sprinkler	NFPA 13, 13D, 13R	175		✓			✓	✓	✓	✓	✓	
Steam	Low-pressure	15	Max 250°		✓[4]		✓[4]		✓[4]		✓[4]	
	Residential	5	Max 227°	✓[4]	✓[4]		✓[4]	✓[4]	✓[4]	✓[4]	✓[4]	

[1] It is recommended that all systems be clearly labeled with the media being conveyed. For further information please consult Viega Technical Services.
[2] All Viega systems must be used with the manufacturer's recommended sealing element. Contact your local Viega representative or Viega Technical Services for specific application temperature, pressure, and concentration limits.
[3] System pressure and temperature ranges depend on sealing element. Any ranges listed above will be overruled by the sealing element limits here:
[3a] EPDM temperature ranges are typically 0°F to 250°F.
[3b] FKM temperature ranges are typically 14°F to 284°F with temperature spikes (24hr) up to 356°F.
[3c] HNBR temperature ranges are typically -40°F to 180°F.
[4] System must contain adequate condensate drainage.
[5] Ambient temperatures should be taken as normal operating conditions for the applications not to exceed sealing element limitations.
[6] Compliant with CSA 6.32 / ANSI LC-4.
[7] Tubing with oxygen barrier should be used for systems with ferrous components.

Approved applications

Media[1]	System Operating Conditions			Product Line, Material, and Sealing Element[2]								
				ProPress			ProPress and MegaPress Stainless			MegaPress		MegaPressG
				Copper			304	316		Carbon Steel		
	Comments	Max Pressure (psig)	Temperature Range (°F)	EPDM	FKM	HNBR	FKM	EPDM	FKM	EPDM	FKM	HNBR
Fuels/Oils/Lubricants												
Ethanol	Pure grain alcohol	200	Ambient[6]	✓				✓				
Mineral Oil							✓		✓		✓	✓
Lube Oil	Petroleum based		Max 150°			✓	✓		✓		✓	✓
Biodiesel	ASTM D6751	140							✓		✓	
Propane		125	-40° to 180°									✓[5]
Butane												✓[5]
Natural Gas	Primarily methane											✓[5]
Heating Fuel Oil			Max 100°			✓	✓		✓		✓	✓
Diesel Fuel						✓	✓		✓		✓	✓
Kerosene			Max 68°				✓		✓		✓	

[1] It is recommended that all systems be clearly labeled with the media being conveyed. For further information please consult Viega Technical Services.
[2] All Viega systems must be used with the manufacturer's recommended sealing element. Contact your local Viega representative or Viega Technical Services for specific application temperature, pressure, and concentration limits.
[3] System pressure and temperature ranges depend on sealing element. Any ranges listed above will be overruled by the sealing element limits here:
[3a] EPDM temperature ranges are typically 0°F to 250°F.
[3b] FKM temperature ranges are typically 14°F to 284°F with temperature spikes (24hr) up to 356°F.
[3c] HNBR temperature ranges are typically -40°F to 180°F.
[4] System contains adequate condensate drainage.
[5] Compliant with CSA 6.32 / ANSI LC-4.
[6] Ambient temperatures should be taken as normal operating conditions for the applications not to exceed sealing element limitations.

Property of Viega LLC

Approved applications

Media[1]	System Operating Conditions			Product Line, Material, and Sealing Element[2]								
				ProPress			ProPress and MegaPress Stainless			MegaPress		MegaPressG
				Copper			304	316		Carbon Steel		
	Comments	Max Pressure (psig)	Temperature Range (°F)	EPDM	FKM	HNBR	FKM	EPDM	FKM	EPDM	FKM	HNBR
Gases												
Compressed Air	Oil Concentration ≤25 mg/m³	200	Max 140°	✓	✓	✓	✓	✓	✓	✓[4]	✓[4]	✓[4]
	Oil Concentration >25 mg/m³				✓	✓	✓		✓		✓[4]	✓[4]
Nitrogen - N_2				✓	✓	✓	✓	✓	✓	✓	✓	✓
Carbon Dioxide - CO_2	Dry			✓	✓	✓	✓	✓	✓	✓	✓	✓
Carbon Monoxide - CO				✓	✓	✓						
Argon - Ar				✓	✓	✓	✓	✓	✓	✓	✓	✓
Ammonia	Anhydrous		Max 120°					✓				
Oxygen - O_2	Non-medical Keep free of oil and grease	140	Max 140°	✓				✓		✓		
Hydrogen - H_2		125		✓	✓	✓	✓	✓	✓	✓	✓	✓
Acetylene	Test pressure 350 psi	20	Ambient[6]				✓	✓	✓	✓	✓	✓
Vacuum	Minimum absolute pressure Maximum differential pressure	750µm Hg 29.2" Hg	Max 160°	✓	✓	✓	✓	✓	✓	✓	✓	✓

[1] It is recommended that all systems be clearly labeled with the media being conveyed. For further information please consult Viega Technical Services.
[2] All Viega systems must be used with the manufacturer's recommended sealing element. Contact your local Viega representative or Viega Technical Services for specific application temperature, pressure, and concentration limits.
[3] System pressure and temperature ranges depend on sealing element. Any ranges listed above will be overruled by the sealing element limits here:
[3a] EPDM temperature ranges are typically 0°F to 250°F.
[3b] FKM temperature ranges are typically 14°F to 284°F with temperature spikes (24hr) up to 356°F.
[3c] HNBR temperature ranges are typically -40°F to 180°F.
[4] System contains adequate condensate drainage.
[5] Compliant with CSA 6.32 / ANSI LC-4.
[6] Ambient temperatures should be taken as normal operating conditions for the applications not to exceed sealing element limitations.

Property of Viega LLC

Approved applications

Media[1]	System Operating Conditions			Product Line, Material, and Sealing Element[2]								
				ProPress			ProPress and MegaPress Stainless			MegaPress		MegaPressG
				Copper			304	316		Carbon Steel		
	Comments	Max Pressure (psig)	Temperature Range (°F)	EPDM	FKM	HNBR	FKM	EPDM	FKM	EPDM	FKM	HNBR
Special Media												
Methanol		200	75°					✓				
Latex Paint			32° to 250°					✓	✓			
Urea Solution	Concentration ≤40%	140	100°					✓				
Caustic Soda	Concentration ≤50%		140°					✓				
Acetone	Liquid	70	-14° to 104°	✓				✓				

[1] It is recommended that all systems be clearly labeled with the media being conveyed. For further information please consult Viega Technical Services.
[2] All Viega systems must be used with the manufacturer's recommended sealing element. Contact your local Viega representative or Viega Technical Services for specific application temperature, pressure, and concentration limits.
[3] System pressure and temperature ranges depend on sealing element. Any ranges listed above will be overruled by the sealing element limits here:
[3a] EPDM temperature ranges are typically 0°F to 250°F.
[3b] FKM temperature ranges are typically 14°F to 284°F with temperature spikes (24hr) up to 356°F.
[3c] HNBR temperature ranges are typically -40°F to 180°F.
[4] System contains adequate condensate drainage.
[5] Compliant with CSA 6.32 / ANSI LC-4.
[6] Ambient temperatures should be taken as normal operating conditions for the applications not to exceed sealing element limitations.

Viega ProPress & Megapress:

Codes, Standards & Listings

Viega ProPress – Plumbing Code References

2018 IPC:

TABLE 605.5
PIPE FITTINGS

MATERIAL	STANDARD
Acrylonitrile butadiene styrene (ABS) plastic	ASTM D2468
Cast iron	ASME B16.4
Chlorinated polyvinyl chloride (CPVC) plastic	ASSE 1061; ASTM D2846; ASTM F437; ASTM F438; ASTM F439; CSA B137.6
Copper or copper alloy	ASME B16.15; ASME B16.18; ASME B16.22; ASME B16.26; ASME B16.51; ASSE 1061; ASTM F1476; ASTM F1548

605.13.5 Press-connect joints. Press-connect joints shall conform to one of the standards indicated in Table 605.5, and shall be installed in accordance with the manufacturer's instructions. Cut tube ends shall be reamed to the full inside diameter of the tube end. Joint surfaces shall be cleaned. The tube shall be fully inserted into the press-connect fitting. Press-connect joints shall be pressed with a tool certified by the manufacturer.

2018 UPC:

TABLE 604.1
MATERIALS FOR BUILDING SUPPLY AND WATER DISTRIBUTION PIPING AND FITTINGS

MATERIAL	BUILDING SUPPLY PIPE AND FITTINGS	WATER DISTRIBUTION PIPE AND FITTINGS	REFERENCED STANDARD(S) PIPE	REFERENCED STANDARD(S) FITTINGS
Copper and Copper Alloys	X	X	ASTM B42, ASTM B43, ASTM B75, ASTM B88, ASTM B135, ASTM B251, ASTM B302, ASTM B447	ASME B16.15, ASME B16.18, ASME B16.22, ASME B16.26, ASME B16.50[2], ASME B16.51, ASSE 1061

605.1.3.2 Press-Connect Fittings. Press-connect fittings for copper or copper alloy pipe or tubing shall have an elastomeric o-ring that forms the joint. The pipe or tubing shall be fully inserted into the fitting, and the pipe or tubing marked at the shoulder of the fitting. Pipe or tubing shall be cut square, chamfered, and reamed to full inside diameter. The fitting alignment shall be checked against the mark on the pipe or tubing to ensure the pipe or tubing is inserted into the fitting. The joint shall be pressed using the tool recommended by the manufacturer.

Viega MegapressG – Fuel Gas Code References

2018 IFGC:

403.10.1 Pipe joints. Schedule 40 and heavier pipe joints shall be threaded, flanged, brazed, welded or assembled with press-connect fittings listed in accordance with ANSI LC-4/CSA 6.32. Pipe lighter than Schedule 40 shall be connected using press-connect fittings, flanges, brazing or welding. Where nonferrous pipe is brazed, the brazing materials shall have a melting point in excess of 1,000°F (538°C). Brazing alloys shall not contain more than 0.05-percent phosphorus.

2018 NFPA 54 / ANSI Z223.1:

5.6.7.1* Pipe Joints. Schedule 40 and heavier pipe joints shall be threaded, flanged, brazed, welded, or assembled with press-connect fittings listed to ANSI LC 4/CSA 6.32, *Press-Connect Metallic Fitting for Use in Fuel Gas Distribution Systems*.

(A) Pipe lighter than Schedule 40 shall be connected using press-connect fittings, flanges, brazing, or welding.

(B) Where nonferrous pipe is brazed, the brazing materials shall have a melting point in excess of 1,000°F (538°C).

(C) Brazing alloys shall not contain more than 0.05 percent phosphorus.

Property of Viega LLC

Propress & MegaPress Code Compliance & Listings

ICC ES PMG-1037 confirms ProPress Compliance for Plumbing, HVAC Systems, and hydronic piping:

- 2006 to 2021 IRC, IPC, IMC
- ICC ES LC 1002-2013

ICC ES PMG-1036 confirms MegaPressG Compliance for fuel gas systems with:

- 2006 to 2021 IFGC, IRC and UPC
- ANSI LC 4/CSA 6.32-2012

Property of Viega LLC

Reliability – Performance Tests: Plumbing & Mechnical Codes

Testing Criteria: ASTM F3226

13.3 Hydrostatic Proof Test

Pressurized to 1.5 times the rated pressure (Propress = 300 psi X1.5 = 450 psi).

13.4 Hydrostatic Burst Test

Pressurized to four times the rated pressure (Propress = 300 psi X 4 = 1200 psi).

13.5 Pull-Out Test

Pressurized to design pressure (Propress = 300 psi) and subjected to an external axial load of: $L = \pi/4(D^2)(p)$

where:

L = applied axial load,
D = pipe/tube OD, and
p = design pressure.

13.6 Vacuum Test

Test shall be conducted @ 6.5 inches of Hg for not less than 5 min.

13.7 Vibration Test

Three tests for 3,000,000 cycles @ 100 Hz, 45 Hz, & 10 Hz

13.8 Fire Test

Subjected to a temperature of 1472 ˚F @ 72 psi for 30 min.

13.9 Impulse Test

Pressure cycling from 0 to 1.5 the design pressure (Propress = 300 psi) at a frequency of 30-100 cycles. Number of cycles shall not be less than 500,000.

Property of Viega LLC

Reliability – Performance Tests: Fuel Gas Codes

Testing Criteria: ANSI LC 4/CSA 6.32-2012

5.2 Leakage

Pressurized to 600psi at 68˚F and 200˚F for 48 hrs

5.3 Pressure Capacity

Pressurized to 400 psi and a torsional load (15 -177 ft-lb) for 48 hrs

5.4 Axial Strength

10,000 cycles of 200 psi water pressure shock

5.5 Torsion

1,000,000 cycles of vibration at 25 Hz at 350 psi

5.6 Bending Strength

Temperature cycling from 68˚F to 200˚F at 150 psi for 5000 cycles

5.7 Impact Strength

Temperature cycling from 68˚F to 200˚F at 150 psi for 5000 cycles

5.8 Resistance to Loosening

Axial load of 200 lbs, pressurized to approx. 15 psi @ 60˚F for 30 hours of vibration at 16 Hz.

5.9 Resistance to Extreme Temperature Cycles

Temperature cycling from -40˚F to 180˚F @ 15 psi for 1 hour

5.10 Resistance to Freezing and Thawing

Freeze/Thaw temperature cycling from -40˚F to 50˚F at 15 psi for 25 cycles

5.12 Exposure to Elevated Temperatures

Pressurized to 1.5 times the operating pressure at 1000˚F for 18 hrs

Property of Viega LLC

Reliability – Performance Tests: Fire Sprinkler Code

Testing Criteria: **UL 213 Fire Sprinkler**

Step 1. Hydrostatic Pressure Test

Cool to -40˚F for 24 hours
Warm to ambient temp
Hydrostatic pressure test at 5X working pressure (1000 psi)

Step 2. High Temperature Test

Static pressure of 125 psi
Warm to 900˚F for 1 hour

Step 3. Burn Test

Static pressure of 125 psi
Immerse piping over 25 gallons of burning heptane
Temperature at pipe surface is 1500˚F

Property of Viega LLC

Viega Goes Beyond the Standard with Seismic Certification



Figure 2.2: UUT-2 Mounted on Shake Table

WEGAI
W.E. GUNDY & ASSOCIATES, INC.
STRUCTURAL & EARTHQUAKE ENGINEERING

REPORT NO. 1311-01

SPECIAL SEISMIC CERTIFICATION REPORT

VIEGA PRESS FITTINGS PRODUCT LINES

Certified to CBC-2013 Section 1705.12 and IBC 2012 Section 1705.12
$S_{DS} = 2.0$, $S_s = 3.0$, $I_p = 1.5$ for $z/h = 1.0$

REPORT PREPARED BY: W. E. GUNDY & ASSOCIATES, INC.

DATE SIGNED OR REVISED: AUGUST 2016

EQUIPMENT MANUFACTURED BY:

VIEGA LLC
100 N. Broadway
Wichita, KS 67202

THIS IS TO CERTIFY THAT THE ABOVE NAMED PRODUCT LINE MEETS OR EXCEEDS ALL OF THE REQUIREMENTS ACCORDING TO CBC-2013 & IBC-2012 FOR SPECIAL SEISMIC CERTIFICATION WITH THE SEISMIC PARAMETERS LISTED ABOVE.

SIGNED:

REGISTERED PROFESSIONAL ENGINEER
TRAVIS E. SOPPE
6115
Exp. 6-30-17
STRUCTURAL
STATE OF CALIFORNIA

P.O. Box 2900 Hailey, ID, 83333
Tel (208) 788-5989 ~ Fax (208) 788-5990
Email: tsoppe@wegai.com
Web: www.wegai.com

Property of Viega LLC



DAN SABETTA

Technical Manager

Dan Sabetta is Technical Manager for the Great Lakes Region for manufacturer Viega, providing education for design professionals, contractors, and inspectors. Dan graduated from The Ohio State University in 2011 with a Bachelor degree in Civil & Environmental Engineering. Prior to that Dan spent over 10 years working in many roles, such as, controls engineering, energy engineering, contracting sales and new system sales.

CONTACT

PHONE:
330-212-7008

WEBSITE:
www.viega.us

EMAIL:
Daniel.sabetta@viega.us

File Attachments for Item:

EC-5 2023 NEC Changes and Updates Chapters 1-3 (Labriola Training Agency)

All certifications (4 hours)

APPLICATION

FOR

Continuing Education Course Approval

Continuing education programs approved for education credit by the Ohio Board of Building Standards may be used for compliance with certification requirements related to code enforcement, plan review, and inspection responsibilities. The credit is to be used to renew the certifications issued by the Ohio Board of Building Standards pursuant to section 3781.10(E) ORC.

Board of Building Standards
6606 Tussing Road, P.O. Box 4009
Reynoldsburg, Ohio 43068-9009
(614) 644-2613 Fax: (614) 644-3147
dic.bbs@com.state.oh.us
www.com.state.oh.us/dic/dicbbs.htm

COURSE SUBMITTER

Course Submitter: John M. Labriola (Contact Name)
Organization: Labriola Training Agency #191 (Organization/Company)
Address: 150 Maplecrest St. SW (Include Room Number, Suite, etc.)
City: North Canton State: Ohio Zip: 44720
E-Mail: j john@ta191.com
Telephone: (330) 497.6309 Fax: n/a
Course Sponsor: None

COURSE INFORMATION

Course Title: 2023 National Electrical Code Changes & Updates (Presentation #1)

New Course Submittal: ■ Update Course: ☐ Prior Approval Number:

Purpose and Objective: The purpose of this course is to provide NEC updates to all attendees, utilizing a custom PowerPoint presentation with graphics and in-depth discussion for each slide, by using a common sense approach. There is no charge for BBS certified personnel.

Number of Instructional Contact Hours that can be obtained upon completion: 4 Hours

If Multi-Session, Number of Instructional Contact Hours Per Session:

Program Applicable for the Following Participants:

Building Official ■ Master Plans Examiner ■ Plumbing Plans Exam. ☐ Electrical Plans Exam. ■ Mechanical Plans Exam. ■ Building Inspector ■ Fire Protection Inspector ■ Mechanical Inspector ■ Plumbing Inspector ☐ Non-Res IU Inspector ■

Res Building Official ■ Res Plans Examiner ■ Res Building Inspector ■ Res Mechanical Inspector ☐ Res IU Inspector ☐

Electrical Safety Inspectors ☐
Location of ESI Course: Arrowhead Golf & Event Center Date(s) of ESI Course(s): Various Dates & Locations TBD

SUBMITTAL CHECKLIST: **Make Sure** all of the Following Information is **Submitted**		Check Off
Course Submitter:	Name of contact person and their certification numbers, organization, address, fax, phone	x
Course Sponsor:	Organization sponsoring or requesting the program (if any)	x
Course Title:	Name of course (related to content)	x
Purpose/Objective:	Describe purpose and how course will improve competency of certification(s) listed	x
Contact Hours:	Indicate instructional time and credit requested in hours (e.g.: 0.5 hr, 1 hr, 3.5 hrs)	x
Participants:	Check off each certification for which credit is requested (for which course relates to certification)	x
Content of Program:	Include collated agenda, time schedule, course outline; list specific sections of code, references, and topics covered	x
Course Materials:	Collated workbooks, handouts, hard copy or electronic versions of program is available	x
Instructor(s) Info.:	Resume of professional/educational qualifications & teaching/training experience/BBS certifications	x
Test Materials:	Copy of quizzes or tests to be given	
Completed Application:		

NOTE: The Board will NOT grant retroactive approval for courses presented prior to approval date.

RECEIVED
JAN 27 2023
BOARD OF BUILDING STANDARDS

Form 3526

www.ta191.com

January 25, 2023

2023 NEC Changes & Updates; Chapters 1 – 3

4 Hour Course Timeline

(1) NEC Code Adoption Process in Ohio & Chapter 34 Residential Code of Ohio (2019)

30 minutes (Slides 1-10)

(2) Chapter 1 – General

45 Minutes (Slides 11-16)

(3) Chapter 2 – Wiring & Protection

150 Minutes (Slides 17-57)

(4) Chapter 3 – Wiring Methods & Materials (300-305)

15 Minutes (Slides 58-61)

4 Hour Total Class Time = 240 Minutes

July 01, 2019

Current Adopted Codes in Ohio – (2017)

Non-Residential Construction (4- Family and Above)

2017 Ohio Building Code (Based on the 2015 International Building Code) 2017

Ohio Mechanical Code (Based on the 2015 International Mechanical Code) 2017

Ohio Plumbing Code (Based on the 2015 International Plumbing Code) 2017

Ohio Fire Code (Based on the 2015 International Fire Code)

2017 NFPA 70 – National Electrical Code **(Effective 11.01.2017)**

2016 NFPA 13 – Standard for Installation of Sprinkler Systems 2016

NFPA 72 – National Fire Alarm and Signaling Code

2015 International Fuel Gas Code

2012 International Energy Conservation Code / ASHRAE 90.1 2013

ICC / ANSI A117.1 2017 Accessible & Usable Buildings and Facilities

Residential Construction (1, 2 and 3- Family Dwellings)

2019 Residential Code of Ohio (Based on the 2018 International Residential Code)

2017 Ohio Plumbing Code

2017 NFPA 70 – National Electrical Code w/ amendments **(07.01.2019)**

2018 International Energy Conservation Code

www.ta191.com

August 01, 2022

Current Adopted Building Codes in West Virginia

The State of West Virginia Fire Commission has adopted statewide the 2018 ICC (International Code Council), family of Codes for any jurisdiction that chooses to enforce building codes. Check locally for enforcement information / details.

2017 Accessible & Usable Buildings & Facilities (A117.1)
2018 International Building Code (IBC)
2013 International Energy Conservation Code (ASHRAE 90.1)
2018 International Existing Building Code (IEBC)
2018 International Fuel Gas Code (IFGC)
2018 International Mechanical Code (IMC)
2018 International Plumbing Code (IPC)
2018 International Property Maintenance Code (IPMC)
2018 International Residential Code (1- & 2- Family) (IRC)
2015 International Energy Code of Residential Buildings (IECC)
2018 International Swimming Pool & Spa Code (ISPSC)

2021 NFPA 1 - West Virginia Fire Code
2016 NFPA 13 - Installation of Sprinkler Systems
2020 NFPA 70 - National Electrical Code
2016 NFPA 72 - National Fire Alarm & Signaling Code
2021 NFPA 101 - West Virginia Life Safety Code

www.ta191.com

CHAPTER 34
ELECTRICAL

SECTION 3401
ELECTRICAL

3401.1 *Electrical.* *The provisions of the National Electrical Code, NFPA 70, shall be incorporated herein and shall govern the installation, testing and operation of the electrical systems of one-, two- and three-family dwellings and their accessory structures except for the following:*

1. ***Section 210.8(A)(2) shall be modified to read:***

   Garages, and also accessory buildings that have a floor located at or below grade level not intended as habitable rooms and limited to storage areas, work areas, and areas of similar use *except for the receptacle located to serve a garage door opener when the device is a single receptacle and located in the ceiling.*

2. ***Section 210.8(A)(5) shall be modified to read:***

   Unfinished portions or areas of the basement not intended as habitable rooms.

   Exceptions:

   1. A receptacle supplying only a permanently installed fire alarm or burglar alarm system shall not be required to have ground-fault circuit-interrupter protection.
   2. *A single receptacle located to serve a sump pump shall not be required to have ground-fault circuit-interrupter protection when there is a duplex receptacle with ground-fault circuit-interrupter protection within six (6) feet of the sump pump.*

3. ***Section 210.8(D) shall be deleted.***

4. ***Section 210.12(A) shall be modified to read:***

   All 120-volt single-phase, 15- and 20-ampere branch circuits supplying outlets or devices installed in dwelling unit kitchens, family rooms, dining rooms, living rooms, parlors, libraries, dens, bedrooms, sun rooms, recreational rooms, closets, hallways, laundry rooms, or similar rooms or areas shall be protected by any of the means described in 210.12(A)(1) through (6):

   (l) A listed combination-type arc-fault circuit interrupter, installed to provide protection of the entire branch circuit.

   (2) A listed branch/feeder-type AFCI installed at the origin of the branch-circuit in combination with a listed outlet branch-circuit type arc-fault circuit interrupter installed at the first outlet box on the branch circuit. The first outlet box in the branch circuit shall be marked to indicate that it is the first outlet of the circuit.

   (3) A listed supplemental arc protection circuit breaker installed at the origin of the branch circuit in combination with a listed outlet branch-circuit type arc-fault circuit interrupter installed at the first outlet box on the branch circuit where all of the following conditions are met:

   a. The branch-circuit wiring shall be continuous from the branch-circuit overcurrent device to the outlet branch-circuit arc-fault circuit interrupter.

   b. The maximum length of the branch-circuit wiring from the branch-circuit overcurrent device to the first outlet shall not exceed 15.2 m (50 ft.) for a 14 AWG conductor or 21.3 m (70 ft.) for a 12 AWG conductor.

   c. The first outlet box in the branch circuit shall be marked to indicate that it is the first outlet of the circuit.

   (4) A listed outlet branch-circuit type arc-fault circuit interrupter installed at the first outlet on the branch circuit in combination with a listed branch-circuit overcurrent protective device where all of the following conditions are met:

   a. The branch-circuit wiring shall be continuous from the branch-circuit overcurrent device to the outlet branch-circuit arc-fault circuit interrupter.

   b. The maximum length of the branch-circuit wiring from the branch-circuit overcurrent device to the first outlet shall not exceed 15.2 m (50 ft.) for a 14 AWG conductor or 21.3 m (70 ft.) for a 12 AWG conductor.

   c. The first outlet box in the branch circuit shall be marked to indicate that it is the first outlet of the circuit.

   d. The combination of the branch-circuit overcurrent device and outlet branch-circuit AFCI shall be identified as meeting the requirements for a system combination-type AFCI and shall be listed as such.

   (5) If RMC, IMC, EMT, Type MC, or steel-armored Type AC cables meeting the requirements of 250.118, metal wireways, metal auxiliary gutters, and metal outlet and junction boxes are installed for the portion of the

www.ta191.com

branch circuit between the branch-circuit overcurrent device and the first outlet, it shall be permitted to install a listed outlet branch-circuit type AFCI at the first outlet to provide protection for the remaining portion of the branch circuit.

(6) Where a listed metal or nonmetallic conduit or tubing or Type MC cable is encased in not less than 50 mm (2 in.) of concrete for the portion of the branch circuit between the branch-circuit overcurrent device and the first outlet, it shall be permitted to install a listed outlet branch-circuit type AFCI at the first outlet to provide protection for the remaining portion of the branch circuit.

Exception *No. 1*: Where an individual branch circuit to a fire alarm system installed in accordance with 760.41(B) or 760.121(B) is installed in RMC, IMC, EMT, or steel-sheathed cable, Type AC or Type MC, meeting the requirements of 250.118, with metal outlet and junction boxes, AFCI protection shall be permitted to be omitted.

Exception No. 2: Branch circuits supplying receptacle outlets installed to serve only the kitchen countertop surfaces shall be permitted to be installed without arc-fault circuit interrupter protection.

5. ***Section 210.64 shall be modified to read:***

At least one 125-volt, single-phase, 15- or 20-ampere-rated receptacle outlet shall be installed in an accessible location within 7.5m (25 ft.) of the indoor electrical service equipment. The required receptacle outlet shall be located within the same room or area as the service equipment.

Exception No. 1: The receptacle outlet shall not be required to be installed in one-, two-, *or three*-family dwellings.

Exception No. 2: Where the service voltage is greater than 120 volts to ground, a receptacle outlet shall not be required for services dedicated to equipment covered in Articles 675 and 682.

SECTION 3402
EMERGENCY AND STANDBY POWER SYSTEMS

3402.1 ***Installation.*** *Emergency and standby power systems shall be installed in accordance with this code and NFPA 70. The performance, classification, transfer, testing, and maintenance of emergency and standby power systems shall also comply with either NFPA 110 (liquid- and gas- fueled systems) or NFPA 111 (battery and inertia systems), as applicable.*

3402.1.1 Stationary generators. *Stationary emergency and standby power generator assemblies shall be listed in accordance with UL 2200.*

3402.1.1.1 Engine-driven generators. *The installation of liquid- and gas-fueled stationary internal combustion engines and gas turbines used to drive generator assemblies shall meet the requirements of NFPA 37.*

3402.1.1.1.1 Fuel tanks connected to generator assemblies. *Fuel tanks piped to and supplying fuel for engine-driven generator assemblies may be engine-mounted, located inside of a building, outside of a building, or on a roof in accordance with NFPA 37 or NFPA 30.*

3402.1.1.1.1.1 Engine-mounted tanks. *Engine-mounted tanks located outdoors may be located in accordance with Section 4.1.4 of NFPA 37 and shall be vented in accordance with NFPA 30. Engine-mounted tanks shall be provided with adequate clearance to enable filling, maintenance, and testing, shall be safeguarded against public access, and shall be protected from impact.*

3402.1.1.1.1.2 Other fuel tanks. *Fuel tanks, other than engine-mounted tanks, piped to and supplying the generator engine shall be located, installed, and vented in accordance with the applicable sections of NFPA 37 or located, installed, and vented in accordance with NFPA 30.*

3402.1.1.1.2 Gaseous fuel supply. *Where an internal combustion engine supplied with gaseous fuel powers emergency or standby generators, the fuel gas storage and piping system shall comply with NFPA 37 and Chapter 24.*

www.ta191.com

2020 NEC Adoption in Ohio

December 2022 Update: Still Unknown / Limited Information

210.8(F) **Outdoor Outlets.** Outdoor outlets (Re: HVAC equipment) supplied by branch circuits rated 150-v to ground or less, 50a or less, shall have GFCI protection for personnel. With the use of adjustable speed drives for energy efficient equipment (split systems) are ***not*** compatible with current Type "A" GFCI protection.

Discussions have been ongoing since prior to September 2020.

Residential Code Advisory Committee (RCAC) to consider the 2023 NEC language:

N Ex: #2 GFCI protection shall not be required for listed HVAC equipment. This exception shall expire September 1, 2026.

This and other "*unknown*" amendments shall be considered by OBBS

www.ta191.com



2023 “Proposed” National Electrical Code (NEC) Changes & Updates

Training Agency #191

150 Maplecrest Street SW
North Canton, Ohio 44720
330.497.6309 Phone

John M. Labriola

www.ta191.com

2023 National Electrical Code Changes & Updates



Not Current Code In Ohio

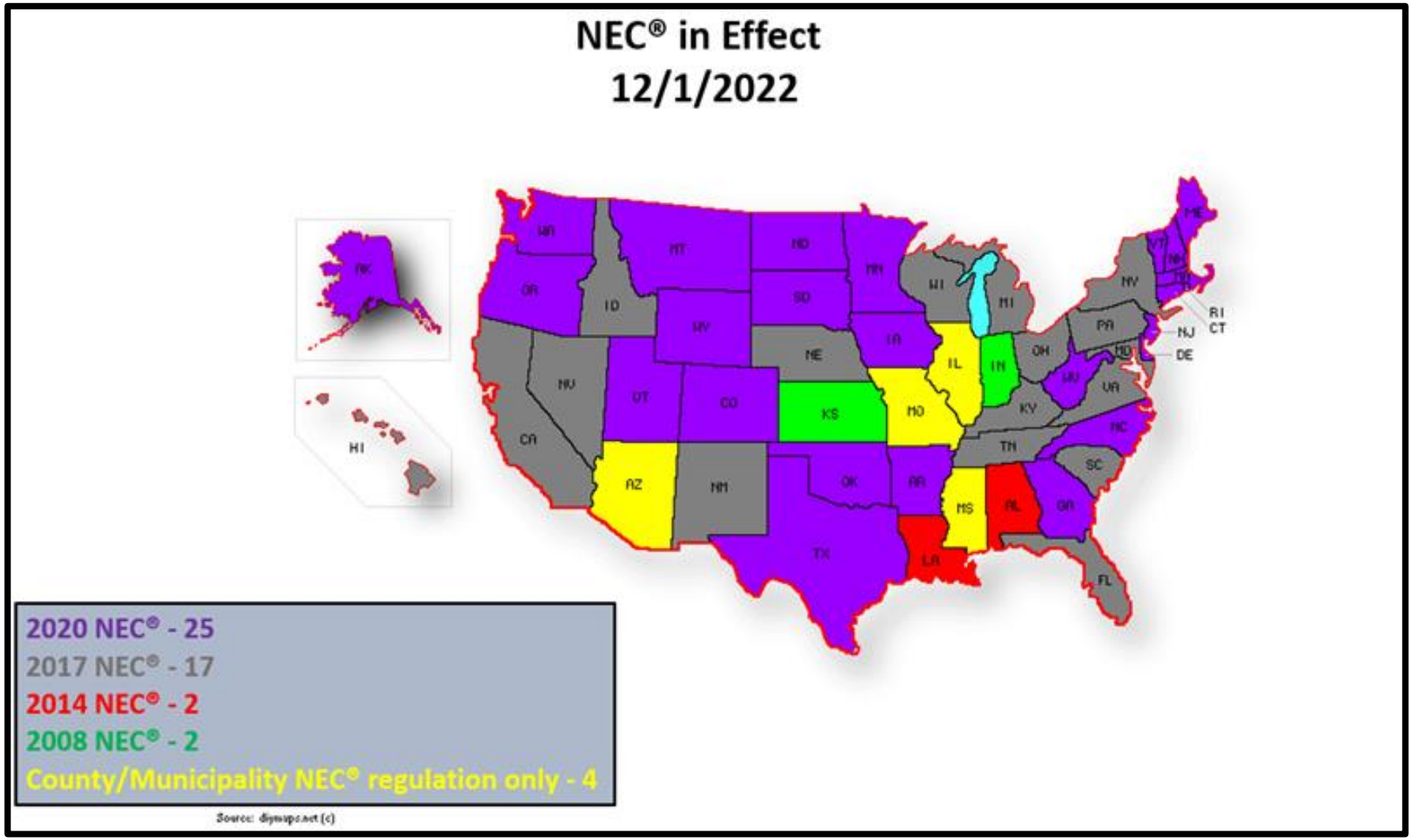
This course is based on the 2023 National Electrical Code (NEC).

The 2023 National Electrical Code has not been adopted in ohio.

Presented for informational purposes only.

Ohio Board of Building Standards

NFPA State Update Map



2023 NEC “10” New Articles

235 – Branch, Feeder, & Service Circuits over 1kV ac & 1.5kV dc

245 – Overcurrent Protection for Systems rated over 1kV ac & 1.5kV dc

305 – General Requirements for Wiring Methods & Materials for Systems rated over 1kV ac & 1.5 kV dc

369 – Insulated Bus Pipe (IBP) / Tubular Covered Conductors (TCC) Systems

371 – Flexible Bus Systems

495 – Equipment over 1kV ac & 1.5kV dc ***(Formerly Article 490)***

512 – Cannabis Oil Equipment / Oil Systems using Flammable Materials

722 – Cables for Power-Limited Circuits & Fault-Managed Power Circuits

724 – Class I Power-Limited & Class I Power-Limited Remote Control & Signaling Systems

726 – Class 4 Fault-Managed Power Systems

Article 100 Definitions

N **Scope.** This article contains only those definitions essential to the application of this Code. It is not intended to include commonly defined general terms or commonly defined technical terms from related codes and standards. An article number in parentheses following the definitions indicates that the definition only applies to that article.

2017 NEC Added Part II – Over 1000 Volts

2020 NEC Added Part III – Hazardous Locations

2023 NEC – Almost all Article .2's are in Article 100

Now almost all definitions utilized in the NEC are in Article 100

Δ 110.16(B) Arc-Flash Hazard Warning

Service Equipment and ***Feeder*** Supplied Equipment.

In other than dwelling units, an addition to the requirements in 110.16(A), a permanent ***arc flash*** label shall be field or factory applied to service equipment and ***feeder supplied equipment rated 1000 amperes or more. The arc flash label shall be in accordance with applicable industry practice and include the date the label was applied.*** The label shall meet the requirements of 110.21(B).

Added Feeders & reduced the ampacity from 1200a to 1000a.

Refer to NFPA 70E-2021

www.ta191.com

Not Current Code in Ohio

N 110.17 Servicing & Maintenance of Equipment

Servicing & electrical preventative maintenance shall be performed by qualified persons trained in servicing & maintenance of equipment & shall comply with the following:

(1) Shall be performed in accordance with the original manufacturers' instructions & information.

(2) Shall utilize identified replacement parts

(a) Provided by original manufacturer

(b) Designed by an experienced engineer

(c) Approved by the AHJ

www.ta191.com

For Informational Purposes Only

N 110.20 Reconditioned Equipment

Reconditioned equipment ***shall*** be permitted except where prohibited elsewhere in this Code. Equipment that is restored to operating condition shall be reconditioned with identified replacement parts, verified under applicable standards, that are either provided by the original equipment manufacturer or that are designed by an engineer experienced in the design of replacement parts for the type of original equipment

N **(A) Equipment required to be Listed**

N **(B) Equipment not required to be Listed**

N **(C) (A) or (B) not available, AHJ may approve (document)**

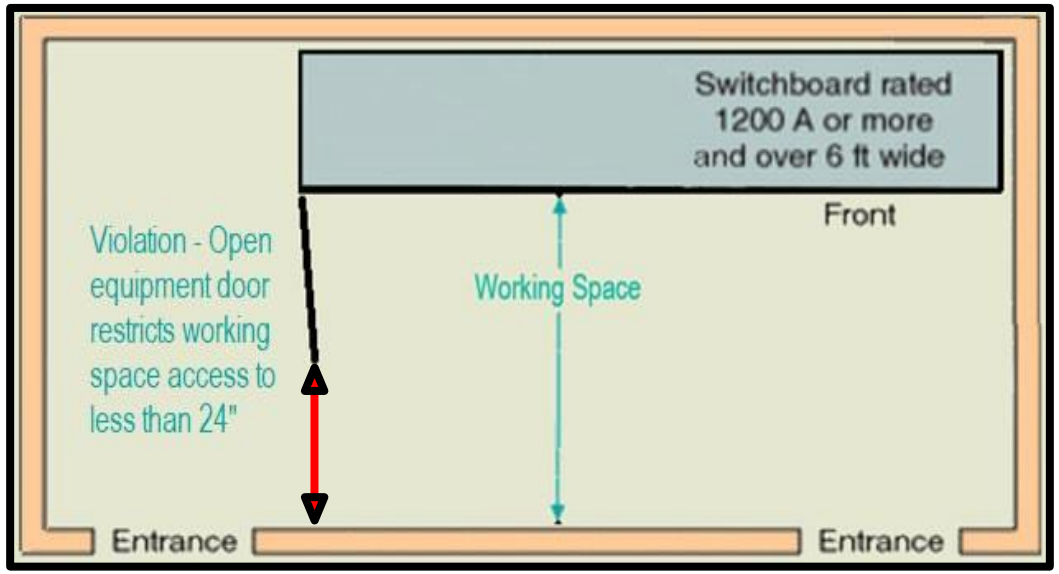
www.ta191.com

Not Current Code In Ohio

Δ 110.26 Working Spaces About Electrical Equipment

"<u>Open</u>" equipment doors shall <u>not</u> impede access to and egress from the working space. Access or egress is impeded if one or more simultaneously opened equipment doors restrict working space access to be less than 24" wide and 6½' high.

***<u>Note</u>**: The intent should be clear, to protect personnel servicing the equipment.*



www.ta191.com

For Informational Purposes Only

N 110.26(A)(6) Working Spaces

Grade level, Floor, or Working Platform

The grade, floor, or platform in the required working space shall be kept clear, and the floor, grade, or platform in the working space ***shall be as level and flat*** as practicable for the entire required depth and width of the working space.

Generally: ***3' in front of equipment &*** **width of equipment**

www.ta191.com

Not Current Code In Ohio

Article 100 - Definitions

Receptacle

A contact device installed at the outlet for the connection of an attachment plug or for direct connection of electrical utilization equipment designed to mate with the corresponding contact device. A single receptacle is a single contact device with no other contact device on the same yoke ***or strap***. A multiple receptacle is two or more contact devices on the same yoke ***or strap.*** (CMP-18)

www.ta191.com

210.8(A), (B), & (E)

Outlet

A point on the wiring system at which current is taken to supply utilization equipment. (CMP-1)

210.8(C) Crawl Space Ltg. Outlets

210.8(D) Specific Appliances

210.8(F) Outdoor Outlets

GFCI Protection Evolution





Type "A" Personnel Protection Trip Level = 4 – 6mA
(Typical design is receptacle or breaker)

Type "B" Equipment Protection Trip Level = 30mA
(rooftop de-icing equipment protection)

Type "C" *SPGFCI* (over 150v to ground) 480v 3ø or Less / Trip Level = 20mA

Type "D" *SPGFCI* (over 150v to ground) 600v 3ø Trip Level – 20mA

Type "E" *"EGFPD" 6mA or adjustable from 10 – 100mA*

Docking Facilities "GFPE" *100mA*

Shore Power "GFPE" protection 30mA

www.ta191.com

Δ 210.8(A) Dwelling Units

GFCI Protection for Personnel

All 125-v through 250-v receptacles installed in the following locations and supplied by single-phase branch circuits rated shall have ground-fault circuit-interrupter for personnel:
(No maximum ampacity noted)

(7) Areas with sinks and permanent provisions for ***food preparation, beverage preparation, or cooking.***

www.ta191.com

For Informational Purposes Only

210.8(A) GFCI Exceptions (Dwellings)

Exceptions 1 - 4

1. **Receptacles, not readily accessible, dedicated circuit for electric snow-melting or pipeline and vessel heating.**
2. **Receptacle supplying only permanently installed premises security system.**
3. **Listed weight-supporting ceiling receptacles *in combination with compatible weight-supporting fittings.***
4. ***Factory mounted receptacles in bathroom exhaust fans (re: installation instructions & listing & labeling)***

Δ 210.8(B) Other than Dwelling Units

GFCI Protection for Personnel

All 125-v through 250-v receptacles installed in the following locations and supplied by 1ø branch circuits rated 50a or less, and 3ø branch circuits rated 100a or less,150-v or less to ground, shall have ground-fault circuit-interrupter for personnel:

(3) Areas with sinks and permanent provisions for food preparation, ***beverage preparation***, or cooking.

(4) *Buffet serving areas with permanent provisions for food serving, beverage serving, or cooking.*

www.ta191.com

For Informational Purposes Only

Δ 210.8(B) Other than Dwelling Units

GFCI Protection for Personnel

(7) Sinks ***where receptacles or cord and-plug-connected fixed or stationary appliances*** **are installed within 6' from the top inside edge of the bowl of the sink.**

N **(13)** ***Aquariums, bait wells, and similar open aquatic vessels or containers, such as tanks or bowls, where receptacles are installed within 6' from the top inside edge or rim or from the conductive support framing of the vessel or container.***

www.ta191.com

Not Current Code In Ohio

Δ 210.8(D) Specific Appliances

GFCI protection shall be provided for the branch circuit or outlet supplying the following appliances, 150-v or less to ground 60a or less; 1ø or 3ø

1. Automotive vacuum cleaners
2. Drinking water coolers / bottle fill stations
3. High-pressure spray washing machines
4. Tire Inflation machines
5. Vending machines
6. Sump pumps
7. Dishwashers
8. ***Electric ranges***
9. ***Wall-mounted ovens***
10. ***Counter-mounted cooking units***
11. Clothes dryers
12. ***Microwave ovens***

www.ta191.com

For Informational Purposes Only

210.8(F) Outdoor Outlets

For dwellings, all outdoor ***outlets***, other than those covered on 210.8(A), Ex.1, including outlets specified in the following locations, and supplied to 1ø branch circuits rated 150-v or less to ground, 50a or less shall be provided with GFCI protected.

1. ***Garages that have floors located at or below grade level.***
2. ***Accessory buildings***
3. ***Boathouses***

Applies to replacing outlet(s) covered by this section!

(Also: 680.22(A)(4) Swimming Pool Outlets)

2020 / NEC 2023 NEC / BBS 10.20.2022 RCAC

State of Ohio (would apply to 1, 2, & 3-family dwellings

****Proposed Amendment****

Re: 210.8(F) Outdoor Outlets (Dwelling Units)

N **Exception #2: GFCI protection shall not be required for listed HVAC equipment. This exception shall expire September 1, 2026**

www.ta191.com

For Informational Purposes Only

Δ 210.11(C)(4) Garage Branch Circuits

In addition to the number of branch circuits by other parts of this section, at least one 120-v, 20a branch circuit shall be installed to supply receptacle outlets, for attached and detached garages with electric power. This circuit shall have no other outlets.

New 2nd Paragraph

Additional branch circuits rated 15a or greater shall be permitted to serve receptacle outlets other than those required by 210.52(G)(1).

www.ta191.com

N 210.12(B) AFCI Protection for Dwelling Units

No Change here; just listed separately

1. Kitchens
2. Family Rooms
3. Dining Rooms
4. Living Rooms
5. Parlors
6. Libraries
7. Dens

8. Bedrooms
9. Sunrooms
10. Recreation Rms.
11. Closets
12. Hallways
13. Laundry Areas
14. Similar Areas

www.ta191.com

For Informational Purposes Only

210.12(C) AFCI Protection for Dormitory Units

All 125-v, 1ø ***10,*** 15- and 20-ampere branch circuits supplying outlets ***or*** devices installed in ***the following locations*** shall be protected by any of the means described in 210.12 (A)(1) - (A)(6).

1. Bedrooms
2. Living Rooms
3. Hallways
4. Closets
5. Bathrooms
6. Similar Locations

www.ta191.com

Not Current Code In Ohio

210.12 (D) AFCI Protection; Other Occupancies

(D) <u>Other Occupancies</u>. ***All*** 125-v 1ø, ***10,*** 15- and 20-ampere branch circuits, supplying outlets ***or*** devices installed in ***the following locations*** shall be protected by any of the means described in 210.12(A)(1) - (A)(6).

1. ***Guest rooms & guest suites of hotel & motels.***
2. ***Areas used exclusively as patient sleeping rooms in nursing homes & limited-care facilities.***
3. ***Areas designed for use exclusively as sleeping quarters in fire, police, ambulance, rescue, ranger stations, & similar locations.***

www.ta191.com

For Informational Purposes Only

N 210.23(A) 10-Ampere Branch Circuits

10-ampere Branch Circuits

210.23(A) ***A 10-ampere branch circuit shall comply with the requirements of 210.25(A)(1) and (A)(2).***

210.23(A)(1) Loads permitted for 10-ampere Branch Circuits.

1. ***Lighting Outlets***
2. ***Dwelling unit exhaust fans or bathroom or laundry room lighting circuits***
3. ***Gas fireplace unit supplied by an individual branch circuit***

www.ta191.com

N 210.23(2) Loads not Permitted for 10-Ampere Branch Circuits

A 10-ampere branch circuit shall

not **supply any of the following:**

1. **Receptacle outlets**
2. **Fixed appliances, except as permitted for individual branch circuits.**
3. **Garage door openers**
4. **Laundry equipment**

www.ta191.com

For Informational Purposes Only

N 210.24 Branch Circuit Requirements; Summary

Expanded this section and tables from applying to Copper conductors only, to include Aluminum and Copper-Clad Aluminum conductors

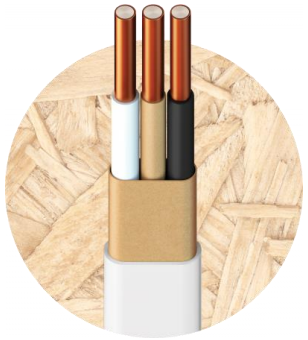


Table 210.24(1) - Applies to Copper Conductors

N **Table 210.24(2) - Applies to both Aluminum & Copper-Clad Conductors**

Δ 210.52(C)(2) Island & Peninsular Countertops & Work Surfaces

Receptacle outlets, ***if*** installed to serve an island or peninsular countertop or work surface, shall be installed in accordance with 210.52(C)(3). ***If a receptacle is not provided to serve an island or peninsular countertop or work surface, provisions shall be provided at the island or peninsular or work surface, provisions shall be provided at the island or peninsula for future addition of a receptacle outlet to serve the island or peninsular countertop or work surface.***

What a Relief!!!

www.ta191.com

For Informational Purposes Only

Δ 210.70(A)(1) Habitable Rooms; Lighting Outlets

Habitable Rooms; Kitchens, *Laundry Areas* & Bathrooms

At least one lighting outlet controlled by a listed mounted control device shall be installed in every habitable room, kitchen, ***laundry areas,*** and bathrooms. The wall-mounted control device shall be located near an entrance to the room on a wall.

Added laundry area to this section. Would Article 314.27(C) require a ceiling suspended (Paddle) fan box?

www.ta191.com

Not Current Code In Ohio

N 215.15 Feeders (Barriers)

Barriers. Barriers shall be placed such that no energized, uninsulated, *ungrounded busbar or terminal* is exposed…….





N **215.15 Feeders**

230.62 Services (2020 NEC)

N **240.21 Transformer Secondaries**

www.ta191.com

For Informational Purposes Only

Article 225 Outside Branch Circuits & Feeders

Part II. Building or Other Structures Supplied by a Feeder(s) or Branch Circuit(s)

Article 230 Services – Part IV. SE Conductors

N **Sections 225.41 & 225.42 / 230.67 & 230.85**

1 & 2-Family Dwelling Emergency Disconnects:

General / Location / Rating / Marking *N* 225.41 / 230.85

Surge Protection: Device / Location / Type / Replacement / Minimum 10kA Ratings

N **225.42 / 230.67**

www.ta191.com

Not Current Code In Ohio

Δ 230.67 Expanded Surge Protection



Expanded Surge Protection Requirements

230.67(A) Surge Protective Device.

1. Dwelling units

2. Dormitory units



3. Guest rooms & guest suites of Hotels & Motels

4. Areas of nursing homes & limited-care facilities used exclusively as patient sleeping rooms

www.ta191.com

For Informational Purposes Only

Δ 230.71 Maximum Number of Service Disconnects

(B) Two to Six Service Disconnecting Means

1. Separate enclosures, each with a main SE disconnect.
2. Panelboards with a main SE disconnect.
3. Vertical switchboard sections that have separate SE disc.
4. SE disconnect in switchgear, ***transfer switches,*** or meter mods where each disconnect is located in a separate compartment.

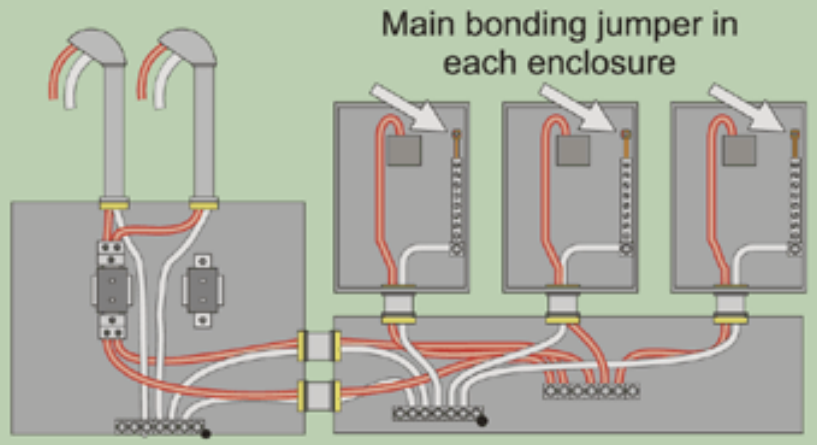
N 5. Meter mods with a main SE disconnect in each metering center.

N 6. MCC's with 1 SE disconnect or a max of 2 SE disconnects with barriers provided between each MCC unit or compartment.

www.ta191.com

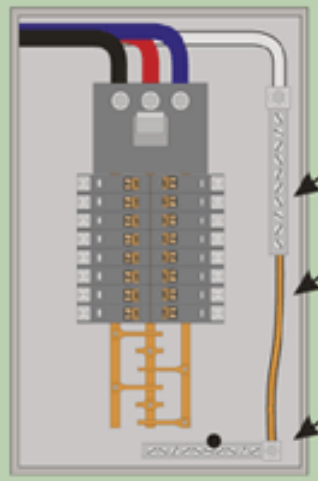
Not Current Code in Ohio

Main Bonding Jumper - Multiple Enclosures

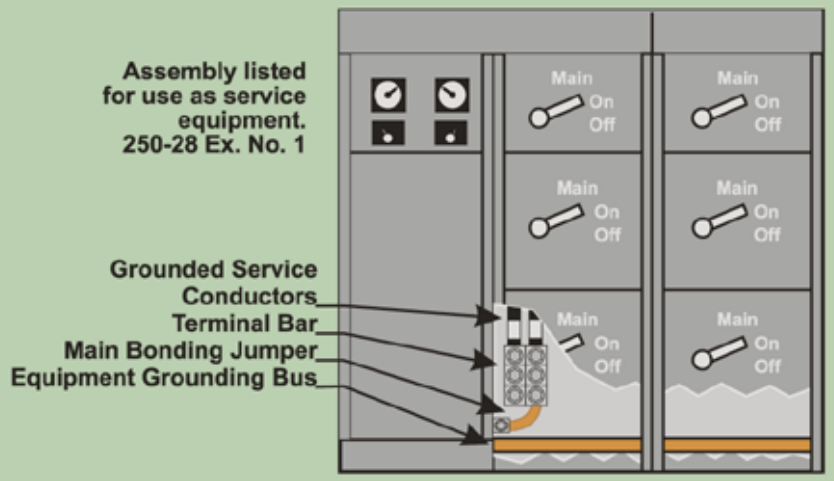


(All conductors not shown)

Main Bonding Jumper



Main Bonding Jumper for Listed Assembly





www.ta191.com

N 230.71(B)(5) & (6) 6 Handle Rule





www.ta191.com

For Informational Purposes Only

230.85(A) Emergency Disconnects; General

For 1 & 2-family dwelling units, an emergency disconnecting means shall be installed.

N* (1) Location.** The disconnecting means shall be installed in a readily accessible location ***on or within sight of the dwelling unit.

***N* (2) Rating. The disconnecting means shall have a short-circuit current rating equal to or greater than the available fault current.**

***N* (3) Grouping. If more than 1 disconnecting means is provided, they shall be grouped.**

www.ta191.com

For Informational Purposes Only

230.85(B) Emergency; Disconnects

N **(B) Disconnects. Each disconnect shall be one of the following:**

1. Service Disconnect

2. A meter disconnect integral to the meter mounting equipment ***not marked as suitable only*** as SUSE equipment, installed in accordance with 230.82

3. Other listed disconnect switch or circuit marked as that is marked SUSE, but ***not marked as suitable only*** as SUSE, installed on the supply side of each service disc

N 230.85(C) Emergency Disconnects

N **Replacements. Where service equipment is *replaced*, all of the requirements of this section shall apply.**

N **Exception:** Where ***only meter sockets, or related raceways and fittings are replaced***, the requirements of this section shall not apply.

For Informational Purposes Only

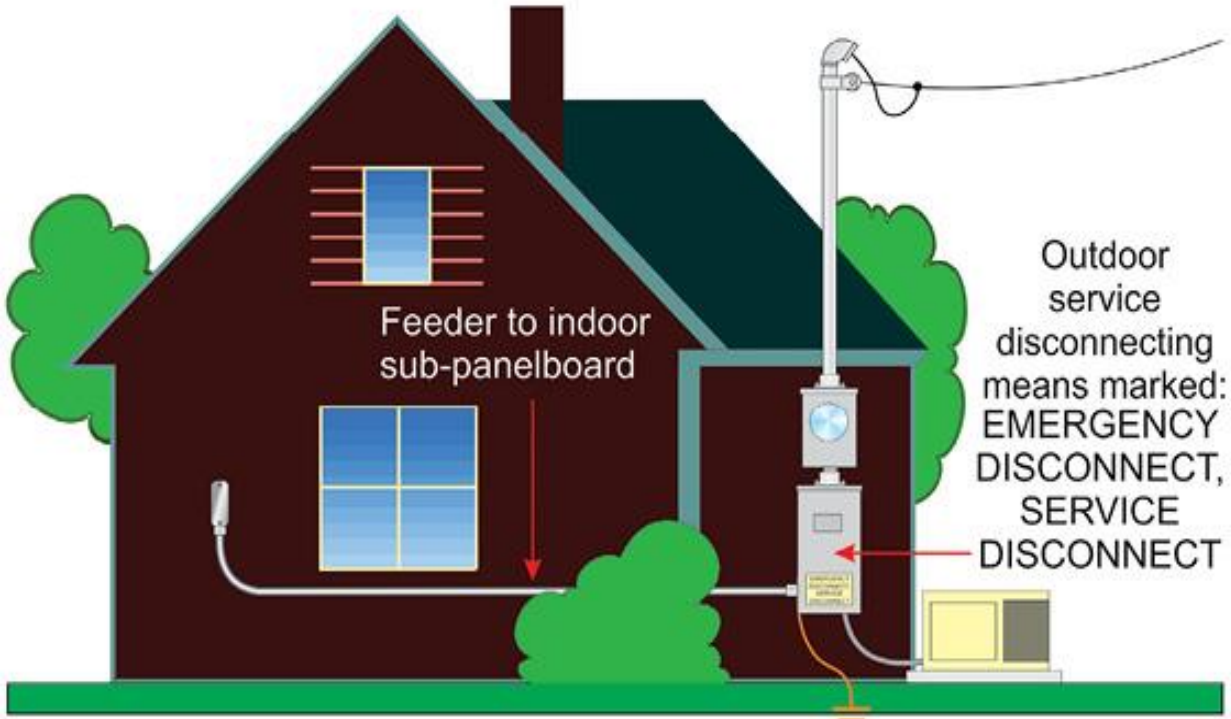
N 230.85(D) Emergency Disconnects

N Identification of Other Isolation Disconnects.

Where equipment for isolation of other energy source systems is not located adjacent to the emergency disconnect required by this section, a plaque or directory identifying the location of all equipment for isolation of other energy sources shall be located adjacent to the disconnecting means required by this section.

RE: Battery, Generator, Interconnected Power Production Sources, and Energy Storage Systems

230.85 Exterior Emergency Disconnect(s)



For dwellings, all service conductors to terminate in disconnecting means having a short-circuit current rating equal to or greater than the available fault current, installed in a readily accessible outdoor location

If more than one disconnec… ined

www.ta191.com



nec

230.85 EXTERIOR EMERGENCY "SE" DISCONNECT

Applies to 1- and 2-Family Dwelling Units

All **service conductors to terminate in a SUSE rated disconnecting means, with adequate SCCR, in a readily accessible *outdoor* location. Grouping is required.**

Intent to protect firefighters / other emergency personnel.



CAN A SMART METER ACT AS AN EMERGENCY DISCONNECT

Until recently I was a proponent of this type of installation. However, I am out of touch with technology. Due to more consumers utilizing multiple energy sources:

1. <u>Commercial power supply</u>

2. <u>Interconnected Power Production Sources</u>

(a) On-site Generator

(b) Photovoltaic System

(c) Wind Energy System

(d) Battery System

(e) Fuel Cell System

(f) Energy Storage System

<u>Posting permanent plaque of sources</u>

N 230.85 (E)(1) Emergency Disconnects

Marking Text

1. Service Disconnect
EMERGENCY DISCONNECT, SERVICE DISCONNECT

2. Meter Disconnects installed in accordance with 230.82(3) as follows: ***EMERGENCY DISCONNECT, METER DISCONNECT, NOT SERVICE EQUIPMENT***

3. Other listed disconnect switches or circuit breakers on the supply side of each service disconnect that are marked suitable for use as SE and marked as follows:

EMERGENCY DISCONNECT NOT SERVICE EQUIPMENT

www.ta191.com

For Informational Purposes Only

N 230.85(E)(2) Emergency Disconnects

Marking Location & Size

Markings shall comply with 110.21(B) & both of the following:

(1) The marking or labels shall be located on the outside front of the disconnect enclosure with ***RED*** background and ***WHITE*** text.

(2) The letters shall be at least (½”) high.

N Article 235 – Branch, Feeder, & Service Circuits over *1000v ac.*

235.1 Scope. This article the general requirements for branch circuits, feeders and services over 1000v ac or 1000v dc, nominal.

235.5(C)(1)(a) *Means of identification*. Separate color coding, marking, tape, tagging or other approved means

235(C)(1)(b) *Posting of identification means*. *Documented in a readily accessible manner at each panelboard.*

Existing installations*. *Required to mark only new system voltage being added.

www.ta191.com

Not Current Code In Ohio

N Article 235 – Branch, Feeder, & Service Circuits over ***1500v dc***

235.5(C)(2) *Branch Circuits Supplied from DC Systems*.

Each ungrounded conductor #4 and larger shall be identified by polarity at all termination, connection and splice points by marking tape, tagging or tape or other approved means and each #6 and smaller ungrounded conductor shall be identified by polarity at all termination points.

The identified methods used for conductors shall be documented at all panelboard locations in a manner readily available or be permanently posted at each panelboard location.

DC Conductor Identification (Positive)

235.3(C)(2)(a) Positive Polarity (DC) *Sizes #6 and smaller.*

Where the positive polarity of a dc system does not serve as the connection point for the grounded conductor, each positive conductor shall be identified by ***one*** of the following means:

(1) A continuous red outer finish

(2) Continuous red stripe along the entire length or (color other than green, white, gray or black)

(3) Imprinted minus signs(+) or the word positive or POS identified not more than 24” along its’ entire length

(4) Approved sleeving or shrink tubing at all terminations

www.ta191.com

For Informational Purposes Only

DC Conductor Identification (Negative)

235.3(C)(2)(b) Negative Polarity (DC) *Sizes #6 and smaller.*

Where the negative polarity of a dc system does not serve as the connection point for the grounded conductor, each positive conductor shall be identified by ***one*** of the following means:

(1) A continuous black outer finish

(2) Continuous black stripe along the entire length or (color other than green, white, gray or red)

(3) Imprinted minus signs(-) or the word negative or NEG identified not more than 24” along its entire length

(4) Approved sleeving or shrink tubing at all terminations

240.4(B) OCD Rated 800a or Less

New 2nd Paragraph

*If the overcurrent protective device is an **adjustable trip device** installed in accordance with 240.4(B)(1),(2), & (3) it **shall be permitted to be set to a value that does not exceed the next higher standard value** above the ampacity of the conductors being protected as shown in 240.6(A) where **restricted access** is accordance with 240.6(C) is provided.*



(1) Continuous Amps

(2) Short-time Pickup

(3) Instantaneous Pickup

(4) Ground Fault Pickup



www.ta191.com

For Informational Purposes Only

N Article 245 – Overcurrent Protection for Systems rated over 1kV ac & 1.5kV dc

New Medium Voltage Conductor Article

245.1 Scope. This article covers overcurrent protection requirements for systems rated over 1kV ac 1.5kv dc, nominal.

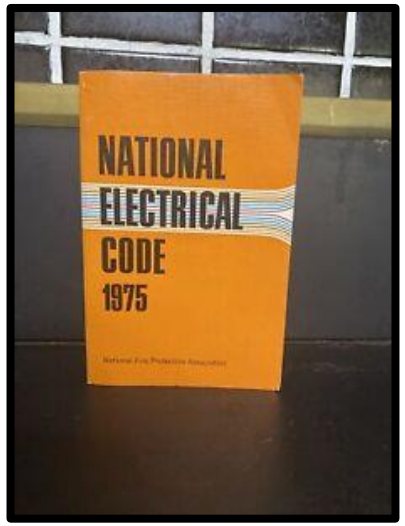
245.21 Circuit Breaker & Fuse protection

245.26 Feeders & Branch Circuits

www.ta191.com

Not Current Code In Ohio

Article 250 Grounding & Bonding



The 2023 NEC Code Cycle is extremely unique in that I found no significant changes in Article 250. This is the 1st time I have experienced this since entering the electrical trade during the 1975 NEC Code Cycle.

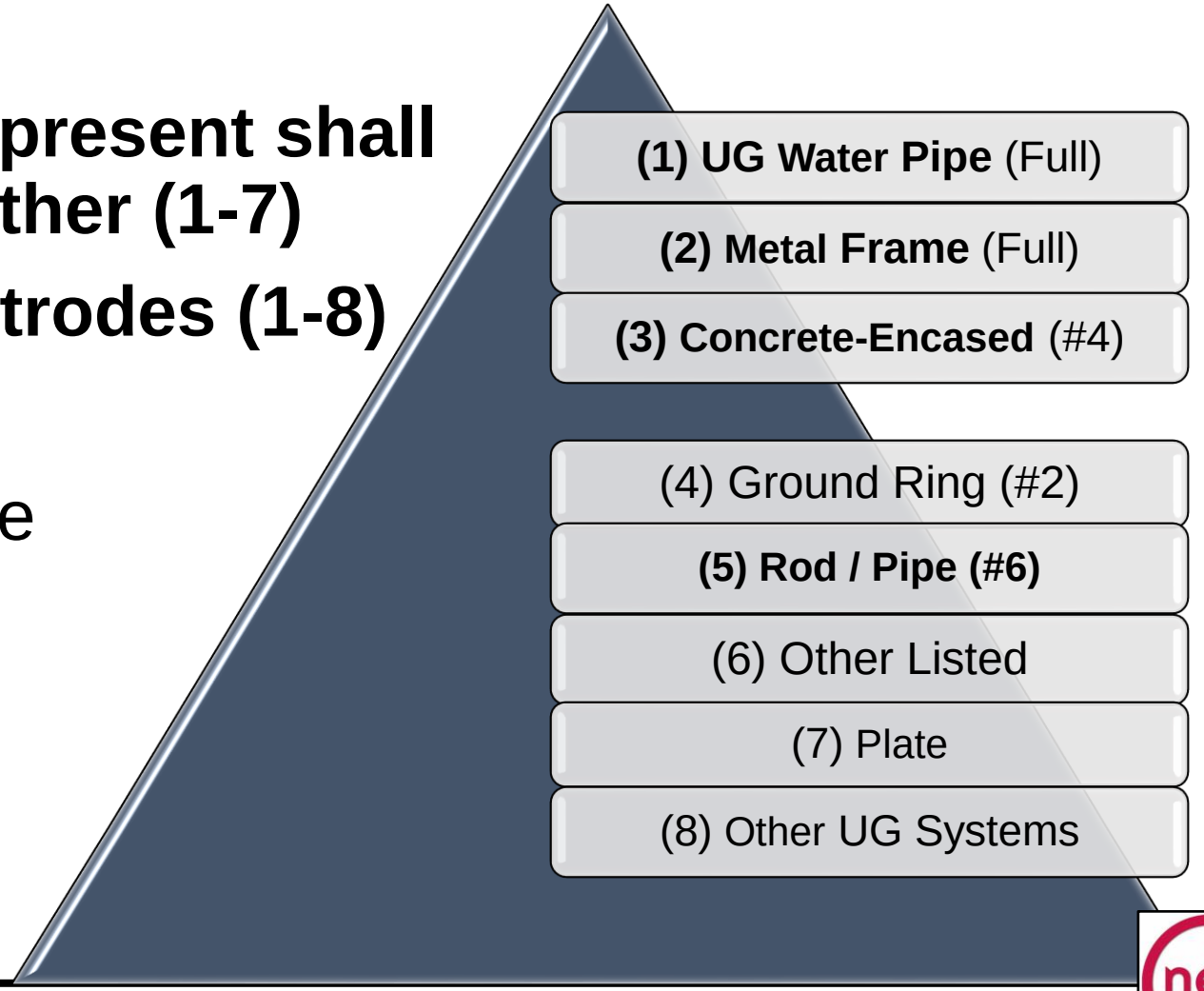
Grounding Triangle / Foundation

250.50 <u>All</u> Electrodes present shall be bonded together (1-7)

250.52 Permitted Electrodes (1-8)

<u>Focus</u>:

1. Metal UG Water Pipe
2. Building Steel
3. Concrete-Encased
4. Rod / Pipe



www.ta191.com

Δ 250.140 Frames of Ranges & Dryers

N (B) Grounded Conductor Connections

Since 1996 the NEC has required 4-wire branch circuits for new installations of Electric Ranges & Dryers

Existing Installations: Expanded Use of 3-wire "SE" Cable

Prior editions of the NEC only permitted 3-wire SE cable that originated in SE equipment.

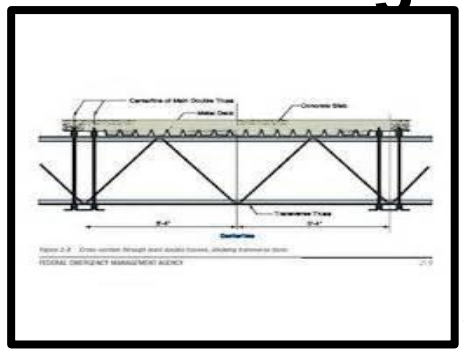
*This change now permits in **"existing installations"**, that the bare SE grounded conductor may be **insulated** or field covered **(taped)** in locations other than SE equipment.*

www.ta191.com

For Informational Purposes Only

Article 300 General Requirements for Wiring Methods & Materials

300.4(E) Cables, raceways or boxes installed under metal roof corrugated decking.



***N* Exception #2**

*The 1½" spacing is **not** required where metal-corrugated sheet roof decking is covered with a **minimum** 2" concrete slab, measured from the top of the corrugated roofing*

****Re: *N* 410.10(F) Exception****

Δ 300.14 Length of Free Conductors

At Outlets, Junctions, and Switch Points

At least 6” of free conductor, measured from the point in the box, where it emerges from its raceway or cable sheath, shall be left at each outlet, junction, and switch point for splices or the connection of luminaires or devices. ***The 6” free conductor shall be permitted to be spliced or unspliced.*** Where an opening to an outlet, junction, or switch point is less than 8” in any dimension, each conductor shall be long enough to extend at least 3” outside the opening.





Δ 300.25 Exit Enclosures (Stair Towers)

Where an exit enclosure is required to have ***fire resistance rating,*** only electrical wiring methods serving equipment permitted by the authority having jurisdiction in the exit enclosure shall be installed within the exit enclosure.

N Exception. ***Where egress lighting on the outside exterior doorways from the exit enclosure, luminaires shall be permitted to be supplied from the inside of the exit enclosure.***



"Self-closing doors are indicative of a fire rating"

N Article 305 – General Requirements for Wiring Methods & Materials for Systems rated over 1kV ac & 1.5 kV dc

New Medium Voltage Conductor Article

305.1 Scope. This article covers wiring methods and materials for systems rated over 1kV ac, 1.5kV dc.

305.3 Exposed runs of MV cables, bare conductors, & bare busbars shall be permitted in locations accessible only to qualified persons. Busbars shall be permitted to be either CU or AL.

Not Current Code In Ohio

Article 310 Conductors for General Wiring

Δ 310.3(B) Conductor Material

Conductors in this article shall be of, aluminum (AA-8000), copper or copper-clad aluminum unless otherwise specified.

Aluminum and copper-clad aluminum shall comply with the following: material shall be ***(listed)***.

For copper-clad aluminum conductors the copper shall form a minimum of 10% of the cross-sectional area of a solid conductor or each strand of a stranded conductors.





Table 310.16 Ampacities of Insulated Conductors with Not More Than Three Current-Carrying Conductors in Raceway, Cable, or Earth (Directly Buried)

Size AWG or kcmil	Temperature Rating of Conductor [See Table 310.4(A)]						Size AWG or kcmil
	60°C (140°F)	75°C (167°F)	90°C (194°F)	60°C (140°F)	75°C (167°F)	90°C (194°F)	
	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, XHWN, USE, ZW	Types TBS, SA, SIS, FEP, FEPB, MI, PFA, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN, Z, ZW-2	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, XHWN, USE	Types TBS, SA, SIS, THHN, THHW, THW-2, THWN-2, RHH, RHW-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN	
	COPPER			ALUMINUM OR COPPER-CLAD ALUMINUM			
18*	—	—	14	—	—	—	—
16*	—	—	18	—	—	—	—
14*	15	20	25	—	—	—	—
12*	20	25	30	15	20	25	12*
10*	30	35	40	25	30	35	10*
8	40	50	55	35	40	45	8
6	55	65	75	40	50	55	6
4	70	85	95	55	65	75	4
3	85	100	115	65	75	85	3
2	95	115	130	75	90	100	2
1	110	130	145	85	100	115	1
1/0	125	150	170	100	120	135	1/0
2/0	145	175	195	115	135	150	2/0
3/0	165	200	225	130	155	175	3/0
4/0	195	230	260	150	180	205	4/0
250	215	255	290	170	205	230	250
300	240	285	320	195	230	260	300
350	260	310	350	210	250	280	350
400	280	335	380	225	270	305	400
500	320	380	430	260	310	350	500
600	350	420	475	285	340	385	600
700	385	460	520	315	375	425	700
750	400	475	535	320	385	435	750
800	410	490	555	330	395	445	800
900	435	520	585	355	425	480	900
1000	455	545	615	375	445	500	1000
1250	495	590	665	405	485	545	1250
1500	525	625	705	435	520	585	1500
1750	545	650	735	455	545	615	1750
2000	555	665	750	470	560	630	2000

www.ta191.com

Article 310 Conductors for General Wiring

Δ 310.3(B) Conductor Material

Conductors in this article shall be of, aluminum (AA-8000), copper or copper-clad aluminum unless otherwise specified.

Aluminum and copper-clad aluminum shall comply with the following: material shall be ***(listed)***.

For copper-clad aluminum conductors the copper shall form a minimum of 10% of the cross-sectional area of a solid conductor or each strand of a stranded conductors.





"Deleted" Article 311 Medium Voltage Conductors & Cables

This Article was New in the 2020 NEC

Previous editions of NEC were Articles 310 & 328

Replaced / Broken down into (3) NEW Articles

N **Article 235- Branch Circuits over 1kV**

N **Article 245- OCP for circuits over 1kV**

N **Article 495- Equipment over 1kV**

N 314.24 (C) Clearances for Side-Wiring Entrances

Where devices or equipment are mounted in boxes having side-wiring entries, the conductors entering from the side shall be protected as covered in (1) & (2), as follows. The term ***side*** applies any wall of a box other than the one opposite to the opening.

1. The rearward projection of the device or equipment shall not extend beyond the centerline of the wiring knockout or other entry.
2. The clearance from the box wall to the installed device or equipment shall not be less than ½”.

www.ta191.com

For informational purposes only

Δ 314.27 Ceiling Boxes for Paddle Fans

2nd Paragraph

Outlet boxes mounted in the ceilings of habitable rooms dwelling occupancies in a location acceptable for the installation of a ceiling-suspended (paddle) fan shall comply with one of the following:

1. Listed for the sole support of ceiling-suspended (paddle) fans.

N 2. ***Installed so as to allow direct access through the box, to structural framing capable of supporting a ceiling-suspended (paddle) fan without removing the box.***

www.ta191.com

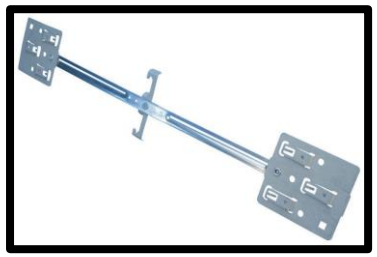
Not Current Code In Ohio

Δ 314.27(E) Weight Supporting Ceiling Receptacles (WSCR), & Weight-Supporting Attachment Fittings (WSAF)

NEW Terminology

Both listed WSCR & WSAF devices







www.ta191.com

For Informational Purposes Only

N Article 315 Medium Voltage Conductors, Cable, Cable Joints & Terminations

315.1 Scope. ***This article covers the use, installation, construction specs, and ampacities of MV medium voltage conductors, cable, cable joints, & cable terminations. This article includes voltage 2001v – 35kV ac & 2001 – 2500v dc.***

315.6 Listing Requirements. ***Type MV cables, joints, terminations, connectors, & associated fittings shall be listed. The listing requirements for MV cable joints, terminations, & connectors shall be effective January 1, 2026.***

N 315.50 Installation of MV Conductors

Part III.

A qualified person(s) with documented training and experience shall perform the installation and testing of Type MV cable. A qualified person(s) with documented training and experience in the installation of Type MV cable joints. A qualified person(s) with documented training and experience in the installation of Type MV cable terminations shall perform installation of Type MV cable terminations.

www.ta191.com

For Informational Purposes Only

N Instrumentation Tray Cable (ITC)

335.1 Scope. This article covers the use, installation, and construction specifications of *instrumentation tray cable* (ITC) for application to instrumentation and control circuits operating at 150v or less and 5 amperes or less.



335.6 Construction.

The insulated conductors of Type ITC cable #22 - #12 AWG Conductors shall be copper or thermocouple alloy.

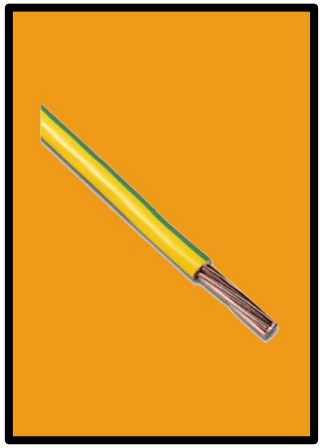


N Article 369 Insulated Bus Pipe (IBP) / Tubular Covered Conductors (TCC) Systems

369.1 Scope. This article covers the use, installation, and construction specifications for insulated pipe (IBP) systems.







www.tal91.com

For Informational Purposes Only

N Article 371 Flexible Bus Systems

371.1 Scope. This article covers the use and installation requirements of flexible bus systems and associated fittings.





www.tal91.com

Not Current Code In Ohio

Δ Article 400 Flexible Cords & Cables

N Part IV. Portable Power Feeder Cables over 2000v, Nominal

N **400.10 General. Part IV applies to single & multiconductor portable power feeder cables over 2000v nominal used to connect portable equipment & machinery.**

Medium Voltage Cable Type "G"



www.tal91.com

For Informational Purposes Only

406.4(D) Receptacle Replacements

Replacements

1. Grounding Type Receptacles
2. Non-Grounding Type Receptacles
3. GFCI Replacements
4. AFCI Replacements – ***Where "AFCI" protection is required (2020)***
5. Tamper-Resistant – ***Where "TR" protection is required (2011)***
6. Weather-Resistant – ***Where "W/R" protection is required (2011)***
7. Controlled Receptacles – ***Based on Situation (2020)***
8. ***N*** GFPE of Protection of Equipment – **Where "GFPE" protection is Required (2023)**

www.ta191.com

Not Current Code In Ohio

406.4 Receptacle Replacements. Grounding (D)(1); Non-grounding (D)(2); GFCI (D)(3); and AFCI (D)(4)

Reference to 210.12 (A), (B) & (C) Required **"AFCI"** Locations

*****2020 NEC 406.4(D) Arc-Fault Circuit-Interrupter (AFCI); Replacement Types*****

(1) Listed outlet branch-circuit AFCI type receptacle

(2) Receptacle protected by listed outlet branch-circuit type AFCI receptacle

(3) A receptacle protected by a listed combination type AFCI circuit breaker

210.12(D) Ex*: Branch Circuit Extensions or Modifications* – Dwelling Units, Dormitory Units, and Guest Rooms and Guest Suites locations only.

(1) 210.12 (A) Dwelling Units. (1-6)

(2) Listed outlet branch-circuit type AFCI at 1st outlet of existing circuit

www.ta191.com

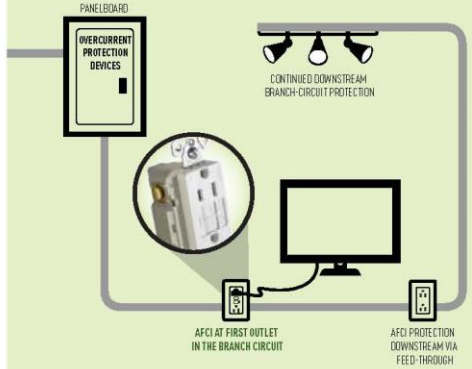
For Informational Purposes Only



Methods for Meeting NEC® Requirements with AFCI and AFCI/GFCI Receptacles

BRANCH-CIRCUIT EXTENSIONS OR MODIFICATIONS

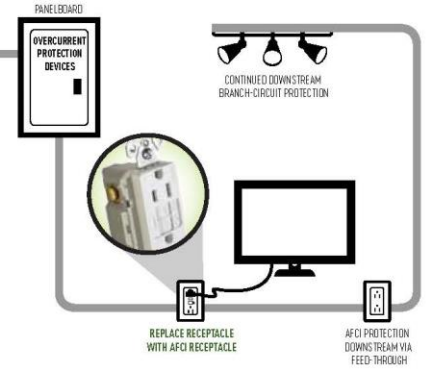
When branch-circuit wiring is modified, replaced or extended, it is permissible to meet the NEC requirement with a listed outlet branch-circuit AFCI receptacle located at the first receptacle outlet of the existing branch circuit.



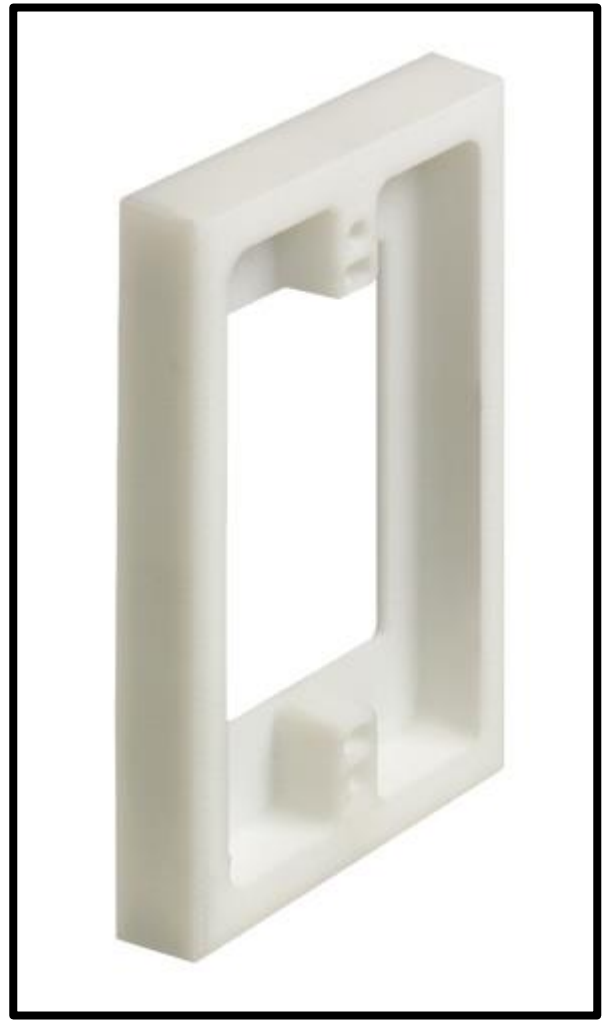
REPLACEMENTS

Where a receptacle outlet is supplied by a branch circuit that requires AFCI protection, it is permissible to meet the NEC requirement with a replacement receptacle that is one of the following:

1. A listed outlet branch-circuit type AFCI receptacle
2. A receptacle protected by a listed outlet branch-circuit type AFCI receptacle



Note: Section 406.4 (D)(4) requires AFCI protection when a receptacle is replaced.



www.ta191.com

AFCI Type Devices

AFCI “TR” Outlet



AFCI / GFCI “TR” Outlet



AFCI Type Devices

AFCI "Deadfront"



20a Hospital Grade AFCI / GFCI "TR" Outlet (Red)



N 406.12 Tamper-Resistant Receptacles

Expanded Locations; 15- & 20-ampere 125v thru 250v

1. Dwelling units
2. Guest rooms & Guest suites
3. Child-care facilities
4. Preschools & educational facilities
5. **Within clinics, medical & dental offices, following areas:**
   (a) Business offices accessible to the public
   (b) Lobbies & Waiting Areas
   (c) Spaces of nursing homes / limited-care facilities
6. **Places awaiting transportation, gyms, skating rinks, fitness centers & auditoriums**
7. Dormitory units
8. **Residential care facilities, assisted living, rehab & group homes**
9. **Foster care facilities, nursing homes & psychiatric hospitals**
10. **Accessible areas of agricultural buildings to the general public & any common areas**

www.ta191.com

For Informational Purposes Only

Δ 410.184 GFCI Protection & Special Purpose (SPGFCI) Protection



Horticultural Lighting Use

NEW Exception:

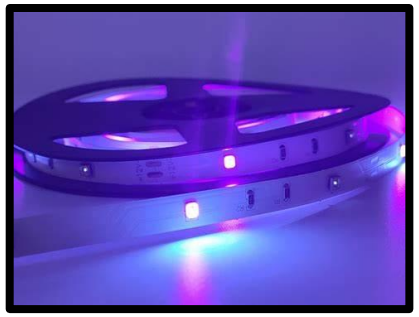
Circuits exceeding 150v to ground shall be protected by a listed special purpose GFCI

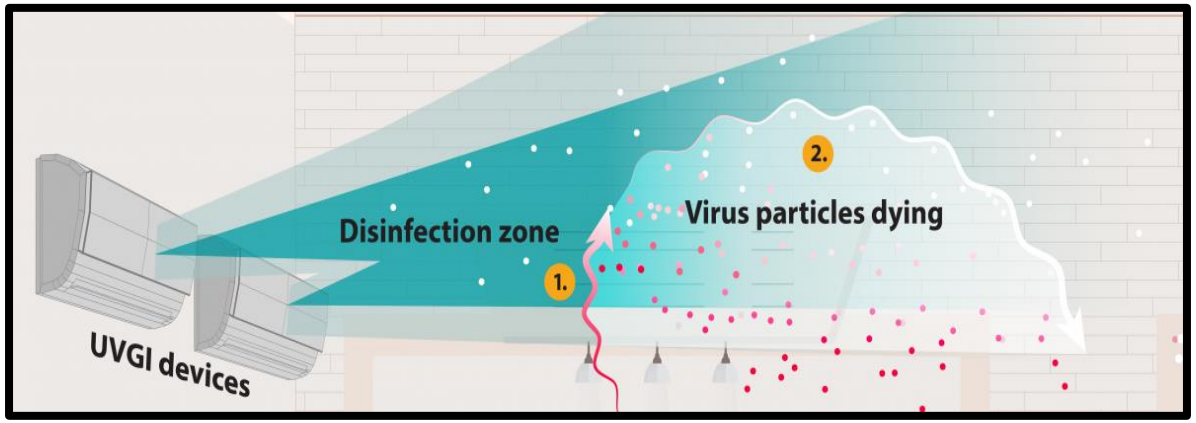
Class "C" Special Purpose Ground-Fault Circuit Interrupter (SPGFCI) Trip level is 15 – 20mA / ckts. over 150v to ground

N Germicidal Irradiation Luminaires

Article 410.190 Part XVII. Special Provisions

Listing, Labeling & Installation Requirements







HVAC Ventilation / UV-C LED lighting systems
Tuberculosis, SARS, & CoV-2 sterilization: reduce hazards

Δ 426.28 Ground-Fault Protection

Fixed Outdoor Electric De-icing & Snow Melting Equipment

Previously 426.44(E) GFCI Protection. In addition to the requirements of 210.8, GFCI protection for personnel shall be provided.

426.28 Ground Fault protection.

GF protection shall be provided for fixed outdoor electric de-icing and snow-melting equipment.

The trip level shall be specified by the manufacturer.

www.ta191.com

Not Current Code In Ohio

Δ 440.11 A/C Disconnects





Expanded Requirement

Disconnecting means shall be capable of disconnecting A/C & refrigeration equipment, including motor-compressors & controllers, from the circuit conductors. If the disconnecting means is readily accessible to unqualified persons, an enclosure door or hinged cover of a disconnecting means enclosure ***that exposes energized parts when open shall require a tool to open or be capable of being locked.***

N Article 495 Equipment Over 1kV ac / 1.5kV dc

Previous NEC Editions was Article 490

495.1 Scope. This article covers the general requirements for equipment operating at over 1000v ac, 1500v dc.

495.22 Isolating Means

495.48 Substation Design & Documentation

495.61 Mobile and Portable Equipment

495.70 Boilers

www.ta191.com

For Informational Purposes Only

Δ Article 500 Hazardous Locations

Classified Locations; Class I, II, & III Locations; Division I & II

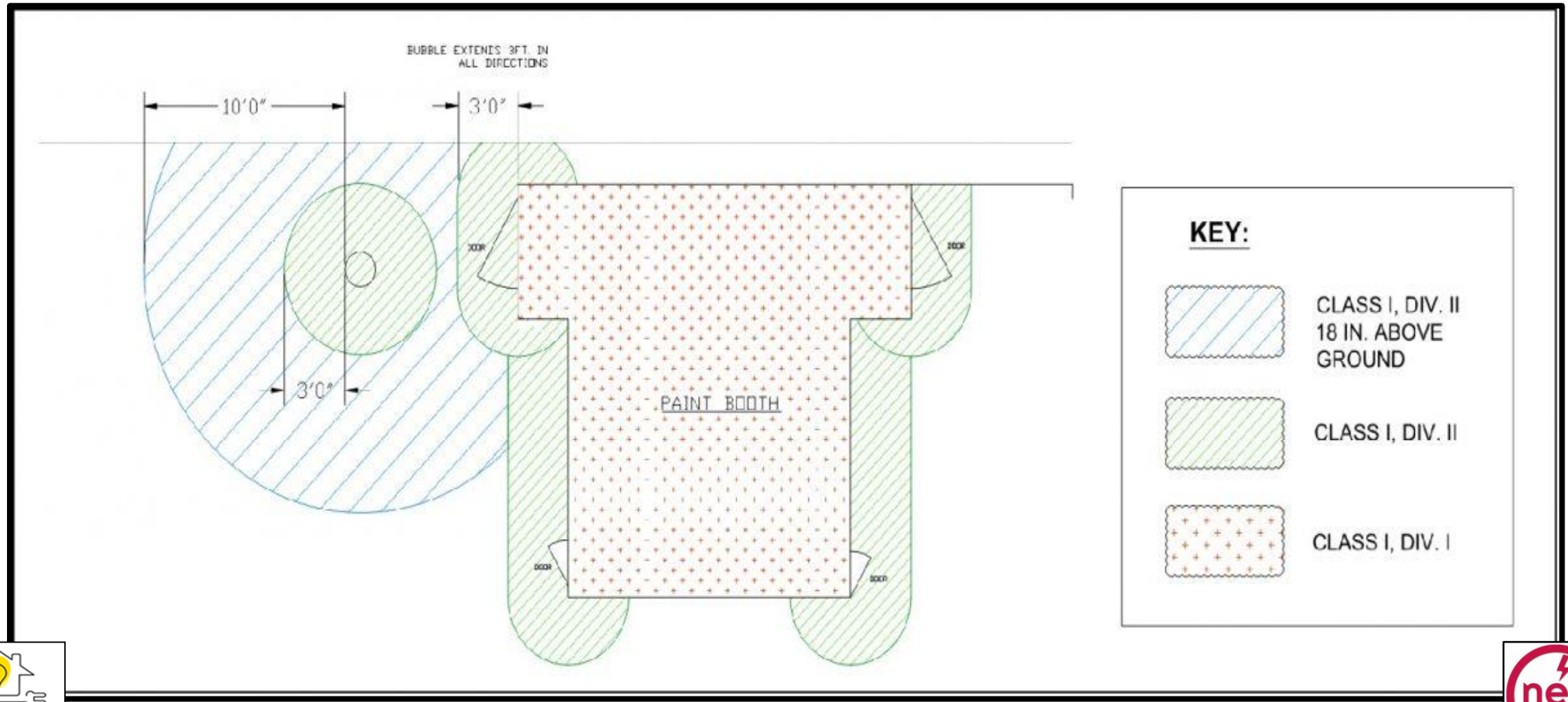
Additional Requirement 500.4 Documentation.

Classified or unclassified areas shall be documented on an area classification drawing & other associated documentation. This documentation shall be available to the authority having jurisdiction (AHJ) and those authorized to design, install, inspect, maintain or operate the equipment.

www.ta191.com

For Informational Purposes Only

Documented Area Classification



www.ta191.com

Not Current Code In Ohio

Δ Article 511 Commercial Garages Repair & Storage

This Article was re-written

511.7 Fixed Wiring Above Hazardous / Classified Locations.
Added ***listed fittings & equipment grounding conductors*** to numerous wiring methods.

517.8 Underground Wiring Below Hazardous Locations.

N Article 512 Cannabis Oil Equipment

512.1 Scope. This article covers cannabis oil preparatory equipment, extraction equipment, booths, post-processing equipment, and systems using flammable materials (flammable gas, flammable liquid-produced vapor, combustible liquid-produced vapor) in commercial & industrial facilities.

512.3 Classified Locations. Cannabis oil equipment & systems that can release flammable materials during operations shall be classified in accordance with 512.3(A) & (B).

www.tal91.com

Not Current Code In Ohio

N Article 512 – Cannabis Oil Equipment / Oil Systems using Flammable Materials

512.3 Classified Locations. Cannabis oil equipment & systems that can release flammable materials during operation. ***Class I Div. 1 or II location***.

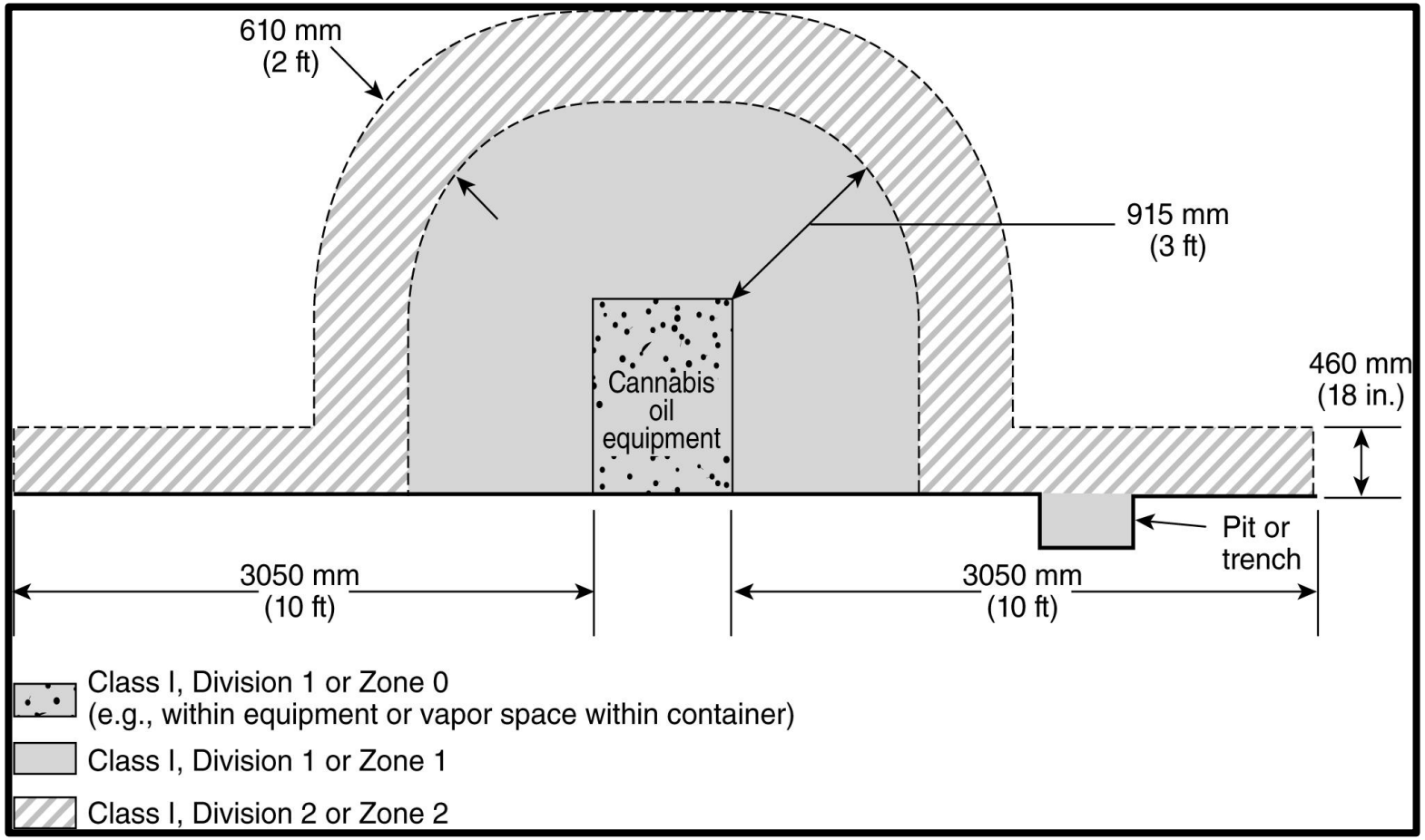




www.ta191.com

For Informational Purposes Only

N 512.3(B) Cannabis Oil Booth



Not Current Code In Ohio

Δ Article 514 Motor Fuel Dispensing Facilities

Δ 514.8 Underground Wiring. (In classified Locations)

The change here is previous editions of the NEC accepted MI, PVC, RTRC, HDPE conduit as an exception to the metal conduit rule. The 2023 NEC 514.8(B) & (C) is now written into positive code language.

No Change: Still requires 2' of cover or change to RMC or IMC

Δ 517 Health Care Facilities

517.1 Scope. ***Inadvertently Deleted***

517.2 Definitions. ***Relocated to Article 100***

517.10(B) Not Covered. ***Pharmacy services not contiguous to Health Care Facilities***

517.12 EGC for Receptacles & Fixed Electrical Equipment in Patient Care Spaces. ***The insulated copper conductor needs to be installed and terminated in each panel all the way to the SE equipment.***

517.30 EES Sources of Power. ***(1) Added utility power & changed (4) from battery system to energy storage system.***

Article 517 Health Care Facilities

517.50 Part V. *Diagnostic Imaging & Treatment Equipment*

Formerly X Ray Installations

(updated for new terminology & technologies)

Added Informational Notes #3 & #4

#3 Diagnostic Equipment

#4 Treatment Equipment

Δ Article 530 Motion Picture & TV Studios & *Remote Locations*

More specific details, restrictions and requirements for associated (portable) equipment than previous editions. Will affect both local and national live broadcasts including news, sporting and possibly any live event.

Part II . Expanded Portable Equipment in Production Areas of Studios & Remote Locations

Part III. Portable Equipment in Support Areas

www.ta191.com

Not Current Code In Ohio

Article 555 Marinas, Boatyards, Floating Buildings & Docking Facilities

This Article has been updated over the past (2) Code Cycles.

555.4 Location of Service Equipment (for a floating building, dock or marina). This section is clearly defined on the location of SE equipment ***(on land)***.

No closer than 5' horizontally from the structure served & 12" minimum above the electrical datum plane (2' above the maximum highest water level under normal conditions).

***N* 555.14 *Areas requiring Equipotential Planes*.**

***N* 555.15 *Replacement of Equipment*. Requires compliance**

***N* 555.36 *Emergency Disconnect*. Each marina power outlet that provides shore power to boats shall have an emergency disconnect.**

***N* 555.37 All Equipment grounding conductors *shall be insulated*.**

Article 625 EV Power Transfer Equipment

Part III. Installation

Δ 625.40 Electric Vehicle Branch Circuit. ***Each outlet installed for the purpose of supplying EVSE greater than 16a or 120v shall be supplied by an individual branch circuit.***

N 625.42(B) Energy Management System. *When more than one or more pieces of equipment are provided with an integral load management control,* ***the system shall*** *be marked to indicate this control is provided.*

*****2020 NEC***** *Each outlet installed for the purpose of charging electric vehicles shall be supplied by an individual branch circuit*.

Each circuit shall have no other outlets.

www.ta191.com

Not Current Code In Ohio

625.60 AC Receptacle outlets used for EVPE

EVPE = Electric Vehicle Power Export Equipment

AC receptacles installed in electric vehicles and intended to allow for connection of off-board utilization equipment shall comply with 625.60 (A) – (D).

(A) Type. The receptacle shall be listed

(B) Rating. Outlet shall

be rated 250-v max, 1ø, 50a max

(C) Overcurrent Protection. Integral to power export system

(D) GFCI Protection for Personnel. All receptacles shall be GFCI protected, indication and reset shall be readily accessible

www.ta191.com

For Informational Purposes Only

Article 625 EV Power Transfer Equipment

Δ ***625.48 Interactive Equipment.*** *EVPE or* ***WPTE*** *that incorporates a power export function & that is part of an interactive system that serves as an optional standby system, an electric power production source, or a bidirectional power feed shall be listed & marked as suitable for that purpose. When used as an optional standby system, the requirements of Parts I & II of Article 702 shall apply.*

N 625.49 Island Mode. EVPE and bidirectional EVSE that incorporate a power export function shall be permitted to be a part of an interconnected power system operating in island mode.

www.ta191.com

Not Current Code In Ohio

The Future is Bidirectional Power Flow

Nissan Leaf V2H



Hyundai Ioniq 5

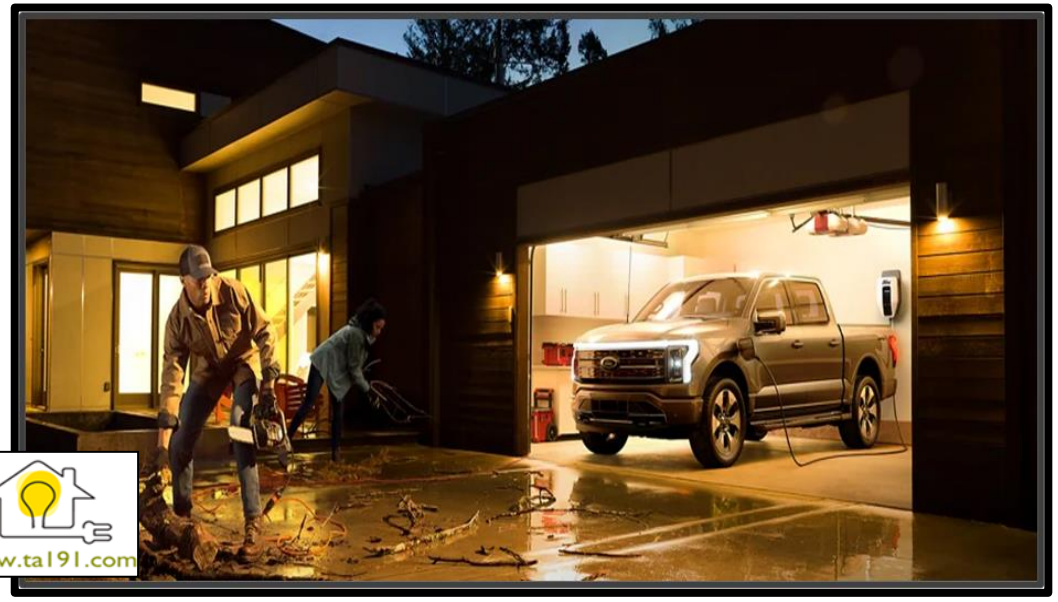


www.ta191.com

2022 Ford F-150 Lightning pick-up

All-Electric. All F-150

Available features include Backup Power that can provide full-home power for up to 3 days, on a fully charge battery and 80-amp Ford Charge station Pro. *When home is properly equipped & home transfer switch disconnects home from the grid*. Based on 30 kWh used per day. Turn your truck into a generator. Pro Power Onboard offers an available 9.6kw max power provided through 11 outlets. (4) 120v outlets in front trunk, (2) in the cab (4) in the bed, and (1) 240-v outlet for tougher tasks.





www.ta191.com

Electrical Vehicle Training Program

EV Champion Training Series is a four-part course developed by the National Renewable Energy Laboratory (NREL) and the FEMP fleet team. Those who attend all four webinars can earn 1.0 CEU and an EV champion Training Certificate from FEMP. A selection of on-demand trainings are available online.

www.energy.gov/eere/femp/electric-vehicle -training

US Department of Energy



The Electrical Vehicle Infrastructure Training Program (EVITP)

The EV market continues to expand everywhere and is critical that ESVE equipment be properly installed to the highest standards to safety and quality. All EVITP Certified Electricians must pass a certification exam for proof of knowledge and skill.

The EVITP provides training and certification for electricians installing electric vehicle supply equipment (ESVE). The EVITP program was designed to provide installers with the most comprehensive training available in the market today.

www.evitp.org

www.ta191.com

For Informational Purposes Only

GFCI Protection Expanded & SPGFCI is NEW (special purpose GFCI protection)

Δ **680.5 GFCI & SPGFCI Protection.**

Δ **The GFCI and SPGFCI requirements in this article, unless otherwise noted, are in addition to the requirements in 210.8.**

GFCI Branch circuit receptacles & outlets (1ø & 3ø) 150v to ground or less, 60a or less. (6mA trip level)

SPGFCI is designed for (1ø & 3ø) receptacles & outlets above 150v to ground, not exceeding 480v with a 20mA trip level.

www.ta191.com

For Informational Purposes Only

Article 680 Swimming Pools, Fountains & Similar Locations

210.21 Pump Motors

680.21(C) Ground Fault Protection. ***Outlets serving pool motors shall have GFCI protection*.**

This section has been expanded over numerous editions of the code. 2020 NEC all outlets150v to ground or less, 60a or less,1ø & 3ø.

Δ **680.21(D)** *Where a pool pump motor is replaced* or ***repaired*** the motor shall be provided with ground-fault protection.

Not Current Code In Ohio

Littlefuse Shock Block 5000

Rated for 32-60amp

SPGFCI 10 - 100mA Increments or

Fixed 20mA Trip Level

208/480/600v Applications

This device is installed in-line between incoming power or existing overcurrent protection and the load.



www.ta191.com

For Informational Purposes Only

Δ 680.22 Receptacles (GFCI & SPGFCI)

680.22(A)(4) GFCI & SPGFCI Protection. *All receptacles rated 125v - 250v 60a or less, located within 20' of the inside walls of the pool shall have GFCI protection* complying with 680.5(B) or SPGFCI protection complying with 680.5(C).

680.22(B)(4) GFCI & SPGFCI Protection in Adjacent Areas. *Luminaires, lighting outlets, & ceiling suspended (paddle) fans mounted in the area extending between 5' & 10' horizontally from the inside walls of a pool shall have GFCI 680.5(B) or SPGFCI protection 680.5(C)* unless installed not less than 5' above the maximum water level & rigidly attached to the structure.

GFCI & SPGFCI Protection Locations

GFCI requirements in the following locations, 150v to ground or less, 60a or less, 125v - 250v (1ø & 3ø), receptacles & outlets

Permanently installed pools, storable pools, immersion pools

680.21(C) Pool Motors Receptacles & Outlets (All)

680.22(A)(4) / 680.32 Receptacles within 20'of inside wall of pool.

680.22(B)(4) Luminaires, Lighting outlets & paddle fans installed 5' & 10' horizontally from the inside walls of a pool.

680.43(A)(2) Receptacles within 10' of the inside of a Self-contained Spas & Hot Tubs & Immersion Pools (both indoor & outdoor).

680.44(A) GFCI & SPGFCI Self-contained Spa & Hot Tubs

Δ 680.26 Equipotential Bonding

680.26(A) Performance. The equipotential bonding grid required by ***680.26(B) & (C)*** to reduce voltage gradients in the pool area ***shall be installed for pools with or without associated electrical equipment related to the pool***.

With or without power, there is still a body of water with chemicals added.

Water + chemicals = battery/voltage



Article 700 Emergency Systems

N **700.11 Wiring, Class 2 Powered Emergency Lighting Systems.**

700.11(A) General.

700.11(B) Identification. Emergency circuits shall be permanently marked…..

(1) All **boxes & enclosures shall be permanently marked**

(2) Exposed cable, tray or raceway shall be perm. marked

(C) Separation of Circuits.

(D) Protection. Installed in raceway, AC or MC cable

Ex. 6’ or less to luminaires / Locked rooms / latched encl.

1013.2 2017 Ohio Building Code

Chapter 10 Means of Egress

Floor Mounted Exit Signs in Group R-1

Where exit signs are required in Group R-1 occupancies, by Section 1013.1, additional low-level exit signs shall be provided in all areas serving guest rooms in Group R-1 occupancies and shall comply with Section 1013.5.

The bottom of the sign shall not be less than 10" or more than 12" above the floor level. The sign shall be flush mounted to the door or wall. Where mounted to the wall, the edge of the sign shall be within 4" of the door frame on the latch side.

OBC 310.3 R-1 Occupancies; "*Sleeping units*" transient in nature.

Re; Hotels, motels, boarding houses and congregate living facilities with less than 10 occupants, and single room occupancies (SRO).

www.ta191.com

Article 706 Energy Storage System

Δ **706.1 Scope.** This article applies to all energy storage systems (ESS) having a capacity greater than 1 kwh that may be stand-alone or interactive with other electric power production sources. These systems are primarily intended to store & provide energy during normal operating conditions.

N **706.7(A) Commissioning. ESSs shall be commissioned upon installation. (*Does not apply to 1 & 2-Family dwelling units*)**

N **(B) 706.7(B) Maintenance. ESSs shall be maintained**

www.ta191.com

For Informational Purposes Only

N Article 722 – Cables for Power-Limited Circuits & Fault-Managed Power Circuits

722.1 Scope. This article covers the general requirements for the installation of single-and multiple-conductor cables used in Class 2 & Class 3 power-limited circuits, power-limited fire alarm (PLFA) circuits & Class 4 fault-managed power circuits.

722.24 Mechanical Execution of Work

722.135 Cable Listing



N **Article 726 Class 4 Fault-Managed Power Systems**

New Class Rating. *Class 4 cables allow the distribution of DC power at higher-voltages. This type of circuit constantly monitors itself (intelligent wiring system) for faults and would shut power off simultaneously if a fault occurs. Capacity to deliver more power than Class I, II, or III systems*.

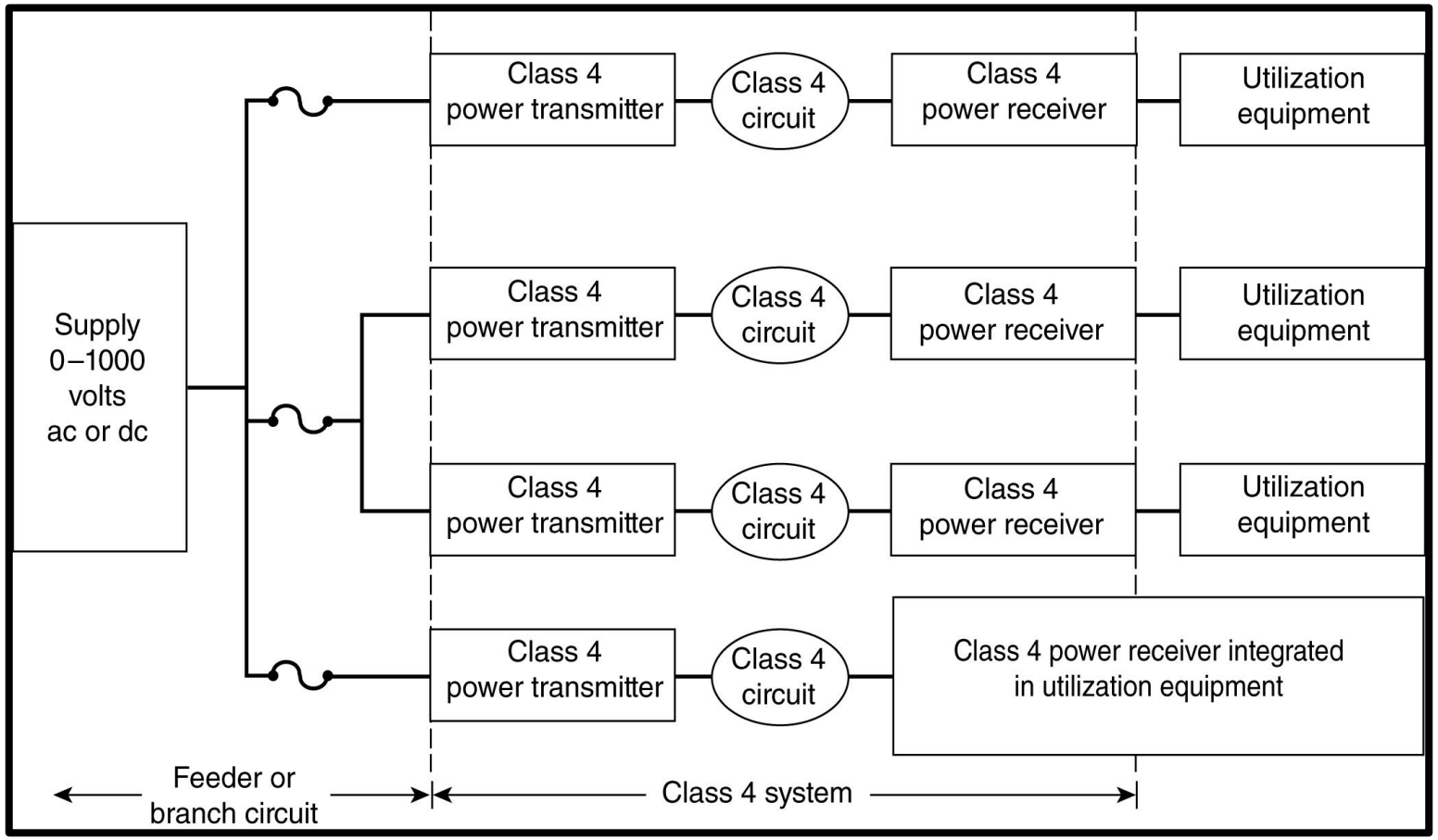
Class 4 power systems are extremely safe from potential fire or shock hazards. Aka Power Energy Transfer (PET), Fault Managed Power; {Built-In Fault Management} (FMP)

Smart Building Technology; 450v L-L / 225v to ground

www.ta191.com

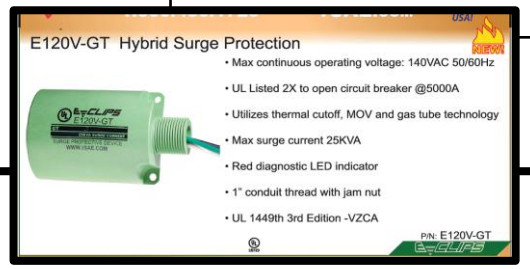
For Informational Purposes Only

N IN 726.121 Class 4 Circuits



Not Current Code In Ohio

Article 760 Fire Alarm Systems



N 760.33 Supply Side Overvoltage Protection

A listed surge-protective device (SPD) shall be installed on the supply side of a fire alarm control panel in accordance with Part II of Article 242.





Typically, the fire alarm control panel is supplied by a single pole 120v circuit.

N* 760.179(D) Cable Jacket Compound. The *cable jacket shall have a high degree of abrasion resistance.

www.ta191.com

2023 National Electrical Code "Proposed" Changes & Updates

Labriola Training Agency #191
www.ta191.com

John M. Labriola
Principal

150 Maplecrest Street SW
North Canton, Ohio 44720

330.497.6309 Phone
330.606.8098 Cell
john@ta191.com

www.ta191.com

Thank You!

File Attachments for Item:

EC-6 2023 NEC Changes and Updates Chapters 3-7 (Labriola Training Agency)

All certifications (4 hours)

www.ta191.com

January 25, 2023

2023 NEC Changes & Updates; Chapters 3 – 7

4 Hour Course Timeline

(1) NEC Code Adoption Process in Ohio & Chapter 34 Residential Code of Ohio (2019)

30 minutes (Slides 1-10)

(2) Chapter 3 – Wiring Methods & Materials (310 -371)

30 Minutes (Slides 11-22)

(3) Chapter 4 – Equipment for General Use

45 Minutes (Slides 23-34)

(4) Chapter 5 – Special Occupancies

45 Minutes (Slides 35-45)

(5) Chapter 6 – Special Equipment

60 Minutes (Slides 46-58)

(6) Chapter 7 – Special Conditions

30 Minutes (Slides 59-66)

4 Hour Total Class Time = 240 Minutes

July 01, 2019

Current Adopted Codes in Ohio – (2017)

Non-Residential Construction (4- Family and Above)

2017 Ohio Building Code (Based on the 2015 International Building Code) 2017

Ohio Mechanical Code (Based on the 2015 International Mechanical Code) 2017

Ohio Plumbing Code (Based on the 2015 International Plumbing Code) 2017

Ohio Fire Code (Based on the 2015 International Fire Code)

2017 NFPA 70 – National Electrical Code **(Effective 11.01.2017)**

2016 NFPA 13 – Standard for Installation of Sprinkler Systems 2016

NFPA 72 – National Fire Alarm and Signaling Code

2015 International Fuel Gas Code

2012 International Energy Conservation Code / ASHRAE 90.1 2013

ICC / ANSI A117.1 2017 Accessible & Usable Buildings and Facilities

Residential Construction (1, 2 and 3- Family Dwellings)

2019 Residential Code of Ohio (Based on the 2018 International Residential Code)

2017 Ohio Plumbing Code

2017 NFPA 70 – National Electrical Code w/ amendments **(07.01.2019)**

2018 International Energy Conservation Code

www.ta191.com

August 01, 2022

Current Adopted Building Codes in West Virginia

The State of West Virginia Fire Commission has adopted statewide the 2018 ICC (International Code Council), family of Codes for any jurisdiction that chooses to enforce building codes. Check locally for enforcement information / details.

2017 Accessible & Usable Buildings & Facilities (A117.1)
2018 International Building Code (IBC)
2013 International Energy Conservation Code (ASHRAE 90.1)
2018 International Existing Building Code (IEBC)
2018 International Fuel Gas Code (IFGC)
2018 International Mechanical Code (IMC)
2018 International Plumbing Code (IPC)
2018 International Property Maintenance Code (IPMC)
2018 International Residential Code (1- & 2- Family) (IRC)
2015 International Energy Code of Residential Buildings (IECC)
2018 International Swimming Pool & Spa Code (ISPSC)

2021 NFPA 1 - West Virginia Fire Code
2016 NFPA 13 - Installation of Sprinkler Systems
2020 NFPA 70 - National Electrical Code
2016 NFPA 72 - National Fire Alarm & Signaling Code
2021 NFPA 101 - West Virginia Life Safety Code

www.ta191.com

CHAPTER 34
ELECTRICAL

SECTION 3401
ELECTRICAL

3401.1 *Electrical.* *The provisions of the National Electrical Code, NFPA 70, shall be incorporated herein and shall govern the installation, testing and operation of the electrical systems of one-, two- and three-family dwellings and their accessory structures except for the following:*

1. ***Section 210.8(A)(2) shall be modified to read:***

   Garages, and also accessory buildings that have a floor located at or below grade level not intended as habitable rooms and limited to storage areas, work areas, and areas of similar use *except for the receptacle located to serve a garage door opener when the device is a single receptacle and located in the ceiling.*

2. ***Section 210.8(A)(5) shall be modified to read:***

   Unfinished portions or areas of the basement not intended as habitable rooms.

   Exceptions:

   1. A receptacle supplying only a permanently installed fire alarm or burglar alarm system shall not be required to have ground-fault circuit-interrupter protection.
   2. *A single receptacle located to serve a sump pump shall not be required to have ground-fault circuit-interrupter protection when there is a duplex receptacle with ground-fault circuit-interrupter protection within six (6) feet of the sump pump.*

3. ***Section 210.8(D) shall be deleted.***

4. ***Section 210.12(A) shall be modified to read:***

   All 120-volt single-phase, 15- and 20-ampere branch circuits supplying outlets or devices installed in dwelling unit kitchens, family rooms, dining rooms, living rooms, parlors, libraries, dens, bedrooms, sun rooms, recreational rooms, closets, hallways, laundry rooms, or similar rooms or areas shall be protected by any of the means described in 210.12(A)(1) through (6):

   (l) A listed combination-type arc-fault circuit interrupter, installed to provide protection of the entire branch circuit.

   (2) A listed branch/feeder-type AFCI installed at the origin of the branch-circuit in combination with a listed outlet branch-circuit type arc-fault circuit interrupter installed at the first outlet box on the branch circuit. The first outlet box in the branch circuit shall be marked to indicate that it is the first outlet of the circuit.

   (3) A listed supplemental arc protection circuit breaker installed at the origin of the branch circuit in combination with a listed outlet branch-circuit type arc-fault circuit interrupter installed at the first outlet box on the branch circuit where all of the following conditions are met:

   a. The branch-circuit wiring shall be continuous from the branch-circuit overcurrent device to the outlet branch-circuit arc-fault circuit interrupter.

   b. The maximum length of the branch-circuit wiring from the branch-circuit overcurrent device to the first outlet shall not exceed 15.2 m (50 ft.) for a 14 AWG conductor or 21.3 m (70 ft.) for a 12 AWG conductor.

   c. The first outlet box in the branch circuit shall be marked to indicate that it is the first outlet of the circuit.

   (4) A listed outlet branch-circuit type arc-fault circuit interrupter installed at the first outlet on the branch circuit in combination with a listed branch-circuit overcurrent protective device where all of the following conditions are met:

   a. The branch-circuit wiring shall be continuous from the branch-circuit overcurrent device to the outlet branch-circuit arc-fault circuit interrupter.

   b. The maximum length of the branch-circuit wiring from the branch-circuit overcurrent device to the first outlet shall not exceed 15.2 m (50 ft.) for a 14 AWG conductor or 21.3 m (70 ft.) for a 12 AWG conductor.

   c. The first outlet box in the branch circuit shall be marked to indicate that it is the first outlet of the circuit.

   d. The combination of the branch-circuit overcurrent device and outlet branch-circuit AFCI shall be identified as meeting the requirements for a system combination-type AFCI and shall be listed as such.

   (5) If RMC, IMC, EMT, Type MC, or steel-armored Type AC cables meeting the requirements of 250.118, metal wireways, metal auxiliary gutters, and metal outlet and junction boxes are installed for the portion of the

www.ta191.com

branch circuit between the branch-circuit overcurrent device and the first outlet, it shall be permitted to install a listed outlet branch-circuit type AFCI at the first outlet to provide protection for the remaining portion of the branch circuit.

(6) Where a listed metal or nonmetallic conduit or tubing or Type MC cable is encased in not less than 50 mm (2 in.) of concrete for the portion of the branch circuit between the branch-circuit overcurrent device and the first outlet, it shall be permitted to install a listed outlet branch-circuit type AFCI at the first outlet to provide protection for the remaining portion of the branch circuit.

Exception *No. 1*: Where an individual branch circuit to a fire alarm system installed in accordance with 760.41(B) or 760.121(B) is installed in RMC, IMC, EMT, or steel-sheathed cable, Type AC or Type MC, meeting the requirements of 250.118, with metal outlet and junction boxes, AFCI protection shall be permitted to be omitted.

Exception No. 2: Branch circuits supplying receptacle outlets installed to serve only the kitchen countertop surfaces shall be permitted to be installed without arc-fault circuit interrupter protection.

5. ***Section 210.64 shall be modified to read:***

At least one 125-volt, single-phase, 15- or 20-ampere-rated receptacle outlet shall be installed in an accessible location within 7.5m (25 ft.) of the indoor electrical service equipment. The required receptacle outlet shall be located within the same room or area as the service equipment.

Exception No. 1: The receptacle outlet shall not be required to be installed in one-, two-, *or three-*family dwellings.

Exception No. 2: Where the service voltage is greater than 120 volts to ground, a receptacle outlet shall not be required for services dedicated to equipment covered in Articles 675 and 682.

SECTION 3402
EMERGENCY AND STANDBY POWER SYSTEMS

3402.1 ***Installation.*** *Emergency and standby power systems shall be installed in accordance with this code and NFPA 70. The performance, classification, transfer, testing, and maintenance of emergency and standby power systems shall also comply with either NFPA 110 (liquid- and gas- fueled systems) or NFPA 111 (battery and inertia systems), as applicable.*

3402.1.1 Stationary generators. *Stationary emergency and standby power generator assemblies shall be listed in accordance with UL 2200.*

3402.1.1.1 Engine-driven generators. *The installation of liquid- and gas-fueled stationary internal combustion engines and gas turbines used to drive generator assemblies shall meet the requirements of NFPA 37.*

3402.1.1.1.1 Fuel tanks connected to generator assemblies. *Fuel tanks piped to and supplying fuel for engine-driven generator assemblies may be engine-mounted, located inside of a building, outside of a building, or on a roof in accordance with NFPA 37 or NFPA 30.*

3402.1.1.1.1.1 Engine-mounted tanks. *Engine-mounted tanks located outdoors may be located in accordance with Section 4.1.4 of NFPA 37 and shall be vented in accordance with NFPA 30. Engine-mounted tanks shall be provided with adequate clearance to enable filling, maintenance, and testing, shall be safeguarded against public access, and shall be protected from impact.*

3402.1.1.1.1.2 Other fuel tanks. *Fuel tanks, other than engine-mounted tanks, piped to and supplying the generator engine shall be located, installed, and vented in accordance with the applicable sections of NFPA 37 or located, installed, and vented in accordance with NFPA 30.*

3402.1.1.1.2 Gaseous fuel supply. *Where an internal combustion engine supplied with gaseous fuel powers emergency or standby generators, the fuel gas storage and piping system shall comply with NFPA 37 and Chapter 24.*

www.ta191.com

2020 NEC Adoption in Ohio

December 2022 Update: Still Unknown / Limited Information

210.8(F) **Outdoor Outlets.** Outdoor outlets (Re: HVAC equipment) supplied by branch circuits rated 150-v to ground or less, 50a or less, shall have GFCI protection for personnel. With the use of adjustable speed drives for energy efficient equipment (split systems) are ***not*** compatible with current Type "A" GFCI protection.

Discussions have been ongoing since prior to September 2020.

Residential Code Advisory Committee (RCAC) to consider the 2023 NEC language:

N Ex: #2 GFCI protection shall not be required for listed HVAC equipment. This exception shall expire September 1, 2026.

This and other "*unknown*" amendments shall be considered by OBBS

www.ta191.com



2023 "Proposed" National Electrical Code (NEC) Changes & Updates

Training Agency #191

150 Maplecrest Street SW
North Canton, Ohio 44720
330.497.6309 Phone

John M. Labriola

www.ta191.com

2023 National Electrical Code Changes & Updates



Not Current Code In Ohio

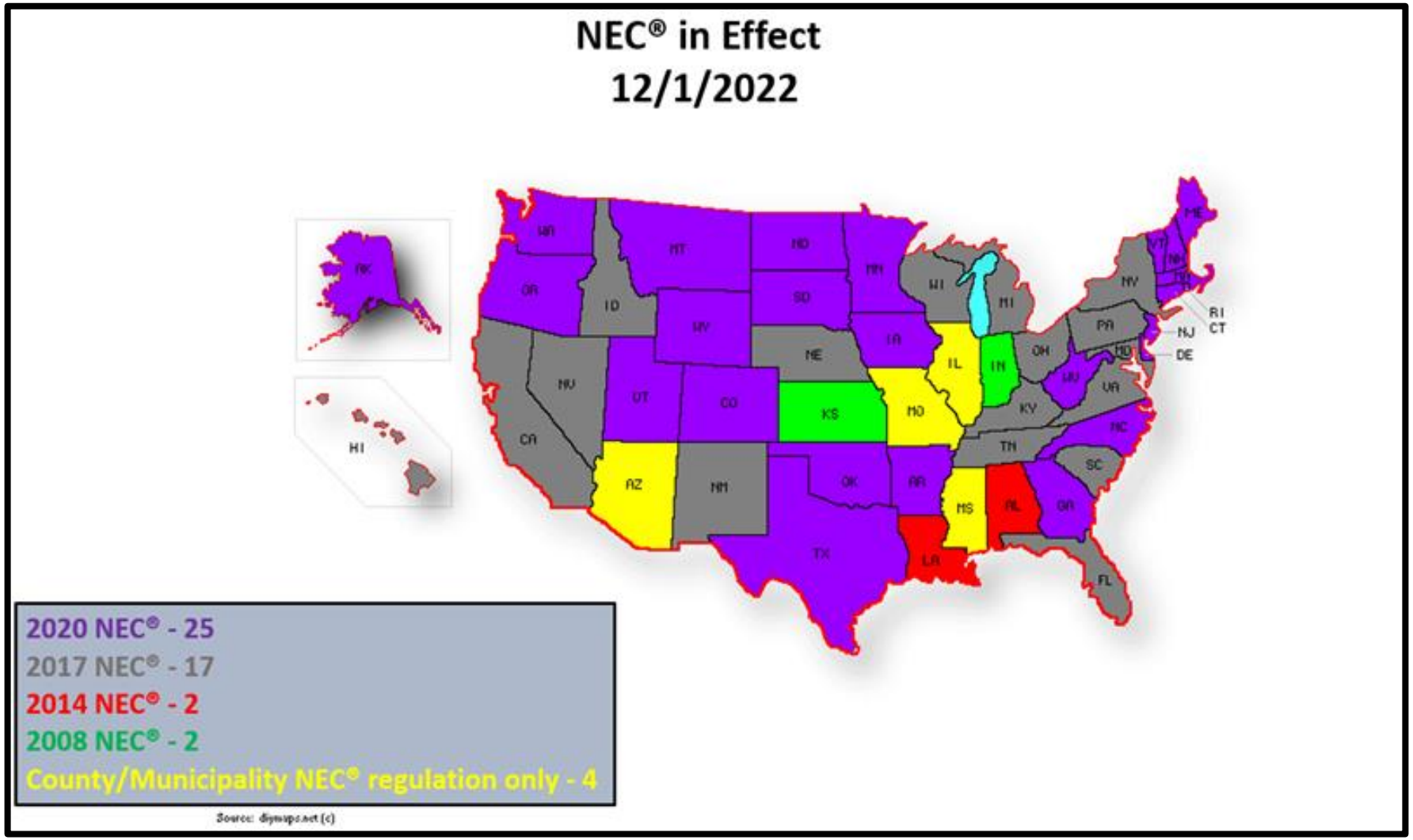
This course is based on the 2023 National Electrical Code (NEC).

The 2023 National Electrical Code has not been adopted in ohio.

Presented for informational purposes only.

Ohio Board of Building Standards

NFPA State Update Map



2023 NEC “10” New Articles

235 – Branch, Feeder, & Service Circuits over 1kV ac & 1.5kV dc

245 – Overcurrent Protection for Systems rated over 1kV ac & 1.5kV dc

305 – General Requirements for Wiring Methods & Materials for Systems rated over 1kV ac & 1.5 kV dc

369 – Insulated Bus Pipe (IBP) / Tubular Covered Conductors (TCC) Systems

371 – Flexible Bus Systems

495 – Equipment over 1kV ac & 1.5kV dc ***(Formerly Article 490)***

512 – Cannabis Oil Equipment / Oil Systems using Flammable Materials

722 – Cables for Power-Limited Circuits & Fault-Managed Power Circuits

724 – Class I Power-Limited & Class I Power-Limited Remote Control & Signaling Systems

726 – Class 4 Fault-Managed Power Systems

Article 100 Definitions

N **Scope.** This article contains only those definitions essential to the application of this Code. It is not intended to include commonly defined general terms or commonly defined technical terms from related codes and standards. An article number in parentheses following the definitions indicates that the definition only applies to that article.

2017 NEC Added Part II – Over 1000 Volts

2020 NEC Added Part III – Hazardous Locations

2023 NEC – Almost all Article .2's are in Article 100

Now almost all definitions utilized in the NEC are in Article 100

www.ta191.com

For Informational Purposes Only

Δ 110.16(B) Arc-Flash Hazard Warning

Service Equipment and ***Feeder*** Supplied Equipment.

In other than dwelling units, an addition to the requirements in 110.16(A), a permanent ***arc flash*** label shall be field or factory applied to service equipment and ***feeder supplied equipment rated 1000 amperes or more. The arc flash label shall be in accordance with applicable industry practice and include the date the label was applied.*** The label shall meet the requirements of 110.21(B).

Added Feeders & reduced the ampacity from 1200a to 1000a.

Refer to NFPA 70E-2021

www.ta191.com

Not Current Code in Ohio

N 110.17 Servicing & Maintenance of Equipment

Servicing & electrical preventative maintenance shall be performed by qualified persons trained in servicing & maintenance of equipment & shall comply with the following:

(1) Shall be performed in accordance with the original manufacturers' instructions & information.

(2) Shall utilize identified replacement parts

(a) Provided by original manufacturer

(b) Designed by an experienced engineer

(c) Approved by the AHJ

www.ta191.com

For Informational Purposes Only

N 110.20 Reconditioned Equipment

Reconditioned equipment ***shall*** be permitted except where prohibited elsewhere in this Code. Equipment that is restored to operating condition shall be reconditioned with identified replacement parts, verified under applicable standards, that are either provided by the original equipment manufacturer or that are designed by an engineer experienced in the design of replacement parts for the type of original equipment

N **(A) Equipment required to be Listed**

N **(B) Equipment not required to be Listed**

N **(C) (A) or (B) not available, AHJ may approve (document)**

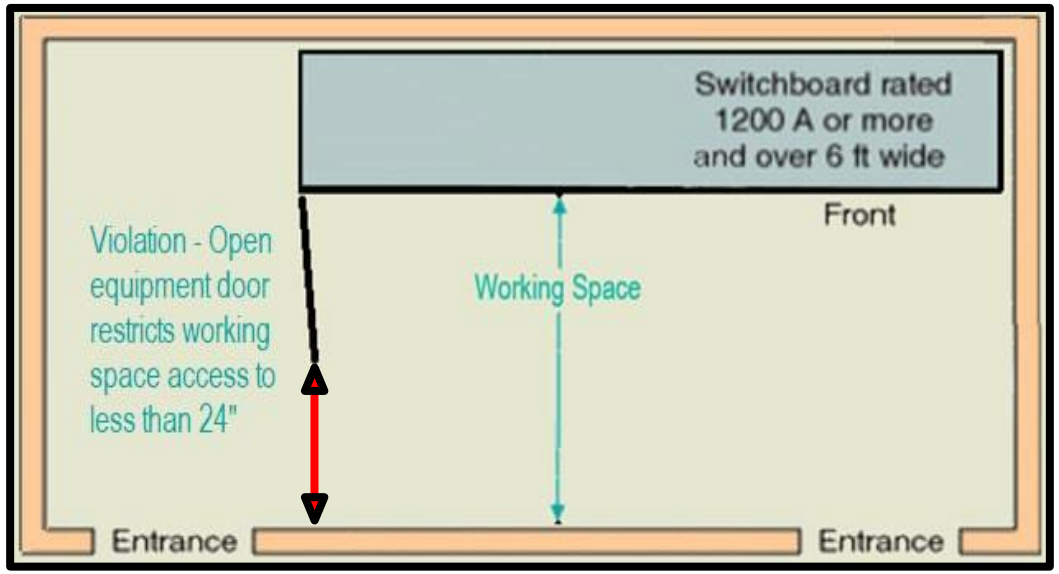
www.ta191.com

Not Current Code In Ohio

Δ 110.26 Working Spaces About Electrical Equipment

"<u>Open</u>" equipment doors shall <u>not</u> impede access to and egress from the working space. Access or egress is impeded if one or more simultaneously opened equipment doors restrict working space access to be less than 24" wide and 6½' high.

***<u>Note</u>**: The intent should be clear, to protect personnel servicing the equipment.*



www.ta191.com

For Informational Purposes Only

N 110.26(A)(6) Working Spaces

Grade level, Floor, or Working Platform

The grade, floor, or platform in the required working space shall be kept clear, and the floor, grade, or platform in the working space ***shall be as level and flat*** as practicable for the entire required depth and width of the working space.

Generally: ***3' in front of equipment &*** **width of equipment**

www.ta191.com

Not Current Code In Ohio

Article 100 - Definitions

Receptacle

A contact device installed at the outlet for the connection of an attachment plug or for direct connection of electrical utilization equipment designed to mate with the corresponding contact device. A single receptacle is a single contact device with no other contact device on the same yoke ***or strap***. A multiple receptacle is two or more contact devices on the same yoke ***or strap.*** (CMP-18)

210.8(A), (B), & (E)

Outlet

A point on the wiring system at which current is taken to supply utilization equipment. (CMP-1)

210.8(C) Crawl Space Ltg. Outlets

210.8(D) Specific Appliances

210.8(F) Outdoor Outlets

GFCI Protection Evolution





Type "A" Personnel Protection Trip Level = 4 – 6mA
(Typical design is receptacle or breaker)

Type "B" Equipment Protection Trip Level = 30mA
(rooftop de-icing equipment protection)

Type "C" *SPGFCI* (over 150v to ground) 480v 3ø or Less / Trip Level = 20mA

Type "D" *SPGFCI* (over 150v to ground) 600v 3ø Trip Level – 20mA

Type "E" *"EGFPD" 6mA or adjustable from 10 – 100mA*

Docking Facilities "GFPE" *100mA*

Shore Power "GFPE" protection 30mA

www.ta191.com

Δ 210.8(A) Dwelling Units

GFCI Protection for Personnel

All 125-v through 250-v receptacles installed in the following locations and supplied by single-phase branch circuits rated shall have ground-fault circuit-interrupter for personnel:
(No maximum ampacity noted)

(7) Areas with sinks and permanent provisions for ***food preparation, beverage preparation, or cooking.***

www.ta191.com

For Informational Purposes Only

210.8(A) GFCI Exceptions (Dwellings)

Exceptions 1 - 4

1. **Receptacles, not readily accessible, dedicated circuit for electric snow-melting or pipeline and vessel heating.**
2. **Receptacle supplying only permanently installed premises security system.**
3. **Listed weight-supporting ceiling receptacles *in combination with compatible weight-supporting fittings.***
4. ***Factory mounted receptacles in bathroom exhaust fans (re: installation instructions & listing & labeling)***

Δ 210.8(B) Other than Dwelling Units

GFCI Protection for Personnel

All 125-v through 250-v receptacles installed in the following locations and supplied by 1ø branch circuits rated 50a or less, and 3ø branch circuits rated 100a or less,150-v or less to ground, shall have ground-fault circuit-interrupter for personnel:

(3) Areas with sinks and permanent provisions for food preparation, ***beverage preparation***, or cooking.

(4) *Buffet serving areas with permanent provisions for food serving, beverage serving, or cooking.*

www.ta191.com

For Informational Purposes Only

Δ 210.8(B) Other than Dwelling Units

GFCI Protection for Personnel

(7) Sinks ***where receptacles or cord and-plug-connected fixed or stationary appliances*** **are installed within 6' from the top inside edge of the bowl of the sink.**

N **(13)** ***Aquariums, bait wells, and similar open aquatic vessels or containers, such as tanks or bowls, where receptacles are installed within 6' from the top inside edge or rim or from the conductive support framing of the vessel or container.***

www.ta191.com

Not Current Code In Ohio

Δ 210.8(D) Specific Appliances

GFCI protection shall be provided for the branch circuit or outlet supplying the following appliances, 150-v or less to ground 60a or less; 1ø or 3ø

1. Automotive vacuum cleaners
2. Drinking water coolers / bottle fill stations
3. High-pressure spray washing machines
4. Tire Inflation machines
5. Vending machines
6. Sump pumps
7. Dishwashers
8. ***Electric ranges***
9. ***Wall-mounted ovens***
10. ***Counter-mounted cooking units***
11. Clothes dryers
12. ***Microwave ovens***

www.ta191.com

For Informational Purposes Only

210.8(F) Outdoor Outlets

For dwellings, all outdoor ***outlets***, other than those covered on 210.8(A), Ex.1, including outlets specified in the following locations, and supplied to 1ø branch circuits rated 150-v or less to ground, 50a or less shall be provided with GFCI protected.

1. ***Garages that have floors located at or below grade level.***
2. ***Accessory buildings***
3. ***Boathouses***

Applies to replacing outlet(s) covered by this section!

(Also: 680.22(A)(4) Swimming Pool Outlets)

2020 / NEC 2023 NEC / BBS 10.20.2022 RCAC

State of Ohio (would apply to 1, 2, & 3-family dwellings

****Proposed Amendment****

Re: 210.8(F) Outdoor Outlets (Dwelling Units)

N **Exception #2: GFCI protection shall not be required for listed HVAC equipment. This exception shall expire September 1, 2026**

www.ta191.com

For Informational Purposes Only

Δ 210.11(C)(4) Garage Branch Circuits

In addition to the number of branch circuits by other parts of this section, at least one 120-v, 20a branch circuit shall be installed to supply receptacle outlets, for attached and detached garages with electric power. This circuit shall have no other outlets.

New 2nd Paragraph

Additional branch circuits rated 15a or greater shall be permitted to serve receptacle outlets other than those required by 210.52(G)(1).

www.ta191.com

N 210.12(B) AFCI Protection for Dwelling Units

No Change here; just listed separately

1. Kitchens
2. Family Rooms
3. Dining Rooms
4. Living Rooms
5. Parlors
6. Libraries
7. Dens

8. Bedrooms
9. Sunrooms
10. Recreation Rms.
11. Closets
12. Hallways
13. Laundry Areas
14. Similar Areas

www.ta191.com

For Informational Purposes Only

210.12(C) AFCI Protection for Dormitory Units

All 125-v, 1ø ***10,*** 15- and 20-ampere branch circuits supplying outlets ***or*** devices installed in ***the following locations*** shall be protected by any of the means described in 210.12 (A)(1) - (A)(6).

1. Bedrooms
2. Living Rooms
3. Hallways
4. Closets
5. Bathrooms
6. Similar Locations

www.ta191.com

Not Current Code In Ohio

210.12 (D) AFCI Protection; Other Occupancies

(D) <u>Other Occupancies</u>. ***All*** 125-v 1ø, ***10,*** 15- and 20-ampere branch circuits, supplying outlets ***or*** devices installed in ***the following locations*** shall be protected by any of the means described in 210.12(A)(1) - (A)(6).

1. ***Guest rooms & guest suites of hotel & motels.***
2. ***Areas used exclusively as patient sleeping rooms in nursing homes & limited-care facilities.***
3. ***Areas designed for use exclusively as sleeping quarters in fire, police, ambulance, rescue, ranger stations, & similar locations.***

www.ta191.com

For Informational Purposes Only

N 210.23(A) 10-Ampere Branch Circuits

10-ampere Branch Circuits

210.23(A) ***A 10-ampere branch circuit shall comply with the requirements of 210.25(A)(1) and (A)(2).***

210.23(A)(1) Loads permitted for 10-ampere Branch Circuits.

1. ***Lighting Outlets***
2. ***Dwelling unit exhaust fans or bathroom or laundry room lighting circuits***
3. ***Gas fireplace unit supplied by an individual branch circuit***

www.ta191.com

N 210.23(2) Loads not Permitted for 10-Ampere Branch Circuits

A 10-ampere branch circuit shall

not **supply any of the following:**

1. **Receptacle outlets**
2. **Fixed appliances, except as permitted for individual branch circuits.**
3. **Garage door openers**
4. **Laundry equipment**

www.ta191.com

For Informational Purposes Only

N 210.24 Branch Circuit Requirements; Summary

Expanded this section and tables from applying to Copper conductors only, to include Aluminum and Copper-Clad Aluminum conductors

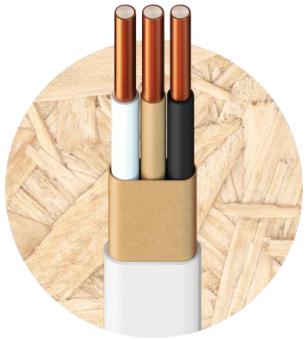


Table 210.24(1) - Applies to Copper Conductors

N **Table 210.24(2) - Applies to both Aluminum & Copper-Clad Conductors**

Δ 210.52(C)(2) Island & Peninsular Countertops & Work Surfaces

Receptacle outlets, ***if*** installed to serve an island or peninsular countertop or work surface, shall be installed in accordance with 210.52(C)(3). ***If a receptacle is not provided to serve an island or peninsular countertop or work surface, provisions shall be provided at the island or peninsular or work surface, provisions shall be provided at the island or peninsula for future addition of a receptacle outlet to serve the island or peninsular countertop or work surface.***

What a Relief!!!

www.ta191.com

For Informational Purposes Only

Δ 210.70(A)(1) Habitable Rooms; Lighting Outlets

Habitable Rooms; Kitchens, *Laundry Areas* & Bathrooms

At least one lighting outlet controlled by a listed mounted control device shall be installed in every habitable room, kitchen, ***laundry areas,*** and bathrooms. The wall-mounted control device shall be located near an entrance to the room on a wall.

Added laundry area to this section. Would Article 314.27(C) require a ceiling suspended (Paddle) fan box?

www.ta191.com

Not Current Code In Ohio

N 215.15 Feeders (Barriers)

Barriers. Barriers shall be placed such that no energized, uninsulated, *ungrounded busbar or terminal* is exposed…….





N 215.15 Feeders

230.62 Services (2020 NEC)

N 240.21 Transformer Secondaries

www.ta191.com

For Informational Purposes Only

Article 225 Outside Branch Circuits & Feeders

Part II. Building or Other Structures Supplied by a Feeder(s) or Branch Circuit(s)

Article 230 Services – Part IV. SE Conductors

N **Sections 225.41 & 225.42 / 230.67 & 230.85**

1 & 2-Family Dwelling Emergency Disconnects:

General / Location / Rating / Marking *N* 225.41 / 230.85

Surge Protection: Device / Location / Type / Replacement / Minimum 10kA Ratings

N **225.42 / 230.67**

www.ta191.com

Not Current Code In Ohio

Δ 230.67 Expanded Surge Protection



Expanded Surge Protection Requirements

230.67(A) Surge Protective Device.

1. Dwelling units
2. ***Dormitory units***
3. ***Guest rooms & guest suites of Hotels & Motels***
4. ***Areas of nursing homes & limited-care facilities used exclusively as patient sleeping rooms***



www.ta191.com

For Informational Purposes Only

Δ 230.71 Maximum Number of Service Disconnects

(B) Two to Six Service Disconnecting Means

1. Separate enclosures, each with a main SE disconnect.
2. Panelboards with a main SE disconnect.
3. Vertical switchboard sections that have separate SE disc.
4. SE disconnect in switchgear, ***transfer switches,*** or meter mods where each disconnect is located in a separate compartment.

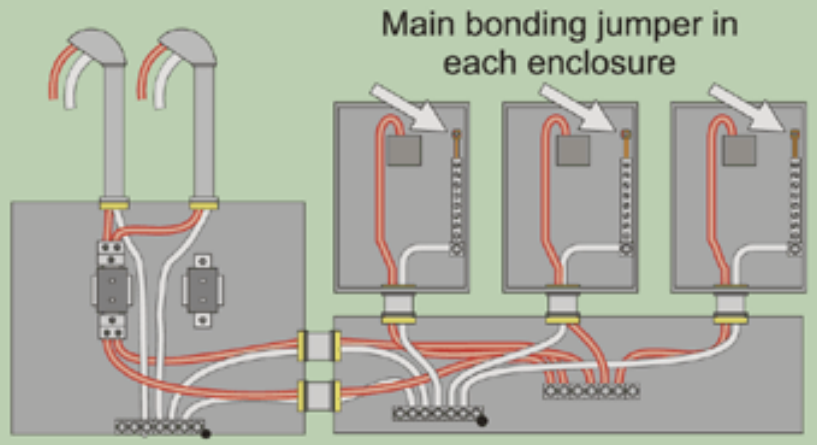
N 5. Meter mods with a main SE disconnect in each metering center.

N 6. MCC's with 1 SE disconnect or a max of 2 SE disconnects with barriers provided between each MCC unit or compartment.

www.ta191.com

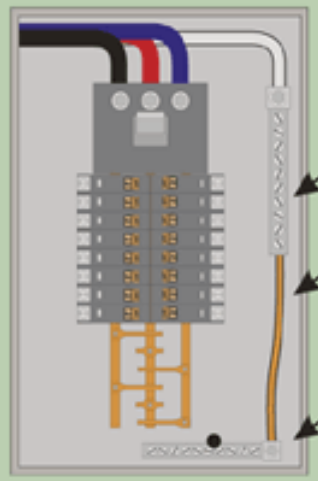
Not Current Code in Ohio

Main Bonding Jumper - Multiple Enclosures

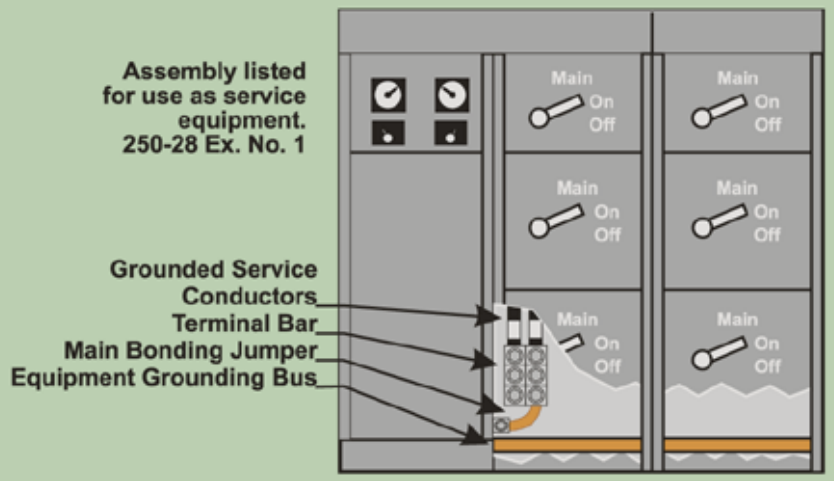


(All conductors not shown)

Main Bonding Jumper



Main Bonding Jumper for Listed Assembly





www.ta191.com

N 230.71(B)(5) & (6) 6 Handle Rule





www.ta191.com

For Informational Purposes Only

230.85(A) Emergency Disconnects; General

For 1 & 2-family dwelling units, an emergency disconnecting means shall be installed.

N* (1) Location.** The disconnecting means shall be installed in a readily accessible location ***on or within sight of the dwelling unit.

***N* (2) Rating. The disconnecting means shall have a short-circuit current rating equal to or greater than the available fault current.**

***N* (3) Grouping. If more than 1 disconnecting means is provided, they shall be grouped.**

www.ta191.com

For Informational Purposes Only

230.85(B) Emergency; Disconnects

N **(B) Disconnects. Each disconnect shall be one of the following:**

1. Service Disconnect

2. A meter disconnect integral to the meter mounting equipment ***not marked as suitable only*** as SUSE equipment, installed in accordance with 230.82

3. Other listed disconnect switch or circuit marked as that is marked SUSE, but ***not marked as suitable only*** as SUSE, installed on the supply side of each service disc

N 230.85(C) Emergency Disconnects

N **Replacements. Where service equipment is *replaced*, all of the requirements of this section shall apply.**

N **Exception:** Where ***only meter sockets, or related raceways and fittings are replaced***, the requirements of this section shall not apply.

For Informational Purposes Only

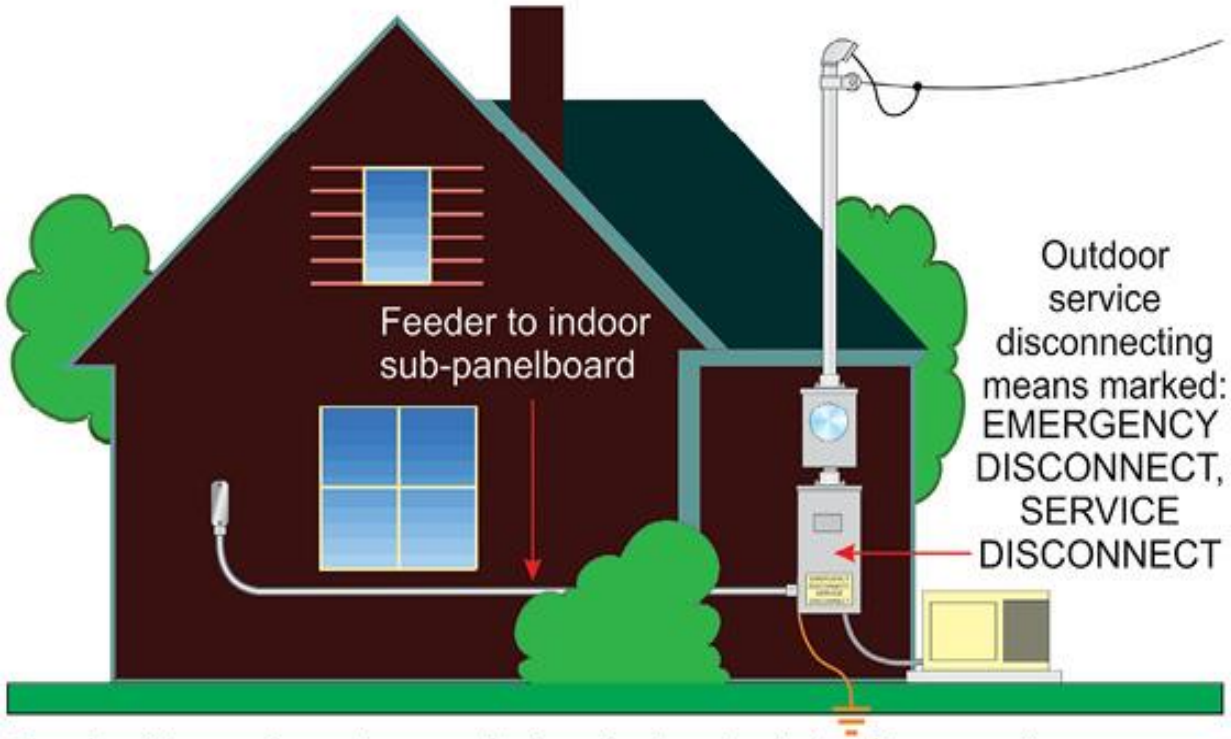
N 230.85(D) Emergency Disconnects

***N* Identification of Other Isolation Disconnects.**

Where equipment for isolation of other energy source systems is not located adjacent to the emergency disconnect required by this section, a plaque or directory identifying the location of all equipment for isolation of other energy sources shall be located adjacent to the disconnecting means required by this section.

RE: Battery, Generator, Interconnected Power Production Sources, and Energy Storage Systems

230.85 Exterior Emergency Disconnect(s)



For dwellings, all service conductors to terminate in disconnecting means having a short-circuit current rating equal to or greater than the available fault current, installed in a readily accessible outdoor location

If more than one disconnec ined



www.ta191.com

230.85 EXTERIOR EMERGENCY "SE" DISCONNECT

Applies to 1- and 2-Family Dwelling Units

All **service conductors to terminate in a SUSE rated disconnecting means, with adequate SCCR, in a readily accessible *outdoor* location. Grouping is required.**

Intent to protect firefighters / other emergency personnel.



CAN A SMART METER ACT AS AN EMERGENCY DISCONNECT

Until recently I was a proponent of this type of installation. However, I am out of touch with technology. Due to more consumers utilizing multiple energy sources:

1. <u>Commercial power supply</u>

2. <u>Interconnected Power Production Sources</u>

(a) On-site Generator

(b) Photovoltaic System

(c) Wind Energy System

(d) Battery System

(e) Fuel Cell System

(f) Energy Storage System

<u>Posting permanent plaque of sources</u>

N 230.85 (E)(1) Emergency Disconnects

Marking Text

1. Service Disconnect
EMERGENCY DISCONNECT, SERVICE DISCONNECT
2. Meter Disconnects installed in accordance with 230.82(3) as follows: ***EMERGENCY DISCONNECT, METER DISCONNECT, NOT SERVICE EQUIPMENT***
3. Other listed disconnect switches or circuit breakers on the supply side of each service disconnect that are marked suitable for use as SE and marked as follows:

EMERGENCY DISCONNECT NOT SERVICE EQUIPMENT

www.ta191.com

For Informational Purposes Only

N 230.85(E)(2) Emergency Disconnects

Marking Location & Size

Markings shall comply with 110.21(B) & both of the following:

(1) The marking or labels shall be located on the outside front of the disconnect enclosure with ***RED*** background and ***WHITE*** text.

(2) The letters shall be at least (½”) high.

N Article 235 – Branch, Feeder, & Service Circuits over ***1000v ac.***

235.1 Scope. This article the general requirements for branch circuits, feeders and services over 1000v ac or 1000v dc, nominal.

235.5(C)(1)(a) *Means of identification*. Separate color coding, marking, tape, tagging or other approved means

235(C)(1)(b) *Posting of identification means*. *Documented in a readily accessible manner at each panelboard.*

Existing installations*. *Required to mark only new system voltage being added.

www.ta191.com

Not Current Code In Ohio

N Article 235 – Branch, Feeder, & Service Circuits over ***1500v dc***

235.5(C)(2) *Branch Circuits Supplied from DC Systems*.

Each ungrounded conductor #4 and larger shall be identified by polarity at all termination, connection and splice points by marking tape, tagging or tape or other approved means and each #6 and smaller ungrounded conductor shall be identified by polarity at all termination points.

The identified methods used for conductors shall be documented at all panelboard locations in a manner readily available or be permanently posted at each panelboard location.

DC Conductor Identification (Positive)

235.3(C)(2)(a) Positive Polarity (DC) *Sizes #6 and smaller.*

Where the positive polarity of a dc system does not serve as the connection point for the grounded conductor, each positive conductor shall be identified by ***one*** of the following means:

(1) A continuous red outer finish

(2) Continuous red stripe along the entire length or (color other than green, white, gray or black)

(3) Imprinted minus signs(+) or the word positive or POS identified not more than 24” along its’ entire length

(4) Approved sleeving or shrink tubing at all terminations

www.ta191.com

For Informational Purposes Only

DC Conductor Identification (Negative)

235.3(C)(2)(b) Negative Polarity (DC) *Sizes #6 and smaller.*

Where the negative polarity of a dc system does not serve as the connection point for the grounded conductor, each positive conductor shall be identified by ***one*** of the following means:

(1) A continuous black outer finish

(2) Continuous black stripe along the entire length or (color other than green, white, gray or red)

(3) Imprinted minus signs(-) or the word negative or NEG identified not more than 24” along its entire length

(4) Approved sleeving or shrink tubing at all terminations

www.ta191.com

240.4(B) OCD Rated 800a or Less

New 2nd Paragraph

*If the overcurrent protective device is an **adjustable trip device** installed in accordance with 240.4(B)(1),(2), & (3) it **shall be permitted to be set to a value that does not exceed the next higher standard value** above the ampacity of the conductors being protected as shown in 240.6(A) where **restricted access** is accordance with 240.6(C) is provided.*



(1) Continuous Amps

(2) Short-time Pickup

(3) Instantaneous Pickup

(4) Ground Fault Pickup



www.ta191.com

For Informational Purposes Only

N Article 245 – Overcurrent Protection for Systems rated over 1kV ac & 1.5kV dc

New Medium Voltage Conductor Article

245.1 Scope. This article covers overcurrent protection requirements for systems rated over 1kV ac 1.5kv dc, nominal.

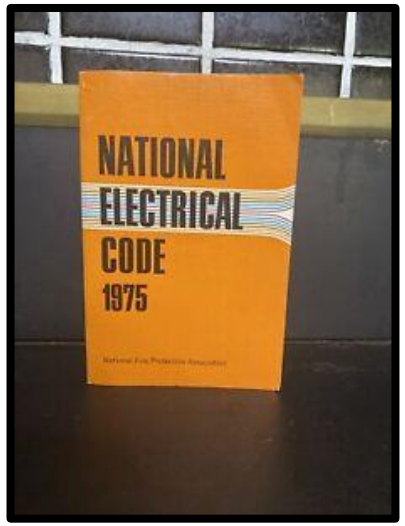
245.21 Circuit Breaker & Fuse protection

245.26 Feeders & Branch Circuits

www.ta191.com

Not Current Code In Ohio

Article 250 Grounding & Bonding



The 2023 NEC Code Cycle is extremely unique in that I found no significant changes in Article 250. This is the 1st time I have experienced this since entering the electrical trade during the 1975 NEC Code Cycle.

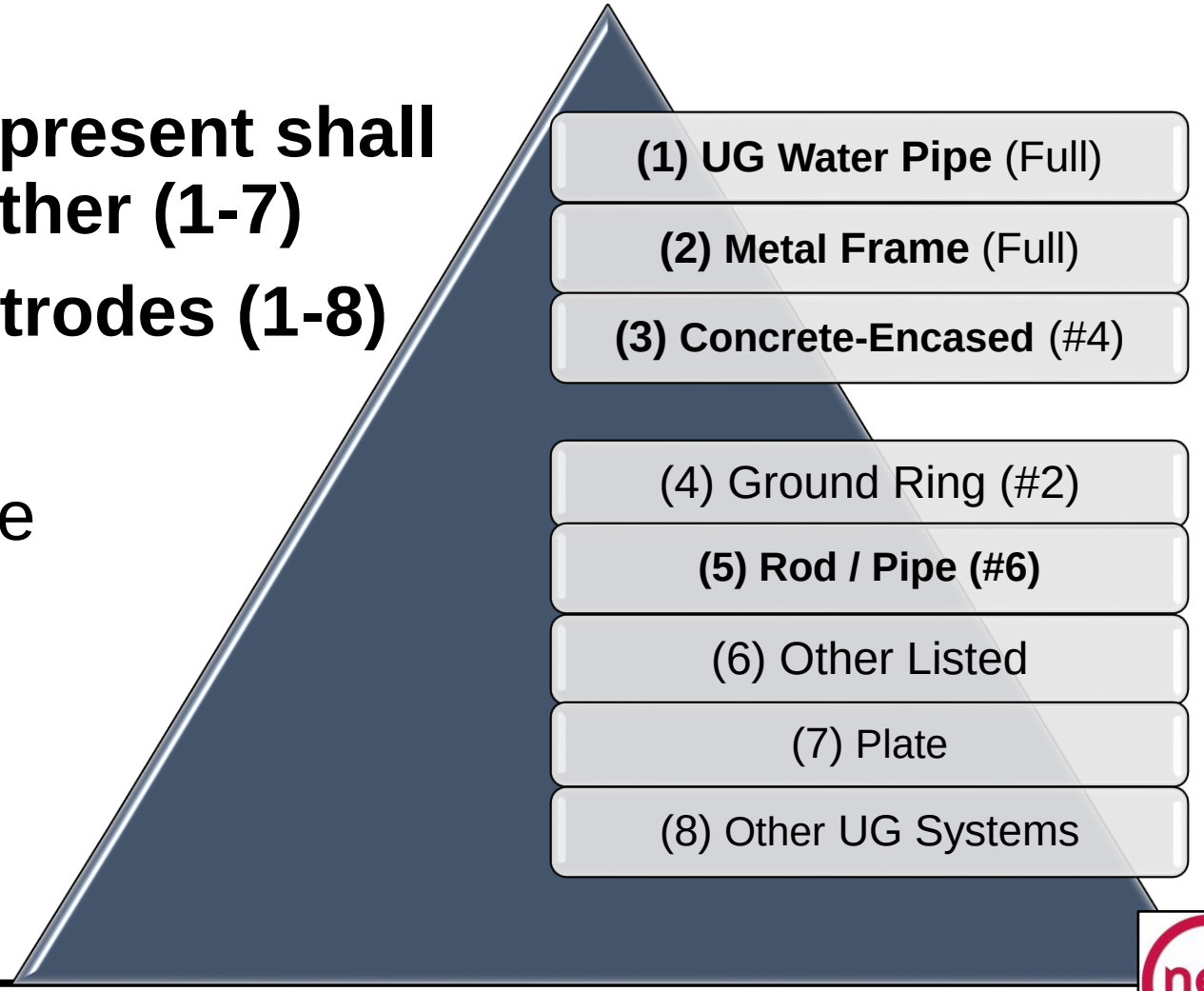
Grounding Triangle / Foundation

250.50 <u>All</u> Electrodes present shall be bonded together (1-7)

250.52 Permitted Electrodes (1-8)

<u>Focus</u>:

1. Metal UG Water Pipe
2. Building Steel
3. Concrete-Encased
4. Rod / Pipe



www.ta191.com

Δ 250.140 Frames of Ranges & Dryers

N (B) Grounded Conductor Connections

Since 1996 the NEC has required 4-wire branch circuits for new installations of Electric Ranges & Dryers

Existing Installations: Expanded Use of 3-wire "SE" Cable

Prior editions of the NEC only permitted 3-wire SE cable that originated in SE equipment.

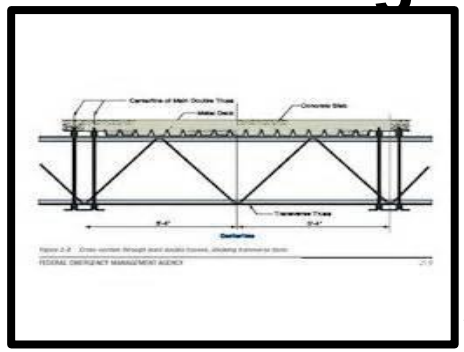
*This change now permits in **"existing installations"**, that the bare SE grounded conductor may be **insulated** or field covered **(taped)** in locations other than SE equipment.*

www.ta191.com

For Informational Purposes Only

Article 300 General Requirements for Wiring Methods & Materials

300.4(E) Cables, raceways or boxes installed under metal roof corrugated decking.



***N* Exception #2**

*The 1½" spacing is **not** required where metal-corrugated sheet roof decking is covered with a **minimum** 2" concrete slab, measured from the top of the corrugated roofing*

****Re: *N* 410.10(F) Exception****

Δ 300.14 Length of Free Conductors

At Outlets, Junctions, and Switch Points

At least 6” of free conductor, measured from the point in the box, where it emerges from its raceway or cable sheath, shall be left at each outlet, junction, and switch point for splices or the connection of luminaires or devices. ***The 6” free conductor shall be permitted to be spliced or unspliced.*** Where an opening to an outlet, junction, or switch point is less than 8” in any dimension, each conductor shall be long enough to extend at least 3” outside the opening.





Δ 300.25 Exit Enclosures (Stair Towers)

Where an exit enclosure is required to have ***fire resistance rating,*** only electrical wiring methods serving equipment permitted by the authority having jurisdiction in the exit enclosure shall be installed within the exit enclosure.

N Exception. ***Where egress lighting on the outside exterior doorways from the exit enclosure, luminaires shall be permitted to be supplied from the inside of the exit enclosure.***



"Self-closing doors are indicative of a fire rating"

N Article 305 – General Requirements for Wiring Methods & Materials for Systems rated over 1kV ac & 1.5 kV dc

New Medium Voltage Conductor Article

305.1 Scope. This article covers wiring methods and materials for systems rated over 1kV ac, 1.5kV dc.

305.3 Exposed runs of MV cables, bare conductors, & bare busbars shall be permitted in locations accessible only to qualified persons. Busbars shall be permitted to be either CU or AL.

Not Current Code In Ohio

Article 310 Conductors for General Wiring

Δ 310.3(B) Conductor Material

Conductors in this article shall be of, aluminum (AA-8000), copper or copper-clad aluminum unless otherwise specified.

Aluminum and copper-clad aluminum shall comply with the following: material shall be ***(listed)***.

For copper-clad aluminum conductors the copper shall form a minimum of 10% of the cross-sectional area of a solid conductor or each strand of a stranded conductors.





Table 310.16 Ampacities of Insulated Conductors with Not More Than Three Current-Carrying Conductors in Raceway, Cable, or Earth (Directly Buried)

Size AWG or kcmil	Temperature Rating of Conductor [See Table 310.4(A)]						Size AWG or kcmil
	60°C (140°F)	75°C (167°F)	90°C (194°F)	60°C (140°F)	75°C (167°F)	90°C (194°F)	
	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, XHWN, USE, ZW	Types TBS, SA, SIS, FEP, FEPB, MI, PFA, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN, Z, ZW-2	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, XHWN, USE	Types TBS, SA, SIS, THHN, THHW, THW-2, THWN-2, RHH, RHW-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN	
	COPPER			ALUMINUM OR COPPER-CLAD ALUMINUM			
18*	—	—	14	—	—	—	—
16*	—	—	18	—	—	—	—
14*	15	20	25	—	—	—	—
12*	20	25	30	15	20	25	12*
10*	30	35	40	25	30	35	10*
8	40	50	55	35	40	45	8
6	55	65	75	40	50	55	6
4	70	85	95	55	65	75	4
3	85	100	115	65	75	85	3
2	95	115	130	75	90	100	2
1	110	130	145	85	100	115	1
1/0	125	150	170	100	120	135	1/0
2/0	145	175	195	115	135	150	2/0
3/0	165	200	225	130	155	175	3/0
4/0	195	230	260	150	180	205	4/0
250	215	255	290	170	205	230	250
300	240	285	320	195	230	260	300
350	260	310	350	210	250	280	350
400	280	335	380	225	270	305	400
500	320	380	430	260	310	350	500
600	350	420	475	285	340	385	600
700	385	460	520	315	375	425	700
750	400	475	535	320	385	435	750
800	410	490	555	330	395	445	800
900	435	520	585	355	425	480	900
1000	455	545	615	375	445	500	1000
1250	495	590	665	405	485	545	1250
1500	525	625	705	435	520	585	1500
1750	545	650	735	455	545	615	1750
2000	555	665	750	470	560	630	2000

www.ta191.com

Article 310 Conductors for General Wiring

Δ 310.3(B) Conductor Material

Conductors in this article shall be of, aluminum (AA-8000), copper or copper-clad aluminum unless otherwise specified.

Aluminum and copper-clad aluminum shall comply with the following: material shall be ***(listed)***.

For copper-clad aluminum conductors the copper shall form a minimum of 10% of the cross-sectional area of a solid conductor or each strand of a stranded conductors.





"Deleted" Article 311 Medium Voltage Conductors & Cables

This Article was New in the 2020 NEC

Previous editions of NEC were Articles 310 & 328

Replaced / Broken down into (3) NEW Articles

N **Article 235- Branch Circuits over 1kV**

N **Article 245- OCP for circuits over 1kV**

N **Article 495- Equipment over 1kV**

N 314.24 (C) Clearances for Side-Wiring Entrances

Where devices or equipment are mounted in boxes having side-wiring entries, the conductors entering from the side shall be protected as covered in (1) & (2), as follows. The term ***side*** applies any wall of a box other than the one opposite to the opening.

1. The rearward projection of the device or equipment shall not extend beyond the centerline of the wiring knockout or other entry.
2. The clearance from the box wall to the installed device or equipment shall not be less than ½”.

www.ta191.com

For informational purposes only

Δ 314.27 Ceiling Boxes for Paddle Fans

2nd Paragraph

Outlet boxes mounted in the ceilings of habitable rooms dwelling occupancies in a location acceptable for the installation of a ceiling-suspended (paddle) fan shall comply with one of the following:

1. Listed for the sole support of ceiling-suspended (paddle) fans.

N 2. ***Installed so as to allow direct access through the box, to structural framing capable of supporting a ceiling-suspended (paddle) fan without removing the box.***

www.ta191.com

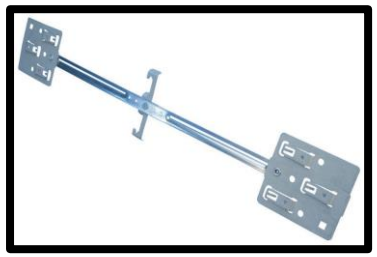
Not Current Code In Ohio

Δ 314.27(E) Weight Supporting Ceiling Receptacles (WSCR), & Weight-Supporting Attachment Fittings (WSAF)

NEW Terminology

Both listed WSCR & WSAF devices







www.ta191.com

For Informational Purposes Only

N Article 315 Medium Voltage Conductors, Cable, Cable Joints & Terminations

315.1 Scope. ***This article covers the use, installation, construction specs, and ampacities of MV medium voltage conductors, cable, cable joints, & cable terminations. This article includes voltage 2001v – 35kV ac & 2001 – 2500v dc.***

315.6 Listing Requirements. ***Type MV cables, joints, terminations, connectors, & associated fittings shall be listed. The listing requirements for MV cable joints, terminations, & connectors shall be effective January 1, 2026.***

N 315.50 Installation of MV Conductors

Part III.

A qualified person(s) with documented training and experience shall perform the installation and testing of Type MV cable. A qualified person(s) with documented training and experience in the installation of Type MV cable joints. A qualified person(s) with documented training and experience in the installation of Type MV cable terminations shall perform installation of Type MV cable terminations.

www.ta191.com

For Informational Purposes Only

N Instrumentation Tray Cable (ITC)

335.1 Scope. This article covers the use, installation, and construction specifications of *instrumentation tray cable* (ITC) for application to instrumentation and control circuits operating at 150v or less and 5 amperes or less.



335.6 Construction.

The insulated conductors of Type ITC cable #22 - #12 AWG Conductors shall be copper or thermocouple alloy.

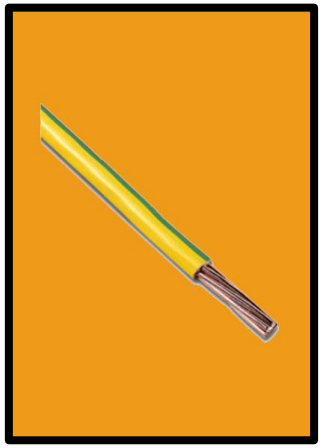


N Article 369 Insulated Bus Pipe (IBP) / Tubular Covered Conductors (TCC) Systems

369.1 Scope. This article covers the use, installation, and construction specifications for insulated pipe (IBP) systems.







www.tal91.com

For Informational Purposes Only

N Article 371 Flexible Bus Systems

371.1 Scope. This article covers the use and installation requirements of flexible bus systems and associated fittings.





www.tal91.com

Not Current Code In Ohio

Δ Article 400 Flexible Cords & Cables

N Part IV. Portable Power Feeder Cables over 2000v, Nominal

N **400.10 General. Part IV applies to single & multiconductor portable power feeder cables over 2000v nominal used to connect portable equipment & machinery.**

Medium Voltage Cable Type "G"



www.tal91.com

For Informational Purposes Only

406.4(D) Receptacle Replacements

Replacements

1. Grounding Type Receptacles
2. Non-Grounding Type Receptacles
3. GFCI Replacements
4. AFCI Replacements – ***Where "AFCI" protection is required (2020)***
5. Tamper-Resistant – ***Where "TR" protection is required (2011)***
6. Weather-Resistant – ***Where "W/R" protection is required (2011)***
7. Controlled Receptacles – ***Based on Situation (2020)***
8. ***N*** GFPE of Protection of Equipment – **Where "GFPE" protection is Required (2023)**

406.4 Receptacle Replacements. Grounding (D)(1); Non-grounding (D)(2); GFCI (D)(3); and AFCI (D)(4)

Reference to 210.12 (A), (B) & (C) Required **"AFCI"** Locations

*****2020 NEC 406.4(D) Arc-Fault Circuit-Interrupter (AFCI); Replacement Types*****

(1) Listed outlet branch-circuit AFCI type receptacle

(2) Receptacle protected by listed outlet branch-circuit type AFCI receptacle

(3) A receptacle protected by a listed combination type AFCI circuit breaker

210.12(D) Ex*: Branch Circuit Extensions or Modifications* – Dwelling Units, Dormitory Units, and Guest Rooms and Guest Suites locations only.

(1) 210.12 (A) Dwelling Units. (1-6)

(2) Listed outlet branch-circuit type AFCI at 1st outlet of existing circuit

www.ta191.com

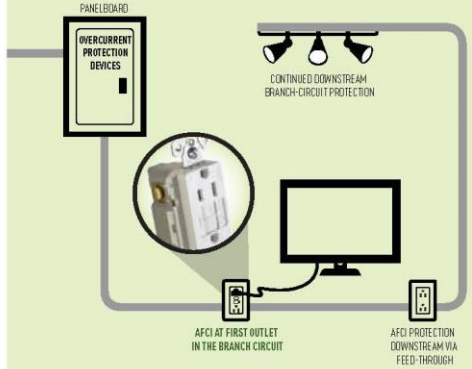
For Informational Purposes Only



Methods for Meeting NEC® Requirements with AFCI and AFCI/GFCI Receptacles

BRANCH-CIRCUIT EXTENSIONS OR MODIFICATIONS

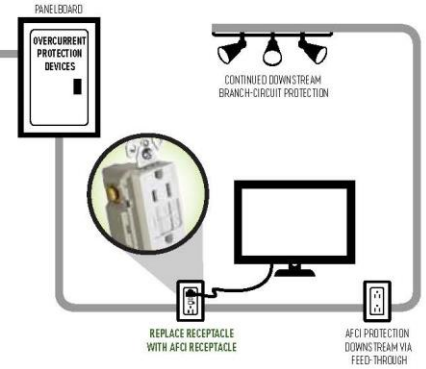
When branch-circuit wiring is modified, replaced or extended, it is permissible to meet the NEC requirement with a listed outlet branch-circuit AFCI receptacle located at the first receptacle outlet of the existing branch circuit.



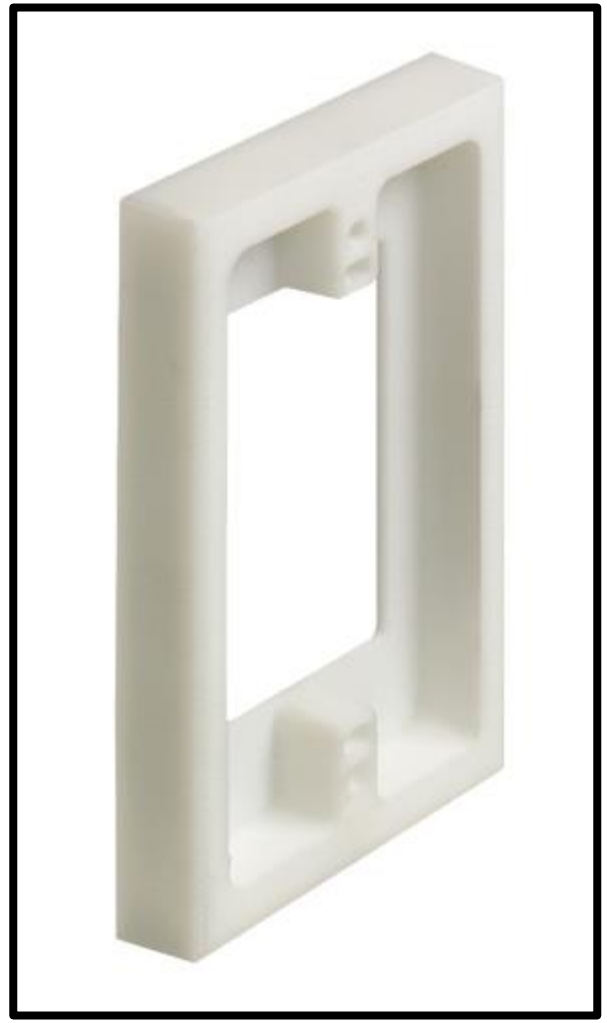
REPLACEMENTS

Where a receptacle outlet is supplied by a branch circuit that requires AFCI protection, it is permissible to meet the NEC requirement with a replacement receptacle that is one of the following:

1. A listed outlet branch-circuit type AFCI receptacle
2. A receptacle protected by a listed outlet branch-circuit type AFCI receptacle



Note: Section 406.4 (D)(4) requires AFCI protection when a receptacle is replaced.



www.ta191.com

AFCI Type Devices

AFCI “TR” Outlet



AFCI / GFCI “TR” Outlet



AFCI Type Devices

AFCI “Deadfront”



20a Hospital Grade AFCI / GFCI “TR” Outlet (Red)



N 406.12 Tamper-Resistant Receptacles

Expanded Locations; 15- & 20-ampere 125v thru 250v

1. Dwelling units
2. Guest rooms & Guest suites
3. Child-care facilities
4. Preschools & educational facilities
5. **Within clinics, medical & dental offices, following areas:**
   (a) Business offices accessible to the public
   (b) Lobbies & Waiting Areas
   (c) Spaces of nursing homes / limited-care facilities
6. **Places awaiting transportation, gyms, skating rinks, fitness centers & auditoriums**
7. Dormitory units
8. **Residential care facilities, assisted living, rehab & group homes**
9. **Foster care facilities, nursing homes & psychiatric hospitals**
10. **Accessible areas of agricultural buildings to the general public & any common areas**

www.ta191.com

For Informational Purposes Only

Δ 410.184 GFCI Protection & Special Purpose (SPGFCI) Protection



Horticultural Lighting Use

NEW Exception:

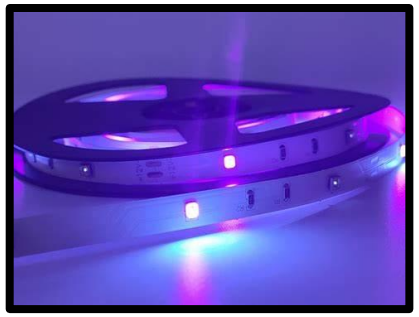
Circuits exceeding 150v to ground shall be protected by a listed special purpose GFCI

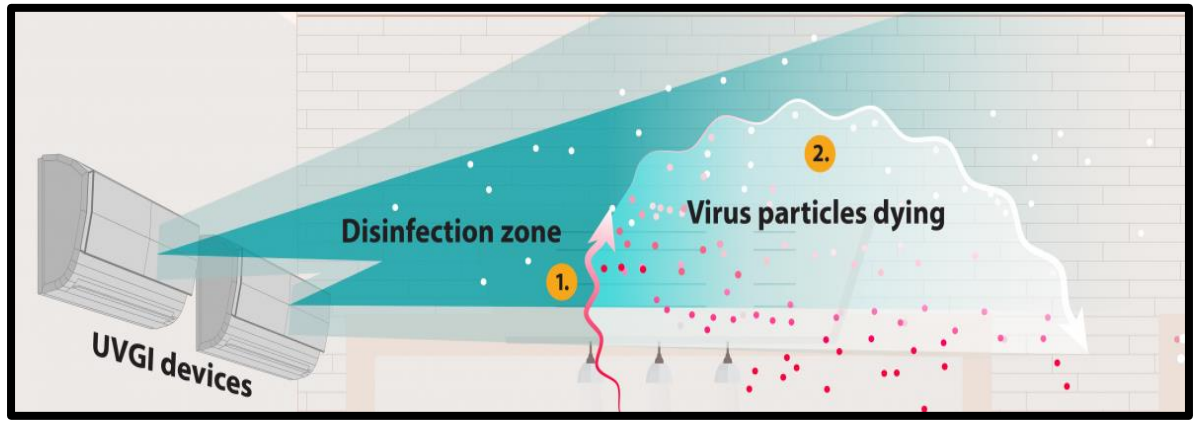
Class "C" Special Purpose Ground-Fault Circuit Interrupter (SPGFCI) Trip level is 15 – 20mA / ckts. over 150v to ground

N Germicidal Irradiation Luminaires

Article 410.190 Part XVII. Special Provisions

Listing, Labeling & Installation Requirements







HVAC Ventilation / UV-C LED lighting systems
Tuberculosis, SARS, & CoV-2 sterilization: reduce hazards

www.ta191.com

For Informational Purposes Only

Δ 426.28 Ground-Fault Protection

Fixed Outdoor Electric De-icing & Snow Melting Equipment

Previously 426.44(E) GFCI Protection. In addition to the requirements of 210.8, GFCI protection for personnel shall be provided.

426.28 Ground Fault protection.

GF protection shall be provided for fixed outdoor electric de-icing and snow-melting equipment.

The trip level shall be specified by the manufacturer.

www.ta191.com

Not Current Code In Ohio

Δ 440.11 A/C Disconnects





Expanded Requirement

Disconnecting means shall be capable of disconnecting A/C & refrigeration equipment, including motor-compressors & controllers, from the circuit conductors. If the disconnecting means is readily accessible to unqualified persons, an enclosure door or hinged cover of a disconnecting means enclosure ***that exposes energized parts when open shall require a tool to open or be capable of being locked.***

N Article 495 Equipment Over 1kV ac / 1.5kV dc

Previous NEC Editions was Article 490

495.1 ***Scope. This article covers the general requirements for equipment operating at over 1000v ac, 1500v dc.***

495.22 ***Isolating Means***

495.48 ***Substation Design & Documentation***

495.61 ***Mobile and Portable Equipment***

495.70 ***Boilers***

www.ta191.com

For Informational Purposes Only

Δ Article 500 Hazardous Locations

Classified Locations; Class I, II, & III Locations; Division I & II

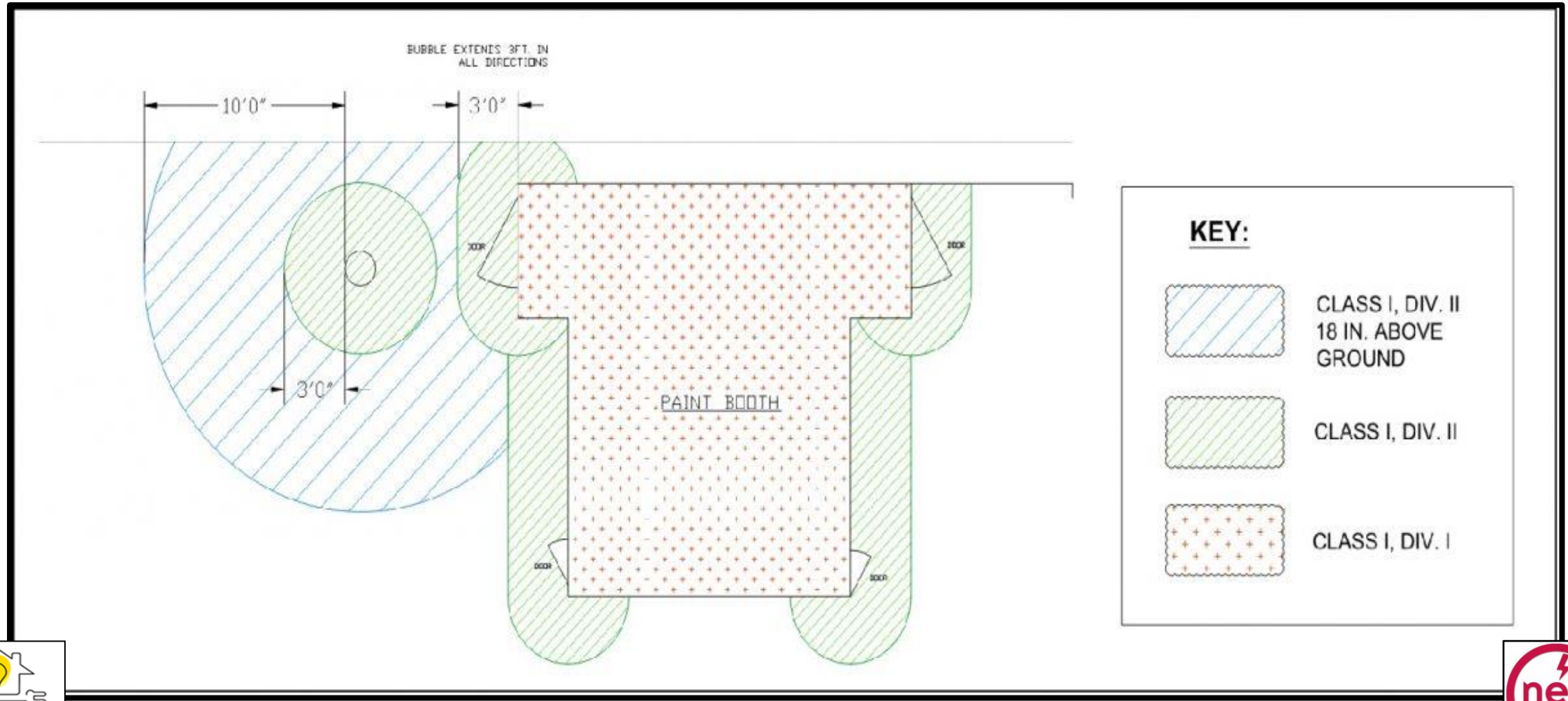
Additional Requirement 500.4 Documentation.

Classified or unclassified areas shall be documented on an area classification drawing & other associated documentation. This documentation shall be available to the authority having jurisdiction (AHJ) and those authorized to design, install, inspect, maintain or operate the equipment.

www.ta191.com

For Informational Purposes Only

Documented Area Classification



www.ta191.com

Not Current Code In Ohio

Δ Article 511 Commercial Garages Repair & Storage

This Article was re-written

511.7 Fixed Wiring Above Hazardous / Classified Locations.
Added ***listed fittings & equipment grounding conductors*** to numerous wiring methods.

517.8 Underground Wiring Below Hazardous Locations.

N Article 512 Cannabis Oil Equipment

512.1 Scope. This article covers cannabis oil preparatory equipment, extraction equipment, booths, post-processing equipment, and systems using flammable materials (flammable gas, flammable liquid-produced vapor, combustible liquid-produced vapor) in commercial & industrial facilities.

512.3 Classified Locations. Cannabis oil equipment & systems that can release flammable materials during operations shall be classified in accordance with 512.3(A) & (B).

www.tal91.com

Not Current Code In Ohio

N Article 512 – Cannabis Oil Equipment / Oil Systems using Flammable Materials

512.3 Classified Locations. Cannabis oil equipment & systems that can release flammable materials during operation. ***Class I Div. 1 or II location***.

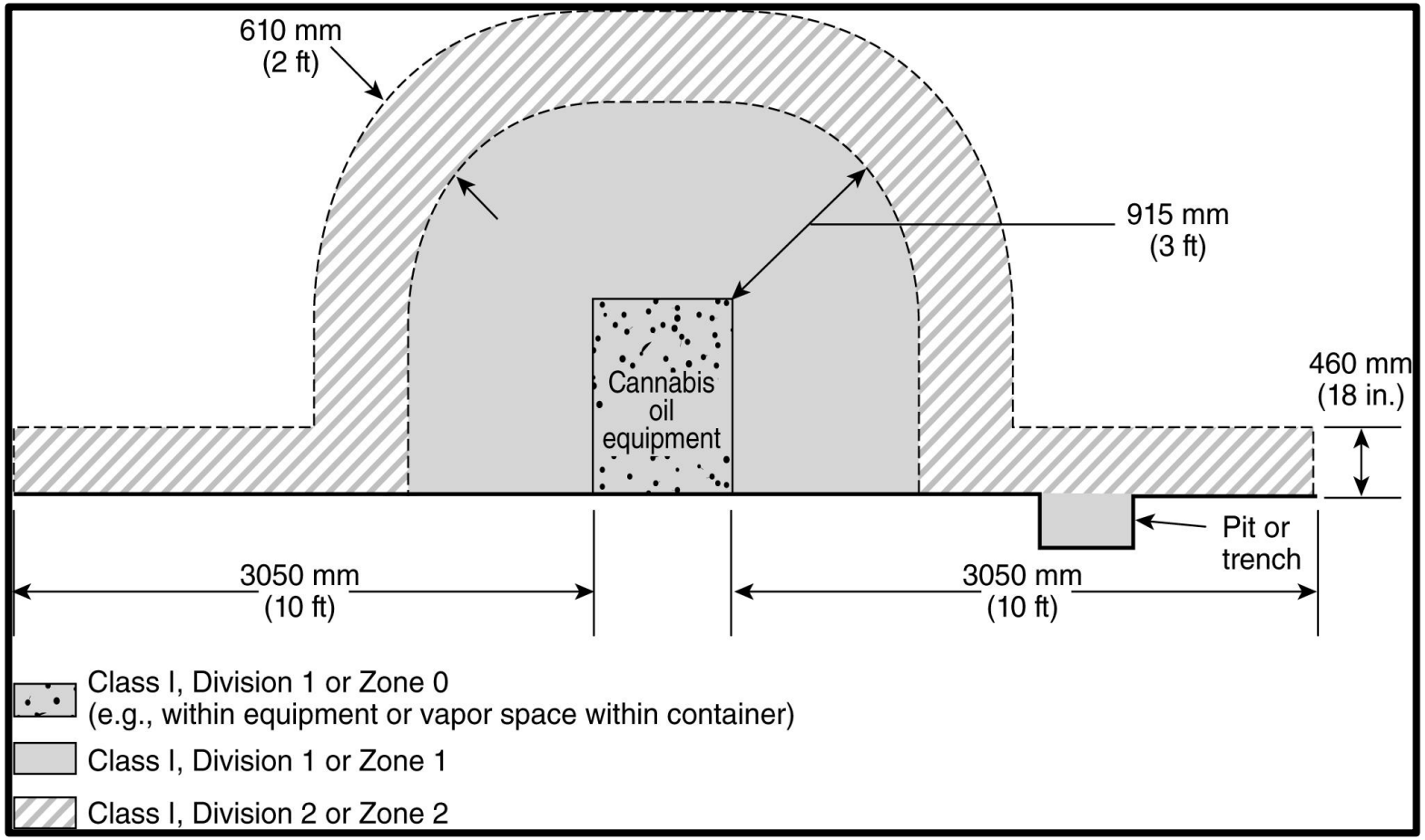




www.tal91.com

For Informational Purposes Only

N 512.3(B) Cannabis Oil Booth



Not Current Code In Ohio

Δ Article 514 Motor Fuel Dispensing Facilities

Δ 514.8 Underground Wiring. (In classified Locations)

The change here is previous editions of the NEC accepted MI, PVC, RTRC, HDPE conduit as an exception to the metal conduit rule. The 2023 NEC 514.8(B) & (C) is now written into positive code language.

No Change: Still requires 2' of cover or change to RMC or IMC

Δ 517 Health Care Facilities

517.1 Scope. ***Inadvertently Deleted***

517.2 Definitions. ***Relocated to Article 100***

517.10(B) Not Covered. ***Pharmacy services not contiguous to Health Care Facilities***

517.12 EGC for Receptacles & Fixed Electrical Equipment in Patient Care Spaces. ***The insulated copper conductor needs to be installed and terminated in each panel all the way to the SE equipment.***

517.30 EES Sources of Power. ***(1) Added utility power & changed (4) from battery system to energy storage system.***

Article 517 Health Care Facilities

517.50 Part V. *Diagnostic Imaging & Treatment Equipment*

Formerly X Ray Installations

(updated for new terminology & technologies)

Added Informational Notes #3 & #4

#3 Diagnostic Equipment

#4 Treatment Equipment

Δ Article 530 Motion Picture & TV Studios & *Remote Locations*

More specific details, restrictions and requirements for associated (portable) equipment than previous editions. Will affect both local and national live broadcasts including news, sporting and possibly any live event.

Part II . Expanded Portable Equipment in Production Areas of Studios & Remote Locations

Part III. Portable Equipment in Support Areas

www.ta191.com

Not Current Code In Ohio

Article 555 Marinas, Boatyards, Floating Buildings & Docking Facilities

This Article has been updated over the past (2) Code Cycles.

555.4 Location of Service Equipment (for a floating building, dock or marina). This section is clearly defined on the location of SE equipment ***(on land)***.

No closer than 5' horizontally from the structure served & 12" minimum above the electrical datum plane (2' above the maximum highest water level under normal conditions).

***N* 555.14 *Areas requiring Equipotential Planes*.**

***N* 555.15 *Replacement of Equipment*. Requires compliance**

***N* 555.36 *Emergency Disconnect*. Each marina power outlet that provides shore power to boats shall have an emergency disconnect.**

***N* 555.37 All Equipment grounding conductors *shall be insulated*.**

www.ta191.com

For Informational Purposes Only

Article 625 EV Power Transfer Equipment

Part III. Installation

Δ 625.40 Electric Vehicle Branch Circuit. ***Each outlet installed for the purpose of supplying EVSE greater than 16a or 120v shall be supplied by an individual branch circuit.***

N 625.42(B) Energy Management System. *When more than one or more pieces of equipment are provided with an integral load management control,* ***the system shall*** *be marked to indicate this control is provided.*

*****2020 NEC***** *Each outlet installed for the purpose of charging electric vehicles shall be supplied by an individual branch circuit*.

Each circuit shall have no other outlets.

www.ta191.com

Not Current Code In Ohio

625.60 AC Receptacle outlets used for EVPE

EVPE = Electric Vehicle Power Export Equipment

AC receptacles installed in electric vehicles and intended to allow for connection of off-board utilization equipment shall comply with 625.60 (A) – (D).

(A) Type. The receptacle shall be listed

(B) Rating. Outlet shall

be rated 250-v max, 1ø, 50a max

(C) Overcurrent Protection. Integral to power export system

(D) GFCI Protection for Personnel. All receptacles shall be GFCI protected, indication and reset shall be readily accessible

www.ta191.com

For Informational Purposes Only

Article 625 EV Power Transfer Equipment

Δ ***625.48 Interactive Equipment.*** *EVPE or* ***WPTE*** *that incorporates a power export function & that is part of an interactive system that serves as an optional standby system, an electric power production source, or a bidirectional power feed shall be listed & marked as suitable for that purpose. When used as an optional standby system, the requirements of Parts I & II of Article 702 shall apply.*

N 625.49 Island Mode. EVPE and bidirectional EVSE that incorporate a power export function shall be permitted to be a part of an interconnected power system operating in island mode.

www.ta191.com

The Future is Bidirectional Power Flow

Nissan Leaf V2H



Hyundai Ioniq 5



www.ta191.com

2022 Ford F-150 Lightning pick-up

All-Electric. All F-150

Available features include Backup Power that can provide full-home power for up to 3 days, on a fully charge battery and 80-amp Ford Charge station Pro. *When home is properly equipped & home transfer switch disconnects home from the grid*. Based on 30 kWh used per day. Turn your truck into a generator. Pro Power Onboard offers an available 9.6kw max power provided through 11 outlets. (4) 120v outlets in front trunk, (2) in the cab (4) in the bed, and (1) 240-v outlet for tougher tasks.





www.ta191.com

Electrical Vehicle Training Program

EV Champion Training Series is a four-part course developed by the National Renewable Energy Laboratory (NREL) and the FEMP fleet team. Those who attend all four webinars can earn 1.0 CEU and an EV champion Training Certificate from FEMP. A selection of on-demand trainings are available online.

www.energy.gov/eere/femp/electric-vehicle -training

US Department of Energy



www.ta191.com

For Informational Purposes Only

The Electrical Vehicle Infrastructure Training Program (EVITP)

The EV market continues to expand everywhere and is critical that ESVE equipment be properly installed to the highest standards to safety and quality. All EVITP Certified Electricians must pass a certification exam for proof of knowledge and skill.

The EVITP provides training and certification for electricians installing electric vehicle supply equipment (ESVE). The EVITP program was designed to provide installers with the most comprehensive training available in the market today.

www.evitp.org

www.ta191.com

For Informational Purposes Only

GFCI Protection Expanded & SPGFCI is NEW (special purpose GFCI protection)

Δ **680.5 GFCI & SPGFCI Protection.**

Δ **The GFCI and SPGFCI requirements in this article, unless otherwise noted, are in addition to the requirements in 210.8.**

GFCI Branch circuit receptacles & outlets (1ø & 3ø) 150v to ground or less, 60a or less. (6mA trip level)

SPGFCI is designed for (1ø & 3ø) receptacles & outlets above 150v to ground, not exceeding 480v with a 20mA trip level.

www.ta191.com

For Informational Purposes Only

Article 680 Swimming Pools, Fountains & Similar Locations

210.21 Pump Motors

680.21(C) Ground Fault Protection. ***Outlets serving pool motors shall have GFCI protection*.**

This section has been expanded over numerous editions of the code. 2020 NEC all outlets150v to ground or less, 60a or less,1ø & 3ø.

Δ **680.21(D)** *Where a pool pump motor is replaced* or ***repaired*** the motor shall be provided with ground-fault protection.

Not Current Code In Ohio

Littlefuse Shock Block 5000

Rated for 32-60amp

SPGFCI 10 - 100mA Increments or

Fixed 20mA Trip Level

208/480/600v Applications

This device is installed in-line between incoming power or existing overcurrent protection and the load.



www.ta191.com

For Informational Purposes Only

Δ 680.22 Receptacles (GFCI & SPGFCI)

680.22(A)(4) GFCI & SPGFCI Protection. *All receptacles rated 125v - 250v 60a or less, located within 20' of the inside walls of the pool shall have GFCI protection* complying with 680.5(B) or SPGFCI protection complying with 680.5(C).

680.22(B)(4) GFCI & SPGFCI Protection in Adjacent Areas. *Luminaires, lighting outlets, & ceiling suspended (paddle) fans mounted in the area extending between 5' & 10' horizontally from the inside walls of a pool shall have GFCI 680.5(B) or SPGFCI protection 680.5(C)* unless installed not less than 5' above the maximum water level & rigidly attached to the structure.

GFCI & SPGFCI Protection Locations

GFCI requirements in the following locations, 150v to ground or less, 60a or less, 125v - 250v (1ø & 3ø), receptacles & outlets

Permanently installed pools, storable pools, immersion pools

680.21(C) Pool Motors Receptacles & Outlets (All)

680.22(A)(4) / 680.32 Receptacles within 20'of inside wall of pool.

680.22(B)(4) Luminaires, Lighting outlets & paddle fans installed 5' & 10' horizontally from the inside walls of a pool.

680.43(A)(2) Receptacles within 10' of the inside of a Self-contained Spas & Hot Tubs & Immersion Pools (both indoor & outdoor).

680.44(A) GFCI & SPGFCI Self-contained Spa & Hot Tubs

Δ 680.26 Equipotential Bonding

680.26(A) Performance. The equipotential bonding grid required by ***680.26(B) & (C)*** to reduce voltage gradients in the pool area ***shall be installed for pools with or without associated electrical equipment related to the pool***.

With or without power, there is still a body of water with chemicals added.

Water + chemicals = battery/voltage



Article 700 Emergency Systems

N **700.11 Wiring, Class 2 Powered Emergency Lighting Systems.**

700.11(A) General.

700.11(B) Identification. Emergency circuits shall be permanently marked…..

(1) All **boxes & enclosures shall be permanently marked**

(2) Exposed cable, tray or raceway shall be perm. marked

(C) Separation of Circuits.

(D) Protection. Installed in raceway, AC or MC cable

Ex. 6’ or less to luminaires / Locked rooms / latched encl.

1013.2 2017 Ohio Building Code

Chapter 10 Means of Egress

Floor Mounted Exit Signs in Group R-1

Where exit signs are required in Group R-1 occupancies, by Section 1013.1, additional low-level exit signs shall be provided in all areas serving guest rooms in Group R-1 occupancies and shall comply with Section 1013.5.

The bottom of the sign shall not be less than 10" or more than 12" above the floor level. The sign shall be flush mounted to the door or wall. Where mounted to the wall, the edge of the sign shall be within 4" of the door frame on the latch side.

OBC 310.3 R-1 Occupancies; "*Sleeping units*" transient in nature.

Re; Hotels, motels, boarding houses and congregate living facilities with less than 10 occupants, and single room occupancies (SRO).

www.ta191.com

Article 706 Energy Storage System

Δ **706.1 Scope.** This article applies to all energy storage systems (ESS) having a capacity greater than 1 kwh that may be stand-alone or interactive with other electric power production sources. These systems are primarily intended to store & provide energy during normal operating conditions.

N **706.7(A) Commissioning. ESSs shall be commissioned upon installation. (*Does not apply to 1 & 2-Family dwelling units*)**

N **(B) 706.7(B) Maintenance. ESSs shall be maintained**

www.ta191.com

For Informational Purposes Only

N Article 722 – Cables for Power-Limited Circuits & Fault-Managed Power Circuits

722.1 Scope. This article covers the general requirements for the installation of single-and multiple-conductor cables used in Class 2 & Class 3 power-limited circuits, power-limited fire alarm (PLFA) circuits & Class 4 fault-managed power circuits.

722.24 Mechanical Execution of Work

722.135 Cable Listing



N **Article 726 Class 4 Fault-Managed Power Systems**

New Class Rating. *Class 4 cables allow the distribution of DC power at higher-voltages. This type of circuit constantly monitors itself (intelligent wiring system) for faults and would shut power off simultaneously if a fault occurs. Capacity to deliver more power than Class I, II, or III systems*.

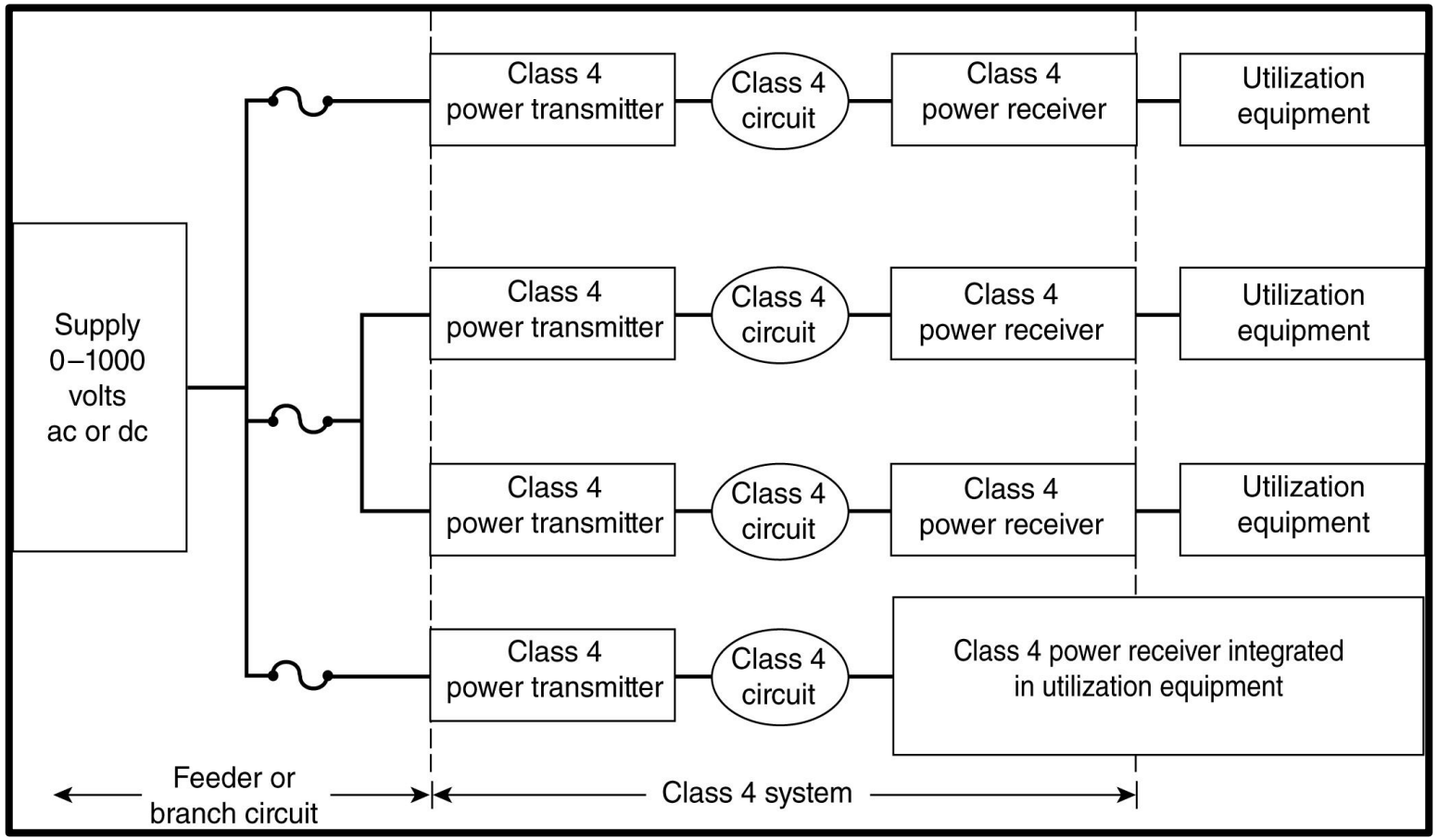
Class 4 power systems are extremely safe from potential fire or shock hazards. Aka Power Energy Transfer (PET), Fault Managed Power; {Built-In Fault Management} (FMP)

Smart Building Technology; 450v L-L / 225v to ground

www.ta191.com

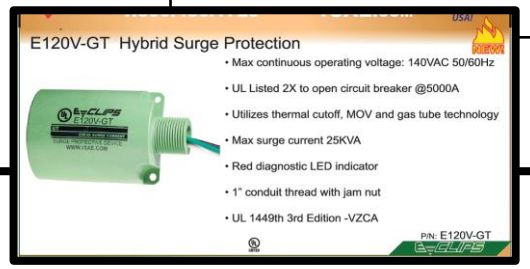
For Informational Purposes Only

N IN 726.121 Class 4 Circuits



Not Current Code In Ohio

Article 760 Fire Alarm Systems



N 760.33 Supply Side Overvoltage Protection

A listed surge-protective device (SPD) shall be installed on the supply side of a fire alarm control panel in accordance with Part II of Article 242.





Typically, the fire alarm control panel is supplied by a single pole 120v circuit.

N* 760.179(D) Cable Jacket Compound. The *cable jacket shall have a high degree of abrasion resistance.

www.ta191.com

Not Current Code In Ohio

2023 National Electrical Code "Proposed" Changes & Updates

Labriola Training Agency #191
www.ta191.com

John M. Labriola
Principal

150 Maplecrest Street SW
North Canton, Ohio 44720

330.497.6309 Phone
330.606.8098 Cell
john@ta191.com

www.ta191.com

Thank You!

APPLICATION

FOR

Continuing Education Course Approval

Continuing education programs approved for education credit by the Ohio Board of Building Standards may be used for compliance with certification requirements related to code enforcement, plan review, and inspection responsibilities. The credit is to be used to renew the certifications issued by the Ohio Board of Building Standards pursuant to section 3781.10(E) ORC.

Board of Building Standards
6606 Tussing Road, P.O. Box 4009
Reynoldsburg, Ohio 43068-9009
(614) 644-2613 Fax: (614) 644-3147
dic.bbs@com.state.oh.us
www.com.state.oh.us/dic/dicbbs.htm

COURSE SUBMITTER:

Course Submitter: John M. Labriola (Contact Name)

Organization: Labriola Training Agency #191 (Organization/Company)

Address: 150 Maplecrest St. SW (Include Room Number, Suite, etc.)

City: North Canton State: Ohio Zip: 44720

E-Mail: j john @ta191.com

Telephone: (330) 497.6309 Fax: n/a

Course Sponsor: None

COURSE INFORMATION

Course Title: 2023 National Electrical Code Changes & Updates (Presentation #2)

New Course Submittal: ■ Update Course: ☐ Prior Approval Number:

Purpose and Objective: The purpose of this course is to provide NEC updates to all attendees, utilizing a custom PowerPoint presentation with graphics and in-depth discussion for each slide, by using a common sense approach. There is no charge for BBS certified personnel.

Number of Instructional Contact Hours that can be obtained upon completion: 4 Hours

If Multi-Session, Number of Instructional Contact Hours Per Session:

Program Applicable for the Following Participants:

Building Official ■ Master Plans Examiner ■ Plumbing Plans Exam. ☐ Electrical Plans Exam. ■ Mechanical Plans Exam. ■ Building Inspector ■ Fire Protection Inspector ■ Mechanical Inspector ■ Plumbing Inspector ☐ Non-Res IU Inspector ■

Res Building Official ■ Res Plans Examiner ■ Res Building Inspector ■ Res Mechanical Inspector ☐ Res IU Inspector ☐

Electrical Safety Inspectors ☐

Location of ESI Course: Arrowhead Golf & Event Center Date(s) of ESI Course(s): Various Dates & Locations TBD

SUBMITTAL CHECKLIST: **Make Sure** all of the Following Information is **Submitted**:		Check Off
Course Submitter:	Name of contact person and their certification numbers, organization, address, fax, phone	x
Course Sponsor:	Organization sponsoring or requesting the program (if any)	x
Course Title:	Name of course (related to content)	x
Purpose/Objective:	Describe purpose and how course will improve competency of certification(s) listed	x
Contact Hours:	Indicate instructional time and credit requested in hours (e.g.: 0.5 hr, 1 hr, 3.5 hrs)	x
Participants:	Check off each certification for which credit is requested (for which course relates to certification)	x
Content of Program:	Include collated agenda, time schedule, course outline; list specific sections of code, references, and topics covered	x
Course Materials:	Collated workbooks, handouts, hard copy or electronic versions of program is available	x
Instructor(s) Info.:	Resume of professional/educational qualifications & teaching/training experience/BBS certifications	x
Test Materials:	Copy of quizzes or tests to be given	
Completed Application:		

NOTE: The Board does NOT grant retroactive approval for courses presented prior to approval date.

RECEIVED

JAN 27 2023

BOARD OF BUILDING STANDARDS

Form 1526

BBS 51023

File Attachments for Item:

EC-7 One Hundred 2023 NEC Changes and Updates (Labriola Training Agency)

All certifications (8 hours)

APPLICATION

FOR

Continuing Education Course Approval

Continuing education programs approved for education credit by the Ohio Board of Building Standards may be used for compliance with certification requirements related to code enforcement, plan review, and inspection responsibilities. The credit is to be used to renew the certifications issued by the Ohio Board of Building Standards pursuant to section 3781.10(E) ORC.

Board of Building Standards
6606 Tussing Road, P.O. Box 4009
Reynoldsburg, Ohio 43068-9009
(614) 644-2613 Fax: (614) 644-3147
dic.bbs@com.state.oh.us
www.com.state.oh.us/dic/dicbbs.htm

COURSE SUBMITTER

Course Submitter: John M. Labriola (Contact Name)

Organization: Labriola Training Agency #191 (Organization Company)

Address: 150 Maplecrest St. SW (Include Room Number, Suite, etc.)

City: North Canton State: Ohio Zip: 44720

E-Mail: john@ta191.com

Telephone: (330) 497.6309 Fax: n/a

Course Sponsor: None

COURSE INFORMATION

Course Title: 100 Significant - 2023 National Electrical Code Changes & Updates

New Course Submittal: ☒ Update Course: ☐ Prior Approval Number: _____

Purpose and Objective: The purpose of this course is to provide NEC updates to all attendees, utilizing a custom PowerPoint presentation with graphics and in-depth discussion for each slide, by using a common sense approach. There is no charge for BBS certified personnel.

Number of Instructional Contact Hours that can be obtained upon completion: 8 Hours

If Multi-Session, Number of Instructional Contact Hours Per Session: _____

Program Applicable for the Following Participants:

Building Official ☒	Master Plans Examiner ☒	Building Inspector ☒	Fire Protection Inspector ☒	Mechanical Inspector ☒
	Plumbing Plans Exam. ☐			Plumbing Inspector ☐
	Electrical Plans Exam. ☒			Non-Res IU Inspector ☒
	Mechanical Plans Exam. ☒			

Res Building Official ☒ Res Plans Examiner ☒ Res Building Inspector ☒ Res Mechanical Inspector ☐ Res IU Inspector ☐

Electrical Safety Inspectors ☐

Location of ESI Course: Arrowhead Golf & Event Center Date(s) of ESI Course(s): February 25, 2023

SUBMITTAL CHECKLIST: **Make Sure** all of the Following Information is **Submitted.**		Check Off
Course Submitter:	Name of contact person and their certification numbers, organization, address, fax, phone	x
Course Sponsor:	Organization sponsoring or requesting the program (if any)	x
Course Title:	Name of course (related to content)	x
Purpose/Objective:	Describe purpose and how course will improve competency of certification(s) listed	x
Contact Hours:	Indicate instructional time and credit requested in hours (e.g.: 0.5 hr, 1 hr, 3.5 hrs)	x
Participants:	Check off each certification for which credit is requested (for which course relates to certification)	x
Content of Program:	Include collated agenda, time schedule, course outline; list specific sections of code, references, and topics covered	x
Course Materials:	Collated workbooks, handouts, hard copy or electronic versions of program is available	x
Instructor(s) Info.:	Resume of professional/educational qualifications & teaching/training experience/BBS certifications	x
Test Materials:	Copy of quizzes or tests to be given	
Completed Application:		

NOTE: The Board does NOT grant retroactive approval for courses presented prior to approval date.

RECEIVED

JAN 27 2023

BOARD OF BUILDING STANDARDS

Labriola
2-17-23 meeting



January 25, 2023

100 Significant – 2023 NEC Changes & Updates

8 Hour Course Timeline

(1) NEC Code Adoption Process in Ohio & Chapter 34 Residential Code of Ohio (2019)

30 minutes (Slides 1-10)

(2) Chapter 1 – General

45 Minutes (Slides 11-16)

(3) Chapter 2 – Wiring & Protection

150 Minutes (Slides 17-57)

(4) Chapter 3 – Wiring Methods & Materials

60 Minutes (Slides 58-73)

(5) Chapter 4 – Equipment for General Use

45 Minutes (Slides 74-85)

(6) Chapter 5 – Special Occupancies

45 Minutes (Slides 86-96)

(7) Chapter 6 – Special Equipment

60 Minutes (Slides 97-109)

(8) Chapter 7 – Special Conditions

45 Minutes (Slides 110- 117)

8 Hour Total Class Time = 480 Minutes

July 01, 2019

Current Adopted Codes in Ohio – (2017)

Non-Residential Construction (4- Family and Above)

2017 Ohio Building Code (Based on the 2015 International Building Code) 2017

Ohio Mechanical Code (Based on the 2015 International Mechanical Code) 2017

Ohio Plumbing Code (Based on the 2015 International Plumbing Code) 2017

Ohio Fire Code (Based on the 2015 International Fire Code)

2017 NFPA 70 – National Electrical Code **(Effective 11.01.2017)**

2016 NFPA 13 – Standard for Installation of Sprinkler Systems 2016

NFPA 72 – National Fire Alarm and Signaling Code

2015 International Fuel Gas Code

2012 International Energy Conservation Code / ASHRAE 90.1 2013

ICC / ANSI A117.1 2017 Accessible & Usable Buildings and Facilities

Residential Construction (1, 2 and 3- Family Dwellings)

2019 Residential Code of Ohio (Based on the 2018 International Residential Code)

2017 Ohio Plumbing Code

2017 NFPA 70 – National Electrical Code w/ amendments **(07.01.2019)**

2018 International Energy Conservation Code

www.ta191.com

August 01, 2022

Current Adopted Building Codes in West Virginia

The State of West Virginia Fire Commission has adopted statewide the 2018 ICC (International Code Council), family of Codes for any jurisdiction that chooses to enforce building codes. Check locally for enforcement information / details.

2017 Accessible & Usable Buildings & Facilities (A117.1)
2018 International Building Code (IBC)
2013 International Energy Conservation Code (ASHRAE 90.1)
2018 International Existing Building Code (IEBC)
2018 International Fuel Gas Code (IFGC)
2018 International Mechanical Code (IMC)
2018 International Plumbing Code (IPC)
2018 International Property Maintenance Code (IPMC)
2018 International Residential Code (1- & 2- Family) (IRC)
2015 International Energy Code of Residential Buildings (IECC)
2018 International Swimming Pool & Spa Code (ISPSC)

2021 NFPA 1 - West Virginia Fire Code
2016 NFPA 13 - Installation of Sprinkler Systems
2020 NFPA 70 - National Electrical Code
2016 NFPA 72 - National Fire Alarm & Signaling Code
2021 NFPA 101 - West Virginia Life Safety Code

www.ta191.com

CHAPTER 34
ELECTRICAL

SECTION 3401
ELECTRICAL

3401.1 *Electrical.* *The provisions of the National Electrical Code, NFPA 70, shall be incorporated herein and shall govern the installation, testing and operation of the electrical systems of one-, two- and three-family dwellings and their accessory structures except for the following:*

1. ***Section 210.8(A)(2) shall be modified to read:***

   Garages, and also accessory buildings that have a floor located at or below grade level not intended as habitable rooms and limited to storage areas, work areas, and areas of similar use *except for the receptacle located to serve a garage door opener when the device is a single receptacle and located in the ceiling.*

2. ***Section 210.8(A)(5) shall be modified to read:***

   Unfinished portions or areas of the basement not intended as habitable rooms.

   Exceptions:

   1. A receptacle supplying only a permanently installed fire alarm or burglar alarm system shall not be required to have ground-fault circuit-interrupter protection.
   2. *A single receptacle located to serve a sump pump shall not be required to have ground-fault circuit-interrupter protection when there is a duplex receptacle with ground-fault circuit-interrupter protection within six (6) feet of the sump pump.*

3. ***Section 210.8(D) shall be deleted.***

4. ***Section 210.12(A) shall be modified to read:***

   All 120-volt single-phase, 15- and 20-ampere branch circuits supplying outlets or devices installed in dwelling unit kitchens, family rooms, dining rooms, living rooms, parlors, libraries, dens, bedrooms, sun rooms, recreational rooms, closets, hallways, laundry rooms, or similar rooms or areas shall be protected by any of the means described in 210.12(A)(1) through (6):

   (l) A listed combination-type arc-fault circuit interrupter, installed to provide protection of the entire branch circuit.

   (2) A listed branch/feeder-type AFCI installed at the origin of the branch-circuit in combination with a listed outlet branch-circuit type arc-fault circuit interrupter installed at the first outlet box on the branch circuit. The first outlet box in the branch circuit shall be marked to indicate that it is the first outlet of the circuit.

   (3) A listed supplemental arc protection circuit breaker installed at the origin of the branch circuit in combination with a listed outlet branch-circuit type arc-fault circuit interrupter installed at the first outlet box on the branch circuit where all of the following conditions are met:

   a. The branch-circuit wiring shall be continuous from the branch-circuit overcurrent device to the outlet branch-circuit arc-fault circuit interrupter.

   b. The maximum length of the branch-circuit wiring from the branch-circuit overcurrent device to the first outlet shall not exceed 15.2 m (50 ft.) for a 14 AWG conductor or 21.3 m (70 ft.) for a 12 AWG conductor.

   c. The first outlet box in the branch circuit shall be marked to indicate that it is the first outlet of the circuit.

   (4) A listed outlet branch-circuit type arc-fault circuit interrupter installed at the first outlet on the branch circuit in combination with a listed branch-circuit overcurrent protective device where all of the following conditions are met:

   a. The branch-circuit wiring shall be continuous from the branch-circuit overcurrent device to the outlet branch-circuit arc-fault circuit interrupter.

   b. The maximum length of the branch-circuit wiring from the branch-circuit overcurrent device to the first outlet shall not exceed 15.2 m (50 ft.) for a 14 AWG conductor or 21.3 m (70 ft.) for a 12 AWG conductor.

   c. The first outlet box in the branch circuit shall be marked to indicate that it is the first outlet of the circuit.

   d. The combination of the branch-circuit overcurrent device and outlet branch-circuit AFCI shall be identified as meeting the requirements for a system combination-type AFCI and shall be listed as such.

   (5) If RMC, IMC, EMT, Type MC, or steel-armored Type AC cables meeting the requirements of 250.118, metal wireways, metal auxiliary gutters, and metal outlet and junction boxes are installed for the portion of the

www.ta191.com

branch circuit between the branch-circuit overcurrent device and the first outlet, it shall be permitted to install a listed outlet branch-circuit type AFCI at the first outlet to provide protection for the remaining portion of the branch circuit.

(6) Where a listed metal or nonmetallic conduit or tubing or Type MC cable is encased in not less than 50 mm (2 in.) of concrete for the portion of the branch circuit between the branch-circuit overcurrent device and the first outlet, it shall be permitted to install a listed outlet branch-circuit type AFCI at the first outlet to provide protection for the remaining portion of the branch circuit.

Exception *No. 1*: Where an individual branch circuit to a fire alarm system installed in accordance with 760.41(B) or 760.121(B) is installed in RMC, IMC, EMT, or steel-sheathed cable, Type AC or Type MC, meeting the requirements of 250.118, with metal outlet and junction boxes, AFCI protection shall be permitted to be omitted.

Exception No. 2: Branch circuits supplying receptacle outlets installed to serve only the kitchen countertop surfaces shall be permitted to be installed without arc-fault circuit interrupter protection.

5. ***Section 210.64 shall be modified to read:***

At least one 125-volt, single-phase, 15- or 20-ampere-rated receptacle outlet shall be installed in an accessible location within 7.5m (25 ft.) of the indoor electrical service equipment. The required receptacle outlet shall be located within the same room or area as the service equipment.

Exception No. 1: The receptacle outlet shall not be required to be installed in one-, two-, *or three-*family dwellings.

Exception No. 2: Where the service voltage is greater than 120 volts to ground, a receptacle outlet shall not be required for services dedicated to equipment covered in Articles 675 and 682.

SECTION 3402
EMERGENCY AND STANDBY POWER SYSTEMS

3402.1 ***Installation.*** *Emergency and standby power systems shall be installed in accordance with this code and NFPA 70. The performance, classification, transfer, testing, and maintenance of emergency and standby power systems shall also comply with either NFPA 110 (liquid- and gas- fueled systems) or NFPA 111 (battery and inertia systems), as applicable.*

3402.1.1 Stationary generators. *Stationary emergency and standby power generator assemblies shall be listed in accordance with UL 2200.*

3402.1.1.1 Engine-driven generators. *The installation of liquid- and gas-fueled stationary internal combustion engines and gas turbines used to drive generator assemblies shall meet the requirements of NFPA 37.*

3402.1.1.1.1 Fuel tanks connected to generator assemblies. *Fuel tanks piped to and supplying fuel for engine-driven generator assemblies may be engine-mounted, located inside of a building, outside of a building, or on a roof in accordance with NFPA 37 or NFPA 30.*

3402.1.1.1.1.1 Engine-mounted tanks. *Engine-mounted tanks located outdoors may be located in accordance with Section 4.1.4 of NFPA 37 and shall be vented in accordance with NFPA 30. Engine-mounted tanks shall be provided with adequate clearance to enable filling, maintenance, and testing, shall be safeguarded against public access, and shall be protected from impact.*

3402.1.1.1.1.2 Other fuel tanks. *Fuel tanks, other than engine-mounted tanks, piped to and supplying the generator engine shall be located, installed, and vented in accordance with the applicable sections of NFPA 37 or located, installed, and vented in accordance with NFPA 30.*

3402.1.1.1.2 Gaseous fuel supply. *Where an internal combustion engine supplied with gaseous fuel powers emergency or standby generators, the fuel gas storage and piping system shall comply with NFPA 37 and Chapter 24.*

www.ta191.com

2020 NEC Adoption in Ohio

December 2022 Update: Still Unknown / Limited Information

210.8(F) **Outdoor Outlets.** Outdoor outlets (Re: HVAC equipment) supplied by branch circuits rated 150-v to ground or less, 50a or less, shall have GFCI protection for personnel. With the use of adjustable speed drives for energy efficient equipment (split systems) are ***not*** compatible with current Type "A" GFCI protection.

Discussions have been ongoing since prior to September 2020.

Residential Code Advisory Committee (RCAC) to consider the 2023 NEC language:

N Ex: #2 GFCI protection shall not be required for listed HVAC equipment. This exception shall expire September 1, 2026.

This and other "*unknown*" amendments shall be considered by OBBS

www.ta191.com



2023 “Proposed” National Electrical Code (NEC) Changes & Updates

Training Agency #191

150 Maplecrest Street SW
North Canton, Ohio 44720
330.497.6309 Phone

John M. Labriola

www.ta191.com

2023 National Electrical Code Changes & Updates



Not Current Code In Ohio

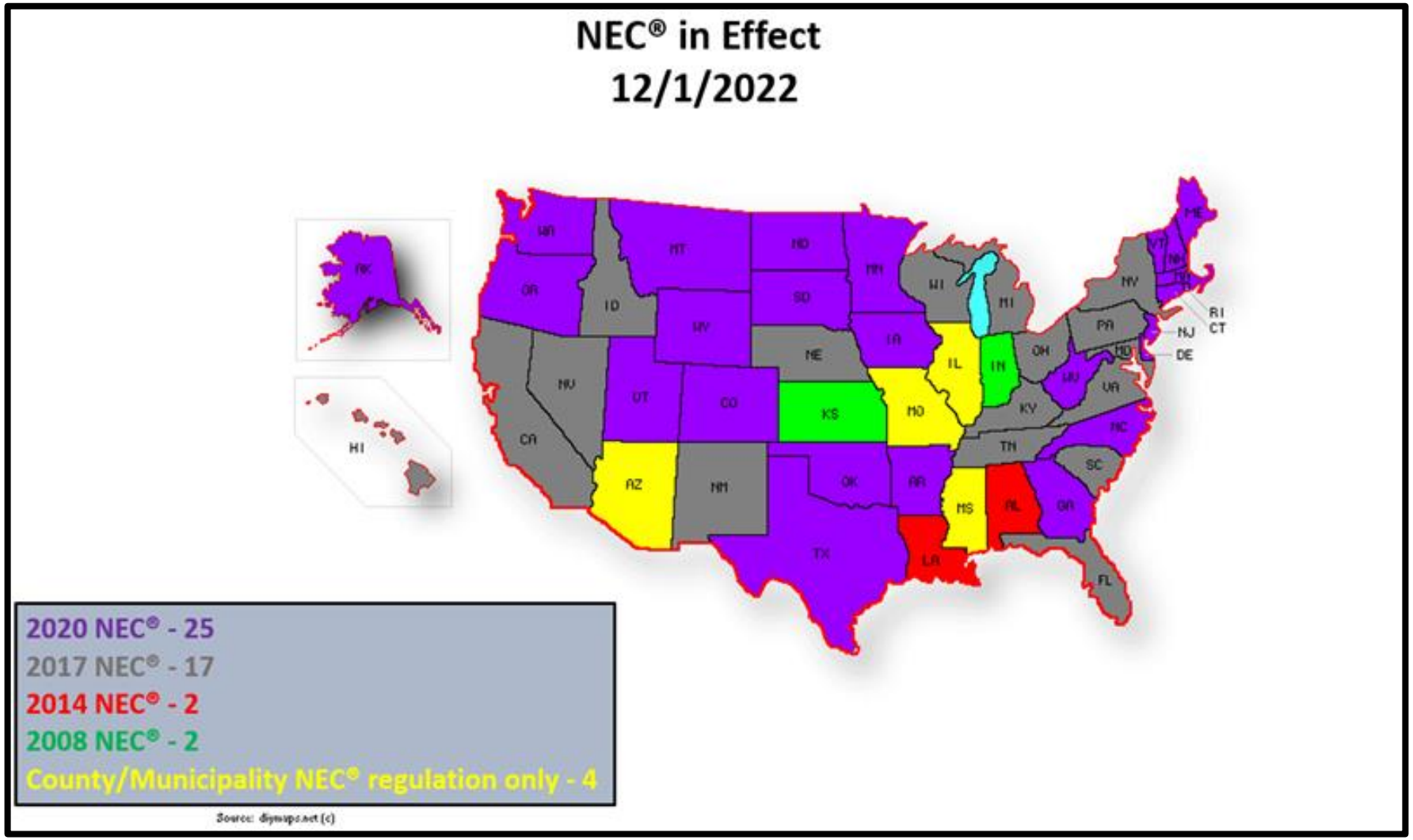
This course is based on the 2023 National Electrical Code (NEC).

The 2023 National Electrical Code has not been adopted in ohio.

Presented for informational purposes only.

Ohio Board of Building Standards

NFPA State Update Map



2023 NEC “10” New Articles

235 – Branch, Feeder, & Service Circuits over 1kV ac & 1.5kV dc

245 – Overcurrent Protection for Systems rated over 1kV ac & 1.5kV dc

305 – General Requirements for Wiring Methods & Materials for Systems rated over 1kV ac & 1.5 kV dc

369 – Insulated Bus Pipe (IBP) / Tubular Covered Conductors (TCC) Systems

371 – Flexible Bus Systems

495 – Equipment over 1kV ac & 1.5kV dc ***(Formerly Article 490)***

512 – Cannabis Oil Equipment / Oil Systems using Flammable Materials

722 – Cables for Power-Limited Circuits & Fault-Managed Power Circuits

724 – Class I Power-Limited & Class I Power-Limited Remote Control & Signaling Systems

726 – Class 4 Fault-Managed Power Systems

www.ta191.com

Article 100 Definitions

N **Scope.** This article contains only those definitions essential to the application of this Code. It is not intended to include commonly defined general terms or commonly defined technical terms from related codes and standards. An article number in parentheses following the definitions indicates that the definition only applies to that article.

2017 NEC Added Part II – Over 1000 Volts

2020 NEC Added Part III – Hazardous Locations

2023 NEC – Almost all Article .2's are in Article 100

Now almost all definitions utilized in the NEC are in Article 100

www.ta191.com

For Informational Purposes Only

Δ 110.16(B) Arc-Flash Hazard Warning

Service Equipment and ***Feeder*** Supplied Equipment.

In other than dwelling units, an addition to the requirements in 110.16(A), a permanent ***arc flash*** label shall be field or factory applied to service equipment and ***feeder supplied equipment rated 1000 amperes or more. The arc flash label shall be in accordance with applicable industry practice and include the date the label was applied.*** The label shall meet the requirements of 110.21(B).

Added Feeders & reduced the ampacity from 1200a to 1000a.

Refer to NFPA 70E-2021

www.ta191.com

N 110.17 Servicing & Maintenance of Equipment

Servicing & electrical preventative maintenance shall be performed by qualified persons trained in servicing & maintenance of equipment & shall comply with the following:

(1) Shall be performed in accordance with the original manufacturers' instructions & information.

(2) Shall utilize identified replacement parts

(a) Provided by original manufacturer

(b) Designed by an experienced engineer

(c) Approved by the AHJ

www.ta191.com

For Informational Purposes Only

N 110.20 Reconditioned Equipment

Reconditioned equipment ***shall*** be permitted except where prohibited elsewhere in this Code. Equipment that is restored to operating condition shall be reconditioned with identified replacement parts, verified under applicable standards, that are either provided by the original equipment manufacturer or that are designed by an engineer experienced in the design of replacement parts for the type of original equipment

N **(A) Equipment required to be Listed**

N **(B) Equipment not required to be Listed**

N **(C) (A) or (B) not available, AHJ may approve (document)**

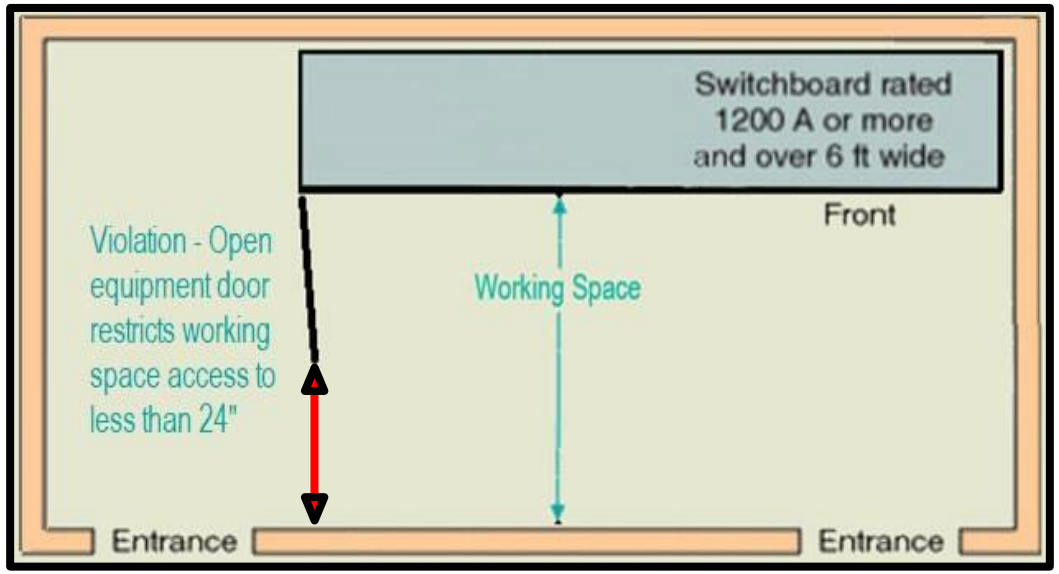
www.ta191.com

Not Current Code In Ohio

Δ 110.26 Working Spaces About Electrical Equipment

"<u>Open</u>" equipment doors shall <u>not</u> impede access to and egress from the working space. Access or egress is impeded if one or more simultaneously opened equipment doors restrict working space access to be less than 24" wide and 6½' high.

***<u>Note</u>**: The intent should be clear, to protect personnel servicing the equipment.*



www.ta191.com

For Informational Purposes Only

N **110.26(A)(6) Working Spaces**

Grade level, Floor, or Working Platform

The grade, floor, or platform in the required working space shall be kept clear, and the floor, grade, or platform in the working space ***shall be as level and flat*** as practicable for the entire required depth and width of the working space.

Generally: ***3' in front of equipment &*** **width of equipment**

www.ta191.com

Not Current Code In Ohio

Article 100 - Definitions

Receptacle

A contact device installed at the outlet for the connection of an attachment plug or for direct connection of electrical utilization equipment designed to mate with the corresponding contact device. A single receptacle is a single contact device with no other contact device on the same yoke ***or strap***. A multiple receptacle is two or more contact devices on the same yoke ***or strap.*** (CMP-18)

210.8(A), (B), & (E)

Outlet

A point on the wiring system at which current is taken to supply utilization equipment. (CMP-1)

210.8(C) Crawl Space Ltg. Outlets

210.8(D) Specific Appliances

210.8(F) Outdoor Outlets

GFCI Protection Evolution





Type "A" Personnel Protection Trip Level = 4 – 6mA
(Typical design is receptacle or breaker)

Type "B" Equipment Protection Trip Level = 30mA
(rooftop de-icing equipment protection)

Type "C" *SPGFCI* (over 150v to ground) 480v 3ø or Less / Trip Level = 20mA

Type "D" *SPGFCI* (over 150v to ground) 600v 3ø Trip Level – 20mA

Type "E" *"EGFPD" 6mA or adjustable from 10 – 100mA*

Docking Facilities "GFPE" *100mA*

Shore Power "GFPE" protection 30mA

www.ta191.com

Δ 210.8(A) Dwelling Units

GFCI Protection for Personnel

All 125-v through 250-v receptacles installed in the following locations and supplied by single-phase branch circuits rated shall have ground-fault circuit-interrupter for personnel:
(No maximum ampacity noted)

(7) Areas with sinks and permanent provisions for ***food preparation, beverage preparation, or cooking.***

www.ta191.com

For Informational Purposes Only

210.8(A) GFCI Exceptions (Dwellings)

Exceptions 1 - 4

1. **Receptacles, not readily accessible, dedicated circuit for electric snow-melting or pipeline and vessel heating.**
2. **Receptacle supplying only permanently installed premises security system.**
3. **Listed weight-supporting ceiling receptacles *in combination with compatible weight-supporting fittings.***
4. ***Factory mounted receptacles in bathroom exhaust fans (re: installation instructions & listing & labeling)***

Δ 210.8(B) Other than Dwelling Units

GFCI Protection for Personnel

All 125-v through 250-v receptacles installed in the following locations and supplied by 1ø branch circuits rated 50a or less, and 3ø branch circuits rated 100a or less,150-v or less to ground, shall have ground-fault circuit-interrupter for personnel:

(3) Areas with sinks and permanent provisions for food preparation, ***beverage preparation***, or cooking.

(4) *Buffet serving areas with permanent provisions for food serving, beverage serving, or cooking.*

www.ta191.com

For Informational Purposes Only

Δ 210.8(B) Other than Dwelling Units

GFCI Protection for Personnel

(7) Sinks ***where receptacles or cord and-plug-connected fixed or stationary appliances*** **are installed within 6' from the top inside edge of the bowl of the sink.**

N **(13)** ***Aquariums, bait wells, and similar open aquatic vessels or containers, such as tanks or bowls, where receptacles are installed within 6' from the top inside edge or rim or from the conductive support framing of the vessel or container.***

www.ta191.com

Not Current Code In Ohio

Δ 210.8(D) Specific Appliances

GFCI protection shall be provided for the branch circuit or outlet supplying the following appliances, 150-v or less to ground 60a or less; 1ø or 3ø

1. Automotive vacuum cleaners
2. Drinking water coolers / bottle fill stations
3. High-pressure spray washing machines
4. Tire Inflation machines
5. Vending machines
6. Sump pumps
7. Dishwashers
8. ***Electric ranges***
9. ***Wall-mounted ovens***
10. ***Counter-mounted cooking units***
11. Clothes dryers
12. ***Microwave ovens***

www.ta191.com

For Informational Purposes Only

210.8(F) Outdoor Outlets

For dwellings, all outdoor ***outlets***, other than those covered on 210.8(A), Ex.1, including outlets specified in the following locations, and supplied to 1ø branch circuits rated 150-v or less to ground, 50a or less shall be provided with GFCI protected.

1. ***Garages that have floors located at or below grade level.***
2. ***Accessory buildings***
3. ***Boathouses***

Applies to replacing outlet(s) covered by this section!

(Also: 680.22(A)(4) Swimming Pool Outlets)

2020 / NEC 2023 NEC / BBS 10.20.2022 RCAC

State of Ohio (would apply to 1, 2, & 3-family dwellings

****Proposed Amendment****

Re: 210.8(F) Outdoor Outlets (Dwelling Units)

N **Exception #2: GFCI protection shall not be required for listed HVAC equipment. This exception shall expire September 1, 2026**

Δ 210.11(C)(4) Garage Branch Circuits

In addition to the number of branch circuits by other parts of this section, at least one 120-v, 20a branch circuit shall be installed to supply receptacle outlets, for attached and detached garages with electric power. This circuit shall have no other outlets.

New 2nd Paragraph

Additional branch circuits rated 15a or greater shall be permitted to serve receptacle outlets other than those required by 210.52(G)(1).

N 210.12(B) AFCI Protection for Dwelling Units

No Change here; just listed separately

1. Kitchens
2. Family Rooms
3. Dining Rooms
4. Living Rooms
5. Parlors
6. Libraries
7. Dens

8. Bedrooms
9. Sunrooms
10. Recreation Rms.
11. Closets
12. Hallways
13. Laundry Areas
14. Similar Areas

www.ta191.com

For Informational Purposes Only

210.12(C) AFCI Protection for Dormitory Units

All 125-v, 1ø ***10,*** 15- and 20-ampere branch circuits supplying outlets ***or*** devices installed in ***the following locations*** shall be protected by any of the means described in 210.12 (A)(1) - (A)(6).

1. Bedrooms
2. Living Rooms
3. Hallways
4. Closets
5. Bathrooms
6. Similar Locations

www.ta191.com

Not Current Code In Ohio

210.12 (D) AFCI Protection; Other Occupancies

(D) **<u>Other Occupancies</u>**. ***All*** 125-v 1ø, ***10,*** 15- and 20-ampere branch circuits, supplying outlets ***or*** devices installed in ***the following locations*** shall be protected by any of the means described in 210.12(A)(1) - (A)(6).

1. ***Guest rooms & guest suites of hotel & motels.***
2. ***Areas used exclusively as patient sleeping rooms in nursing homes & limited-care facilities.***
3. ***Areas designed for use exclusively as sleeping quarters in fire, police, ambulance, rescue, ranger stations, & similar locations.***

www.ta191.com

For Informational Purposes Only

N 210.23(A) 10-Ampere Branch Circuits

10-ampere Branch Circuits

210.23(A) ***A 10-ampere branch circuit shall comply with the requirements of 210.25(A)(1) and (A)(2).***

210.23(A)(1) Loads permitted for 10-ampere Branch Circuits.

1. ***Lighting Outlets***
2. ***Dwelling unit exhaust fans or bathroom or laundry room lighting circuits***
3. ***Gas fireplace unit supplied by an individual branch circuit***

www.ta191.com

N 210.23(2) Loads not Permitted for 10-Ampere Branch Circuits

A 10-ampere branch circuit shall

not **supply any of the following:**

1. **Receptacle outlets**
2. **Fixed appliances, except as permitted for individual branch circuits.**
3. **Garage door openers**
4. **Laundry equipment**

www.ta191.com

For Informational Purposes Only

N 210.24 Branch Circuit Requirements; Summary

Expanded this section and tables from applying to Copper conductors only, to include Aluminum and Copper-Clad Aluminum conductors

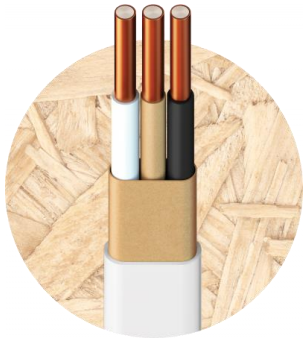


Table 210.24(1) - Applies to Copper Conductors

N **Table 210.24(2) - Applies to both Aluminum & Copper-Clad Conductors**

Δ 210.52(C)(2) Island & Peninsular Countertops & Work Surfaces

Receptacle outlets, ***if*** installed to serve an island or peninsular countertop or work surface, shall be installed in accordance with 210.52(C)(3). ***If a receptacle is not provided to serve an island or peninsular countertop or work surface, provisions shall be provided at the island or peninsular or work surface, provisions shall be provided at the island or peninsula for future addition of a receptacle outlet to serve the island or peninsular countertop or work surface.***

What a Relief!!!

www.ta191.com

For Informational Purposes Only

Δ 210.70(A)(1) Habitable Rooms; Lighting Outlets

Habitable Rooms; Kitchens, *Laundry Areas* & Bathrooms

At least one lighting outlet controlled by a listed mounted control device shall be installed in every habitable room, kitchen, ***laundry areas,*** and bathrooms. The wall-mounted control device shall be located near an entrance to the room on a wall.

Added laundry area to this section. Would Article 314.27(C) require a ceiling suspended (Paddle) fan box?

www.ta191.com

Not Current Code In Ohio

N 215.15 Feeders (Barriers)

Barriers. Barriers shall be placed such that no energized, uninsulated, *ungrounded busbar or terminal* is exposed…….





N **215.15 Feeders**

230.62 Services (2020 NEC)

N **240.21 Transformer Secondaries**

www.ta191.com

For Informational Purposes Only

Article 225 Outside Branch Circuits & Feeders

Part II. Building or Other Structures Supplied by a Feeder(s) or Branch Circuit(s)

Article 230 Services – Part IV. SE Conductors

N **Sections 225.41 & 225.42 / 230.67 & 230.85**

1 & 2-Family Dwelling Emergency Disconnects:

General / Location / Rating / Marking *N* 225.41 / 230.85

Surge Protection: Device / Location / Type / Replacement / Minimum 10kA Ratings

N **225.42 / 230.67**

www.ta191.com

Δ 230.67 Expanded Surge Protection



Expanded Surge Protection Requirements

230.67(A) Surge Protective Device.

1. Dwelling units
2. ***Dormitory units***
3. ***Guest rooms & guest suites of Hotels & Motels***
4. ***Areas of nursing homes & limited-care facilities used exclusively as patient sleeping rooms***



www.ta191.com

For Informational Purposes Only

Δ 230.71 Maximum Number of Service Disconnects

(B) Two to Six Service Disconnecting Means

1. Separate enclosures, each with a main SE disconnect.
2. Panelboards with a main SE disconnect.
3. Vertical switchboard sections that have separate SE disc.
4. SE disconnect in switchgear, ***transfer switches,*** or meter mods where each disconnect is located in a separate compartment.

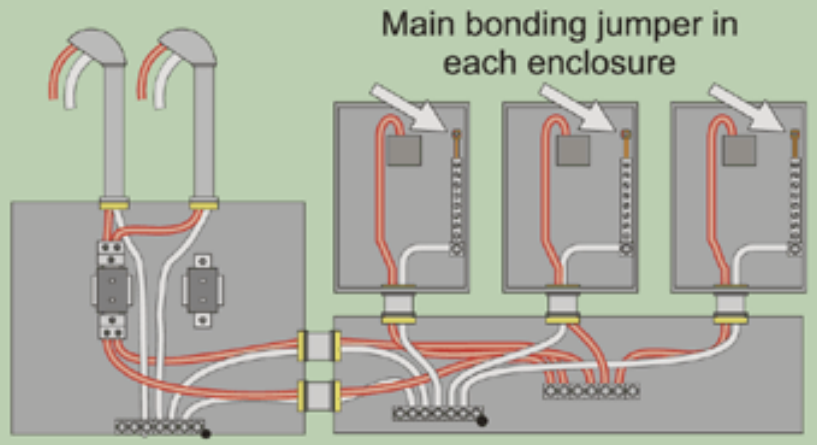
N 5. Meter mods with a main SE disconnect in each metering center.

N 6. MCC's with 1 SE disconnect or a max of 2 SE disconnects with barriers provided between each MCC unit or compartment.

www.ta191.com

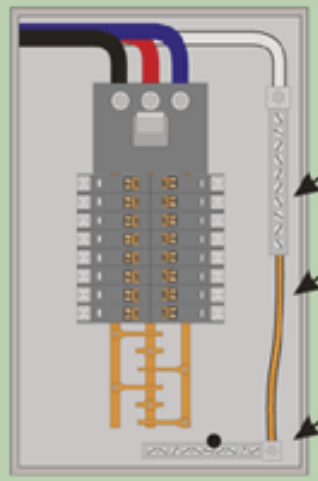
Not Current Code in Ohio

Main Bonding Jumper - Multiple Enclosures

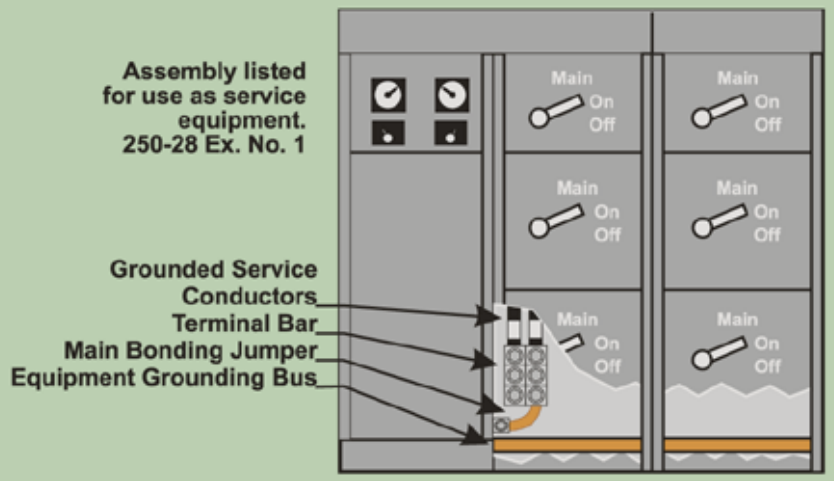


(All conductors not shown)

Main Bonding Jumper



Main Bonding Jumper for Listed Assembly





www.ta191.com

N 230.71(B)(5) & (6) 6 Handle Rule





www.ta191.com

For Informational Purposes Only

230.85(A) Emergency Disconnects; General

For 1 & 2-family dwelling units, an emergency disconnecting means shall be installed.

N* (1) Location.** The disconnecting means shall be installed in a readily accessible location ***on or within sight of the dwelling unit.

***N* (2) Rating. The disconnecting means shall have a short-circuit current rating equal to or greater than the available fault current.**

***N* (3) Grouping. If more than 1 disconnecting means is provided, they shall be grouped.**

www.ta191.com

For Informational Purposes Only

230.85(B) Emergency; Disconnects

N **(B) Disconnects. Each disconnect shall be one of the following:**

1. Service Disconnect

2. A meter disconnect integral to the meter mounting equipment ***not marked as suitable only*** as SUSE equipment, installed in accordance with 230.82

3. Other listed disconnect switch or circuit marked as that is marked SUSE, but ***not marked as suitable only*** as SUSE, installed on the supply side of each service disc

www.ta191.com

N 230.85(C) Emergency Disconnects

N **Replacements. Where service equipment is *replaced*, all of the requirements of this section shall apply.**

N **Exception:** Where ***only meter sockets, or related raceways and fittings are replaced***, the requirements of this section shall not apply.

For Informational Purposes Only

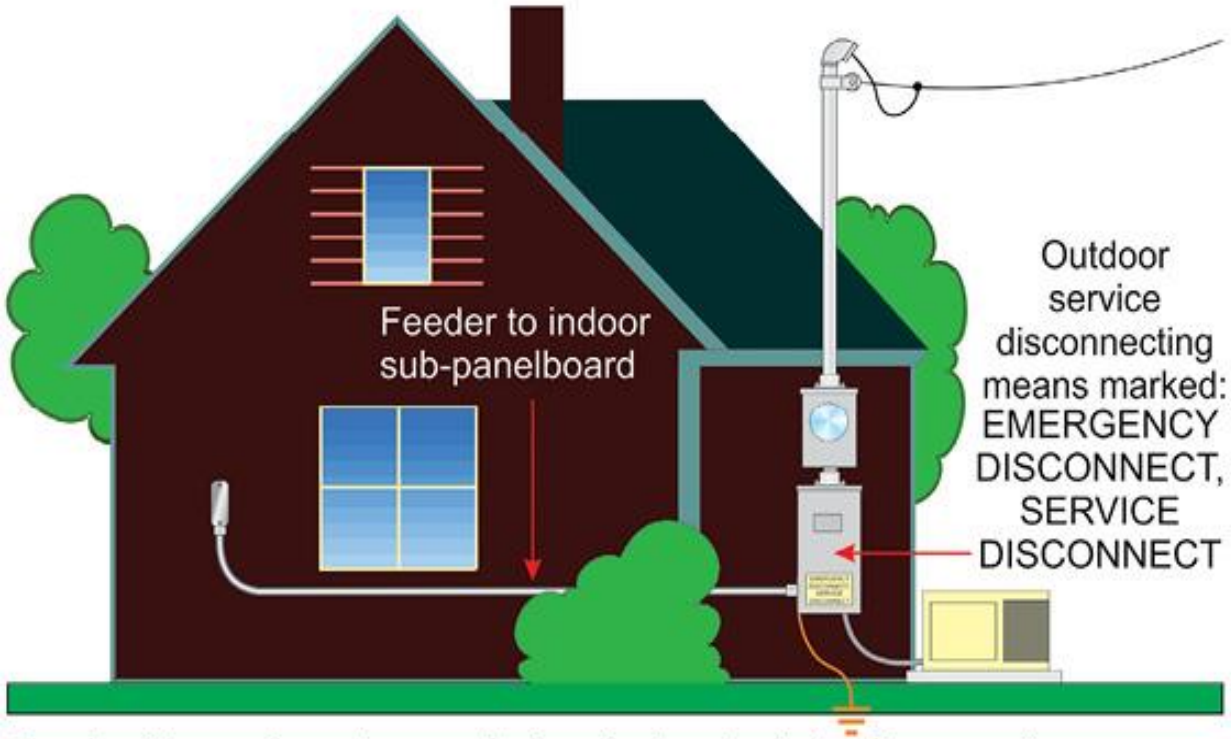
N 230.85(D) Emergency Disconnects

***N* Identification of Other Isolation Disconnects.**

Where equipment for isolation of other energy source systems is not located adjacent to the emergency disconnect required by this section, a plaque or directory identifying the location of all equipment for isolation of other energy sources shall be located adjacent to the disconnecting means required by this section.

RE: Battery, Generator, Interconnected Power Production Sources, and Energy Storage Systems

230.85 Exterior Emergency Disconnect(s)



For dwellings, all service conductors to terminate in disconnecting means having a short-circuit current rating equal to or greater than the available fault current, installed in a readily accessible outdoor location

If more than one disconnec ined



www.ta191.com

nec

230.85 EXTERIOR EMERGENCY "SE" DISCONNECT

Applies to 1- and 2-Family Dwelling Units

All **service conductors to terminate in a SUSE rated disconnecting means, with adequate SCCR, in a readily accessible *outdoor* location. Grouping is required.**

Intent to protect firefighters / other emergency personnel.



CAN A SMART METER ACT AS AN EMERGENCY DISCONNECT

Until recently I was a proponent of this type of installation. However, I am out of touch with technology. Due to more consumers utilizing multiple energy sources:

1. <u>Commercial power supply</u>

2. <u>Interconnected Power Production Sources</u>

(a) On-site Generator

(b) Photovoltaic System

(c) Wind Energy System

(d) Battery System

(e) Fuel Cell System

(f) Energy Storage System

<u>Posting permanent plaque of sources</u>

N 230.85 (E)(1) Emergency Disconnects

Marking Text

1. Service Disconnect
EMERGENCY DISCONNECT, SERVICE DISCONNECT
2. Meter Disconnects installed in accordance with 230.82(3) as follows: ***EMERGENCY DISCONNECT, METER DISCONNECT, NOT SERVICE EQUIPMENT***
3. Other listed disconnect switches or circuit breakers on the supply side of each service disconnect that are marked suitable for use as SE and marked as follows:

EMERGENCY DISCONNECT NOT SERVICE EQUIPMENT

www.ta191.com

For Informational Purposes Only

N 230.85(E)(2) Emergency Disconnects

Marking Location & Size

Markings shall comply with 110.21(B) & both of the following:

(1) The marking or labels shall be located on the outside front of the disconnect enclosure with ***RED*** background and ***WHITE*** text.

(2) The letters shall be at least (½”) high.

N Article 235 – Branch, Feeder, & Service Circuits over ***1000v ac.***

235.1 Scope. This article the general requirements for branch circuits, feeders and services over 1000v ac or 1000v dc, nominal.

235.5(C)(1)(a) *Means of identification*. Separate color coding, marking, tape, tagging or other approved means

235(C)(1)(b) *Posting of identification means*. *Documented in a readily accessible manner at each panelboard.*

Existing installations*. *Required to mark only new system voltage being added.

www.ta191.com

Not Current Code In Ohio

N Article 235 – Branch, Feeder, & Service Circuits over ***1500v dc***

235.5(C)(2) *Branch Circuits Supplied from DC Systems*.

Each ungrounded conductor #4 and larger shall be identified by polarity at all termination, connection and splice points by marking tape, tagging or tape or other approved means and each #6 and smaller ungrounded conductor shall be identified by polarity at all termination points.

The identified methods used for conductors shall be documented at all panelboard locations in a manner readily available or be permanently posted at each panelboard location.

DC Conductor Identification (Positive)

235.3(C)(2)(a) Positive Polarity (DC) *Sizes #6 and smaller.*

Where the positive polarity of a dc system does not serve as the connection point for the grounded conductor, each positive conductor shall be identified by ***one*** of the following means:

(1) A continuous red outer finish

(2) Continuous red stripe along the entire length or (color other than green, white, gray or black)

(3) Imprinted minus signs(+) or the word positive or POS identified not more than 24” along its’ entire length

(4) Approved sleeving or shrink tubing at all terminations

www.ta191.com

For Informational Purposes Only

DC Conductor Identification (Negative)

235.3(C)(2)(b) Negative Polarity (DC) *Sizes #6 and smaller.*

Where the negative polarity of a dc system does not serve as the connection point for the grounded conductor, each positive conductor shall be identified by ***one*** of the following means:

(1) A continuous black outer finish

(2) Continuous black stripe along the entire length or (color other than green, white, gray or red)

(3) Imprinted minus signs(-) or the word negative or NEG identified not more than 24” along its entire length

(4) Approved sleeving or shrink tubing at all terminations

www.ta191.com

240.4(B) OCD Rated 800a or Less

New 2nd Paragraph

*If the overcurrent protective device is an **adjustable trip device** installed in accordance with 240.4(B)(1),(2), & (3) it **shall be permitted to be set to a value that does not exceed the next higher standard value** above the ampacity of the conductors being protected as shown in 240.6(A) where **restricted access** is accordance with 240.6(C) is provided.*



(1) Continuous Amps

(2) Short-time Pickup

(3) Instantaneous Pickup

(4) Ground Fault Pickup



www.ta191.com

For Informational Purposes Only

N Article 245 – Overcurrent Protection for Systems rated over 1kV ac & 1.5kV dc

New Medium Voltage Conductor Article

245.1 Scope. This article covers overcurrent protection requirements for systems rated over 1kV ac 1.5kv dc, nominal.

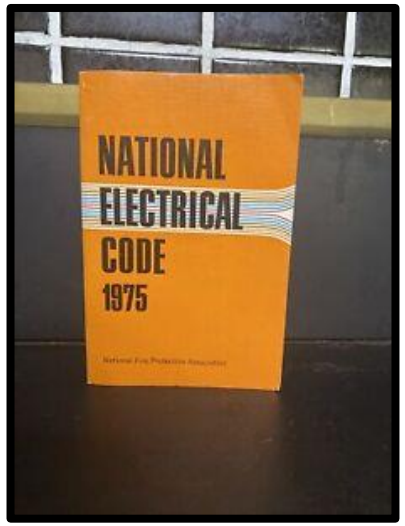
245.21 Circuit Breaker & Fuse protection

245.26 Feeders & Branch Circuits

www.ta191.com

Not Current Code In Ohio

Article 250 Grounding & Bonding



The 2023 NEC Code Cycle is extremely unique in that I found no significant changes in Article 250. This is the 1st time I have experienced this since entering the electrical trade during the 1975 NEC Code Cycle.

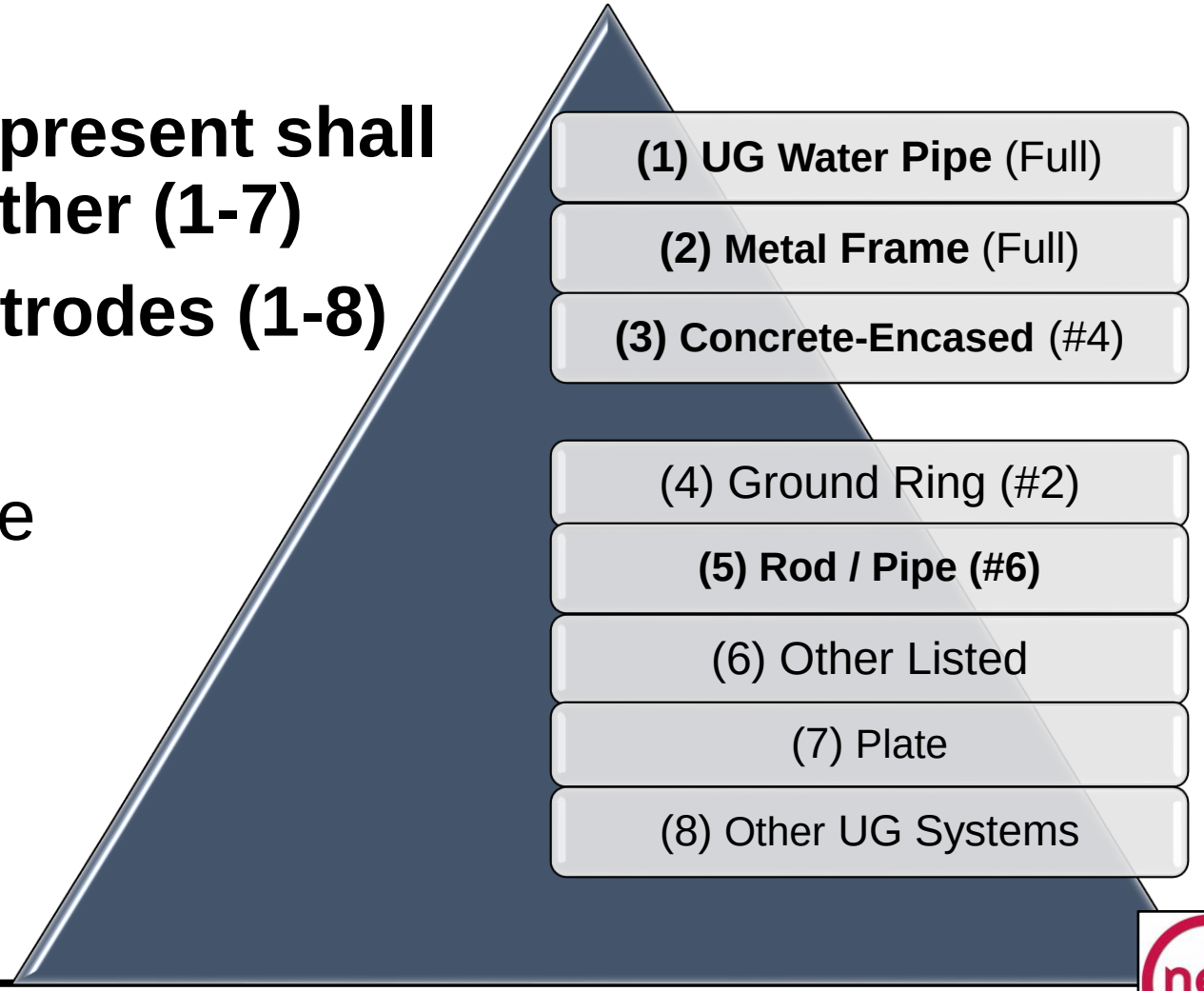
Grounding Triangle / Foundation

250.50 <u>All</u> Electrodes present shall be bonded together (1-7)

250.52 Permitted Electrodes (1-8)

<u>Focus</u>:

1. Metal UG Water Pipe
2. Building Steel
3. Concrete-Encased
4. Rod / Pipe



Δ 250.140 Frames of Ranges & Dryers

N (B) Grounded Conductor Connections

Since 1996 the NEC has required 4-wire branch circuits for new installations of Electric Ranges & Dryers

Existing Installations: Expanded Use of 3-wire "SE" Cable

Prior editions of the NEC only permitted 3-wire SE cable that originated in SE equipment.

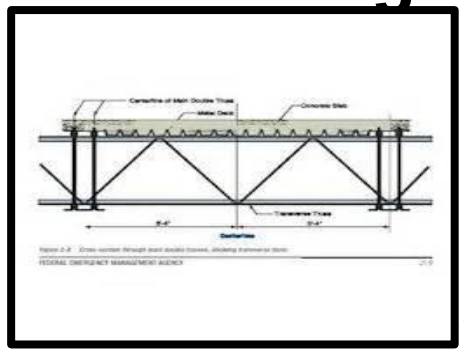
*This change now permits in **"existing installations"**, that the bare SE grounded conductor may be **insulated** or field covered **(taped)** in locations other than SE equipment.*

www.ta191.com

For Informational Purposes Only

Article 300 General Requirements for Wiring Methods & Materials

300.4(E) Cables, raceways or boxes installed under metal roof corrugated decking.



***N* Exception #2**

*The 1½" spacing is **not** required where metal-corrugated sheet roof decking is covered with a **minimum** 2" concrete slab, measured from the top of the corrugated roofing*

****Re: *N* 410.10(F) Exception****

Δ 300.14 Length of Free Conductors

At Outlets, Junctions, and Switch Points

At least 6” of free conductor, measured from the point in the box, where it emerges from its raceway or cable sheath, shall be left at each outlet, junction, and switch point for splices or the connection of luminaires or devices. ***The 6” free conductor shall be permitted to be spliced or unspliced.*** Where an opening to an outlet, junction, or switch point is less than 8” in any dimension, each conductor shall be long enough to extend at least 3” outside the opening.





Δ 300.25 Exit Enclosures (Stair Towers)

Where an exit enclosure is required to have ***fire resistance rating,*** only electrical wiring methods serving equipment permitted by the authority having jurisdiction in the exit enclosure shall be installed within the exit enclosure.

N Exception. ***Where egress lighting on the outside exterior doorways from the exit enclosure, luminaires shall be permitted to be supplied from the inside of the exit enclosure.***



"Self-closing doors are indicative of a fire rating"

N Article 305 – General Requirements for Wiring Methods & Materials for Systems rated over 1kV ac & 1.5 kV dc

New Medium Voltage Conductor Article

305.1 Scope. This article covers wiring methods and materials for systems rated over 1kV ac, 1.5kV dc.

305.3 Exposed runs of MV cables, bare conductors, & bare busbars shall be permitted in locations accessible only to qualified persons. Busbars shall be permitted to be either CU or AL.

Not Current Code In Ohio

Article 310 Conductors for General Wiring

Δ 310.3(B) Conductor Material

Conductors in this article shall be of, aluminum (AA-8000), copper or copper-clad aluminum unless otherwise specified.

Aluminum and copper-clad aluminum shall comply with the following: material shall be ***(listed)***.

For copper-clad aluminum conductors the copper shall form a minimum of 10% of the cross-sectional area of a solid conductor or each strand of a stranded conductors.





Table 310.16 Ampacities of Insulated Conductors with Not More Than Three Current-Carrying Conductors in Raceway, Cable, or Earth (Directly Buried)

Size AWG or kcmil	Temperature Rating of Conductor [See Table 310.4(A)]						Size AWG or kcmil
	60°C (140°F)	75°C (167°F)	90°C (194°F)	60°C (140°F)	75°C (167°F)	90°C (194°F)	
	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, XHWN, USE, ZW	Types TBS, SA, SIS, FEP, FEPB, MI, PFA, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN, Z, ZW-2	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, XHWN, USE	Types TBS, SA, SIS, THHN, THHW, THW-2, THWN-2, RHH, RHW-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN	
	COPPER			ALUMINUM OR COPPER-CLAD ALUMINUM			
18*	—	—	14	—	—	—	—
16*	—	—	18	—	—	—	—
14*	15	20	25	—	—	—	—
12*	20	25	30	15	20	25	12*
10*	30	35	40	25	30	35	10*
8	40	50	55	35	40	45	8
6	55	65	75	40	50	55	6
4	70	85	95	55	65	75	4
3	85	100	115	65	75	85	3
2	95	115	130	75	90	100	2
1	110	130	145	85	100	115	1
1/0	125	150	170	100	120	135	1/0
2/0	145	175	195	115	135	150	2/0
3/0	165	200	225	130	155	175	3/0
4/0	195	230	260	150	180	205	4/0
250	215	255	290	170	205	230	250
300	240	285	320	195	230	260	300
350	260	310	350	210	250	280	350
400	280	335	380	225	270	305	400
500	320	380	430	260	310	350	500
600	350	420	475	285	340	385	600
700	385	460	520	315	375	425	700
750	400	475	535	320	385	435	750
800	410	490	555	330	395	445	800
900	435	520	585	355	425	480	900
1000	455	545	615	375	445	500	1000
1250	495	590	665	405	485	545	1250
1500	525	625	705	435	520	585	1500
1750	545	650	735	455	545	615	1750
2000	555	665	750	470	560	630	2000

www.ta191.com

Article 310 Conductors for General Wiring

Δ 310.3(B) Conductor Material

Conductors in this article shall be of, aluminum (AA-8000), copper or copper-clad aluminum unless otherwise specified.

Aluminum and copper-clad aluminum shall comply with the following: material shall be ***(listed)***.

For copper-clad aluminum conductors the copper shall form a minimum of 10% of the cross-sectional area of a solid conductor or each strand of a stranded conductors.





"Deleted" Article 311 Medium Voltage Conductors & Cables

This Article was New in the 2020 NEC

Previous editions of NEC were Articles 310 & 328

Replaced / Broken down into (3) NEW Articles

N **Article 235- Branch Circuits over 1kV**

N **Article 245- OCP for circuits over 1kV**

N **Article 495- Equipment over 1kV**

N 314.24 (C) Clearances for Side-Wiring Entrances

Where devices or equipment are mounted in boxes having side-wiring entries, the conductors entering from the side shall be protected as covered in (1) & (2), as follows. The term ***side*** applies any wall of a box other than the one opposite to the opening.

1. The rearward projection of the device or equipment shall not extend beyond the centerline of the wiring knockout or other entry.
2. The clearance from the box wall to the installed device or equipment shall not be less than ½”.

www.ta191.com

For informational purposes only

Δ 314.27 Ceiling Boxes for Paddle Fans

2nd Paragraph

Outlet boxes mounted in the ceilings of habitable rooms dwelling occupancies in a location acceptable for the installation of a ceiling-suspended (paddle) fan shall comply with one of the following:

1. Listed for the sole support of ceiling-suspended (paddle) fans.

N 2. ***Installed so as to allow direct access through the box, to structural framing capable of supporting a ceiling-suspended (paddle) fan without removing the box.***

www.ta191.com

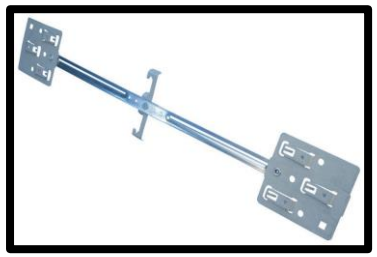
Not Current Code In Ohio

Δ 314.27(E) Weight Supporting Ceiling Receptacles (WSCR), & Weight-Supporting Attachment Fittings (WSAF)

NEW Terminology

Both listed WSCR & WSAF devices







www.ta191.com

For Informational Purposes Only

N Article 315 Medium Voltage Conductors, Cable, Cable Joints & Terminations

315.1 Scope. ***This article covers the use, installation, construction specs, and ampacities of MV medium voltage conductors, cable, cable joints, & cable terminations. This article includes voltage 2001v – 35kV ac & 2001 – 2500v dc.***

315.6 Listing Requirements. ***Type MV cables, joints, terminations, connectors, & associated fittings shall be listed. The listing requirements for MV cable joints, terminations, & connectors shall be effective January 1, 2026.***

N 315.50 Installation of MV Conductors

Part III.

A qualified person(s) with documented training and experience shall perform the installation and testing of Type MV cable. A qualified person(s) with documented training and experience in the installation of Type MV cable joints. A qualified person(s) with documented training and experience in the installation of Type MV cable terminations shall perform installation of Type MV cable terminations.

www.ta191.com

For Informational Purposes Only

N Instrumentation Tray Cable (ITC)

335.1 Scope. This article covers the use, installation, and construction specifications of *instrumentation tray cable* (ITC) for application to instrumentation and control circuits operating at 150v or less and 5 amperes or less.



335.6 Construction.

The insulated conductors of Type ITC cable #22 - #12 AWG Conductors shall be copper or thermocouple alloy.

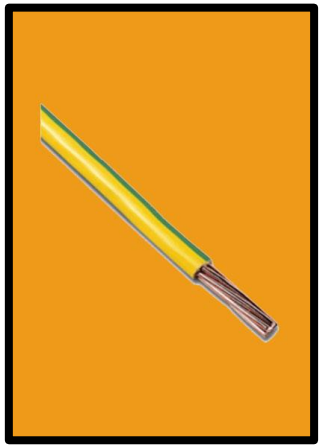


N Article 369 Insulated Bus Pipe (IBP) / Tubular Covered Conductors (TCC) Systems

369.1 Scope. This article covers the use, installation, and construction specifications for insulated pipe (IBP) systems.







www.tal91.com

For Informational Purposes Only

N Article 371 Flexible Bus Systems

371.1 Scope. This article covers the use and installation requirements of flexible bus systems and associated fittings.





Not Current Code In Ohio

Δ Article 400 Flexible Cords & Cables

N Part IV. Portable Power Feeder Cables over 2000v, Nominal

N **400.10 General. Part IV applies to single & multiconductor portable power feeder cables over 2000v nominal used to connect portable equipment & machinery.**

Medium Voltage Cable Type "G"



www.tal91.com

For Informational Purposes Only

406.4(D) Receptacle Replacements

Replacements

1. Grounding Type Receptacles
2. Non-Grounding Type Receptacles
3. GFCI Replacements
4. AFCI Replacements – ***Where "AFCI" protection is required (2020)***
5. Tamper-Resistant – ***Where "TR" protection is required (2011)***
6. Weather-Resistant – ***Where "W/R" protection is required (2011)***
7. Controlled Receptacles – ***Based on Situation (2020)***
8. ***N*** GFPE of Protection of Equipment – **Where "GFPE" protection is Required (2023)**

www.ta191.com

Not Current Code In Ohio

406.4 Receptacle Replacements. Grounding (D)(1); Non-grounding (D)(2); GFCI (D)(3); and AFCI (D)(4)

Reference to 210.12 (A), (B) & (C) Required **"AFCI"** Locations

*****2020 NEC 406.4(D) Arc-Fault Circuit-Interrupter (AFCI); Replacement Types*****

(1) Listed outlet branch-circuit AFCI type receptacle

(2) Receptacle protected by listed outlet branch-circuit type AFCI receptacle

(3) A receptacle protected by a listed combination type AFCI circuit breaker

210.12(D) Ex*: Branch Circuit Extensions or Modifications* – Dwelling Units, Dormitory Units, and Guest Rooms and Guest Suites locations only.

(1) 210.12 (A) Dwelling Units. (1-6)

(2) Listed outlet branch-circuit type AFCI at 1st outlet of existing circuit

www.ta191.com

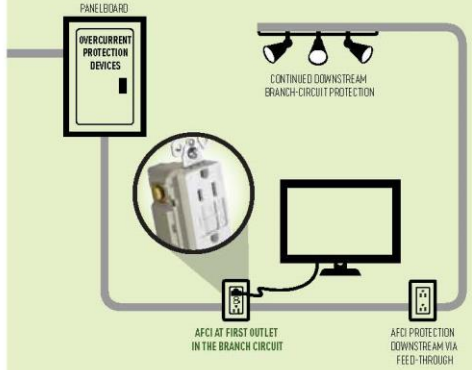
For Informational Purposes Only



Methods for Meeting NEC® Requirements with AFCI and AFCI/GFCI Receptacles

BRANCH-CIRCUIT EXTENSIONS OR MODIFICATIONS

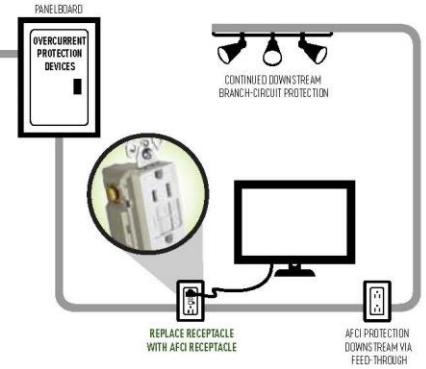
When branch-circuit wiring is modified, replaced or extended, it is permissible to meet the NEC requirement with a listed outlet branch-circuit AFCI receptacle located at the first receptacle outlet of the existing branch circuit.



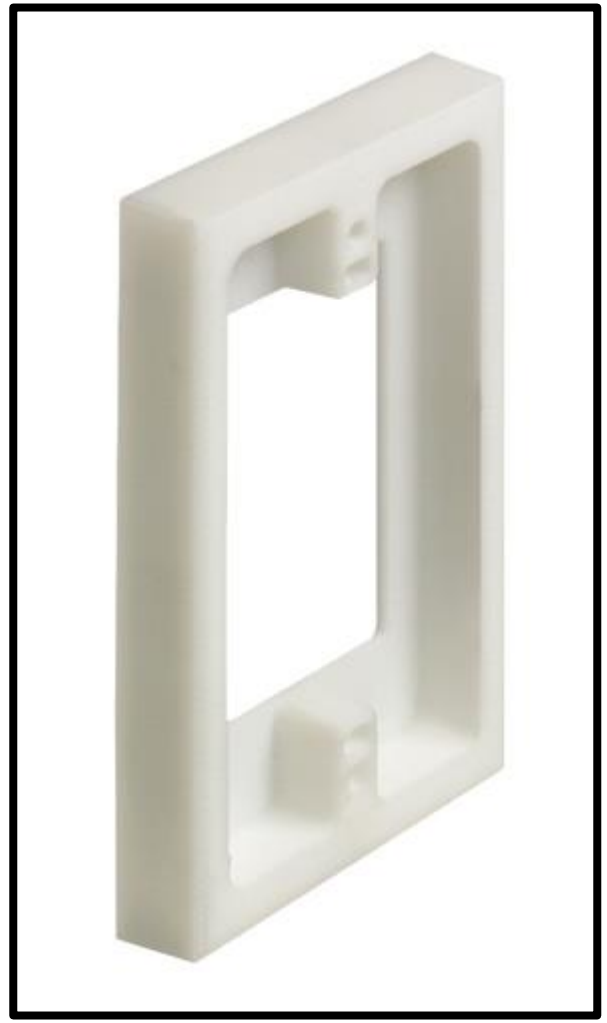
REPLACEMENTS

Where a receptacle outlet is supplied by a branch circuit that requires AFCI protection, it is permissible to meet the NEC requirement with a replacement receptacle that is one of the following:

1. A listed outlet branch-circuit type AFCI receptacle
2. A receptacle protected by a listed outlet branch-circuit type AFCI receptacle



Note: Section 406.4 (D)(4) requires AFCI protection when a receptacle is replaced.



www.ta191.com

AFCI Type Devices

AFCI "TR" Outlet



AFCI / GFCI "TR" Outlet



AFCI Type Devices

AFCI “Deadfront”



20a Hospital Grade AFCI / GFCI “TR” Outlet (Red)



N 406.12 Tamper-Resistant Receptacles

Expanded Locations; 15- & 20-ampere 125v thru 250v

1. Dwelling units
2. Guest rooms & Guest suites
3. Child-care facilities
4. Preschools & educational facilities
5. **Within clinics, medical & dental offices, following areas:**
   (a) Business offices accessible to the public
   (b) Lobbies & Waiting Areas
   (c) Spaces of nursing homes / limited-care facilities
6. **Places awaiting transportation, gyms, skating rinks, fitness centers & auditoriums**
7. Dormitory units
8. **Residential care facilities, assisted living, rehab & group homes**
9. **Foster care facilities, nursing homes & psychiatric hospitals**
10. **Accessible areas of agricultural buildings to the general public & any common areas**

Δ 410.184 GFCI Protection & Special Purpose (SPGFCI) Protection



Horticultural Lighting Use

NEW Exception:

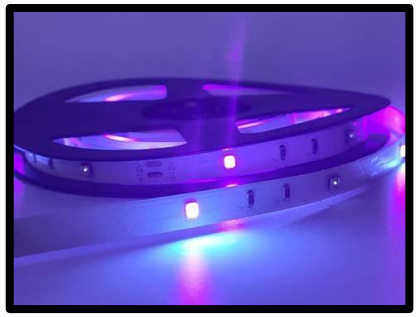
Circuits exceeding 150v to ground shall be protected by a listed special purpose GFCI

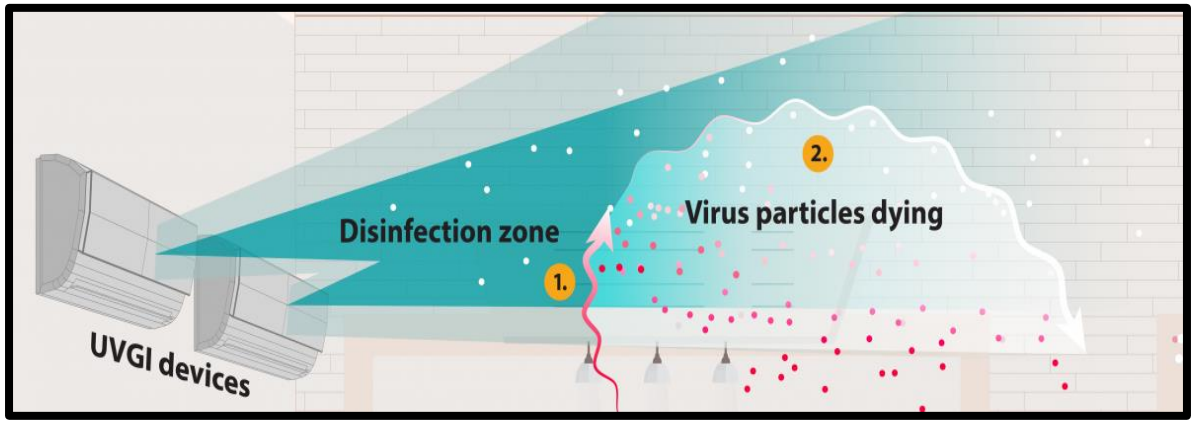
Class "C" Special Purpose Ground-Fault Circuit Interrupter (SPGFCI) Trip level is 15 – 20mA / ckts. over 150v to ground

N Germicidal Irradiation Luminaires

Article 410.190 Part XVII. Special Provisions

Listing, Labeling & Installation Requirements







HVAC Ventilation / UV-C LED lighting systems
Tuberculosis, SARS, & CoV-2 sterilization: reduce hazards

www.ta191.com

For Informational Purposes Only

Δ 426.28 Ground-Fault Protection

Fixed Outdoor Electric De-icing & Snow Melting Equipment

Previously 426.44(E) GFCI Protection. In addition to the requirements of 210.8, GFCI protection for personnel shall be provided.

426.28 Ground Fault protection.

GF protection shall be provided for fixed outdoor electric de-icing and snow-melting equipment.

The trip level shall be specified by the manufacturer.

www.ta191.com

Not Current Code In Ohio

Δ 440.11 A/C Disconnects





Expanded Requirement

Disconnecting means shall be capable of disconnecting A/C & refrigeration equipment, including motor-compressors & controllers, from the circuit conductors. If the disconnecting means is readily accessible to unqualified persons, an enclosure door or hinged cover of a disconnecting means enclosure ***that exposes energized parts when open shall require a tool to open or be capable of being locked.***

N Article 495 Equipment Over 1kV ac / 1.5kV dc

Previous NEC Editions was Article 490

495.1 Scope. This article covers the general requirements for equipment operating at over 1000v ac, 1500v dc.

495.22 Isolating Means

495.48 Substation Design & Documentation

495.61 Mobile and Portable Equipment

495.70 Boilers

www.ta191.com

For Informational Purposes Only

Δ Article 500 Hazardous Locations

Classified Locations; Class I, II, & III Locations; Division I & II

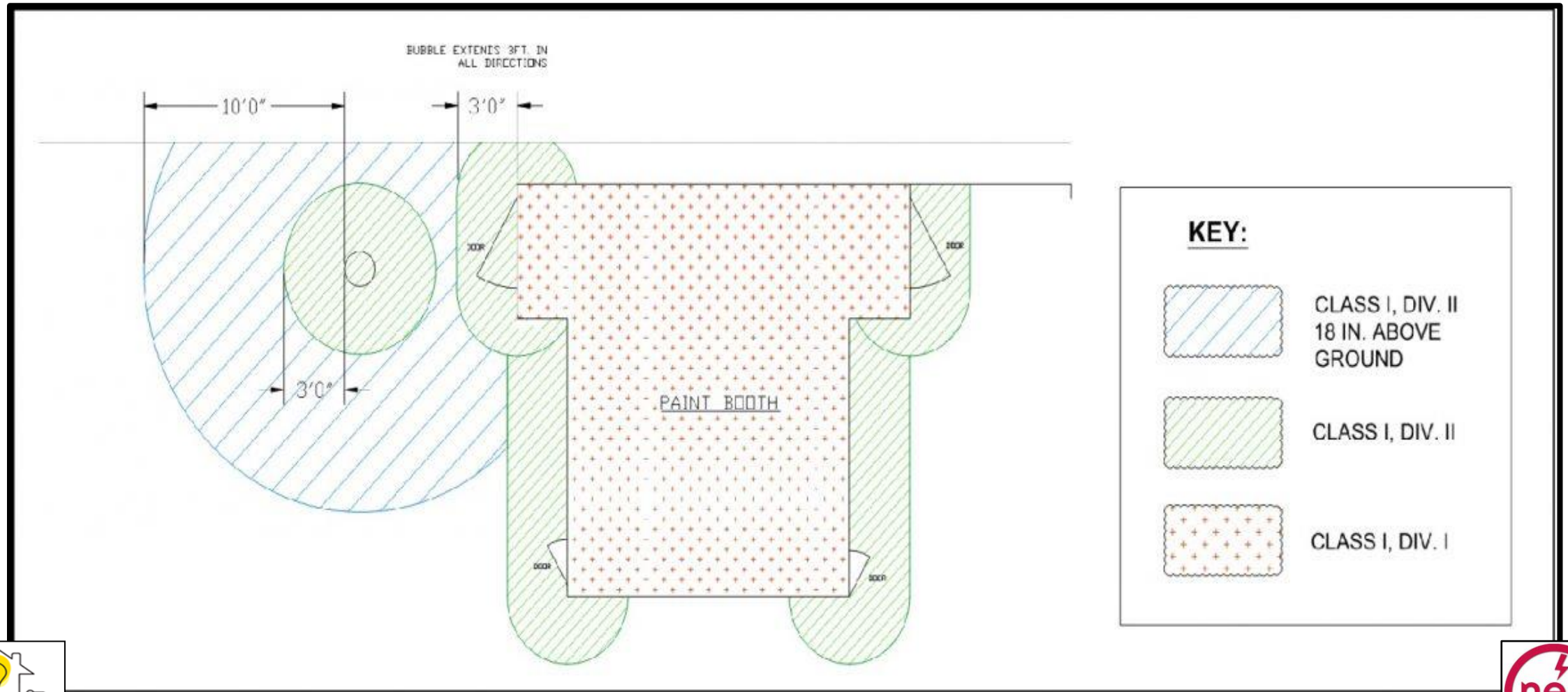
Additional Requirement 500.4 Documentation.

Classified or unclassified areas shall be documented on an area classification drawing & other associated documentation. This documentation shall be available to the authority having jurisdiction (AHJ) and those authorized to design, install, inspect, maintain or operate the equipment.

www.ta191.com

For Informational Purposes Only

Documented Area Classification



Δ Article 511 Commercial Garages Repair & Storage

This Article was re-written

511.7 Fixed Wiring Above Hazardous / Classified Locations.
Added ***listed fittings & equipment grounding conductors*** to numerous wiring methods.

517.8 Underground Wiring Below Hazardous Locations.

N Article 512 Cannabis Oil Equipment

512.1 Scope. This article covers cannabis oil preparatory equipment, extraction equipment, booths, post-processing equipment, and systems using flammable materials (flammable gas, flammable liquid-produced vapor, combustible liquid-produced vapor) in commercial & industrial facilities.

512.3 Classified Locations. Cannabis oil equipment & systems that can release flammable materials during operations shall be classified in accordance with 512.3(A) & (B).

www.ta191.com

Not Current Code In Ohio

N Article 512 – Cannabis Oil Equipment / Oil Systems using Flammable Materials

512.3 Classified Locations. Cannabis oil equipment & systems that can release flammable materials during operation. ***Class I Div. 1 or II location***.

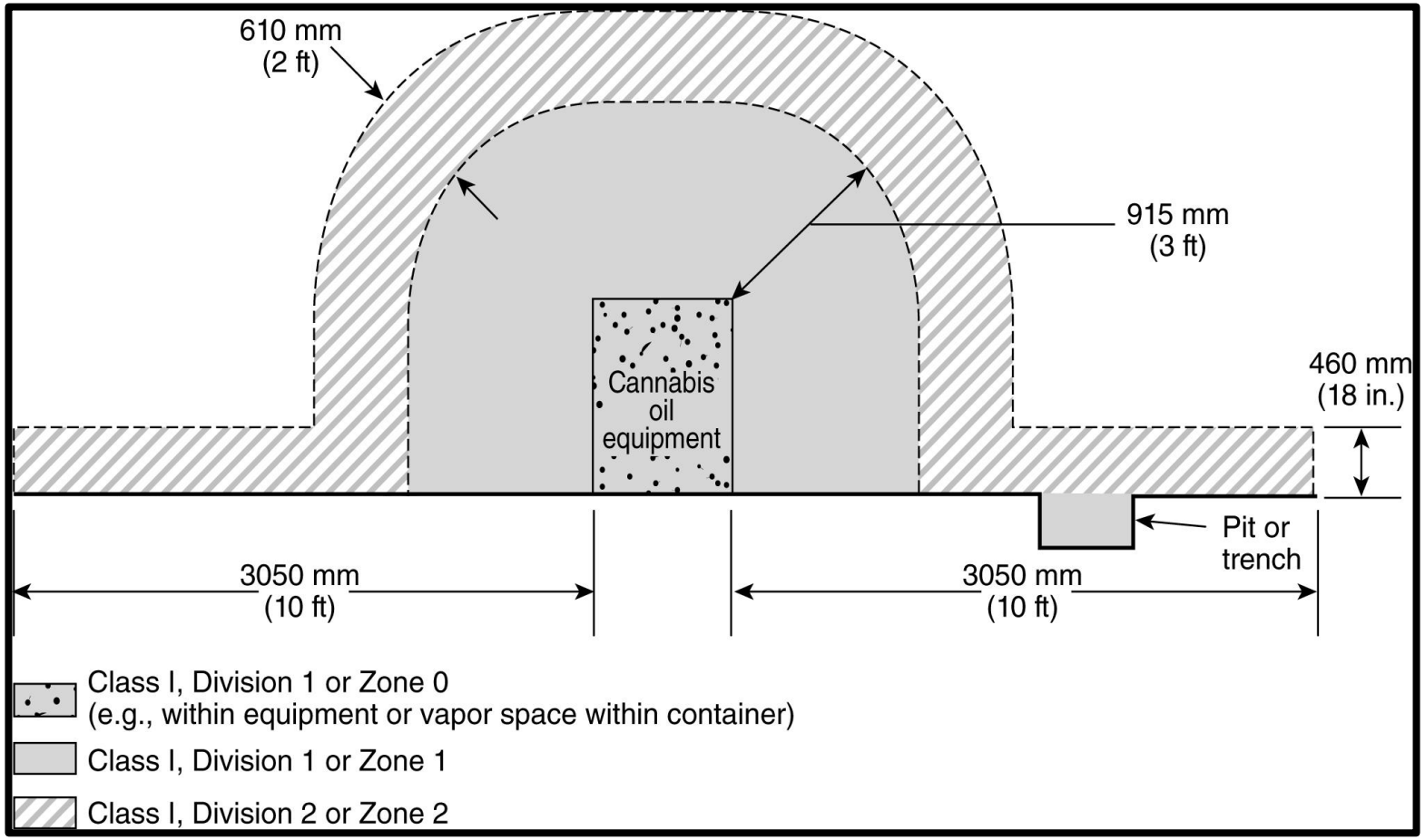




www.ta191.com

For Informational Purposes Only

N 512.3(B) Cannabis Oil Booth



Not Current Code In Ohio

Δ Article 514 Motor Fuel Dispensing Facilities

Δ 514.8 Underground Wiring. (In classified Locations)

The change here is previous editions of the NEC accepted MI, PVC, RTRC, HDPE conduit as an exception to the metal conduit rule. The 2023 NEC 514.8(B) & (C) is now written into positive code language.

No Change: Still requires 2' of cover or change to RMC or IMC

Δ 517 Health Care Facilities

517.1 Scope. ***Inadvertently Deleted***

517.2 Definitions. ***Relocated to Article 100***

517.10(B) Not Covered. ***Pharmacy services not contiguous to Health Care Facilities***

517.12 EGC for Receptacles & Fixed Electrical Equipment in Patient Care Spaces. ***The insulated copper conductor needs to be installed and terminated in each panel all the way to the SE equipment.***

517.30 EES Sources of Power. ***(1) Added utility power & changed (4) from battery system to energy storage system.***

Article 517 Health Care Facilities

517.50 Part V. *Diagnostic Imaging & Treatment Equipment*

Formerly X Ray Installations

(updated for new terminology & technologies)

Added Informational Notes #3 & #4

#3 Diagnostic Equipment

#4 Treatment Equipment

Δ Article 530 Motion Picture & TV Studios & *Remote Locations*

More specific details, restrictions and requirements for associated (portable) equipment than previous editions. Will affect both local and national live broadcasts including news, sporting and possibly any live event.

Part II . Expanded Portable Equipment in Production Areas of Studios & Remote Locations

Part III. Portable Equipment in Support Areas

www.ta191.com

Not Current Code In Ohio

Article 555 Marinas, Boatyards, Floating Buildings & Docking Facilities

This Article has been updated over the past (2) Code Cycles.

555.4 Location of Service Equipment (for a floating building, dock or marina). This section is clearly defined on the location of SE equipment ***(on land)***.

No closer than 5' horizontally from the structure served & 12" minimum above the electrical datum plane (2' above the maximum highest water level under normal conditions).

***N* 555.14 *Areas requiring Equipotential Planes*.**

***N* 555.15 *Replacement of Equipment*. Requires compliance**

***N* 555.36 *Emergency Disconnect*. Each marina power outlet that provides shore power to boats shall have an emergency disconnect.**

***N* 555.37 All Equipment grounding conductors *shall be insulated*.**

Article 625 EV Power Transfer Equipment

Part III. Installation

Δ 625.40 Electric Vehicle Branch Circuit. *Each outlet installed for the purpose of supplying EVSE greater than 16a or 120v shall be supplied by an individual branch circuit.*

N 625.42(B) Energy Management System. *When more than one or more pieces of equipment are provided with an integral load management control,* ***the system shall*** *be marked to indicate this control is provided.*

*****2020 NEC***** *Each outlet installed for the purpose of charging electric vehicles shall be supplied by an individual branch circuit*.

Each circuit shall have no other outlets.

www.ta191.com

Not Current Code In Ohio

625.60 AC Receptacle outlets used for EVPE

EVPE = Electric Vehicle Power Export Equipment

AC receptacles installed in electric vehicles and intended to allow for connection of off-board utilization equipment shall comply with 625.60 (A) – (D).

(A) Type. The receptacle shall be listed

(B) Rating. Outlet shall

be rated 250-v max, 1ø, 50a max

(C) Overcurrent Protection. Integral to power export system

(D) GFCI Protection for Personnel. All receptacles shall be GFCI protected, indication and reset shall be readily accessible

www.ta191.com

For Informational Purposes Only

Article 625 EV Power Transfer Equipment

Δ ***625.48 Interactive Equipment.*** *EVPE or* ***WPTE*** *that incorporates a power export function & that is part of an interactive system that serves as an optional standby system, an electric power production source, or a bidirectional power feed shall be listed & marked as suitable for that purpose. When used as an optional standby system, the requirements of Parts I & II of Article 702 shall apply.*

N 625.49 Island Mode. EVPE and bidirectional EVSE that incorporate a power export function shall be permitted to be a part of an interconnected power system operating in island mode.

www.ta191.com

Not Current Code In Ohio

The Future is Bidirectional Power Flow

Nissan Leaf V2H



Hyundai Ioniq 5

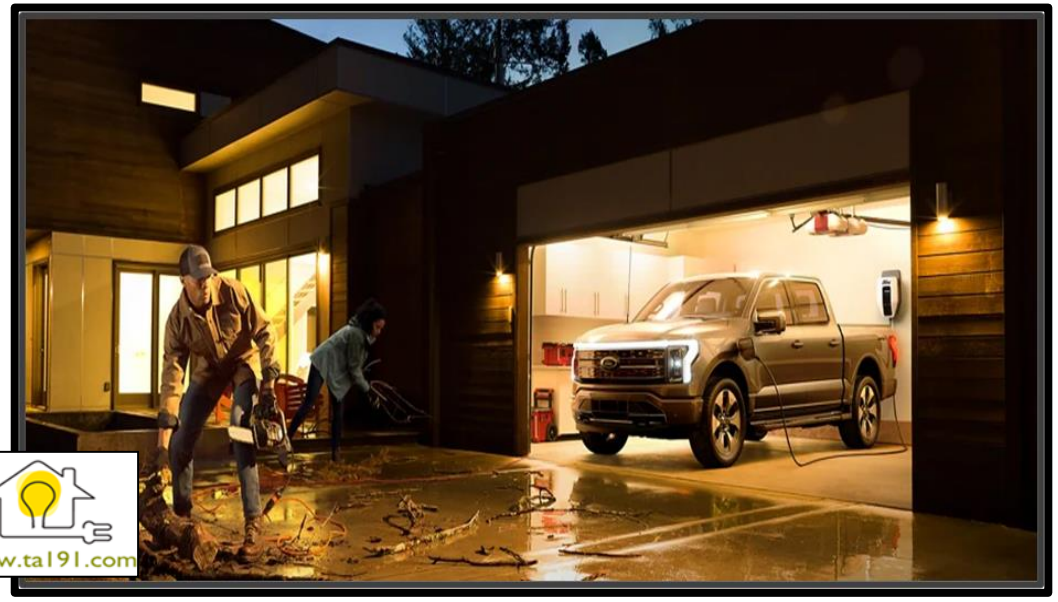


www.ta191.com

2022 Ford F-150 Lightning pick-up

All-Electric. All F-150

Available features include Backup Power that can provide full-home power for up to 3 days, on a fully charge battery and 80-amp Ford Charge station Pro. *When home is properly equipped & home transfer switch disconnects home from the grid*. Based on 30 kWh used per day. Turn your truck into a generator. Pro Power Onboard offers an available 9.6kw max power provided through 11 outlets. (4) 120v outlets in front trunk, (2) in the cab (4) in the bed, and (1) 240-v outlet for tougher tasks.





www.ta191.com

Electrical Vehicle Training Program

EV Champion Training Series is a four-part course developed by the National Renewable Energy Laboratory (NREL) and the FEMP fleet team. Those who attend all four webinars can earn 1.0 CEU and an EV champion Training Certificate from FEMP. A selection of on-demand trainings are available online.

www.energy.gov/eere/femp/electric-vehicle -training

US Department of Energy



www.ta191.com

For Informational Purposes Only

The Electrical Vehicle Infrastructure Training Program (EVITP)

The EV market continues to expand everywhere and is critical that ESVE equipment be properly installed to the highest standards to safety and quality. All EVITP Certified Electricians must pass a certification exam for proof of knowledge and skill.

The EVITP provides training and certification for electricians installing electric vehicle supply equipment (ESVE). The EVITP program was designed to provide installers with the most comprehensive training available in the market today.

www.evitp.org

www.ta191.com

For Informational Purposes Only

GFCI Protection Expanded & SPGFCI is NEW (special purpose GFCI protection)

Δ **680.5 GFCI & SPGFCI Protection.**

Δ **The GFCI and SPGFCI requirements in this article, unless otherwise noted, are in addition to the requirements in 210.8.**

GFCI Branch circuit receptacles & outlets (1ø & 3ø) 150v to ground or less, 60a or less. (6mA trip level)

SPGFCI is designed for (1ø & 3ø) receptacles & outlets above 150v to ground, not exceeding 480v with a 20mA trip level.

www.ta191.com

For Informational Purposes Only

Article 680 Swimming Pools, Fountains & Similar Locations

210.21 Pump Motors

680.21(C) Ground Fault Protection. ***Outlets serving pool motors shall have GFCI protection*.**

This section has been expanded over numerous editions of the code. 2020 NEC all outlets150v to ground or less, 60a or less,1ø & 3ø.

Δ **680.21(D)** *Where a pool pump motor is replaced* or ***repaired*** the motor shall be provided with ground-fault protection.

Not Current Code In Ohio

Littlefuse Shock Block 5000

Rated for 32-60amp

SPGFCI 10 - 100mA Increments or

Fixed 20mA Trip Level

208/480/600v Applications

This device is installed in-line between incoming power or existing overcurrent protection and the load.



www.ta191.com

For Informational Purposes Only

Δ 680.22 Receptacles (GFCI & SPGFCI)

680.22(A)(4) GFCI & SPGFCI Protection. *All receptacles rated 125v - 250v 60a or less, located within 20' of the inside walls of the pool shall have GFCI protection* complying with 680.5(B) or SPGFCI protection complying with 680.5(C).

680.22(B)(4) GFCI & SPGFCI Protection in Adjacent Areas. *Luminaires, lighting outlets, & ceiling suspended (paddle) fans mounted in the area extending between 5' & 10' horizontally from the inside walls of a pool shall have GFCI 680.5(B) or SPGFCI protection 680.5(C)* unless installed not less than 5' above the maximum water level & rigidly attached to the structure.

GFCI & SPGFCI Protection Locations

GFCI requirements in the following locations, 150v to ground or less, 60a or less, 125v - 250v (1ø & 3ø), receptacles & outlets

Permanently installed pools, storable pools, immersion pools

680.21(C) Pool Motors Receptacles & Outlets (All)

680.22(A)(4) / 680.32 Receptacles within 20'of inside wall of pool.

680.22(B)(4) Luminaires, Lighting outlets & paddle fans installed 5' & 10' horizontally from the inside walls of a pool.

680.43(A)(2) Receptacles within 10' of the inside of a Self-contained Spas & Hot Tubs & Immersion Pools (both indoor & outdoor).

680.44(A) GFCI & SPGFCI Self-contained Spa & Hot Tubs

Δ 680.26 Equipotential Bonding

680.26(A) Performance. The equipotential bonding grid required by ***680.26(B) & (C)*** to reduce voltage gradients in the pool area ***shall be installed for pools with or without associated electrical equipment related to the pool***.

With or without power, there is still a body of water with chemicals added.

Water + chemicals = battery/voltage



www.ta191.com

For Informational Purposes Only

Article 700 Emergency Systems

N **700.11 Wiring, Class 2 Powered Emergency Lighting Systems.**

700.11(A) General.

700.11(B) Identification. Emergency circuits shall be permanently marked…..

(1) All **boxes & enclosures shall be permanently marked**

(2) Exposed cable, tray or raceway shall be perm. marked

(C) Separation of Circuits.

(D) Protection. Installed in raceway, AC or MC cable

Ex. 6’ or less to luminaires / Locked rooms / latched encl.

1013.2 2017 Ohio Building Code

Chapter 10 Means of Egress

Floor Mounted Exit Signs in Group R-1

Where exit signs are required in Group R-1 occupancies, by Section 1013.1, additional low-level exit signs shall be provided in all areas serving guest rooms in Group R-1 occupancies and shall comply with Section 1013.5.

The bottom of the sign shall not be less than 10" or more than 12" above the floor level. The sign shall be flush mounted to the door or wall. Where mounted to the wall, the edge of the sign shall be within 4" of the door frame on the latch side.

OBC 310.3 R-1 Occupancies; "*Sleeping units*" transient in nature.

Re; Hotels, motels, boarding houses and congregate living facilities with less than 10 occupants, and single room occupancies (SRO).

www.ta191.com

Article 706 Energy Storage System

Δ **706.1 Scope.** This article applies to all energy storage systems (ESS) having a capacity greater than 1 kwh that may be stand-alone or interactive with other electric power production sources. These systems are primarily intended to store & provide energy during normal operating conditions.

N **706.7(A) Commissioning. ESSs shall be commissioned upon installation. (*Does not apply to 1 & 2-Family dwelling units*)**

N **(B) 706.7(B) Maintenance. ESSs shall be maintained**

www.ta191.com

For Informational Purposes Only

N Article 722 – Cables for Power-Limited Circuits & Fault-Managed Power Circuits

722.1 Scope. This article covers the general requirements for the installation of single-and multiple-conductor cables used in Class 2 & Class 3 power-limited circuits, power-limited fire alarm (PLFA) circuits & Class 4 fault-managed power circuits.

722.24 Mechanical Execution of Work

722.135 Cable Listing



N **Article 726 Class 4 Fault-Managed Power Systems**

New Class Rating. *Class 4 cables allow the distribution of DC power at higher-voltages. This type of circuit constantly monitors itself (intelligent wiring system) for faults and would shut power off simultaneously if a fault occurs. Capacity to deliver more power than Class I, II, or III systems*.

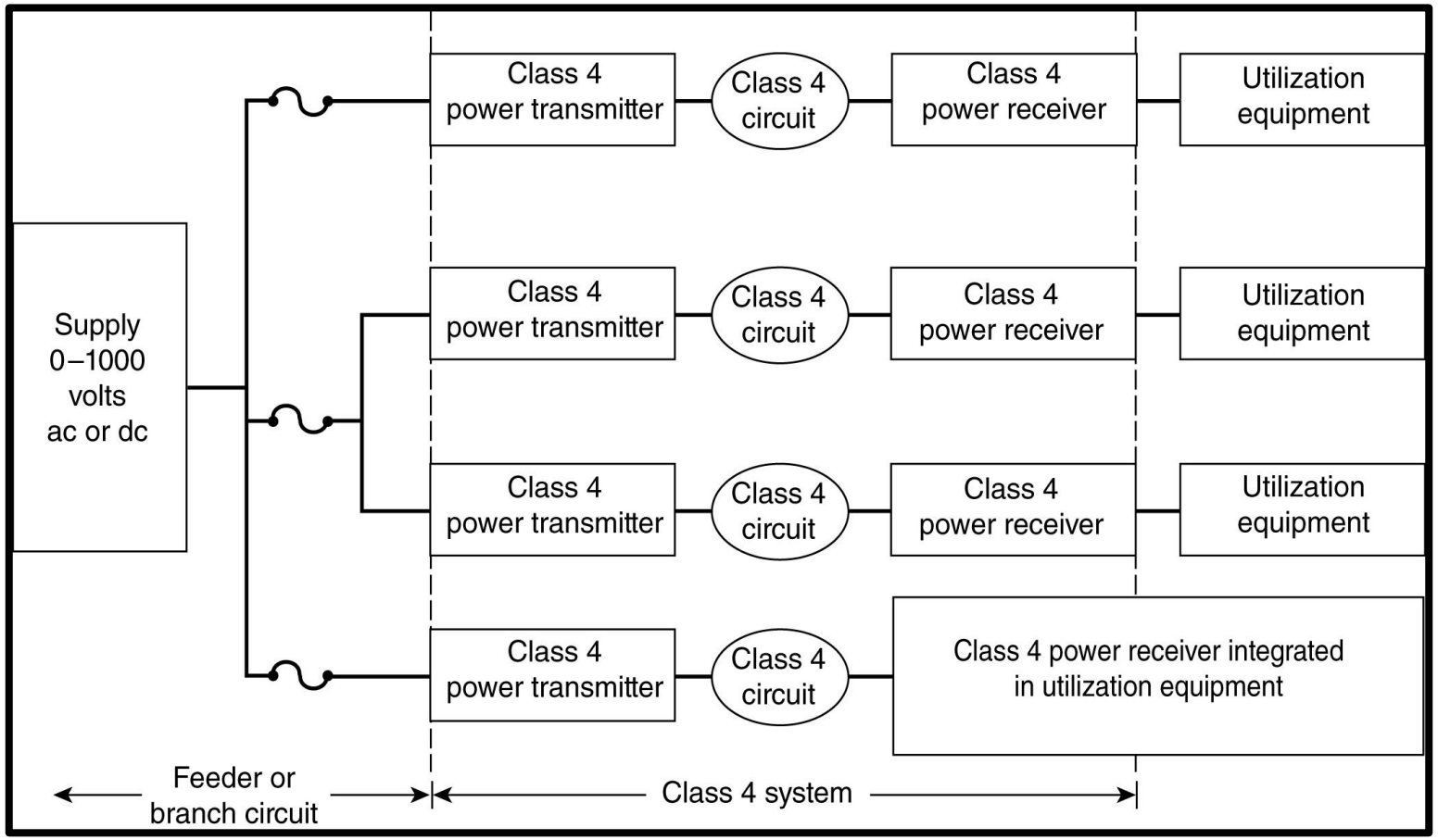
Class 4 power systems are extremely safe from potential fire or shock hazards. Aka Power Energy Transfer (PET), Fault Managed Power; {Built-In Fault Management} (FMP)

Smart Building Technology; 450v L-L / 225v to ground

www.ta191.com

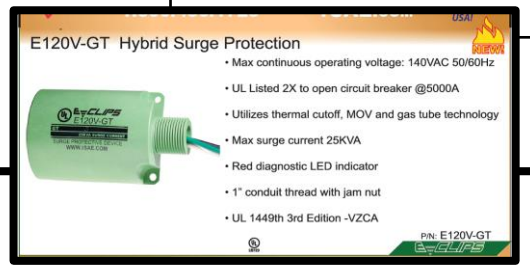
For Informational Purposes Only

N IN 726.121 Class 4 Circuits



Not Current Code In Ohio

Article 760 Fire Alarm Systems



N 760.33 Supply Side Overvoltage Protection

A listed surge-protective device (SPD) shall be installed on the supply side of a fire alarm control panel in accordance with Part II of Article 242.





Typically, the fire alarm control panel is supplied by a single pole 120v circuit.

N* 760.179(D) Cable Jacket Compound. The *cable jacket shall have a high degree of abrasion resistance.

www.ta191.com

Not Current Code In Ohio

2023 National Electrical Code "Proposed" Changes & Updates

Labriola Training Agency #191
www.ta191.com

John M. Labriola
Principal

150 Maplecrest Street SW
North Canton, Ohio 44720

330.497.6309 Phone
330.606.8098 Cell
john@ta191.com

www.ta191.com

Thank You!

File Attachments for Item:

EC-8 National Electric Code 2017 Review with Update of Changes (Electrical League of Ohio)

All certifications (two sessions of 4 hours each)

The Electrical League of Ohio

Presents:

National Electrical Code Conference

National Electrical Code Review of 2017 NEC with update of changes

March 1, 2023

Presented By: John Labriola and Timothy Pool

For Informational Purposes Only

Article 100
Definitions

Article 100 Definitions

***N* Scope.** This article contains only those definitions essential to the application of this *Code*. It is not intended to include commonly defined general terms or commonly defined technical terms from related codes and standards. An article number in parentheses following the definitions indicates that the definition only applies to that article.

2017 Code created Part 2 for over 1000 volts

2020 Code created Part 3 for Hazardous Locations

2023 Code put them back into one Part. Now almost all definitions utilized in the NEC are in Article 100

For Informational Purposes Only

Article 110.12
Mechanical Execution of Work

For Informational Purposes Only

Article 110.12 Execution of Work.

Removed the words "workman-like" to be more inclusive



2017 - 110.12 Mechanical Execution of Work.

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

2023 - 110.12 Mechanical Execution of Work.

Electrical equipment shall be installed in a professional and skillful manner.

Informational Note: See ANSI/NECA 1-2015, *Standard for Good Workmanship in Electrical Construction,* and other ANSI-approved installation standards for information on accepted industry practices.

For Informational Purposes Only

Article 110.16(B)
Arc Flash Warning

For Informational Purposes Only

Article 110.16(B) Arc-Flash Warning

2017 Code

110.16(B) Service Equipment.

In other than dwelling units, in addition to the requirements in (A) (a generic arc flash warning label), a permanent label shall be field or factory applied to **service equipment** rated **1200 amps or more**. The label shall meet the requirements of 110.21(B) and contain the following information:

(1) Nominal system voltage

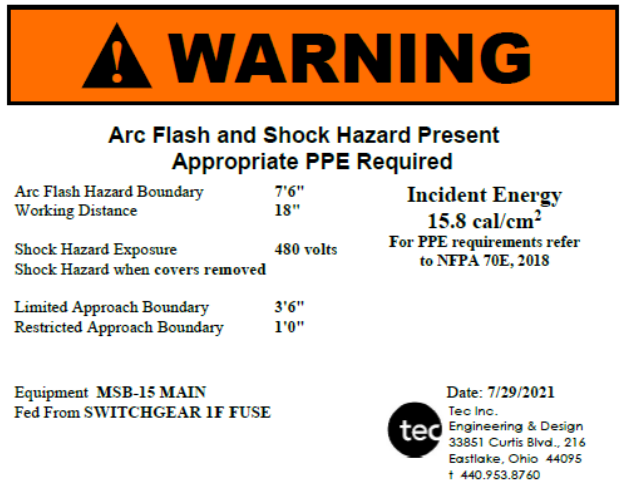
(2) Available fault current at the service overcurrent protective devices

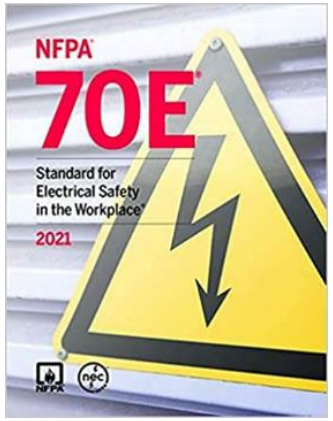
(3) The clearing time of service overcurrent protective devices based on the available fault current at the service equipment

(4) The date the label was applied

For Informational Purposes Only

Article 110.16(B) Arc-Flash Warning





110.16(B) Service Equipment and Feeder Supplied Equipment.

In other than dwelling units, in addition to the requirements in 110.16(A), a permanent arc flash label shall be field or factory applied to service equipment and feeder supplied equipment rated 1000 amperes or more. The arc flash label shall be in accordance with applicable industry practice and include the date the label was applied. The label shall meet the requirements of 110.21(B).

2020 Code requires arc flash label to industry practice, includes feeders and increases to 1200 amps.

For Informational Purposes Only

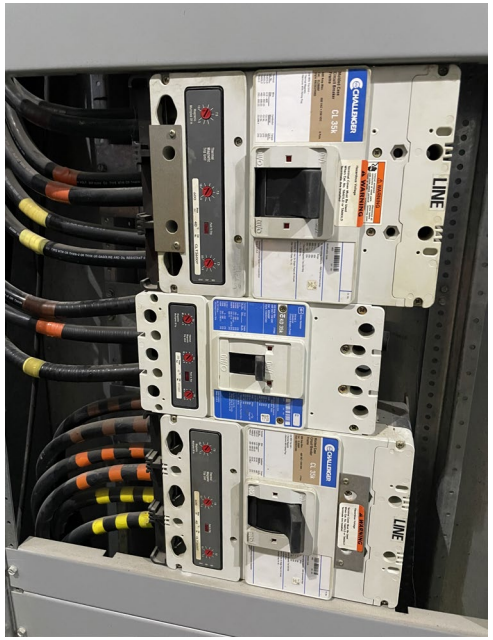
Article 110.17

Servicing and Maintenance of Equipment

For Informational Purposes Only

N Article 110.17 Servicing and Maintenance

New in 2023!



110.17 Servicing and Maintenance of Equipment.

Servicing and electrical preventive maintenance shall be performed by qualified persons trained in servicing and maintenance of equipment and shall comply with the following:

performed in accordance with the original equipment manufacturer's (OEM) instructions and information included in the listing information, applicable industry standards, or as approved by the authority having jurisdiction.

(Verified replacement parts by original manufacturer, under applicable product standards. The replacement parts shall comply with at least one of the following:

a. Be provided by the original equipment manufacturer

b. Be designed by an engineer experienced in the design of replacement parts for the type of equipment being serviced or maintained

c. Be approved by the authority having jurisdiction

For Informational Purposes Only

Article 110.17 Servicing and Maintenance

NFPA 70B is a recommended practice – not a code. There are committees actively trying to make it a code.

New in 2023

110.17 Servicing and Maintenance of Equipment.

Informational Note No. 1: For equipment that is not listed or field labeled, or for which components are no longer available from the original equipment manufacturer, one way to determine suitability is to review the documentation that accompanies the replacement parts.

Informational Note No. 2: See NFPA 70B, Recommended Practice for Electrical Equipment Maintenance, for information related to preventive maintenance for electrical, electronic, and communication systems and equipment.

For Informational Purposes Only

Article 110.20
Reconditioned Equipment

For Informational Purposes Only

Article 110.20 Reconditioned Equipment



110.20 Reconditioned Equipment.

Reconditioned equipment shall be permitted except where prohibited elsewhere in this *Code*. Equipment that is restored to operating condition shall be reconditioned with identified replacement parts, verified under applicable standards, that are either provided by the original equipment manufacturer or that are designed by an engineer experienced in the design of replacement parts for the type of equipment being reconditioned.

For Informational Purposes Only

Article 110.20 Reconditioned Equipment



110.20(A) Equipment Required to Be Listed.

Equipment that is reconditioned and required by this *Code* to be listed shall be listed or field labeled as reconditioned using available instructions from the original equipment manufacturer.

110.20(B) Equipment Not Required to Be Listed.

Equipment that is reconditioned and not required by this *Code* to be listed shall comply with one of the following:

(1) Be listed or field labeled as reconditioned

(2) Have the reconditioning performed in accordance with the original equipment manufacturer instructions

For Informational Purposes Only

Article 110.20 Reconditioned Equipment



110.20(C) Approved Equipment.

If the options specified in 110.20(A) or (B) are not available, the authority having jurisdiction shall be permitted to approve reconditioned equipment, and the reconditioner shall provide the authority having jurisdiction with documentation of the changes to the product.

For Informational Purposes Only

Article 110.26
Working Space

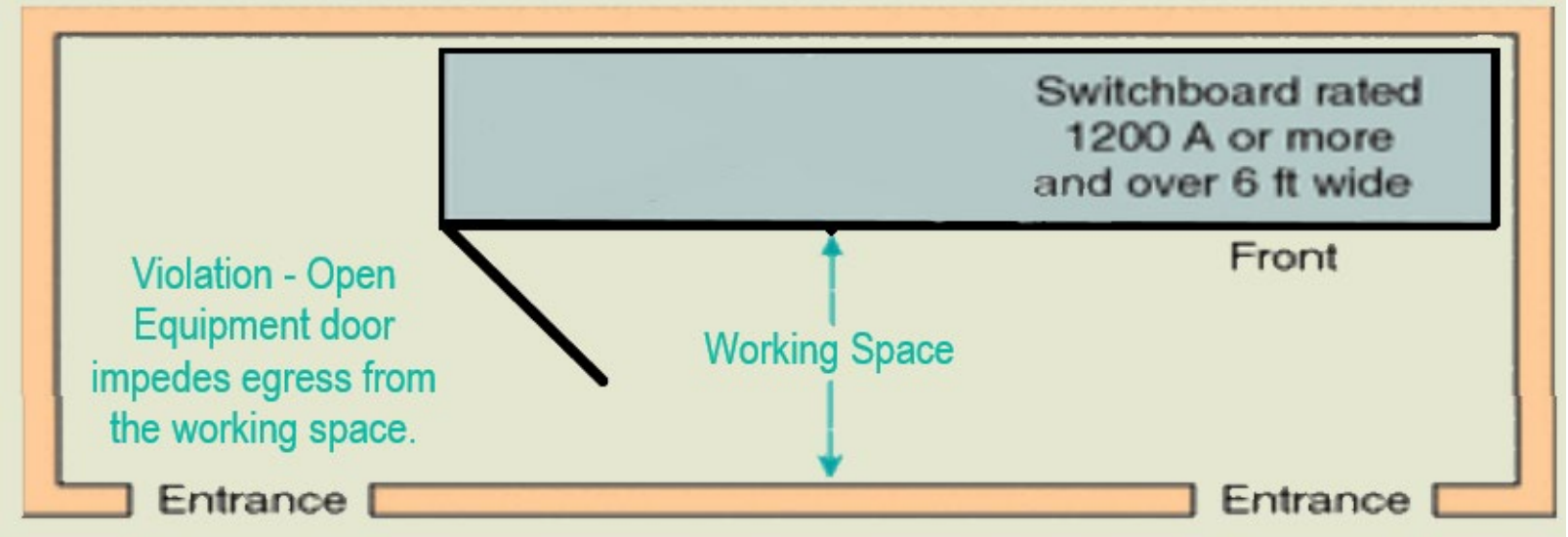
For Informational Purposes Only

ARTICLE 110.26 Spaces About Electrical Equipment

110.26(C) Entrance to Working Space

Open equipment doors shall not impede the entry to or egress from the working space.

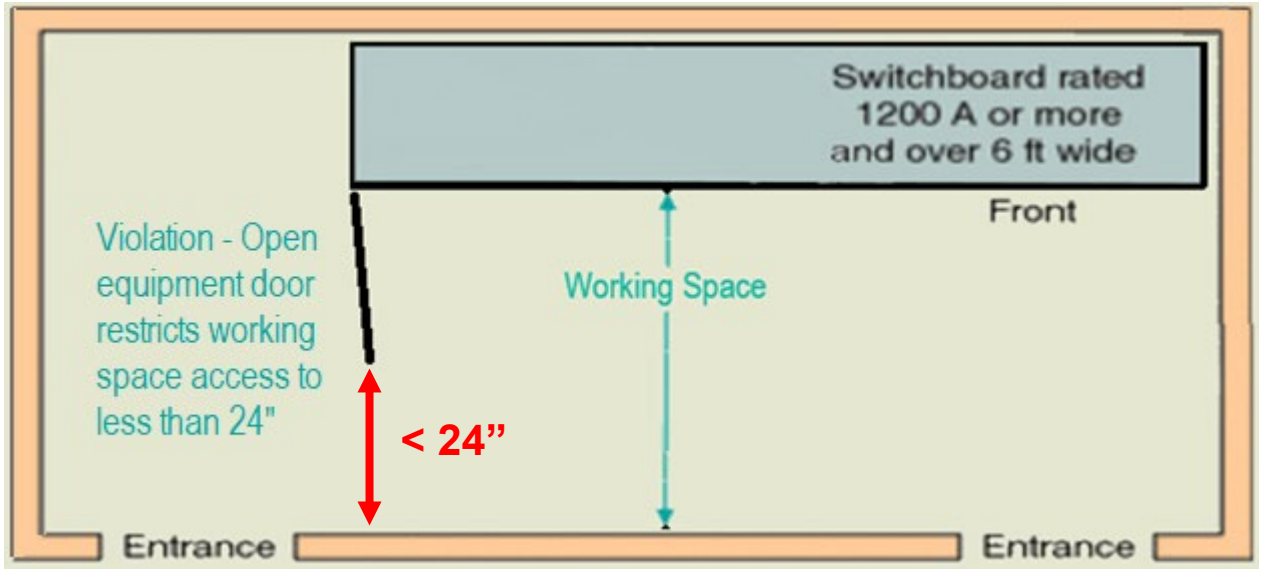
Added in 2020 Code



Not Clear what this means?

ARTICLE 110.26 Spaces About Electrical Equipment

2023 Code



Note: The intent should be clear, protect personnel servicing the equipment.

110.26 Spaces About Electrical Equipment.

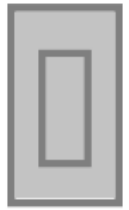
Working space, and access to and egress from working space, shall be provided and maintained about all electrical equipment to permit ready and safe operation and maintenance of such equipment. Open equipment doors shall not impede access to and egress from the working space. Access or egress is impeded if one or more simultaneously opened equipment doors restrict working space access to be less than 610 mm (24 in.) wide and 2.0 m ($6\frac{1}{2}$ ft) high.

For Informational Purposes Only

N 110.26(A)(6) Working Spaces



Raised sump pump covers in the working space would not be level





(A)(6) Grade level, Floor, or Working Platform

The grade, floor, or platform in the required working space shall be kept clear, and the floor, grade, or platform in the working space shall be as level and flat as practicable for the entire required depth and width of the working space.

Generally: 3’ in front of equipment & width of equipment

Not Current Code In Ohio For Informational Purposes Only

Article 210.8
GFCI

For Informational Purposes Only

Article 100 - Definitions

Receptacle

A contact device installed at the outlet for the connection of an attachment plug or for direct connection of electrical utilization equipment designed to mate with the corresponding contact device. A single receptacle is a single contact device with no other contact device on the same yoke ***or strap***. A multiple receptacle is two or more contact devices on the same yoke ***or strap.*** (CMP-18)

210.8(A), (B), & (E)

Outlet

A point on the wiring system at which current is taken to supply utilization equipment. (CMP-1)

210.8(C) Crawl Space Ltg. Outlets

210.8(D) Specific Appliances

210.8(F) Outdoor Outlets

For Informational Purposes Only

Article 210.8 GFCI Protection Evolution



Type “A” Personnel Protection Trip Level = 4 – 6mA
(Typical design is receptacle or breaker)

Type “B” Equipment Protection Trip Level = 30mA (rooftop de-icing equipment protection)

Type “C” SPGFCI (over 150v to ground) 480v 3ø or Less / Trip Level = 20mA

Type “D” SPGFCI (over 150v to ground) 600v 3ø Trip Level – 20mA

Type “E” “EGFPD” 6mA or adjustable from 10 – 100mA

Docking Facilities “GFPE” 100mA

Shore Power “GFPE” protection 30mA

For Informational Purposes Only

Article 210.8 GFCI Dwelling Units

210.8(A) GFCI (Dwelling Units)
GFCI protection is required for all 125 through 250V, 1 phase receptacles (all amperages).

Exemption in the Ohio Building Residential Code for Dishwashers and Sump Pumps

(1) Bathrooms
(2) Garages and accessory buildings (storage)
(3) Outdoors
(4) Crawl Spaces – at or below grade
(5) Basements (Finished and Unfinished)

(6) Kitchens (Removed only where installed to serve countertop surfaces – now implies all kitchen receptacles.)

(7) Areas with sinks and permanent provisions for food preparation, beverage preparation, or cooking

(8) Sinks - within 6 feet of the top inside edge of the bowl
(8) Boathouses
(9) Bathtubs and Shower Stalls
(10) Laundry areas (everywhere in the room (even the ceiling)
(11) Indoor damp and wet locations (patios / mud rooms, etc.)

For Informational Purposes Only

Article 210.8 GFCI Dwelling Units



210.8(A) GFCI (Dwelling Units)

(7) Areas with sinks and permanent provisions for food preparation, beverage preparation, or cooking

For Informational Purposes Only

210.8(A) GFCI Exceptions (Dwellings)

Exceptions 1 - 4

Receptacles, not readily accessible, dedicated circuit for electric snow-melting or pipeline and vessel heating.

Receptacle supplying only permanently installed premises security system.

Listed weight-supporting ceiling receptacles in combination with compatible weight-supporting fittings.

Factory mounted receptacles in bathroom exhaust fans (re: installation instructions & listing & labeling)

Not Current Code In Ohio
For Informational Purposes Only

Article 210.8 GFCI

Article 422.5 applies to:

- Dishwashers
- Drinking fountains / Bottle Fill Stations
- Sump pumps
- Vending Machines
- Pool motors

210.8(B) GFCI (Non-Dwellings)

GFCI protection is required for all 125 through 250V, single-phase receptacles up to 50 amps and three-phase receptacles up to 100 amps.

- Bathrooms
- Kitchens
- Areas with a sink and permanent provisions for either food preparation or cooking
- Rooftops
- Outdoors
- Sinks - within 6 feet of the inside edge of the bowl
- Indoor damp and wet locations – (basements, barns)
- Locker Rooms with showering facilities
- Garages, accessory buildings, service bays and similar
- Laundry Areas

Article 210.8 GFCI

Commercial Areas with a sink and permanent provisions for food preparation, beverage preparation, or cooking





For Informational Purposes Only

Article 210.8 GFCI



210.8(B) GFCI (Non-Dwellings)

GFCI protection is required for all 125 through 250V , single-phase receptacles up to 50 amps and three-phase receptacles up to 100 amps.

Changes include:

- Kitchens or areas with a sink and permanent provisions for food preparation, beverage preparation, or cooking
- Buffet serving areas
- Aquariums, bait wells and similar open aquatic vessels or containers such as tanks or bowls where the receptacle is installed within 6’ from the top inside edge or rim.

For Informational Purposes Only

Δ 210.8(B) Other than Dwelling Units

GFCI Protection for Personnel

All 125-v through 250-v receptacles installed in the following locations and supplied by 1ø branch circuits rated 50a or less, and 3ø branch circuits rated 100a or less,150-v or less to ground, shall have ground-fault circuit-interrupter for personnel:

(3) Areas with sinks and permanent provisions for food preparation, beverage preparation, or cooking.

(4) Buffet serving areas with permanent provisions for food serving, beverage serving, or cooking.

For Informational Purposes Only
For Informational Purposes Only

Δ 210.8(B) Other than Dwelling Units

GFCI Protection for Personnel

(7) Sinks where receptacles or cord and-plug-connected fixed or stationary appliances are installed within 6’ from the top inside edge of the bowl of the sink.

N (13) Aquariums, bait wells, and similar open aquatic vessels or containers, such as tanks or bowls, where receptacles are installed within 6’ from the top inside edge or rim or from the conductive support framing of the vessel or container.

Not Current Code In Ohio For Informational Purposes Only

GFCI protection shall be provided for the branch circuit or outlet supplying the following appliances, 150-v or less to ground 60a or less; 1ø or 3ø

Automotive vacuum cleaners

Drinking water coolers / bottle fill stations

High-pressure spray washing

Tire Inflation machines

Vending machines

Sump pumps

7. Dishwashers machines
8. ***Electric ranges***
9. ***Wall-mounted ovens***
10. ***Counter-mounted cooking units***
11. Clothes dryers
12. ***Microwave ovens***

For Informational Purposes Only

For Informational Purposes Only

210.8(F) Outdoor Outlets

For dwellings, all outdoor outlets, other than those covered on 210.8(A), Ex.1, including outlets specified in the following locations, and supplied to 1ø branch circuits rated 150-v or less to ground, 50a or less shall be provided with GFCI protected.

1. Garages that have floors located at or below grade level.
2. Accessory buildings
3. Boathouses

Applies to replacing outlet(s) covered by this section!

(Also: 680.22(A)(4) Swimming Pool Outlets)

2020 / NEC 2023 NEC / BBS 10.20.2022 RCAC

State of Ohio (would apply to 1, 2, & 3-family dwellings

Proposed Amendment



Re: 210.8(F) Outdoor Outlets (Dwelling Units)

***N* Exception #2:** GFCI protection shall not be required for listed HVAC equipment. This exception shall expire September 1, 2026

For Informational Purposes Only

Article 210.11(C)(4)
Garage Branch Circuits

For Informational Purposes Only

Δ 210.11(C)(4) Garage Branch Circuits

In addition to the number of branch circuits by other parts of this section, at least one 120-v, 20a branch circuit shall be installed to supply receptacle outlets, for attached and detached garages with electric power. This circuit shall have no other outlets.

New 2nd Paragraph:

Additional branch circuits rated 15a or greater shall be permitted to serve receptacle outlets other than those required by 210.52(G)(1).

Not Current Code In Ohio
For Informational Purposes Only

Article 210.12(B)
AFCI Protection for Dwelling Units

For Informational Purposes Only

N 210.12(B) AFCI Protection for Dwelling Units

No Change here; just listed separately:

(1) Kitchens
(2) Family rooms
(3) Dining rooms
(4) Living rooms
(5) Parlors
(6) Libraries
(7) Dens
(8) Bedrooms
(9) Sunrooms
(10) Recreation rooms
(11) Closets
(12) Hallways
(13) Laundry areas
(14) Similar areas

For Informational Purposes Only
For Informational Purposes Only

210.12(C) AFCI Protection for Dormitory Units

No change from 2020: All 125-v, 1ø 10, 15- and 20-ampere branch circuits supplying outlets or devices installed in the following locations shall be protected by any of the means described in 210.12 (A)(1) - (A)(6).

(1) Bedrooms
(2) Living rooms
(3) Hallways
(4) Closets
(5) Bathrooms
(6) Similar rooms

Not Current Code In Ohio
For Informational Purposes Only

210.12 (D) AFCI Protection; Other Occupancies

Other Occupancies. All 125-v 1ø, 10, 15- and 20-ampere branch circuits, supplying outlets or devices installed in the following locations shall be protected by any of the means described in 210.12(A)(1) - (A)(6).

Guest rooms & guest suites of hotel & motels.

Areas used exclusively as patient sleeping rooms in nursing homes & limited-care facilities.

Areas designed for use exclusively as sleeping quarters in fire, police, ambulance, rescue, ranger stations, & similar locations.

For Informational Purposes Only
For Informational Purposes Only

N 210.23(A) 10-Ampere Branch Circuits

10-ampere Branch Circuits

210.23(A) A 10-ampere branch circuit shall comply with the requirements of 210.25(A)(1) and (A)(2).

210.23(A)(1) Loads permitted for 10-ampere Branch Circuits.

1. Lighting Outlets
2. Dwelling unit exhaust fans or bathroom or laundry room lighting circuits
3. Gas fireplace unit supplied by an individual branch circuit

N Article 210.23(2) Loads not Permitted for 10-Ampere Branch Circuits

A 10-ampere branch circuit shall

not supply any of the following:

Receptacle outlets

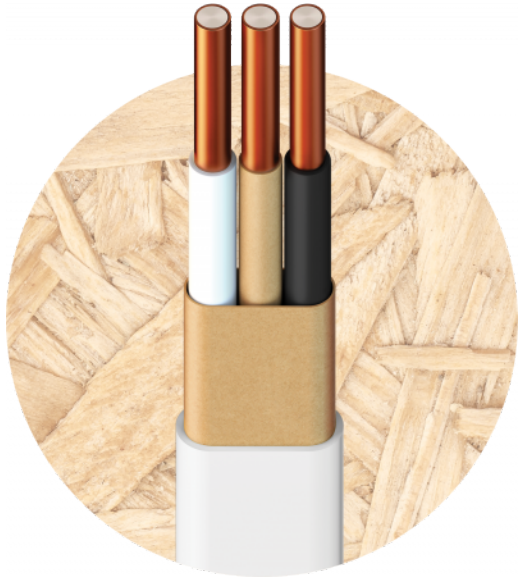
Fixed appliances, except as permitted for individual branch circuits.

Garage door openers

Laundry equipment

For Informational Purposes Only
For Informational Purposes Only

Article 210.24 Branch Circuit Requirements; Summary



***N* 210.24 Branch Circuit** - Expanded this section and tables from applying to Copper conductors only, to include Aluminum and Copper-Clad Aluminum conductors

Table 210.24(1) - Applies to Copper Conductors

***N* Table 210.24(2)** - Applies to both Aluminum & Copper-Clad Conductors

Article 210.52(C)(3)
Receptacle Outlet Location

For Informational Purposes Only

Δ 210.52(C)(2) Island & Peninsular Countertops & Work Surfaces

Receptacle outlets, if installed to serve an island or peninsular countertop or work surface, shall be installed in accordance with 210.52(C)(3). If a receptacle is not provided to serve an island or peninsular countertop or work surface, provisions shall be provided at the island or peninsular or work surface, provisions shall be provided at the island or peninsula for future addition of a receptacle outlet to serve the island or peninsular countertop or work surface.

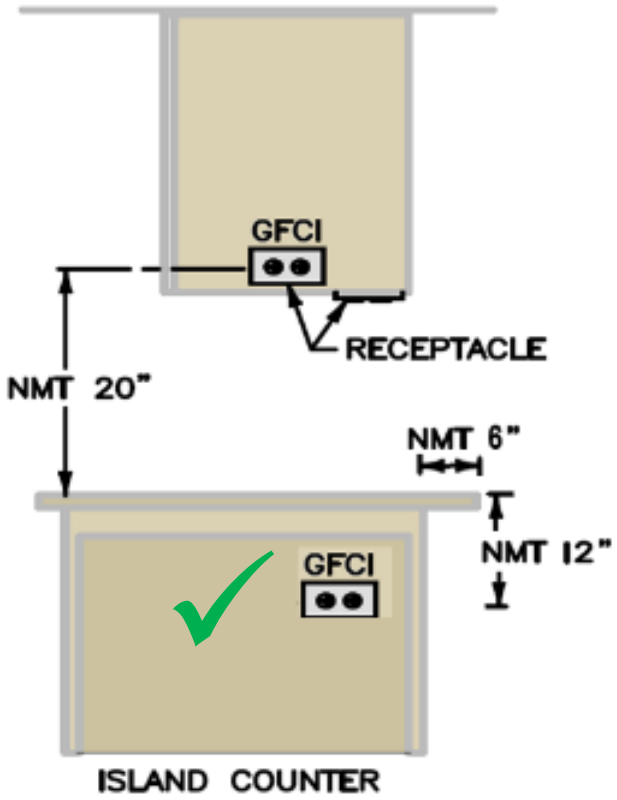
What a Relief!!!

For Informational Purposes Only
For Informational Purposes Only

210.52(C)(3) Receptacle Outlet Location

ELECTRICAL LEAGUE of Ohio

2017 / 2020 NEC



210.52(C)(3) Receptacle Outlet Location.

Receptacle outlets shall be located in one or more of the following:

(1) On or above countertop or work surfaces: On or above, but not more than 500 mm (20 in.) above, the countertop or work surface.

(2) In countertop or work surfaces: Receptacle outlet assemblies listed for use in countertops or work surfaces shall be permitted to be installed in countertops or work surfaces.

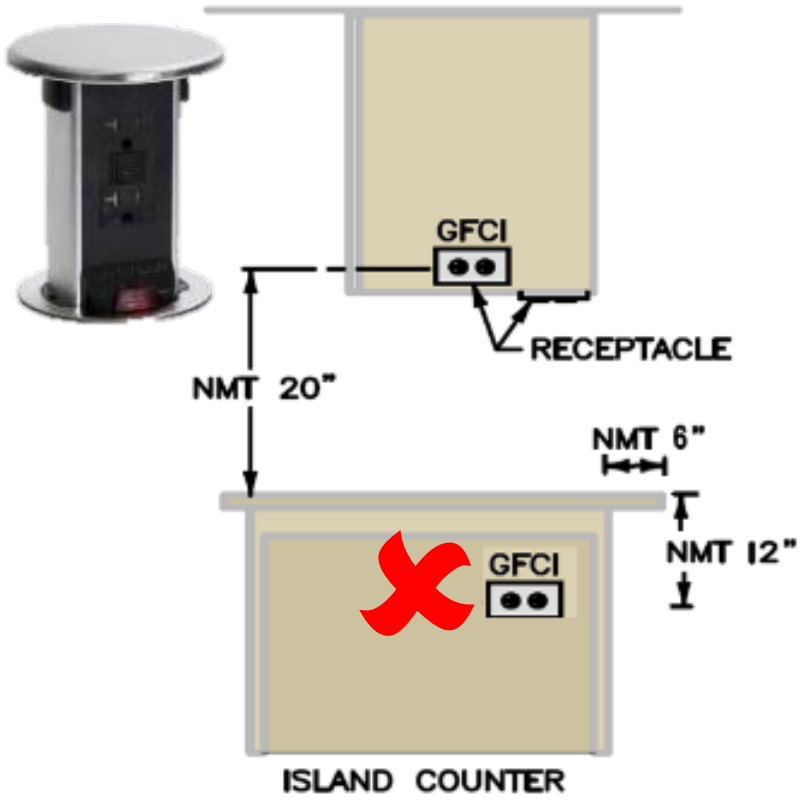
(3) Below countertop or work surface: Not more than 300 mm (12 in.) below the countertop or work surface. Receptacles installed below a countertop or work surface shall not be located where the countertop or work surface extends more than 150 mm (6 in.) beyond its support base.

For Informational Purposes Only

210.52(C)(3) Receptacle Outlet Location

ELECTRICAL LEAGUE of Ohio

2023 NEC



210.52(C)(3) Receptacle Outlet Location.

Receptacle outlets shall be located in one or more of the following:

(1) On or above, but not more than 500 mm (20 in.) above, a countertop or work surface

(2) In a countertop using receptacle outlet assemblies listed for use in countertops

(3) In a work surface using receptacle outlet assemblies listed for use in work surfaces or listed for use in countertops

Receptacle outlets rendered not readily accessible by appliances fastened in place, appliance garages, sinks, or rangetops as covered in 210.52(C)(1), Exception No. 1, or appliances occupying assigned spaces shall not be considered as these required outlets.

For Informational Purposes Only

Article 210.70(A)(1)
Habitable Rooms; Lighting Outlets

For Informational Purposes Only

Δ 210.70(A)(1) Habitable Rooms; Lighting Outlets

Habitable Rooms; Kitchens, Laundry Areas & Bathrooms

At least one lighting outlet controlled by a listed mounted control device shall be installed in every habitable room, kitchen, laundry areas, and bathrooms. The wall-mounted control device shall be located near an entrance to the room on a wall.

Added laundry area to this section. Would Article 314.27(C) require a ceiling suspended (Paddle) fan box?

Not Current Code In Ohio
For Informational Purposes Only

Article 215.15
Feeders (Barriers)

For Informational Purposes Only

N 215.15 Feeders (Barriers)

Barriers. Barriers shall be placed such that no energized, uninsulated, ungrounded busbar or terminal is exposed…….

N 215.15 Feeders

230.62 Services (2020 NEC)

N 240.21 Transformer Secondaries





For Informational Purposes Only
For Informational Purposes Only

Article 225
Outside Branch Circuits & Feeders

For Informational Purposes Only

Article 225 Outside Branch Circuits & Feeders
Part II. Building or Other Structures Supplied by a Feeder(s) or Branch Circuit(s)
Article 230 Services – Part IV. SE Conductors

N Sections 225.41 & 225.42 / 230.67 & 230.85

1 & 2-Family Dwelling Emergency Disconnects:

General / Location / Rating / Marking N 225.41 / 230.85

Surge Protection: Device / Location / Type / Replacement / Minimum 10kA Ratings

N 225.42 / 230.67

Not Current Code In Ohio For Informational Purposes Only

Article 230.67
Surge Protection

For Informational Purposes Only

Δ Article 230.67 Surge Protection





230.67 Surge Protection.

230.67(A) Surge-Protective Device.

All services supplying the following occupancies shall be provided with a surge-protective device (SPD):

(1) Dwelling units

(2) Dormitory units

(3) Guest rooms and guest suites of hotels and motels

(4) Areas of nursing homes and limited-care facilities used exclusively as patient sleeping rooms

Informational Note: See 517.10(B)(2)

Added dwelling units in 2020 and expanded in 2023

Article 230 Services

242.9 Indicating. There is also a new requirement that surge protective devices (SPDs) provide an indication that they are functioning properly.

2023 NEC added a rating

230.67 Surge Protection.

230.67(E) Ratings.

SPDs shall have a nominal discharge current rating (In) of not less than 10kA.





Δ 230.67 Expanded Surge Protection

Expanded Surge Protection Requirements

230.67(A) Surge Protective Device.

Dwelling units

Dormitory units

Guest rooms & guest suites of Hotels & Motels

Areas of nursing homes & limited-care facilities used exclusively as patient sleeping rooms

For Informational Purposes Only
For Informational Purposes Only

Article 230.71

Maximum Number of Service Disconnects

Δ 230.71 Maximum Number of Service Disconnects

Two to Six Service Disconnecting Means

Separate enclosures, each with a main SE disconnect.

Panelboards with a main SE disconnect.

Vertical switchboard sections that have separate SE disc.

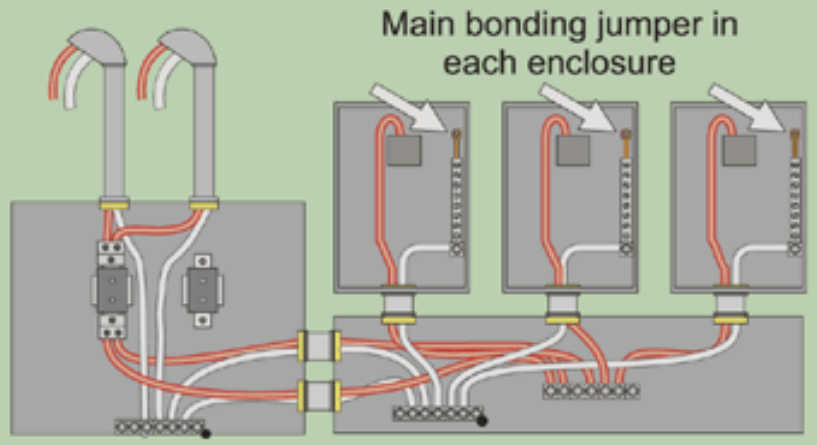
SE disconnect in switchgear, transfer switches, or meter mods where each disconnect is located in a separate compartment.

N 5. Meter mods with a main SE disconnect in each metering center.

N 6. MCC's with 1 SE disconnect or a max of 2 SE disconnects with barriers provided between each MCC unit or compartment.

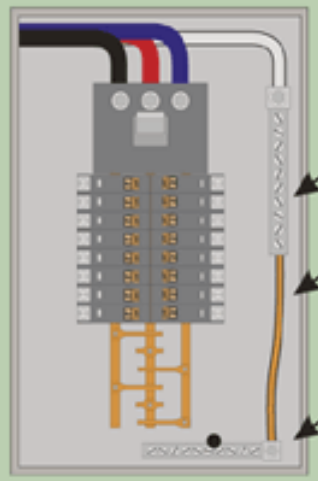
Not Current Code in Ohio For Informational Purposes Only

Main Bonding Jumper - Multiple Enclosures

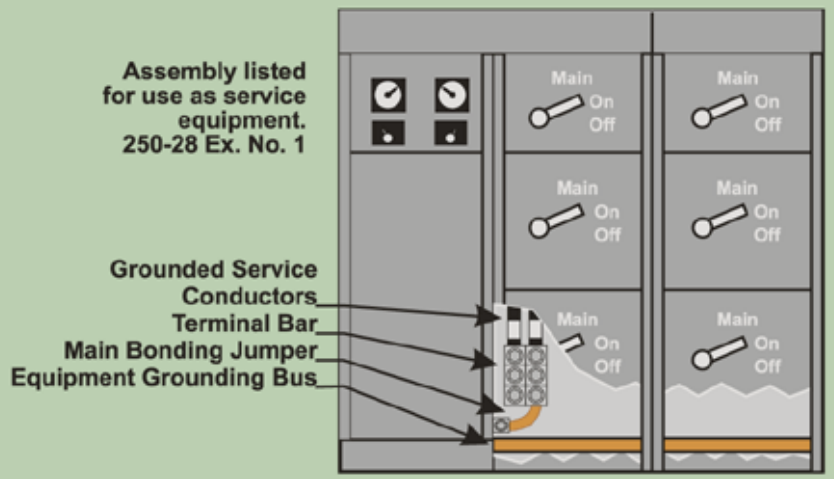


(All conductors not shown)

Main Bonding Jumper



Main Bonding Jumper for Listed Assembly





nformational Purposes Only

N 230.71(B)(5) & (6) 6 Handle Rule





For Informational Purposes Only

For Informational Purposes Only

Article 230.85(A)
Emergency Disconnects; General

For Informational Purposes Only

230.85(A) Emergency Disconnects; General

For 1 & 2-family dwelling units, an emergency disconnecting means shall be installed.

N (1) Location. The disconnecting means shall be installed in a readily accessible location on or within sight of the dwelling unit.

N (2) Rating. The disconnecting means shall have a short-circuit current rating equal to or greater than the available fault current.

N (3) Grouping. If more than 1 disconnecting means is provided, they shall be grouped.

For Informational Purposes Only
For Informational Purposes Only

230.85(B) Emergency; Disconnects

N (B) Disconnects. Each disconnect shall be one of the following:

1. Service Disconnect
2. A meter disconnect integral to the meter mounting equipment not marked as suitable only as SUSE equipment, installed in accordance with 230.82
3. Other listed disconnect switch or circuit marked as that is marked SUSE, but not marked as suitable only as SUSE, installed on the supply side of each service disc.

Not Current Code in Ohio For Informational Purposes Only

N 230.85(C) Emergency Disconnects

N Replacements. Where service equipment is replaced, all of the requirements of this section shall apply.

N Exception: Where only meter sockets, or related raceways and fittings are replaced, the requirements of this section shall not apply.

For Informational Purposes Only
For Informational Purposes Only

N 230.85(D) Emergency Disconnects

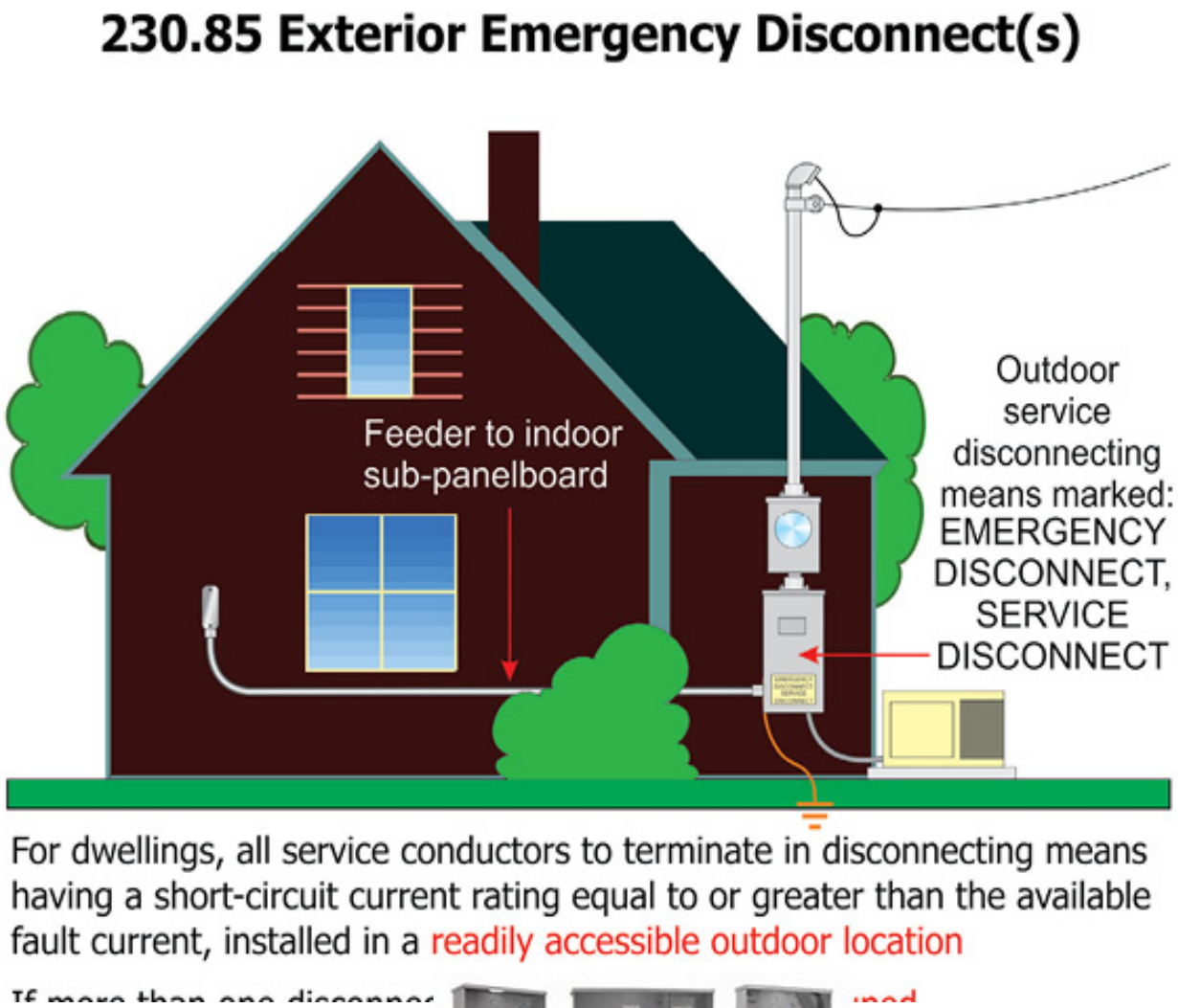
N Identification of Other Isolation Disconnects.

Where equipment for isolation of other energy source systems is not located adjacent to the emergency disconnect required by this section, a plaque or directory identifying the location of all equipment for isolation of other energy sources shall be located adjacent to the disconnecting means required by this section.

RE: Battery, Generator, Interconnected Power Production Sources, and Energy Storage Systems

Not Current Code in Ohio
For Informational Purposes Only

230.85 Exterior Emergency “SE” Disconnect





Applies to 1- and 2-Family Dwelling Units

All service conductors to terminate in a SUSE rated disconnecting means, with adequate SCCR, in a readily accessible outdoor location. Grouping is required.

Intent to protect firefighters / other emergency personnel.

For Informational Purposes Only

Can a smart meter act as an emergency disconnect

Until recently I was a proponent of t
with technology. Due to more cons

1. Commercial power supply
2. Interconnected Power Productio
(a) On-site Generator
(b) Photovoltaic System
(c) Wind Energy System
(d) Battery System
(e) Fuel Cell System
(f) Energy Storage System

Posting permanent plaque of sourc



For Informational Purposes Only

N 230.85 (E)(1) Emergency Disconnects

Marking Text

Service Disconnect
EMERGENCY DISCONNECT, SERVICE DISCONNECT

Meter Disconnects installed in accordance with 230.82(3) as follows: EMERGENCY DISCONNECT, METER DISCONNECT, NOT SERVICE EQUIPMENT

Other listed disconnect switches or circuit breakers on the supply side of each service disconnect that are marked suitable for use as SE and marked as follows:

EMERGENCY DISCONNECT NOT SERVICE EQUIPMENT

For Informational Purposes Only
For Informational Purposes Only

N 230.85(E)(2) Emergency Disconnects

Marking Location & Size

Markings shall comply with 110.21(B) & both of the following:

(1) The marking or labels shall be located on the outside front of the disconnect enclosure with RED background and WHITE text.

(2) The letters shall be at least (½”) high.

Not Current Code in Ohio For Informational Purposes Only

Article 235

Branch, Feeder, & Service Circuits over 1000v ac.

For Informational Purposes Only

N Article 235 – Branch, Feeder, & Service Circuits over 1000v ac.

235.1 Scope. This article the general requirements for branch circuits, feeders and services over 1000v ac or 1000v dc, nominal.

235.5(C)(1)(a) Means of identification. Separate color coding, marking, tape, tagging or other approved means

235(C)(1)(b) Posting of identification means. Documented in a readily accessible manner at each panelboard.

Existing installations. Required to mark only new system voltage being added.

Not Current Code In Ohio For Informational Purposes Only

N Article 235 – Branch, Feeder, & Service Circuits over 1500v dc

235.5(C)(2) Branch Circuits Supplied from DC Systems.

Each ungrounded conductor #4 and larger shall be identified by polarity at all termination, connection and splice points by marking tape, tagging or tape or other approved means and each #6 and smaller ungrounded conductor shall be identified by polarity at all termination points.

The identified methods used for conductors shall be documented at all panelboard locations in a manner readily available or be permanently posted at each panelboard location.

Not Current Code In Ohio For Informational Purposes Only

DC Conductor Identification (Positive)

235.3(C)(2)(a) Positive Polarity (DC) Sizes #6 and smaller.

Where the positive polarity of a dc system does not serve as the connection point for the grounded conductor, each positive conductor shall be identified by one of the following means:

(1) A continuous red outer finish

(2) Continuous red stripe along the entire length or (color other than green, white, gray or black)

(3) Imprinted minus signs(+) or the word positive or POS identified not more than 24” along its’ entire length

(4) Approved sleeving or shrink tubing at all terminations

For Informational Purposes Only
For Informational Purposes Only

DC Conductor Identification (Negative)

235.3(C)(2)(b) Negative Polarity (DC) Sizes #6 and smaller.

Where the negative polarity of a dc system does not serve as the connection point for the grounded conductor, each positive conductor shall be identified by one of the following means:

(1) A continuous black outer finish

(2) Continuous black stripe along the entire length or (color other than green, white, gray or red)

(3) Imprinted minus signs(-) or the word negative or NEG identified not more than 24” along its entire length

(4) Approved sleeving or shrink tubing at all terminations

Not Current Code In Ohio
For Informational Purposes Only

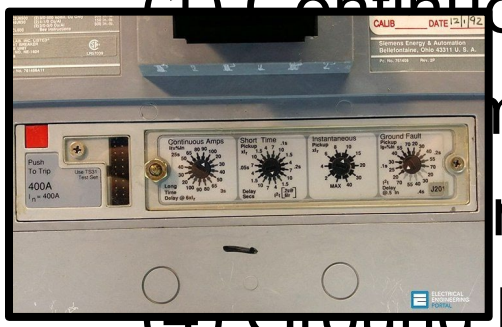
Article 240.4(B)
OCD Rated 800A or Less

For Informational Purposes Only

240.4(B) OCD Rated 800a or Less

New 2nd Paragraph

If the overcurrent protective device is an adjustable trip device installed in accordance with 240.4(B)(1),(2), & (3) it shall be permitted to be set to a value that does not exceed the next higher standard value above the ampacity of the conductors being protected as shown in 240.6(A) where restricted access is accordance with 240.6(C) is provided.



(1) Continuous Amps

me Pickup

neous Pickup

(4) Ground Fault Pickup



For Informational Purposes Only

For Informational Purposes Only

Article 245

Overcurrent Protection for Systems rated over 1kV ac & 1.5kV dc

For Informational Purposes Only

N Article 245 – Overcurrent Protection for Systems rated over 1kV ac & 1.5kV dc

New Medium Voltage Conductor Article

245.1 Scope. This article covers overcurrent protection requirements for systems rated over 1kV ac 1.5kv dc, nominal.

245.21 Circuit Breaker & Fuse protection

245.26 Feeders & Branch Circuits

Not Current Code In Ohio For Informational Purposes Only

Article 250
Grounding Triangle / Foundation

For Informational Purposes Only

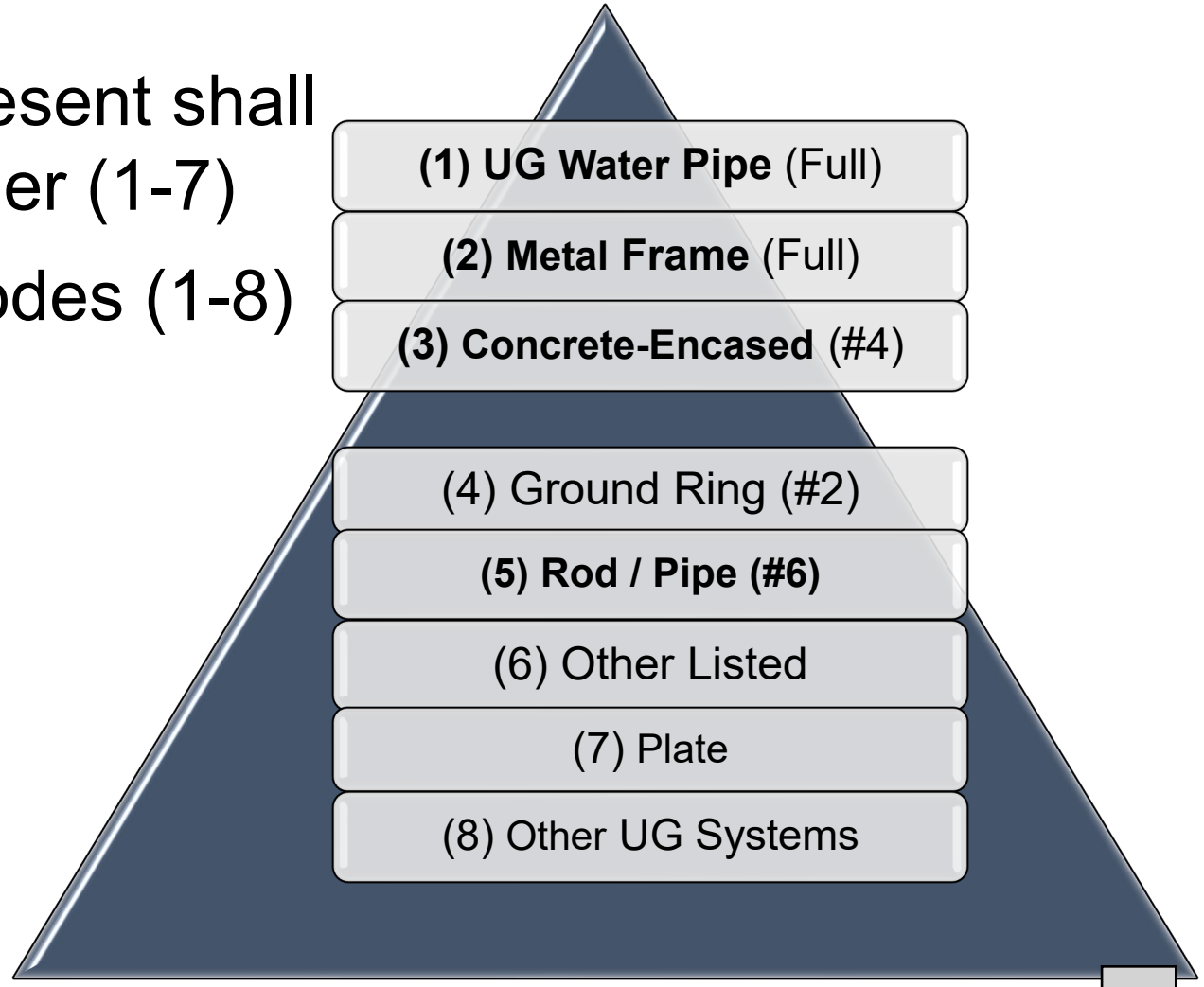
Grounding Triangle / Foundation

250.50 All Electrodes present shall be bonded together (1-7)

250.52 Permitted Electrodes (1-8)

Focus:

1. Metal UG Water Pipe
2. Building Steel
3. Concrete-Encased
4. Rod / Pipe



For Informational Purposes Only

Article 250.140
Frames of Ranges & Dryers

For Informational Purposes Only

Δ 250.140 Frames of Ranges & Dryers

N (B) Grounded Conductor Connections

Since 1996 the NEC has required 4-wire branch circuits for new installations of Electric Ranges & Dryers

Existing Installations: Expanded Use of 3-wire “SE” Cable

Prior editions of the NEC only permitted 3-wire SE cable that originated in SE equipment.

This change now permits in “existing installations”, that the bare SE grounded conductor may be insulated or field covered (taped) in locations other than SE equipment.

For Informational Purposes Only
For Informational Purposes Only

Break to Vendor Tables

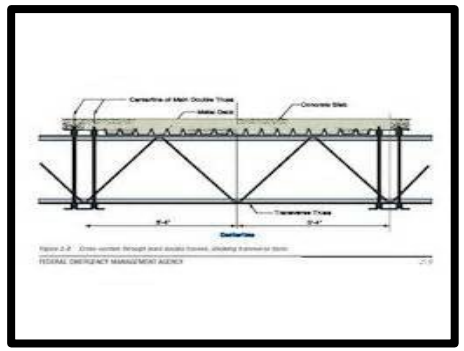
For Informational Purposes Only

Article 300

General Requirements for Wiring Methods & Materials

For Informational Purposes Only

Article 300 General Requirements for Wiring Methods & Materials



300.4(E) Cables, raceways or boxes installed under metal roof corrugated decking.

N Exception #2

The 1½” spacing is not required where metal-corrugated sheet roof decking is covered with a minimum 2” concrete slab, measured from the top of the corrugated roofing

Re: N 410.10(F) Exception

Article 300.14
Length of Free Conductors

For Informational Purposes Only

Δ 300.14 Length of Free Conductors

At Outlets, Junctions, and Switch Points

At least 6” of free conductor, measured from the point in the box, where it emerges from its raceway or cable sheath, shall be left at each outlet, junction, and switch point for splices or the connection of luminaires or devices. The 6” free conductor shall be permitted to be spliced or unspliced. Where an openin cti int is less than 8” in an n c e long enough to extend e t





Article 300.25
Exit Enclosures (Stair Towers)

For Informational Purposes Only

Δ 300.25 Exit Enclosures (Stair Towers)

Where an exit enclosure is required to have fire resistance rating, only electrical wiring methods serving equipment permitted by the authority having jurisdiction in the exit enclosure shall be installed within the exit enclosure.

N Exception. Where egress lighting on the outside exterior doorways from the exit enclosure, luminaires shall be permitted to be supplied from the inside of the exit enclosure.



"Self-closing doors are indicative of a fire rating"

Not Current Code In Ohio For Informational Purposes Only

Article 305

General Requirements for Wiring Methods & Materials for Systems rated over 1kV ac & 1.5 kV dc

For Informational Purposes Only

N Article 305 – General Requirements for Wiring Methods & Materials for Systems rated over 1kV ac & 1.5 kV dc

New Medium Voltage Conductor Article

305.1 Scope. This article covers wiring methods and materials for systems rated over 1kV ac, 1.5kV dc.

305.3 Exposed runs of MV cables, bare conductors, & bare busbars shall be permitted in locations accessible only to qualified persons. Busbars shall be permitted to be either CU or AL.

Not Current Code In Ohio
For Informational Purposes Only

Article 310
Conductors for General Wiring
Aluminum AA-8000 Series Alloy

For Informational Purposes Only

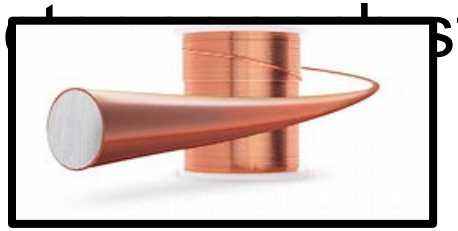
Article 310 Conductors for General Wiring

Δ 310.3(B) Conductor Material

Conductors in this article shall be of, aluminum (AA-8000), copper or copper-clad aluminum unless otherwise specified.

Aluminum and copper-clad aluminum shall comply with the following: material shall be (listed).

For copper-clad aluminum conductors the copper shall form a minimum of 10% of the cross-sectional area of a solid conductor or strand of a stranded conductor





For Informational Purposes Only

For Informational Purposes Only

ELECTRICAL LEAGUE of Ohio

Table 310.16 Ampacities of Insulated Conductors with Not More Than Three Current-Carrying Conductors in Raceway, Cable, or Earth (Directly Buried)

Size AWG or kcmil	Temperature Rating of Conductor [See Table 310.4(A)]						Size AWG or kcmil
	60°C (140°F)	75°C (167°F)	90°C (194°F)	60°C (140°F)	75°C (167°F)	90°C (194°F)	
	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, XHWN, USE, ZW	Types TBS, SA, SIS, FEP, FEPB, MI, PFA, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN, Z, ZW-2	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, XHWN, USE	Types TBS, SA, SIS, THHN, THHW, THW-2, THWN-2, RHH, RHW-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN	
	COPPER			ALUMINUM OR COPPER-CLAD ALUMINUM			
18*	—	—	14	—	—	—	—
16*	—	—	18	—	—	—	—
14*	15	20	25	—	—	—	—
12*	20	25	30	15	20	25	12*
10*	30	35	40	25	30	35	10*
8	40	50	55	35	40	45	8
6	55	65	75	40	50	55	6
4	70	85	95	55	65	75	4
3	85	100	115	65	75	85	3
2	95	115	130	75	90	100	2
1	110	130	145	85	100	115	1
1/0	125	150	170	100	120	135	1/0
2/0	145	175	195	115	135	150	2/0
3/0	165	200	225	130	155	175	3/0
4/0	195	230	260	150	180	205	4/0
250	215	255	290	170	205	230	250
300	240	285	320	195	230	260	300
350	260	310	350	210	250	280	350
400	280	335	380	225	270	305	400
500	320	380	430	260	310	350	500
600	350	420	475	285	340	385	600
700	385	460	520	315	375	425	700
750	400	475	535	320	385	435	750
800	410	490	555	330	395	445	800
900	435	520	585	355	425	480	900
1000	455	545	615	375	445	500	1000
1250	495	590	665	405	485	545	1250
1500	525	625	705	435	520	585	1500
1750	545	650	735	455	545	615	1750
2000	555	665	750	470	560	630	2000

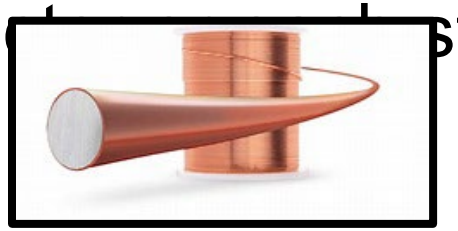
Article 310 Conductors for General Wiring

Δ 310.3(B) Conductor Material

Conductors in this article shall be of, aluminum (AA-8000), copper or copper-clad aluminum unless otherwise specified.

Aluminum and copper-clad aluminum shall comply with the following: material shall be (listed).

For copper-clad aluminum conductors the copper shall form a minimum of 10% of the cross-sectional area of a solid conductor or strand of a stranded conductor





For Informational Purposes Only

For Informational Purposes Only

Deleted Article 311
Medium Voltage Conductors & Cables

For Informational Purposes Only

“Deleted” Article 311 Medium Voltage Conductors & Cables

This Article was New in the 2020 NEC

Previous editions of NEC were Articles 310 & 328

Replaced / Broken down into (3) NEW Articles

N Article 235- Branch Circuits over 1kV
N Article 245- OCP for circuits over 1kV
N Article 495- Equipment over 1kV

Article 314.24(C)
Clearances for Side-Wiring Entrances

For Informational Purposes Only

N 314.24 (C) Clearances for Side-Wiring Entrances

Where devices or equipment are mounted in boxes having side-wiring entries, the conductors entering from the side shall be protected as covered in (1) & (2), as follows. The term side applies any wall of a box other than the one opposite to the opening.

1. The rearward projection of the device or equipment shall not extend beyond the centerline of the wiring knockout or other entry.

2. The clearance from the box wall to the installed device or equipment shall not be less than ½”.

For informational purposes only
For Informational Purposes Only

Article 314.27

Ceiling fan boxes and Weight Supporting Ceiling Receptacles

For Informational Purposes Only

Δ 314.27 Ceiling Boxes for Paddle Fans

2nd Paragraph

Outlet boxes mounted in the ceilings of habitable rooms dwelling occupancies in a location acceptable for the installation of a ceiling-suspended (paddle) fan shall comply with one of the following:

1. Listed for the sole support of ceiling-suspended (paddle) fans.

N 2. Installed so as to allow direct access through the box, to structural framing capable of supporting a ceiling-suspended (paddle) fan without removing the box.

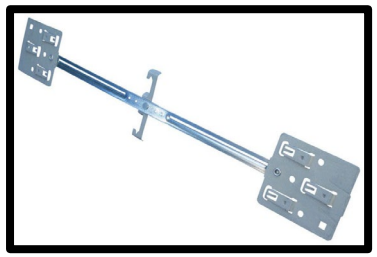
Not Current Code In Ohio For Informational Purposes Only

Δ 314.27(E) Weight Supporting Ceiling Receptacles (WSCR), & Weight-Supporting Attachment Fittings (WSAF)

NEW Terminology

Both listed WSCR & WSAF devices







For Informational Purposes Only
For Informational Purposes Only

New Article 314.27

Medium Voltage Conductors, Cable, Cable Joints & Terminations

For Informational Purposes Only

N Article 315 Medium Voltage Conductors, Cable, Cable Joints & Terminations

315.1 Scope. This article covers the use, installation, construction specs, and ampacities of MV medium voltage conductors, cable, cable joints, & cable terminations. This article includes voltage 2001v – 35kV ac & 2001 – 2500v dc.

315.6 Listing Requirements. Type MV cables, joints, terminations, connectors, & associated fittings shall be listed. The listing requirements for MV cable joints, terminations, & connectors shall be effective January 1, 2026.

Not Current Code In Ohio For Informational Purposes Only

N 315.50 Installation of MV Conductors

Part III.

A qualified person(s) with documented training and experience shall perform the installation and testing of Type MV cable. A qualified person(s) with documented training and experience in the installation of Type MV cable joints. A qualified person(s) with documented training and experience in the installation of Type MV cable terminations shall perform installation of Type MV cable terminations.

For Informational Purposes Only
For Informational Purposes Only

Article 335.1
Instrumentation Tray Cable (ITC)

For Informational Purposes Only

N Instrumentation Tray Cable (ITC)





335.1 Scope. This article covers the use, installation, and construction specifications of instrumentation tray cable (ITC) for application to instrumentation and control circuits operating at 150v or less and 5 amperes or less.

335.6 Construction. The insulated conductors of Type ITC cable #22 - #12 AWG Conductors shall be copper or thermocouple alloy.

Not Current Code In Ohio
For Informational Purposes Only

Article 369

Insulated Bus Pipe (IBP) / Tubular Covered Conductors (TCC) Systems)

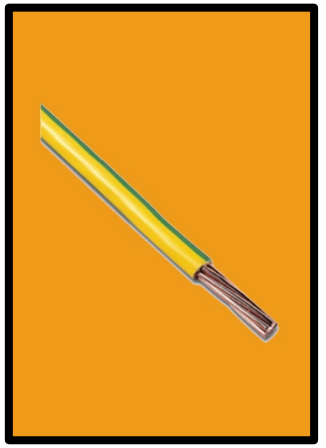
For Informational Purposes Only

N Article 369 Insulated Bus Pipe (IBP) / Tubular Covered Conductors (TCC) Systems

369.1 Scope. This article covers the use, installation, and construction specifications for insulated pipe (IBP) systems.







For Informational Purposes Only

For Informational Purposes Only

Article 371
Flexible Bus Systems

N Article 371 Flexible Bus Systems

371.1 Scope. This article covers the use and installation requirements of flexible bus systems and associated fittings.





Article 400
Flexible Cords & Cables

For Informational Purposes Only

Δ Article 400 Flexible Cords & Cables

N Part IV. Portable Power Feeder Cables over 2000v, Nominal

N 400.10 General. Part IV applies to single & multiconductor portable power feeder cables over 2000v nominal used to connect portable equipment & machinery.

Medium Voltage Cable Type “G”



For Informational Purposes Only
For Informational Purposes Only

Article 406.4(D)
Receptacle Replacements

For Informational Purposes Only

406.4(D) Receptacle Replacements

Replacements

Grounding Type Receptacles

Non-Grounding Type Receptacles

GFCI Replacements

AFCI Replacements – Where “AFCI” protection is required (2020)

Tamper-Resistant – Where “TR” protection is required (2011)

Weather-Resistant – Where “W/R” protection is required (2011)

Controlled Receptacles – Based on Situation (2020)

8. N GFPE of Protection of Equipment – Where “GFPE” protection is Required (2023)

Not Current Code In Ohio For Informational Purposes Only

406.4 Receptacle Replacements: Grounding (D)(1); Non-grounding (d)(2); GFCI (d)(3); and AFCI (D)(4);

Reference to 210.12 (A), (B) & (C) Required “AFCI” Locations

2020 NEC 406.4(D) Arc-Fault Circuit-Interrupter (AFCI); Replacement Types

Listed outlet branch-circuit AFCI type receptacle

Receptacle protected by listed outlet branch-circuit type AFCI receptacle

A receptacle protected by a listed combination type AFCI circuit breaker

210.12(D) Ex: Branch Circuit Extensions or Modifications – Dwelling Units, Dormitory Units, and Guest Rooms and Guest Suites locations only.

(1) 210.12 (A) Dwelling Units. (1-6)

(2) Listed outlet branch-circuit type AFCI at 1st outlet of existing circuit

For Informational Purposes Only

For Informational Purposes Only

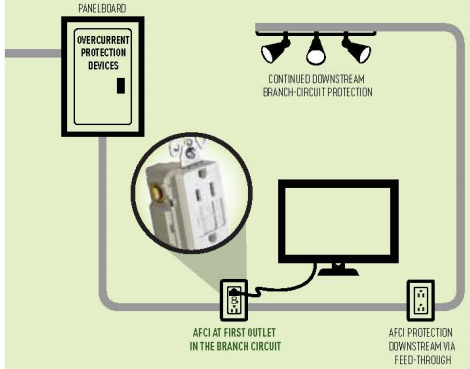
ELECTRICAL LEAGUE of Ohio



Methods for Meeting NEC® Requirements with AFCI and AFCI/GFCI Receptacles

BRANCH-CIRCUIT EXTENSIONS OR MODIFICATIONS

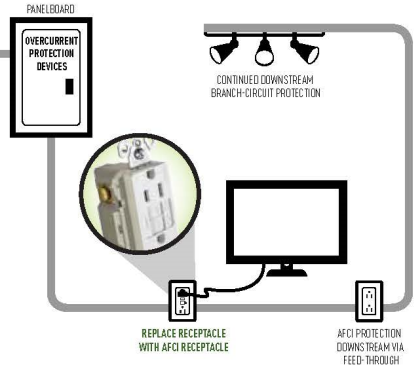
When branch-circuit wiring is modified, replaced or extended, it is permissible to meet the NEC requirement with a listed outlet branch-circuit AFCI receptacle located at the first receptacle outlet of the existing branch circuit.



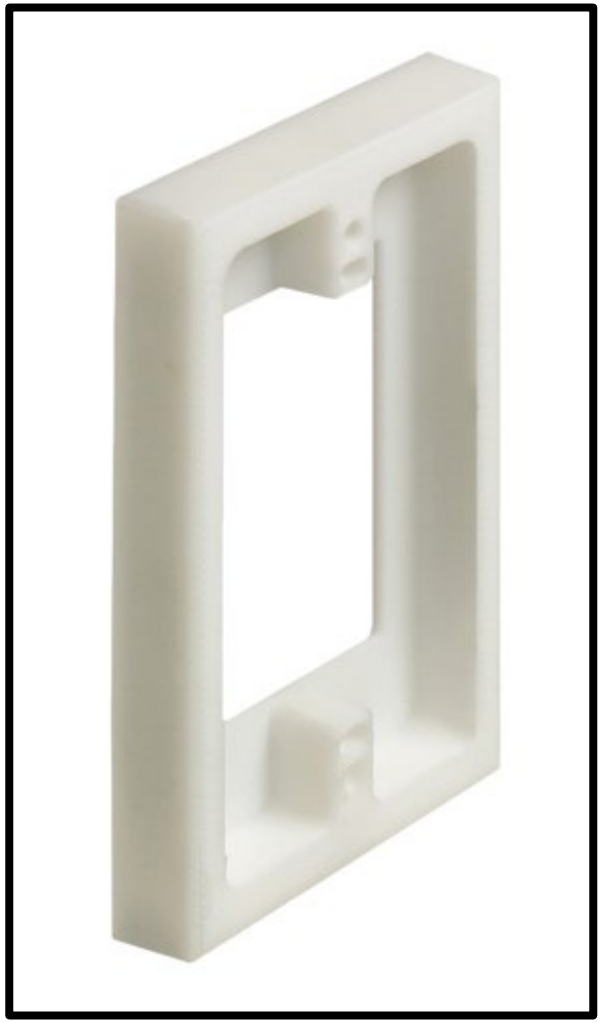
REPLACEMENTS

Where a receptacle outlet is supplied by a branch circuit that requires AFCI protection, it is permissible to meet the NEC requirement with a replacement receptacle that is one of the following:

1. A listed outlet branch-circuit type AFCI receptacle
2. A receptacle protected by a listed outlet branch-circuit type AFCI receptacle



Note: Section 406.4 (D)(4) requires AFCI protection when a receptacle is replaced.



AFCI Type Devices

AFCI “TR” Outlet



- AFCI / GFCI “TR” Outlet



For Informational Purposes Only

AFCI Type Devices

AFCI “Deadfront”



- 20a Hospital Grade AFCI / GFCI “TR” Outlet (Red)



For Informational Purposes Only

Article 406.12
Tamper-Resistant Receptacles

For Informational Purposes Only

N 406.12 Tamper-Resistant Receptacles

Expanded Locations; 15- & 20-ampere 125v thru 250v

Dwelling units

Guest rooms & Guest suites

Child-care facilities

Preschools & educational facilities

Within clinics, medical & dental offices, following areas:

(a) Business offices accessible to the public

(b) Lobbies & Waiting Areas

(c) Spaces of nursing homes / limited-care facilities

Places awaiting transportation, gyms, skating rinks, fitness centers & auditoriums

Dormitory units

Residential care facilities, assisted living, rehab & group homes

Foster care facilities, nursing homes & psychiatric hospitals

Accessible areas of agricultural buildings to the general public & any common areas

For Informational Purposes Only
For Informational Purposes Only

Article 410.184

GFCI Protection & Special Purpose (SPGFCI) Protection for Lighting

For Informational Purposes Only

Δ 410.184 GFCI Protection & Special Purpose (SPGFCI) Protection

Horticultural Lighting Use



eption:

xceeding 150v to ground shall be protected by a listed special purpose GFCI

Class “C” Special Purpose Ground-Fault Circuit Interrupter (SPGFCI) Trip level is 15 – 20mA / ckts. over 150v to ground

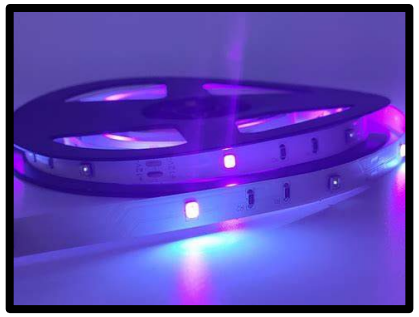
Not Current Code In Ohio

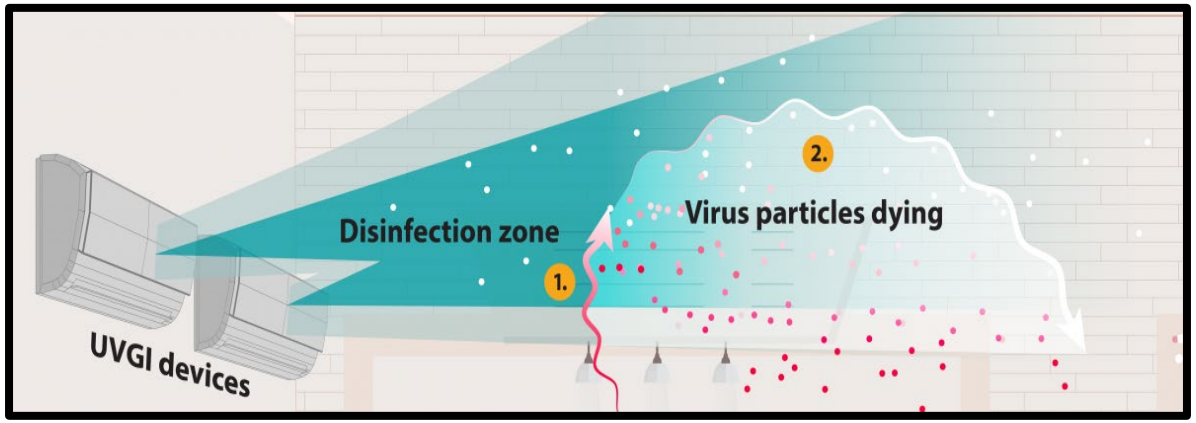
For Informational Purposes Only

N Germicidal Irradiation Luminaires

Article 410.190 Part XVII. Special Provisions

Listing, Labeling & Installation Requirements







HVAC Ventilation / UV-C LED lighting systems
Tuberculosis, SARS, & CoV-2 sterilization: reduce hazards

For Informational Purposes Only
For Informational Purposes Only

Article 426.28

Ground-Fault Protection for De-icing and Snow Melting

For Informational Purposes Only

Δ 426.28 Ground-Fault Protection

Fixed Outdoor Electric De-icing & Snow Melting Equipment

Previously 426.44(E) GFCI Protection. In addition to the requirements of 210.8, GFCI protection for personnel shall be provided.

426.28 Ground Fault protection.

GF protection shall be provided for fixed outdoor electric de-icing and snow-melting equipment.

The trip level shall be specified by the manufacturer.

Not Current Code In Ohio
For Informational Purposes Only

Article 440.11
Refrigeration Equipment Disconnects

For Informational Purposes Only

Δ 440.11 A/C Disconnects





Expanded Requirement

Disconnecting means shall be capable of disconn & refrigeration equipment, including motor-compressors & controllers, from the circuit conductors. If the disconnecting means is readily accessible to unqualified persons, an enclosure door or hinged cover of a disconnecting means enclosure that exposes energized parts when open shall require a tool to open or be capable of being locked.

Not Current Code In Ohio For Informational Purposes Only

Article 495

Equipment operating over 1000V ac / 1500V dc

For Informational Purposes Only

N Article 495 Equipment Over 1kV ac / 1.5kV dc

Previous NEC Editions was Article 490

495.1 Scope. This article covers the general requirements for equipment operating at over 1000v ac, 1500v dc.

495.22 Isolating Means

495.48 Substation Design & Documentation

495.61 Mobile and Portable Equipment

495.70 Boilers

For Informational Purposes Only
For Informational Purposes Only

Article 500
Hazardous Locations

For Informational Purposes Only

Δ Article 500 Hazardous Locations

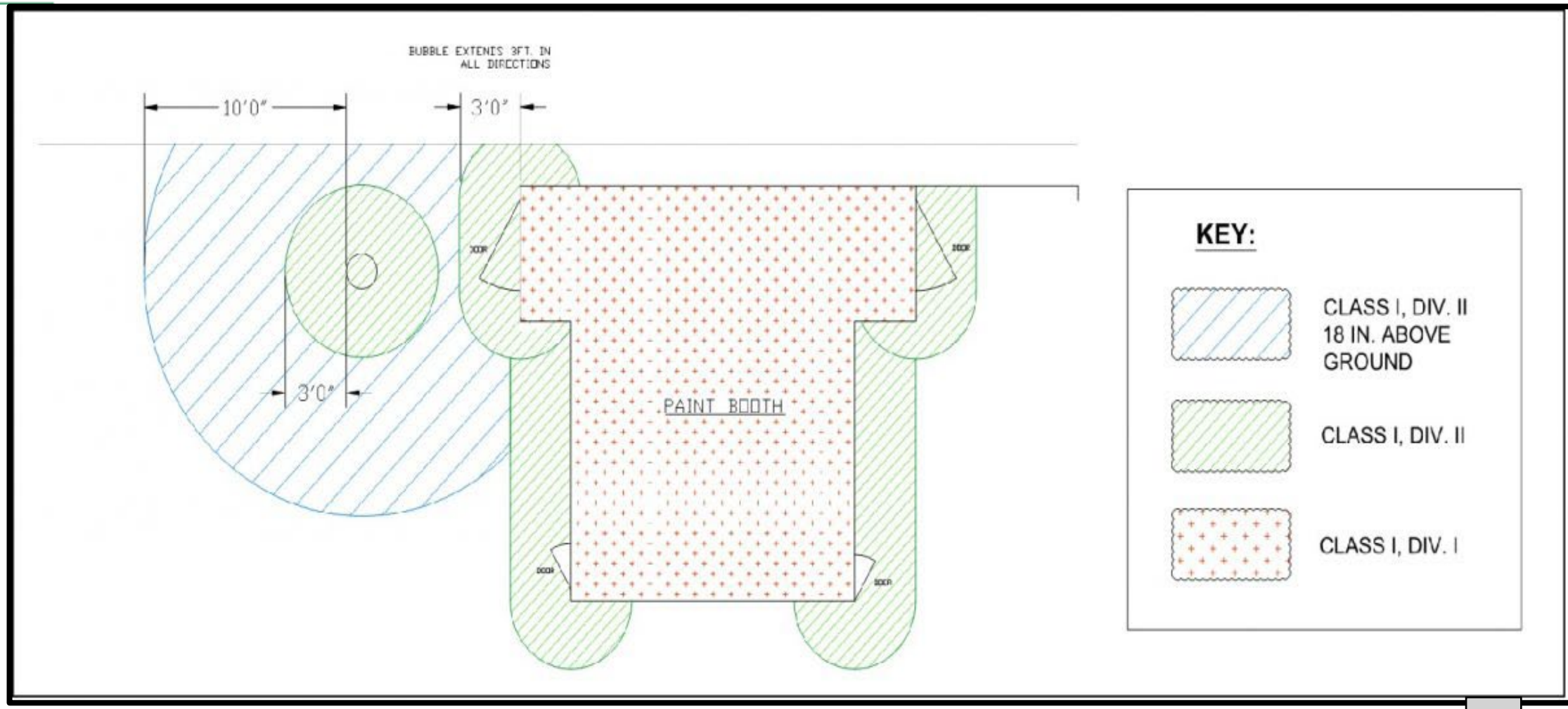
Classified Locations; Class I, II, & III Locations; Division I & II

Additional Requirement 500.4 Documentation.

Classified or unclassified areas shall be documented on an area classification drawing & other associated documentation. This documentation shall be available to the authority having jurisdiction (AHJ) and those authorized to design, install, inspect, maintain or operate the equipment.

For Informational Purposes Only
For Informational Purposes Only

Documented Area Classification



Not Current Code In Ohio For Informational Purposes Only

Article 511
Commercial Garages Repair & Storage

For Informational Purposes Only

Δ Article 511 Commercial Garages Repair & Storage

This Article was re-written

511.7 Fixed Wiring Above Hazardous / Classified Locations. Added listed fittings & equipment grounding conductors to numerous wiring methods.

517.8 Underground Wiring Below Hazardous Locations.

For Informational Purposes Only
For Informational Purposes Only

Article 512
Cannabis Oil Equipment

For Informational Purposes Only

N Article 512 Cannabis Oil Equipment

512.1 Scope. This article covers cannabis oil preparatory equipment, extraction equipment, booths, post-processing equipment, and systems using flammable materials (flammable gas, flammable liquid-produced vapor, combustible liquid-produced vapor) in commercial & industrial facilities.

512.3 Classified Locations. Cannabis oil equipment & systems that can release flammable materials during operations shall be classified in accordance with 512.3(A) & (B).

Not Current Code In Ohio For Informational Purposes Only

N Article 512 – Cannabis Oil Equipment / Oil Systems using Flammable Materials

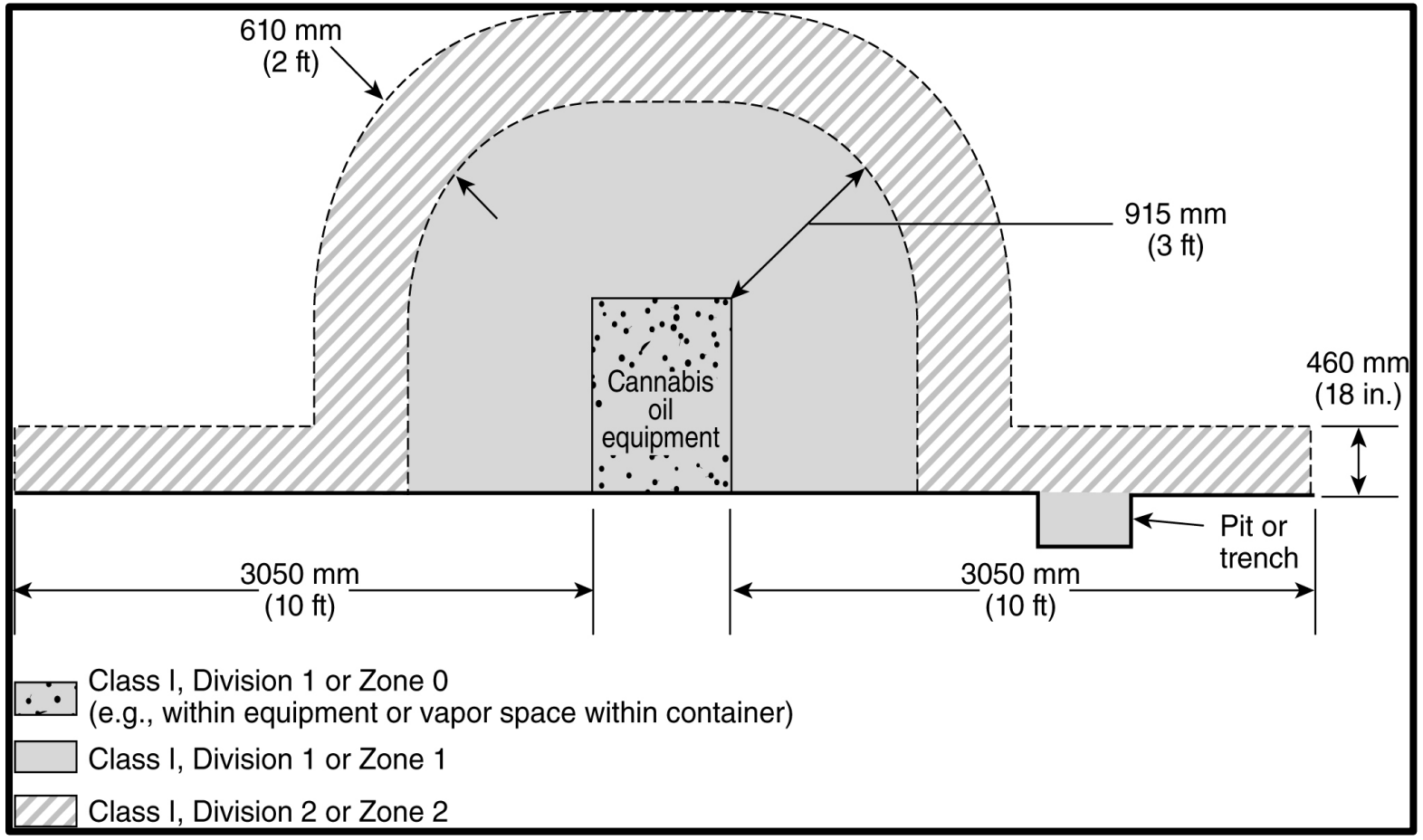
512.3 Classified Locations. Cannabis oil equipment & systems that can release flammable materials during operation. Class I Div. 1 or II location.





For Informational Purposes Only
For Informational Purposes Only

N 512.3(B) Cannabis Oil Booth



Article 514
Motor Fuel Dispensing Facilities

For Informational Purposes Only

Δ Article 514 Motor Fuel Dispensing Facilities

Δ 514.8 Underground Wiring. (In classified Locations)

The change here is previous editions of the NEC accepted MI, PVC, RTRC, HDPE conduit as an exception to the metal conduit rule. The 2023 NEC 514.8(B) & (C) is now written into positive code language.

No Change: Still requires 2’ of cover or change to RMC or IMC

For Informational Purposes Only
For Informational Purposes Only

Article 517
Health Care Facilities

For Informational Purposes Only

Δ 517 Health Care Facilities

517.1 Scope. Inadvertently Deleted

517.2 Definitions. Relocated to Article 100

517.10(B) Not Covered. Pharmacy services not contiguous to Health Care Facilities

517.12 EGC for Receptacles & Fixed Electrical Equipment in Patient Care Spaces. The insulated copper conductor needs to be installed and terminated in each panel all the way to the SE equipment.

517.30 EES Sources of Power. (1) Added utility power & changed (4) from battery system to energy storage system.

Not Current Code In Ohio For Informational Purposes Only

Article 517 Health Care Facilities

517.50 Part V. Diagnostic Imaging & Treatment Equipment

Formerly X Ray Installations

(updated for new terminology & technologies)

Added Informational Notes #3 & #4

#3 Diagnostic Equipment

#4 Treatment Equipment

For Informational Purposes Only
For Informational Purposes Only

Article 530

Motion Picture & TV Studios & Remote Locations

For Informational Purposes Only

Δ Article 530 Motion Picture & TV Studios & Remote Locations

More specific details, restrictions and requirements for associated (portable) equipment than previous editions. Will affect both local and national live broadcasts including news, sporting and possibly any live event.

Part II . Expanded Portable Equipment in Production Areas of Studios & Remote Locations

Part III. Portable Equipment in Support Areas

Not Current Code In Ohio For Informational Purposes Only

Article 555

Marinas, Boatyards, Floating Buildings & Docking Facilities

For Informational Purposes Only

Article 555 Marinas, Boatyards, Floating Buildings & Docking Facilities

This Article has been updated over the past (2) Code Cycles.

555.4 Location of Service Equipment (for a floating building, dock or marina). This section is clearly defined on the location of SE equipment (on land).

No closer than 5’ horizontally from the structure served & 12” minimum above the electrical datum plane (2’ above the maximum highest water level under normal conditions).

N 555.14 Areas requiring Equipotential Planes.

N 555.15 Replacement of Equipment. Requires compliance

N 555.36 Emergency Disconnect. Each marina power outlet that provides shore power to boats shall have an emergency disconnect.

N 555.37 All Equipment grounding conductors shall be insulated.

For Informational Purposes Only
For Informational Purposes Only

Article 625
EV Power Transfer Equipment

For Informational Purposes Only

Article 625 EV Power Transfer Equipment

Part III. Installation

Δ 625.40 Electric Vehicle Branch Circuit. Each outlet installed for the purpose of supplying EVSE greater than 16a or 120v shall be supplied by an individual branch circuit.

N 625.42(B) Energy Management System. When more than one or more pieces of equipment are provided with an integral load management control, the system shall be marked to indicate this control is provided.

2020 NEC Each outlet installed for the purpose of charging electric vehicles shall be supplied by an individual branch circuit.

Each circuit shall have no other outlets.

Not Current Code In Ohio For Informational Purposes Only

625.60 AC Receptacle outlets used for EVPE

EVPE = Electric Vehicle Power Export Equipment

AC receptacles installed in electric vehicles and intended to allow for connection of off-board utilization equipment shall comply with 625.60 (A) – (D).

(A) Type. The receptacle shall be listed

(B) Rating. Outlet shall

be rated 250-v max, 1ø, 50a max

(C) Overcurrent Protection. Integral to power export system

(D) GFCI Protection for Personnel. All receptacles shall be GFCI protected, indication and reset shall be readily accessible

For Informational Purposes Only
For Informational Purposes Only

Article 625 EV Power Transfer Equipment

Δ 625.48 Interactive Equipment. EVPE or WPTE that incorporates a power export function & that is part of an interactive system that serves as an optional standby system, an electric power production source, or a bidirectional power feed shall be listed & marked as suitable for that purpose. When used as an optional standby system, the requirements of Parts I & II of Article 702 shall apply.

N 625.49 Island Mode. EVPE and bidirectional EVSE that incorporate a power export function shall be permitted to be a part of an interconnected power system operating in island mode.

Not Current Code In Ohio
For Informational Purposes Only

The Future is Bidirectional Power Flow

ELECTRICAL LEAGUE of Ohio

Nissan Leaf V2H

- Hyundai Ioniq 5





For Informational Purposes Only

2022 Ford F-150 Lightning pick-up

All-Electric. All F-150

Available features include Backup Power that can provide full-home power for up to 3 days, on a fully charge battery and 80-amp Ford Charge station Pro. *When home is properly equipped & home transfer switch disconnects home



on 3
Pro
owe
nk,
gher

formatio



Article 680.5

SPGFCI at Swimming Pools, Fountains and Similar Locations

For Informational Purposes Only

GFCI Protection Expanded & SPGFCI is NEW (special purpose GFCI protection)

Δ 680.5 GFCI & SPGFCI Protection.

Δ The GFCI and SPGFCI requirements in this article, unless otherwise noted, are in addition to the requirements in 210.8.

GFCI Branch circuit receptacles & outlets (1ø & 3ø) 150v to ground or less, 60a or less. (6mA trip level)

SPGFCI is designed for (1ø & 3ø) receptacles & outlets above 150v to ground, not exceeding 480v with a 20mA trip level.

For Informational Purposes Only
For Informational Purposes Only

Article 680 Swimming Pools, Fountains & Similar Locations

210.21 Pump Motors

680.21(C) Ground Fault Protection. Outlets serving pool motors shall have GFCI protection.

This section has been expanded over numerous editions of the code. 2020 NEC all outlets150v to ground or less, 60a or less,1ø & 3ø.

Δ 680.21(D) Where a pool pump motor is replaced or repaired the motor shall be provided with ground-fault protection.

Not Current Code In Ohio For Informational Purposes Only

Littlefuse Shock Block 5000

Rated for 32-60amp

SPGFCI 10 - 100mA Increments or

Fixed 20mA Trip Level

208/480/600v Applications

This device is installed in-line between incoming power or existing overcurrent protection and the load.



For Informational Purposes Only
For Informational Purposes Only

Δ 680.22 Receptacles (GFCI & SPGFCI)

680.22(A)(4) GFCI & SPGFCI Protection. All receptacles rated 125v - 250v 60a or less, located within 20’ of the inside walls of the pool shall have GFCI protection complying with 680.5(B) or SPGFCI protection complying with 680.5(C).

680.22(B)(4) GFCI & SPGFCI Protection in Adjacent Areas. Luminaires, lighting outlets, & ceiling suspended (paddle) fans mounted in the area extending between 5’ & 10’ horizontally from the inside walls of a pool shall have GFCI 680.5(B) or SPGFCI protection 680.5(C) unless installed not less than 5’ above the maximum water level & rigidly attached to the structure.

Not Current Code in Ohio For Informational Purposes Only

GFCI & SPGFCI Protection Locations

GFCI requirements in the following locations, 150v to ground or less, 60a or less, 125v - 250v (1ø & 3ø), receptacles & outlets

Permanently installed pools, storable pools, immersion pools

680.21(C) Pool Motors Receptacles & Outlets (All)

680.22(A)(4) / 680.32 Receptacles within 20'of inside wall of pool.

680.22(B)(4) Luminaires, Lighting outlets & paddle fans installed 5' & 10' horizontally from the inside walls of a pool.

680.43(A)(2) Receptacles within 10' of the inside of a Self-contained Spas & Hot Tubs & Immersion Pools (both indoor & outdoor).

680.44(A) GFCI & SPGFCI Self-contained Spa & Hot Tubs

Not Current Code In Ohio For Informational Purposes Only

Δ 680.26 Equipotential Bonding



680.26(A) Performance. The equipotential bonding grid required by 680.26(B) & (C) to reduce voltage gradients in the pool area shall be installed for pools with or without associated electrical equipment related to the pool.

With or without power, there is still a body of water with chemicals added.

Water + chemicals = battery/voltage

For Informational Purposes Only
For Informational Purposes Only

Article 700
Emergency Systems

For Informational Purposes Only

Article 700 Emergency Systems

N 700.11 Wiring, Class 2 Powered Emergency Lighting Systems. 700.11(A) General.

700.11(B) Identification. Emergency circuits shall be permanently marked…..

All boxes & enclosures shall be permanently marked

Exposed cable, tray or raceway shall be perm. marked

(C) Separation of Circuits.

(D) Protection. Installed in raceway, AC or MC cable

Ex. 6’ or less to luminaires / Locked rooms / latched encl.

For Informational Purposes Only

Article 706
Energy Storage System

For Informational Purposes Only

Article 706 Energy Storage System

Δ 706.1 Scope. This article applies to all energy storage systems (ESS) having a capacity greater than 1 kwh that may be stand-alone or interactive with other electric power production sources. These systems are primarily intended to store & provide energy during normal operating conditions.

N 706.7(A) Commissioning. ESSs shall be commissioned upon installation. (Does not apply to 1 & 2-Family dwelling units)

N (B) 706.7(B) Maintenance. ESSs shall be maintained

For Informational Purposes Only
For Informational Purposes Only

Article 722
Fault Tolerant Systems

For Informational Purposes Only

N Article 722 – Cables for Power-Limited Circuits & Fault-Managed Power Circuits

722.1 Scope. This article covers the general requirements for the installation of single-and multiple-conductor cables used in Class 2 & Class 3 power-limited circuits, power-limited fire alarm (PLFA) circuits & Class 4 fault-managed power circuits.

722.24 Mechanical Execution of W

722.135 Cable Listing



Not Current Code In Ohio For Informational Purposes Only

N Article 726 Class 4 Fault-Managed Power Systems

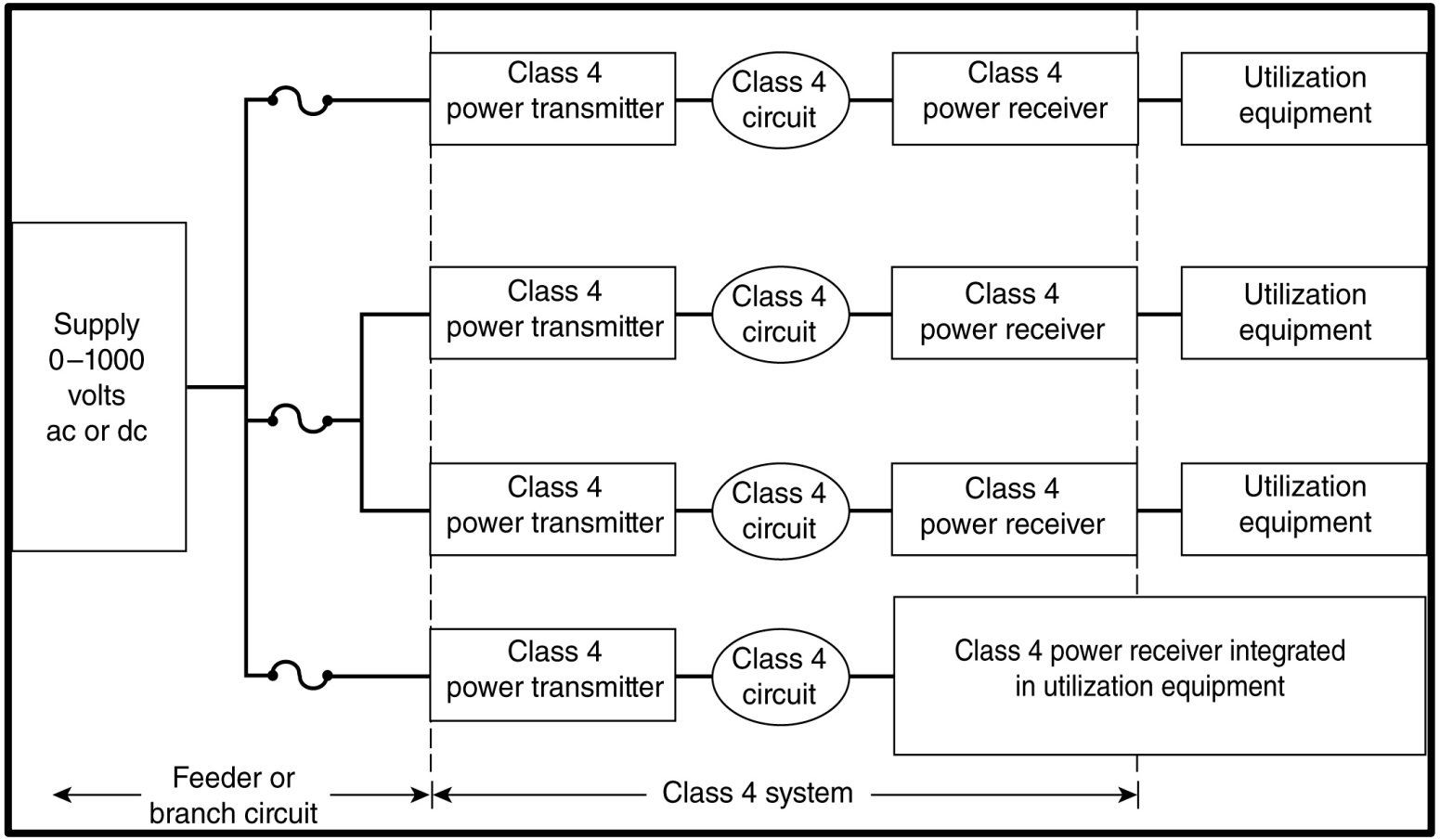
New Class Rating. Class 4 cables allow the distribution of DC power at higher-voltages. This type of circuit constantly monitors itself (intelligent wiring system) for faults and would shut power off simultaneously if a fault occurs. Capacity to deliver more power than Class I, II, or III systems.

Class 4 power systems are extremely safe from potential fire or shock hazards. Aka Power Energy Transfer (PET), Fault Managed Power; {Built-In Fault Management} (FMP)

Smart Building Technology; 450v L-L / 225v to ground

For Informational Purposes Only
For Informational Purposes Only

N Article 726.121 Class 4 Circuits



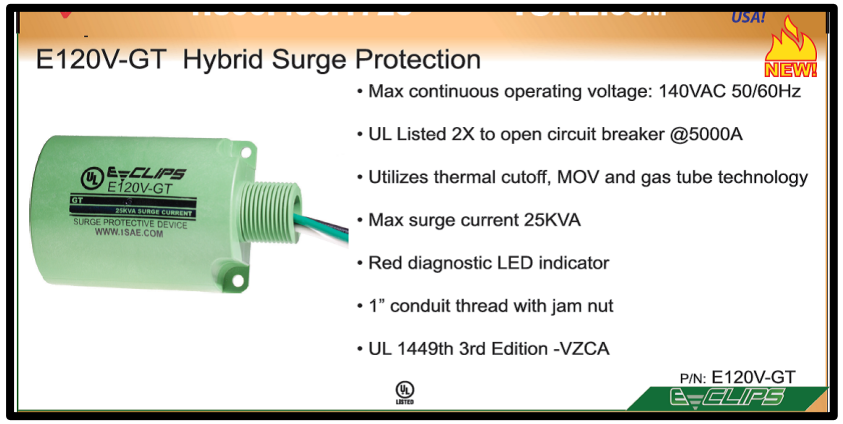
Not Current Code In Ohio

For Informational Purposes Only

Article 760
Fire Alarm Systems

For Informational Purposes Only

Article 760 Fire Alarm Systems



N 760.33 Supply Side Overvoltage Protection

A listed surge-protective device (SPD) shall be installed on the supply side of a fire alarm control panel in accordance with Part II of Article 242.

Typically, the fire alarm control panel is supplied by a single pole 120v circuit.





N 760.179(D) Cable Jacket Compound. The cable jacket shall have a high degree of abrasion resistance.

Not Current Code In Ohio
For Informational Purposes Only

Electrical League of Ohio

Health and Safety National Electrical Code Expo

End of Presentation

Thank You!

For Informational Purposes Only

Application for Continuing Education Approval
Course Conditions and Guidelines

The Ohio Board of Building Standards is committed to the ongoing education and professional development of board-certified personnel through the delivery of high-quality, accurate and engaging professional continuing education content. To this end, the Board reviews and approves Continuing Education Courses for building department personnel.

Board approval is granted for course instruction on current codes and standards, including the OBC, OMC, OPC, and RCO, and any other content areas directly related to the responsibilities of the certification for which credit is being requested.

Promotion: Any person or organization promoting an approved course is required to make full and accurate disclosure regarding course title, course approval number, number of credit hours, categories for which the BBS has approved the class, and fees in promotion materials and advertising. ***The Board does not grant retroactive approval. It is recommended that courses be submitted for approval well in advance of any scheduling of classes and advertising***. Advertising may not falsely state BBS approval before approval is granted. Course providers may state that BBS approval is pending.

Application Submission: All Applications and associated materials shall be submitted by email in .pdf format. Instructions for completing the application are attached.

Certificate of Completion: Course providers shall provide participants a certificate of completion containing the following information:

- Name of participant
- Title of approved courses
- BBS approval #
- BBS approved certifications
- Date of the continuing education program
- Number of approved credit hours awarded, and
- Signature of authorized sponsor or instructor.

Any person or organization administering an approved course shall return a completed BBS Course Attendance form by email.

Participants: Participants must attend the complete course as presented by the instructor to receive credit hours approved by the Board. The organization or instructor of online courses shall plan and execute methods to verify the individual's attendance and completion of the course. No partial credit will be given to any participant who failed to complete the entire course as approved.

Board approval: All courses are approved for the calendar year in which application is made. Courses may be renewed so long as the referenced code is in effect, and the CEUs, certification and content remain unchanged. When the referenced code is updated, courses must be updated, and new approvals obtained.

Facility/training area: BBS Course may be delivered in person or online, or both, at the sponsor's option.
Course facilities shall include the following:

In Person Classes:
Sufficient seating capacity
ADA accessible facilities
Appropriate Audio/Visual devices for delivery
Writing surfaces for participants

Online Classes:
Web-accessible
ADA accessible delivery
Tech support available
Live and recorded courses permitted

In-person facilities shall comfortably and safely seat at least the number of attendees present in the room and shall be climate controlled, non-smoking, and sound controlled so that outside noise will not interfere with the training.

Ohio | Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: Theresa Hanna Wiehn

Organization: Electrical League of Ohio

Address: 20575 Center Ridge Road, Suite 117, Rocky River OHIO 44116

E-mail: terrihanna-wiehn@sbcglobal.net Telephone: 440-333-5040

Website: www.electricalleague.com

Conference Sponsor (if applicable)_____ Conference Email:_____

Check here if Course Renewal:_____ Prior course number _____ *(i.e. BBS2018-429)*

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: National Electrical Code Review of 2017 NEC with Update of Changes

Course instructor: Tim Pool and John Labriola

Course description: Will cover selected articlers in the 2017 NEC with a look ahead at the potential changes to those articles. Articles will be selected with most significant changes to the installing electrician to complete a safe and complianat installation. NEC 2023 discussion will take place 10 minutes of the hour (break time) to not interfer with the 50 minute instruction content on NEC 2017 and 2020

Instructional hours per session: 4 hours Number of Sessions: 2

Course Date(s) and Location: March 1, 2023 Holiday Inn Cleveland South, Independence Ohio

Special Content:

Code Administration: ☑
Existing Buildings: ☑
Electrical Instruction: ☑
Plumbing Instruction: ☐

Conference Course: _____
Conference Name: _____
Conference location: _____

Course to be offered online? ☐ **On Demand** ☐ **Webinar** ☐

Course Website: _____

Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation)*:

_____

Course applicable for the following certifications

Residential Certifications Only: ☑
Administrative Course, All Certifications: ☑
Commercial Certifications: ☑

Application materials included:

☑ Course Outline or Course Learning Objectives
☑ Presentation Materials/Slides (not required for roundtable courses)
☐ Assessment Materials (for online courses)
☑ Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

Instructions for new Continuing Education Approval form

Provider Information

1. Please include all contact information.
2. If course is not part of a conference, leave conference sponsor and email blank.

Course Renewal

1. Indicate if the course is being submitted for renewal. Include prior approval letter and write in prior course number.
2. Certification approval for courses has now changed: all existing courses being renewed will be approved within the new classification system.
    a. Courses previously approved for only residential certifications will be approved for all residential certifications.
    b. Courses previously approved for at least on commercial certification will now be approved for all commercial certifications and all residential certifications.
    c. Courses on required instruction topics, Ohio Ethics, Code Administration and Existing Buildings, will be noted as Administrative Courses and be approved for all certifications.
3. Courses being renewed should skip the New Course information section and are not required to submit outline, agenda, slides or other instructional materials for review. Skip to Special Content, and mark any item that applies to the course.

New Course Information

1. Enter course title, name of instructor, and a brief description of the course content. Learning objectives may be substituted for course description, if desired.
2. Number of instructional hours per session is the length of instructional time.
3. Number of sessions: can be 1 or the number of sessions planned.
4. Course date(s) and location: not necessary at this time, enter if known.

Special Content

1. Indicate if the course will meet instructional time in Code Administration or Existing Buildings.
2. Indicate if the course is a plumbing or electrical course, for ESIAC review and trainee course tracking.
3. If the course is associated with a conference, indicate the conference name and location, as this will allow BBS to coordinate approvals with the conference provider.
4. If the course will be offered online, specify whether it will be on demand or offered as a virtual webinar, or both. Include website where the course will be provided.

Course applicable for the following certifications

This section represents a major change from previous BBS course approval forms.

1. If the course is only for residential certifications, check 'Residential Certifications Only'. The course, if approved, will be approved for all residential certifications.
2. If the course is appropriate for any commercial certifications, check Commercial Certifications. The course, if approved, will be approved for all commercial certification **AND** all residential certifications.
3. If the course is intended to meet required instruction in Code Administration (Chapter 1) or Existing Buildings (commercial or residential) check 'Administrative Course, All Certifications'.

Application Materials Included

This is a checklist for the course submitter's use, to be sure all materials necessary for review are included with the application. All materials should be submitted in .pdf format, along with the application, via email to Michael.Lane@com.ohio.gov or BBS@com.ohio.gov

Electrical League of Ohio
National Electrical Code Conference

National Electrical Code Review of 2017 NEC with update of changes – 4 hours

Presented By: John M. Labriola, ESI
Timothy G. Pool, PE, RCDD, ESI 7011

Executive Summary of course: This class will be presented at the Electrical League of Ohio Code Conference on March 1, 2023, and will cover selected articles in the 2017 National Electrical Code with a look ahead at the potential changes to those articles in the 2023 code. The articles selected will be those most significant to the installing electrician to complete a safe and code compliant installation. Note: The proposed 2023 code updates will be covered during the scheduled break periods and proper notification will be given that the code updates are for informational purposes only and not currently adopted in Ohio.

Session 1: 2 hours (No Break) 3:00 - 5:00 pm

Chapter 1: General Conditions

- Article 100: Definitions consolidation and code making panel (CMP): 5 minutes
- Article 110.12: Mechanical Execution of Work: 5 minutes
- Article 110.16: Arc Flash Warning: 5 minutes
- Article 110.17 Servicing and Maintenance of Equipment: 5 minutes
- Article 110.20 Reconditioned Equipment: 10 minutes
- Article 110.26: Working Space: 5 minutes

Chapter 2: Wiring and Protection

- Article 210.8 GFCI Requirements: 15 minutes
- Article 210.11(C)(4) Garage Branch Circuits: 5 minutes
- Article 201.12(B) AFCI Requirements: 5 minutes
- Article 210.52(C)(3) Receptacle Outlet Location: 5 minutes
- Article 210.70(A)(1) Habitable Rooms; Lighting Outlets: 5 minutes
- Article 215.15 Feeders (Barriers): 5 minutes
- Article 225 Outside Branch Circuits & Feeders: 5 minutes
- Article 230.67 Surge Protection: 5 minutes
- Article 230.71 Maximum Number of Service Disconnects: 5 minutes
- Article 230.85(A) Emergency Disconnects; General: 5 minutes
- Article 235 Branch, Feeder, & Service Circuits over 1000v ac.: 5 minutes
- Article 240.4(B) OCP Rated 800A or Less: 5 minutes
- Article 245 OCP for Systems rated over 1kV ac & 1.5kV dc: 5 minutes
- Article 250 Grounding Triangle / Foundation: 5 minutes
- Article 250.140 Frames of Ranges & Dryers: 5 minutes

Break for Conference Vendor Table
5:00 - 6:30 pm

Session 2: 2 hours (No Break) 6:30 - 8:30 pm

Chapter 3: Wiring Methods and Material

- Article 300 General Requirements for Wiring Methods & Materials — 5 minutes
- Article 300.14 Length of Free Conductors — 5 minutes
- Article 300.25 Exit Enclosures (Stair Towers) — 2 minutes
- Article 305 Systems rated over 1kV ac & 1.5 kV dc — 2 minutes
- Article 310 Conductors for General Wiring Aluminum Alloy — 5 minutes
- Article 311 Medium Voltage Conductors & Cables – Deleted — 5 minutes
- Article 314.24(C) Clearances for Side-Wiring Entrances — 5 minutes
- Article 314.27 Ceiling fan boxes — 2 minutes
- Article 314.27 Medium Voltage Conductors, Cable, Cable Joints — 5 minutes
- Article 335.1 Instrumentation Tray Cable (ITC) — 2 minutes
- Article 369 Insulated Bus Pipe (IBP) / Tubular Covered Conductors — 2 minutes
- Article 371 Flexible Bus Systems — 2 minutes

Chapter 4: General Equipment

- Article 400 Flexible Cords & Cables — 5 minutes
- Article 406.4(D) Receptacle Replacements — 5 minutes
- Article 406.12 Tamper-Resistant Receptacles — 5 minutes
- Article 410.184 GFCI Protection for lighting — 2 minutes
- Article 426.28 GFP for De-icing and Snow Melting — 2 minutes
- Article 440.11 Refrigeration Equipment Disconnects — 2 minutes
- Article 495 Equipment operating over 1000V ac / 1500V dc — 5 minutes

Chapter 5: Special Occupancies

- Article 500 Hazardous Locations — 5 minutes
- Article 511 Commercial Garages Repair & Storage — 2 minutes
- Article 512 Cannabis Oil Equipment — 5 minutes
- Article 514 Motor Fuel Dispensing Facilities — 2 minutes
- Article 517 Health Care Facilities — 5 minutes
- Article 530 Motion Picture & TV Studios & Remote Locations — 2 minutes
- Article 555 Marinas, Boatyards, Floating Buildings & Docking — 5 minutes

Chapter 6: Special Equipment

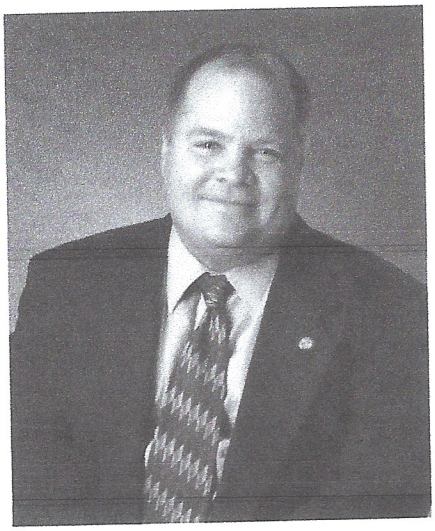
- Article 625 EV Power Transfer Equipment — 10 minutes
- Article 680.5 SPGFCI at Swimming Pools, Fountains — 5 minutes

Chapter 7: Special Systems

- Article 700 Emergency Systems — 2 minutes
- Article 706 Energy Storage Systems — 2 minutes
- Article 722 Fault Tolerant Systems — 5 minutes
- Article 760 Fire Alarm Systems — 2 minutes

End of Presentation

STAFF PROFILE : TIMOTHY G POOL, PE, RCDD



- principal
- director of electrical engineering

Mr. Timothy Pool has over 30 years experience as an Electrical Engineer and Electrical Project Manager in total design of building electrical systems, information technology systems and industrial/process design. As an electrical Project Engineer for Tec, Inc., he is in responsible charge of the power distribution, lighting and control systems designed for commercial, industrial and institutional type buildings. Mr. Pool serves as Director of Electrical Engineering for the firm.

Mr. Pool has completed information technology and electrical engineering design for a number of library projects including KSU Trumball and Ashtabula Campus Libraries. He has also designed the information technology systems for several public libraries, most recently, Morely Public Library in Painesville, Ohio and Hudson Public Library in Hudson, Ohio. Mr. Pool has completed engineering design, including information technology, for several recreation and dormitories such as the Lake Erie College Recreation Center and Dickinson Dormitory.

Mr. Pool served a dual role as Project Manager/Project Engineer for the recently completed City of Willoughby Municipal Courthouse project. As Project Manager his responsibility was to coordinate the mechanical and electrical engineering effort with respect to the overall project. He was responsible for obtaining and disseminating pertinent project information and act as a contact person for the other design team members.

Another outstanding asset is Mr. Pool's knowledge of the National Electrical Code and National Fire Code. Mr. Pool provides class training and guidance to the electrical industry and many electrical contracting firms throughout Northeast Ohio.

Mr. Pool's role in completing this project would be to provide information technology design and to ensure Tec's established design standards are adhered to, and also act as a technical resource. He will be responsible for quality assurance relative to the electrical design. Mr. Pool is excited to commit the necessary time to fulfill his responsibilities for the successful completion of the proposed projects.

John M. Labriola
150 Maplecrest St. SW
North Canton, Ohio 44720
HOME (330) 497-6309 FAX (330) 497-6463 CELL (330) 606-8098

Personal Bio'

- Retired Chief Building Official for Summit County
- Past Building Department Experience: Chief Building Official, City of Canton; Back-Up Building and Electrical Inspector, City of Alliance; Building and Electrical Inspector, City of North Canton and Chief Electrical Inspector for Stark County
- State of Ohio Licenses: Building Inspector, Building Official, Building Plans Examiner, Electrical Plans Examiner, Electrical Safety Inspector, Fire Protection Plans Examiner, Mechanical Plans Examiner and Residential Building Official
- Member of Professional Organizations: American Institute of Architects (Akron), Building Officials Code Officials of Northeast Ohio, National Fire Protection Association, Five County Building Officials Association, Ohio Building Officials Association and International Association of Electrical Inspectors.

June 2006	Chief Building Official: City of Canton, Ohio
1997	City of North Canton, Ohio: Building and Electrical Inspector
2004	Successfully Completed: South Carolina Electrical Contractor Examination
1997-1986	Stark County, Ohio: Chief Electrical Inspector
1988-1984	City of Louisville, Ohio: Part-time Electrical Inspector
1984	Passed State of Ohio Electrical Safety Inspector Examination
1981	Passed 1st of many Electrical Contractor Examinations
1980	Passed Journeyman Electrician Exam
1976	Started in Electrical Industry

State of Ohio Certifications Held:

Chief Building Official, Electrical Plans Examiner, Building Inspector, Residential Building Official, Electrical Contractor License #14617.

International Code Council Certifications Held:

Chief Building Official, Building Plans Examiner, Electrical Plans Examiner, Mechanical Plans Examiner, Commercial Mechanical Inspector.

File Attachments for Item:

EC-9 National Electric Code 2017 Wire and Raceway Sizing for Electrical Systems (Electrical League of Ohio)

All certifications (4 hours)

APPLICATION FOR CONTINUING EDUCATION APPROVAL
COURSE CONDITIONS AND GUIDELINES

The Ohio Board of Building Standards is committed to the ongoing education and professional development of board-certified personnel through the delivery of high-quality, accurate and engaging professional continuing education content. To this end, the Board reviews and approves Continuing Education Courses for building department personnel.

Board approval is granted for course instruction on current codes and standards, including the OBC, OMC, OPC, and RCO, and any other content areas directly related to the responsibilities of the certification for which credit is being requested.

Promotion: Any person or organization promoting an approved course is required to make full and accurate disclosure regarding course title, course approval number, number of credit hours, categories for which the BBS has approved the class, and fees in promotion materials and advertising. ***The Board does not grant retroactive approval. It is recommended that courses be submitted for approval well in advance of any scheduling of classes and advertising***. Advertising may not falsely state BBS approval before approval is granted. Course providers may state that BBS approval is pending.

Application Submission: All Applications and associated materials shall be submitted by email in .pdf format. Instructions for completing the application are attached.

Certificate of Completion: Course providers shall provide participants a certificate of completion containing the following information:

- Name of participant
- Title of approved courses
- BBS approval #
- BBS approved certifications
- Date of the continuing education program
- Number of approved credit hours awarded, and
- Signature of authorized sponsor or instructor.

Any person or organization administering an approved course shall return a completed BBS Course Attendance form by email.

Participants: Participants must attend the complete course as presented by the instructor to receive credit hours approved by the Board. The organization or instructor of online courses shall plan and execute methods to verify the individual's attendance and completion of the course. No partial credit will be given to any participant who failed to complete the entire course as approved.

Board approval: All courses are approved for the calendar year in which application is made. Courses may be renewed so long as the referenced code is in effect, and the CEUs, certification and content remain unchanged. When the referenced code is updated, courses must be updated, and new approvals obtained.

Facility/training area: BBS Course may be delivered in person or online, or both, at the sponsor's option.
Course facilities shall include the following:

In Person Classes:
- Sufficient seating capacity
- ADA accessible facilities
- Appropriate Audio/Visual devices for delivery
- Writing surfaces for participants

Online Classes:
- Web-accessible
- ADA accessible delivery
- Tech support available
- Live and recorded courses permitted

In-person facilities shall comfortably and safely seat at least the number of attendees present in the room and shall be climate controlled, non-smoking, and sound controlled so that outside noise will not interfere with the training.

Ohio | Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: Theresa Hanna Wiehn

Organization: Electrical League of Ohio

Address: 20575 Center Ridge Road, Suite 117, Rocky River OHIO 44116

E-mail: terrihanna-wiehn@sbcglobal.net Telephone: 440-333-5040

Website: www.electricalleague.com

Conference Sponsor (if applicable)_____ Conference Email:_____

Check here if Course Renewal:_____ Prior course number _____ *(i.e. BBS2018-429)*

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: National Electrical Code Wire and Raceway Sizing for Electrical Systems

Course instructor: Tim Pool

Course description: explanation of the wire ampicity tabaleand how to correctly size wire for the overcurrent protective .device and load served. Wil cover raceway installation requirements and fill percentages for building wiring.

Instructional hours per session: 4 hours Number of Sessions: 1

Course Date(s) and Location: Eaton, 12975 Corporate Drive Unit F, Parma OH 44131

Special Content:

Code Administration: ☑
Existing Buildings: ☑
Electrical Instruction: ☑
Plumbing Instruction: ☐

Conference Course: _____
Conference Name: _____
Conference location: _____

Course to be offered online? ☐ **On Demand** ☐ **Webinar** ☐

Course Website: _____

Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation)*:

_____

Course applicable for the following certifications

Residential Certifications Only: ☑
Administrative Course, All Certifications: ☑
Commercial Certifications: ☑

Application materials included:

☑ Course Outline or Course Learning Objectives
☑ Presentation Materials/Slides (not required for roundtable courses)
☐ Assessment Materials (for online courses)
☑ Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

Instructions for new Continuing Education Approval form

Provider Information

1. Please include all contact information.
2. If course is not part of a conference, leave conference sponsor and email blank.

Course Renewal

1. Indicate if the course is being submitted for renewal. Include prior approval letter and write in prior course number.
2. Certification approval for courses has now changed: all existing courses being renewed will be approved within the new classification system.
    a. Courses previously approved for only residential certifications will be approved for all residential certifications.
    b. Courses previously approved for at least on commercial certification will now be approved for all commercial certifications and all residential certifications.
    c. Courses on required instruction topics, Ohio Ethics, Code Administration and Existing Buildings, will be noted as Administrative Courses and be approved for all certifications.
3. Courses being renewed should skip the New Course information section and are not required to submit outline, agenda, slides or other instructional materials for review. Skip to Special Content, and mark any item that applies to the course.

New Course Information

1. Enter course title, name of instructor, and a brief description of the course content. Learning objectives may be substituted for course description, if desired.
2. Number of instructional hours per session is the length of instructional time.
3. Number of sessions: can be 1 or the number of sessions planned.
4. Course date(s) and location: not necessary at this time, enter if known.

Special Content

1. Indicate if the course will meet instructional time in Code Administration or Existing Buildings.
2. Indicate if the course is a plumbing or electrical course, for ESIAC review and trainee course tracking.
3. If the course is associated with a conference, indicate the conference name and location, as this will allow BBS to coordinate approvals with the conference provider.
4. If the course will be offered online, specify whether it will be on demand or offered as a virtual webinar, or both. Include website where the course will be provided.

Course applicable for the following certifications

This section represents a major change from previous BBS course approval forms.

1. If the course is only for residential certifications, check 'Residential Certifications Only'. The course, if approved, will be approved for all residential certifications.
2. If the course is appropriate for any commercial certifications, check Commercial Certifications. The course, if approved, will be approved for all commercial certification **AND** all residential certifications.
3. If the course is intended to meet required instruction in Code Administration (Chapter 1) or Existing Buildings (commercial or residential) check 'Administrative Course, All Certifications'.

Application Materials Included

This is a checklist for the course submitter's use, to be sure all materials necessary for review are included with the application. All materials should be submitted in .pdf format, along with the application, via email to Michael.Lane@com.ohio.gov or BBS@com.ohio.gov

Electrical League of Ohio
National Electrical Code

4-hour Course Outline on
"Wire and Raceway Sizing for Electrical Systems"

Presented By: Timothy G. Pool, PE, RCDD, ESI 7011

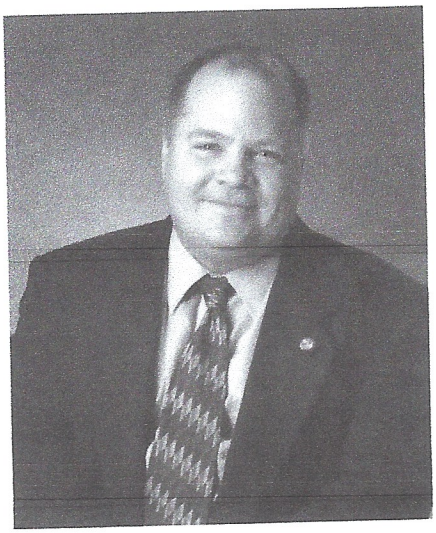
Executive Summary of course: This class will specifically give those attending an explanation of the wire ampacity tables and how to correctly size wire for the overcurrent protective device and load served. In addition, this class will cover raceway installation requirements and fill percentages for building wiring.

Wire and Raceway Sizing for Electrical Systems

- **Definitions – 20 min**
  - Exposed vs. Concealed
  - Accessible vs. Readily Accessible
  - Fault Current
- **Electrical Connections – 60 min**
  - Copper vs. Aluminum
  - 60, 75 and 90 degree C terminations
  - Equipment listings
  - Protection of conductors
- **Overcurrent Protection and Wire Size – 60 min**
  - Next standard Size Device
  - Branch Circuit and Feeder Taps
  - Sizing the grounding conductor based on overcurrent device
- **General Wiring Methods – 40 min**
  - Protection from damage
  - Number of Conductors in Cable Trays and Raceway, and Ampacity Adjustment
  - Copper vs. Aluminum
- **Raceways – 60 min**
  - AC
  - MC
  - IMC
  - PVC
  - EMT
  - RMC
  - Auxiliary Gutters
  - Number of Conductors in Cable Trays

Total Class Time: 4 Hours

STAFF PROFILE : TIMOTHY G POOL, PE, RCDD



- principal
- director of electrical engineering

Mr. Timothy Pool has over 30 years experience as an Electrical Engineer and Electrical Project Manager in total design of building electrical systems, information technology systems and industrial/process design. As an electrical Project Engineer for Tec, Inc., he is in responsible charge of the power distribution, lighting and control systems designed for commercial, industrial and institutional type buildings. Mr. Pool serves as Director of Electrical Engineering for the firm.

Mr. Pool has completed information technology and electrical engineering design for a number of library projects including KSU Trumball and Ashtabula Campus Libraries. He has also designed the information technology systems for several public libraries, most recently, Morely Public Library in Painesville, Ohio and Hudson Public Library in Hudson, Ohio. Mr. Pool has completed engineering design, including information technology, for several recreation and dormitories such as the Lake Erie College Recreation Center and Dickinson Dormitory.

Mr. Pool served a dual role as Project Manager/Project Engineer for the recently completed City of Willoughby Municipal Courthouse project. As Project Manager his responsibility was to coordinate the mechanical and electrical engineering effort with respect to the overall project. He was responsible for obtaining and disseminating pertinent project information and act as a contact person for the other design team members.

Another outstanding asset is Mr. Pool's knowledge of the National Electrical Code and National Fire Code. Mr. Pool provides class training and guidance to the electrical industry and many electrical contracting firms throughout Northeast Ohio.

Mr. Pool's role in completing this project would be to provide information technology design and to ensure Tec's established design standards are adhered to, and also act as a technical resource. He will be responsible for quality assurance relative to the electrical design. Mr. Pool is excited to commit the necessary time to fulfill his responsibilities for the successful completion of the proposed projects.

The Electrical League

Presents:

Wire and Raceway Sizing for Electrical Systems

Presented By:

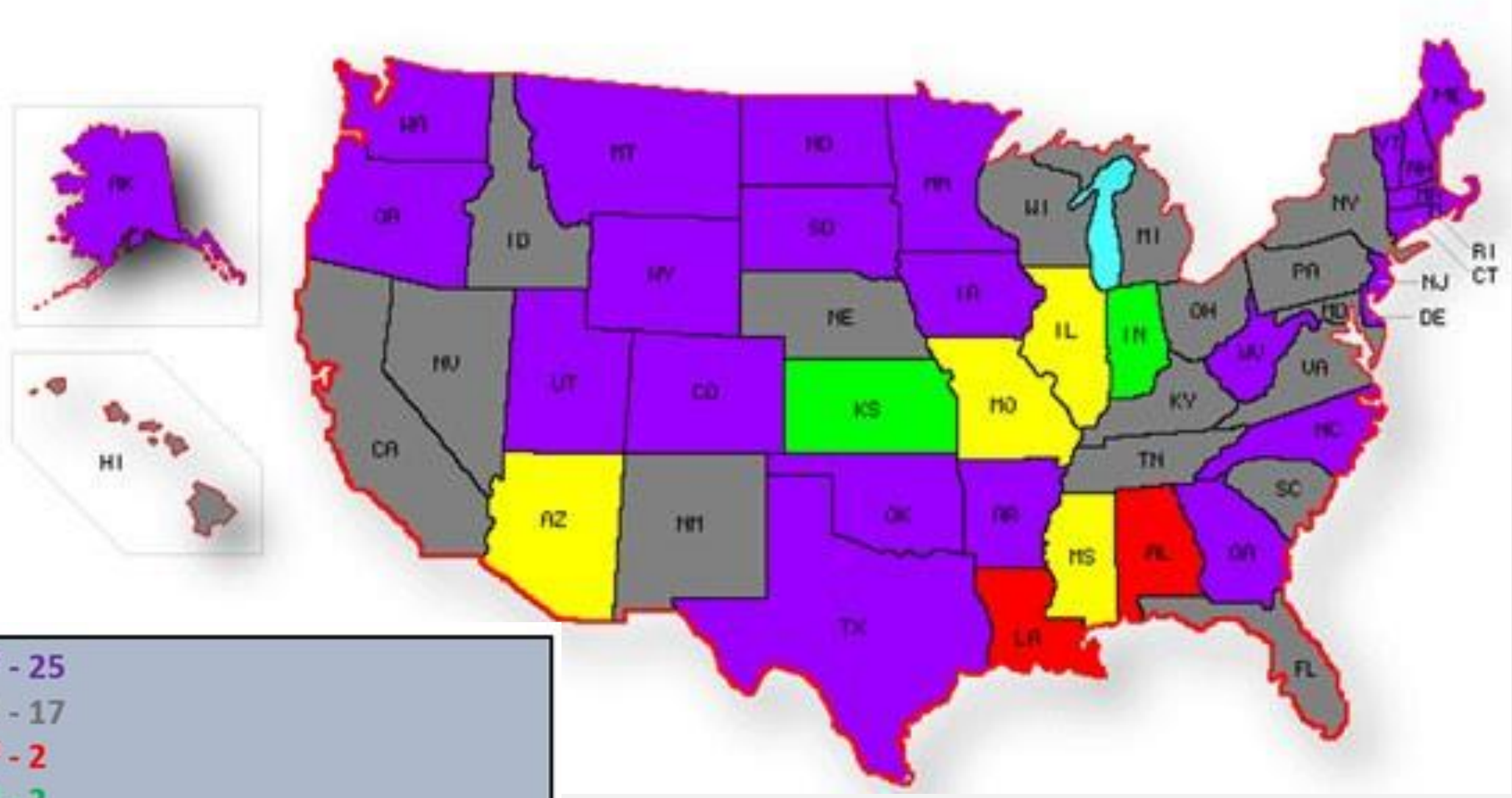
Timothy Pool, P.E.

1050

Electric League
of Western Pennsylvania

Code Update Status

NEC® in Effect
12/1/2022



2020 NEC® - 25
2017 NEC® - 17
2014 NEC® - 2
2008 NEC® - 2
County/Municipality NEC® regulation only - 4

NEC® Update Process In Progress
12/1/2022

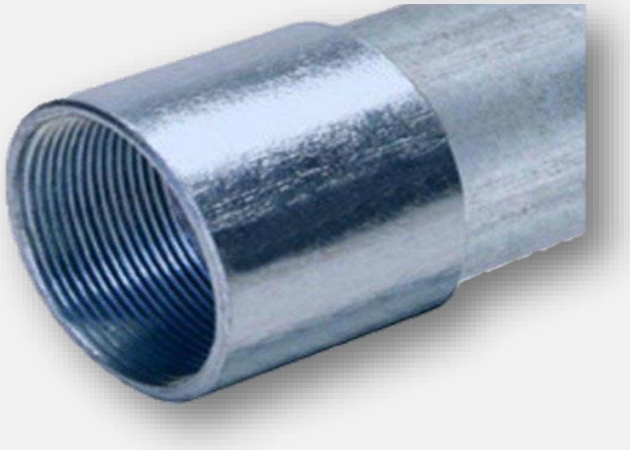


2023 NEC® Update Process Underway - 5
2020 NEC® Update Process Underway - 10
Current Update Process Completed - 31
(See NEC® in Effect Map for Updated Edition)
County/Municipality NEC® regulation only - 4

Electric League
of Western Pennsylvania

Definitions

ARTICLE 100 Definitions



Conduit, Intermediate Metal (IMC). (Intermediate Metal Conduit)

A steel threadable raceway of circular cross section designed for the physical protection and routing of conductors and cables and for use as an equipment grounding conductor when installed with its integral or associated coupling and appropriate fittings. (CMP-8)

ARTICLE 100 Definitions



Conduit, Rigid Metal (RMC). (Rigid Metal Conduit)

A threadable raceway of circular cross section designed for the physical protection and routing of conductors and cables and for use as an equipment grounding conductor when installed with its integral or associated coupling and appropriate fittings. (CMP -8)

ARTICLE 100 Definitions



Conduit, Rigid Polyvinyl Chloride (PVC). (Rigid Polyvinyl Chloride Conduit)

A rigid nonmetallic raceway of circular cross section, with integral or associated couplings, connectors, and fittings for the installation of electrical conductors and cables. (CMP-8)

ARTICLE 100 Definitions

EMT is not described as a conduit – it is a “tube”:



Tubing, Electrical Metallic (EMT). (Electrical Metallic Tubing)

An unthreaded thinwall raceway of circular cross section designed for the physical protection and routing of conductors and cables and for use as an equipment grounding conductor when installed utilizing appropriate fittings. (CMP-8)

ARTICLE 100 Definitions



Raceway.

An enclosed channel designed expressly for holding wires, cables, or busbars, with additional functions as permitted in this Code. (CMP-8)

Both Conduit and Tubing are considered raceways.

ARTICLE 100 Definitions





Raceway, Surface Metal. (Surface Metal Raceway)

A metal raceway that is intended to be mounted to the surface of a structure, with associated couplings, connectors, boxes, and fittings for the installation of electrical conductors. (CMP-8)

Raceway, Surface Nonmetallic. (Surface Nonmetallic Raceway)

A nonmetallic raceway that is intended to be mounted to the surface of a structure, with associated couplings, connectors, boxes, and fittings for the installation of electrical conductors. (CMP-8)

ARTICLE 100 Definitions



Conductor, Insulated. (Insulated Conductor)

A conductor encased within material of composition and thickness that is recognized by this Code as electrical insulation. (CMP-6)

Article 310.4 has the recognized conductor insulation types.

ARTICLE 100 Definitions



Cable, Armored (Type AC). (Armored Cable)

A fabricated assembly of insulated conductors in a flexible interlocked metallic armor. (CMP-6)

Cable, Metal Clad (Type MC). (Metal Clad Cable)

A factory assembly of one or more insulated circuit conductors with or without optical fiber members enclosed in an armor of interlocking metal tape, or a smooth or corrugated metallic sheath. (CMP-6)

ARTICLE 100 Definitions



Cable, Nonmetallic-Sheathed (Type NM).

Insulated conductors enclosed within an overall nonmetallic jacket. (CMP-6)

Cable, Nonmetallic-Sheathed (Type NMC).

Insulated conductors enclosed within an overall, corrosion resistant, nonmetallic jacket. (CMP-6)

Chapter 9 – Conductor and Cable Fill

Table 1 Percent of Cross Section of Conduit and Tubing for Conductors and Cables	
Number of Conductors and/or Cables	Cross-Sectional Area (%)
1	53
2	31
Over 2	40

Summary: Percent of cross section applies to both conduit and tubing and conductors and cables

Electric League
of Western Pennsylvania

Units of Measurement

ARTICLE 90.9 Units of Measurement

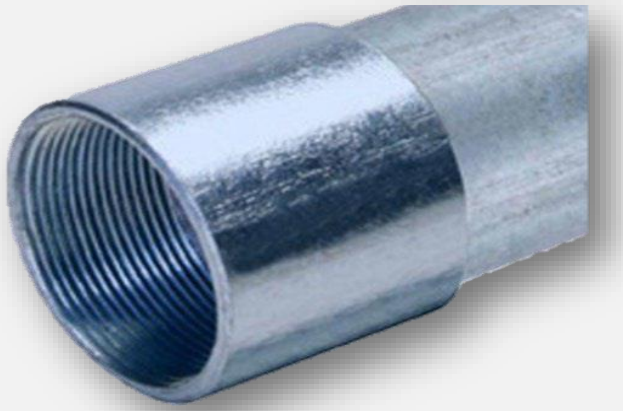
Chapter 8

2” EMT Diameter:

2.067

2” Rigid Steel Diameter:

2.083



90.9 Units of Measurement.

(C) Permitted Uses of Soft Conversion. The cases given in 90.9(C)(1) through (C)(4) shall not be required to use hard conversion and shall be permitted to use soft conversion.

(1) Trade Sizes. Where the actual measured size of a product is not the same as the nominal size, trade size designators shall be used rather than dimensions. **Trade practices shall be followed in all cases.**

(2) Extracted Material (from another standard), (3) Industry Practice, (4) Safety

Chapter 9 - Table 4

Article 358 — Electrical Metallic Tubing (EMT)

Metric Designator	Trade Size	Over 2 Wires 40%		60%		1 Wire 53%		2 Wires 31%		Nominal Internal Diameter		Total Area 100%	
		mm²	in.²	mm²	in.²	mm²	in.²	mm²	in.²	mm	in.	mm²	in.²
16	1/2	78	0.122	118	0.182	104	0.161	61	0.094	15.8	0.622	196	0.304
21	3/4	137	0.213	206	0.320	182	0.283	106	0.165	20.9	0.824	343	0.533
27	1	222	0.346	333	0.519	295	0.458	172	0.268	26.6	1.049	556	0.864
35	1 1/4	387	0.598	581	0.897	513	0.793	300	0.464	35.1	1.380	968	1.496
41	1 1/2	526	0.814	788	1.221	696	1.079	407	0.631	40.9	1.610	1314	2.036
53	2	866	1.342	1299	2.013	1147	1.778	671	1.040	52.5	2.067	2165	3.356
63	2 1/2	1513	2.343	2270	3.515	2005	3.105	1173	1.816	69.4	2.731	3783	5.858
78	3	2280	3.538	3421	5.307	3022	4.688	1767	2.742	85.2	3.356	5701	8.846
91	3 1/2	2980	4.618	4471	6.927	3949	6.119	2310	3.579	97.4	3.834	7451	11.545
103	4	3808	5.901	5712	8.852	5046	7.819	2951	4.573	110.1	4.334	9521	14.753
129	5	5220	8.085	7830	12.127	6916	10.713	4045	6.266	128.9	5.073	13050	20.212
155	6	7528	11.663	11292	17.495	9975	15.454	5834	9.039	154.8	6.093	18821	29

Chapter 9 - Table 4

Article 344 — Rigid Metal Conduit (RMC)

Metric Designator	Trade Size	Over 2 Wires 40%		60%		1 Wire 53%		2 Wires 31%		Nominal Internal Diameter		Total Area 100%	
		mm²	in.²	mm²	in.²	mm²	in.²	mm²	in.²	mm	in.	mm²	in.²
12	3/8	—	—	—	—	—	—	—	—	—	—	—	—
16	1/2	81	0.125	122	0.188	108	0.166	63	0.097	16.1	0.632	204	0.314
21	3/4	141	0.220	212	0.329	187	0.291	109	0.170	21.2	0.836	353	0.549
27	1	229	0.355	344	0.532	303	0.470	177	0.275	27.0	1.063	573	0.887
35	1 1/4	394	0.610	591	0.916	522	0.809	305	0.473	35.4	1.394	984	1.526
41	1 1/2	533	0.829	800	1.243	707	1.098	413	0.642	41.2	1.624	1333	2.071
53	2	879	1.363	1319	2.045	1165	1.806	681	1.056	52.9	2.083	2198	3.408
63	2 1/2	1255	1.946	1882	2.919	1663	2.579	972	1.508	63.2	2.489	3137	4.866
78	3	1936	3.000	2904	4.499	2565	3.974	1500	2.325	78.5	3.090	4840	7.499
91	3 1/2	2584	4.004	3877	6.006	3424	5.305	2003	3.103	90.7	3.570	6461	10.010
103	4	3326	5.153	4990	7.729	4408	6.828	2578	3.994	102.9	4.050	8316	12.882
129	5	5220	8.085	7830	12.127	6916	10.713	4045	6.266	128.9	5.073	13050	20.212
155	6	7528	11.663	11292	17.495	9975	15.454	5834	9.039	154.8	6.093	18821	29.1

Chapter 9 - Table 4

Article 352 — Rigid PVC Conduit (PVC), Schedule 80

Metric Designator	Trade Size	Over 2 Wires 40%		60%		1 Wire 53%		2 Wires 31%		Nominal Internal Diameter		Total Area 100%	
		mm²	in.²	mm²	in.²	mm²	in.²	mm²	in.²	mm	in.	mm²	in.²
12	3/8	—	—	—	—	—	—	—	—	—	—	—	—
16	1/2	56	0.087	85	0.130	75	0.115	44	0.067	13.4	0.526	141	0.217
21	3/4	105	0.164	158	0.246	139	0.217	82	0.127	18.3	0.722	263	0.409
27	1	178	0.275	267	0.413	236	0.365	138	0.213	23.8	0.936	445	0.688
35	1 1/4	320	0.495	480	0.742	424	0.656	248	0.383	31.9	1.255	799	1.237
41	1 1/2	442	0.684	663	1.027	585	0.907	342	0.530	37.5	1.476	1104	1.711
53	2	742	1.150	1113	1.725	983	1.523	575	0.891	48.6	1.913	1855	2.874
63	2 1/2	1064	1.647	1596	2.471	1410	2.183	825	1.277	58.2	2.290	2660	4.119
78	3	1660	2.577	2491	3.865	2200	3.414	1287	1.997	72.7	2.864	4151	6.442
91	3 1/2	2243	3.475	3365	5.213	2972	4.605	1738	2.693	84.5	3.326	5608	8.688
103	4	2907	4.503	4361	6.755	3852	5.967	2253	3.490	96.2	3.786	7268	11.258
129	5	4607	7.142	6911	10.713	6105	9.463	3571	5.535	121.1	4.768	11518	17.855
155	6	6605	10.239	9908	15.359	8752	13.567	5119	7.935	145.0	5.709	16513	2

Chapter 9 – Conductor and Cable Fill

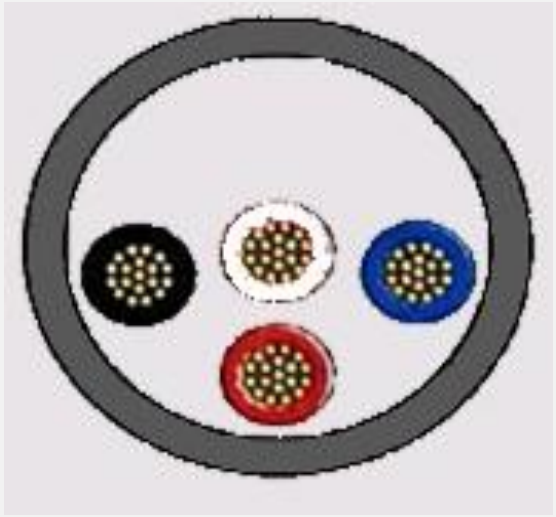
Table 1 Percent of Cross Section of Conduit and Tubing for Conductors and Cables	
Number of Conductors and/or Cables	Cross-Sectional Area (%)
1	53
2	31
Over 2	40

Summary: The fill percentage value is different for the type of raceway you are installing – the conductors might fit in RMC but may not fit in PVC Schedule 80.

Electric League
of Western Pennsylvania

Article 300 – General Wiring Methods

Article 300
General Wiring Methods

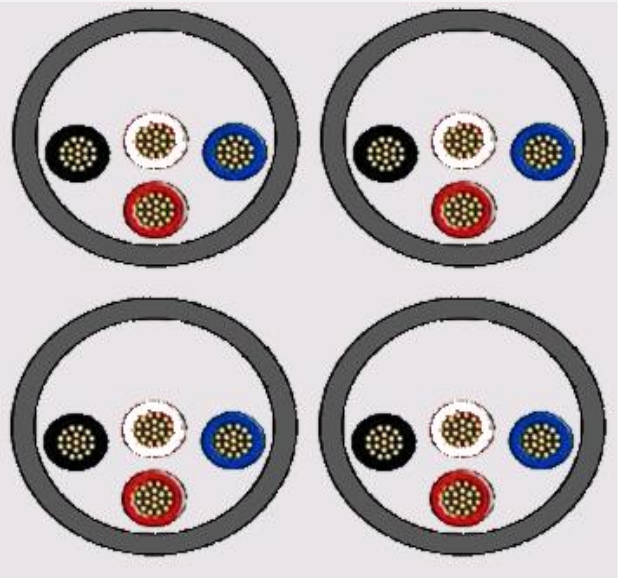


300.3(B) Conductors of the Same Circuit.

All conductors of the same circuit and, where used, the grounded conductor and all equipment grounding conductors and bonding conductors shall be contained within the same raceway, auxiliary gutter, cable tray, cablebus assembly, trench, cable, or cord, unless otherwise permitted in accordance with 300.3(B)(1) through (B)(4).

Per 300.3(B)(2) article 250.130(C) allows grounding conductor outside of the cable for non-grounded receptacle replacement

Article 300
General Wiring Methods



300.3(B)(1) Paralleled Installations.

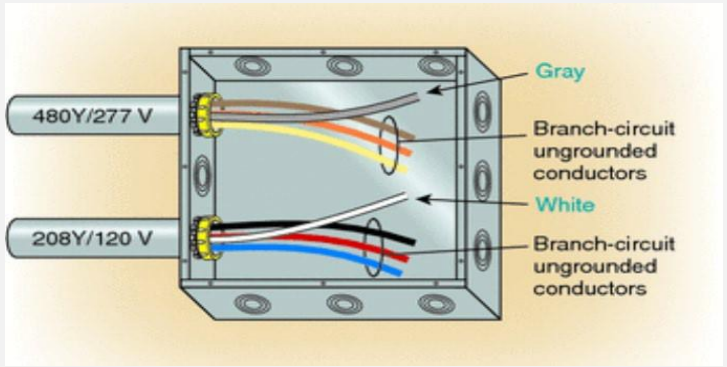
Conductors shall be permitted to be run in parallel in accordance with the provisions of 310.10(G). The requirement to run all circuit conductors within the same raceway, auxiliary gutter, cable tray, trench, cable, or cord shall apply separately to each portion of the paralleled installation, and the equipment grounding conductors shall comply with 250.122. Connections, taps, or extensions made from paralleled conductors shall connect to all conductors of the paralleled set, grounded and ungrounded, as applicable. Parallel runs in cable trays shall comply with 392.20(C).

Article 300
General Wiring Methods

300.3 (C) Conductors of Different Systems.

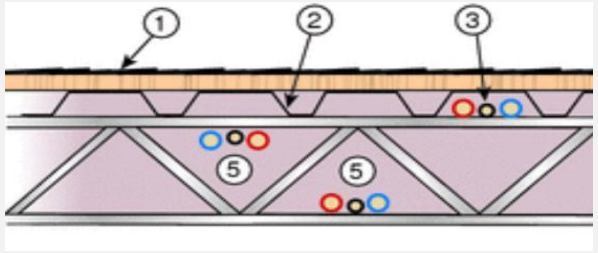
(1) 1000 Volts, Nominal, or Less. Conductors of ac and dc circuits, rated 1000 volts, nominal, or less, **shall be permitted** to occupy the same equipment wiring enclosure, cable, or raceway. All conductors shall have an insulation rating equal to at least the maximum circuit voltage applied to any conductor within the enclosure, cable, or raceway.

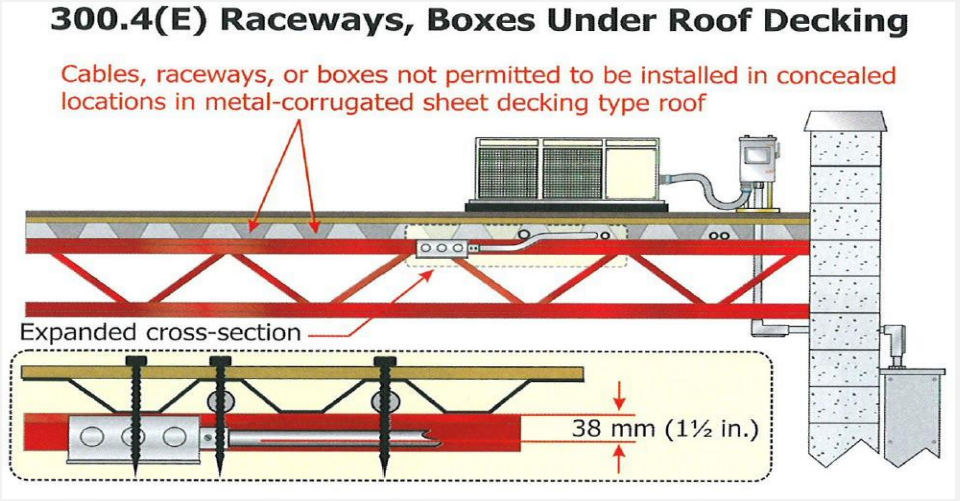
Secondary wiring to electric-discharge lamps of 1000 volts or less, if insulated for the secondary voltage involved, shall be permitted to occupy the same luminaire, sign, or outline lighting enclosure as the branch-circuit conductors.



Informational Note No. 1: See 725.136(A) for Class 2 and Class 3 circuit conductors. (cannot be mixed with power)

Article 300
General Wiring Methods





300.4 Protection Against Physical Damage.

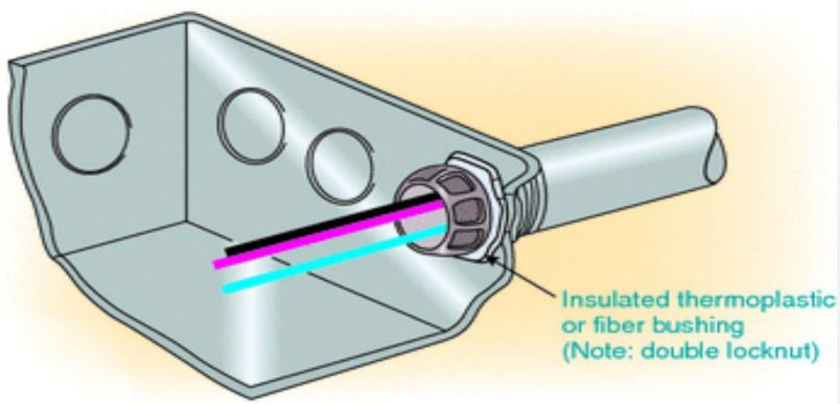
(E) Cables, Raceways, or Boxes Installed in or Under Roof Decking. A cable, raceway, or box, installed in exposed or concealed locations under metal-corrugated sheet roof decking, shall be installed and supported so there is not less than 38 mm (1 1/2 in.) measured from the lowest surface of the roof decking to the top of the cable, raceway, or box. A cable raceway or box shall not be installed in concealed locations in metal-corrugated, sheet decking-type roof.

This is protection from roof repair

Exception: Rigid and IMC conduit

Article 300
General Wiring Methods





300.4(G) Fittings.

Where raceways contain 4 AWG or larger insulated circuit conductors, and these conductors enter a cabinet, a box, an enclosure, or a raceway, the conductors shall be protected in accordance with any of the following:

(1) An identified fitting providing a smoothly rounded insulating surface

(2) A listed metal fitting that has smoothly rounded edges

Article 300
General Wiring Methods





300.4(G) Fittings.

(3) Separation from the fitting or raceway using an identified insulating material that is securely fastened in place

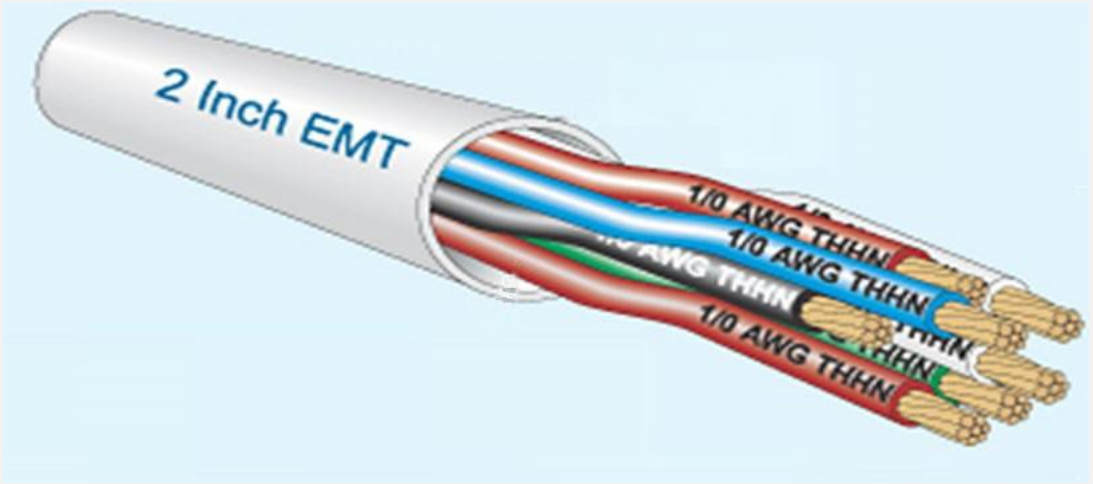
(4) Threaded hubs or bosses that are an integral part of a cabinet, box, enclosure, or raceway providing a smoothly rounded or flared entry for conductors

Conduit bushings constructed wholly of insulating material shall not be used to secure a fitting or raceway. The insulating fitting or insulating material shall have a temperature rating not less than the insulation temperature rating of the installed conductors.

Article 300
General Wiring Methods

Table 1 Percent of Cross Section of Conduit and Tubing for Conductors and Cables

Number of Conductors and/or Cables	Cross-Sectional Area (%)
1	53
2	31
Over 2	40

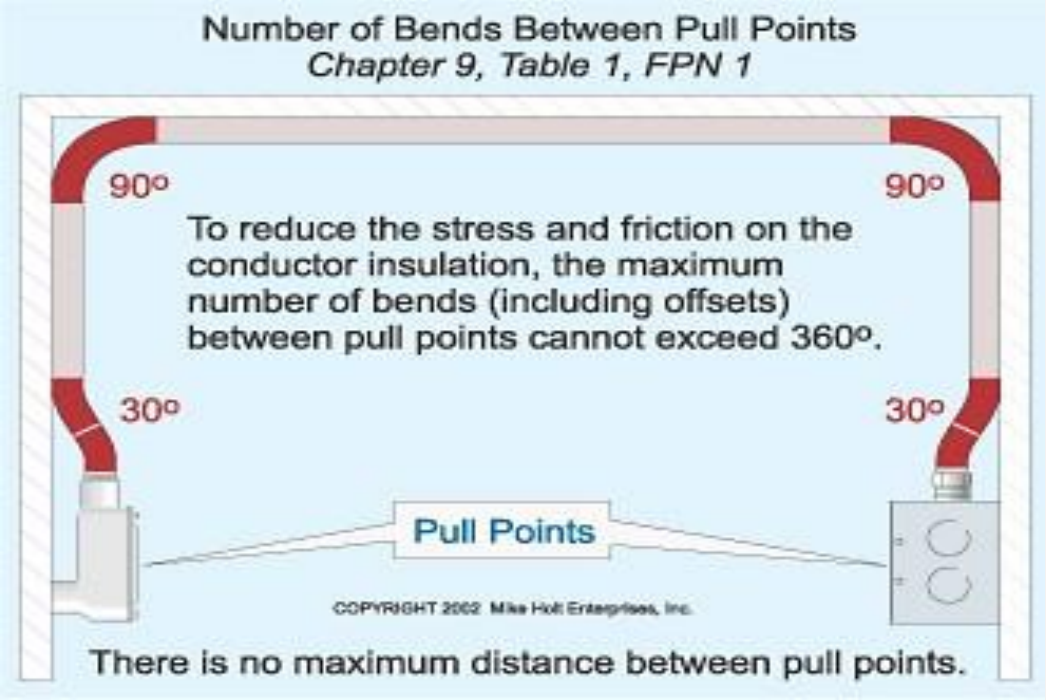


300.17 Number and Size of Conductors in Raceway.

The number and size of conductors in any raceway shall not be more than will permit dissipation of the heat and ready installation or withdrawal of the conductors without damage to the conductors or to their insulation.

Information note points to all the raceway sections which refer to chapter 9 table 1.

Article 300
General Wiring Methods



Conduit nipples less than 24" long can be filled to 60% without de-rating!

Table 9

Informational Note No. 1: Table 1 is based on common conditions of proper cabling and alignment of conductors where the length of the pull and the number of bends are within reasonable limits. It should be recognized that, for certain conditions, a larger size conduit or a lesser conduit fill should be considered.

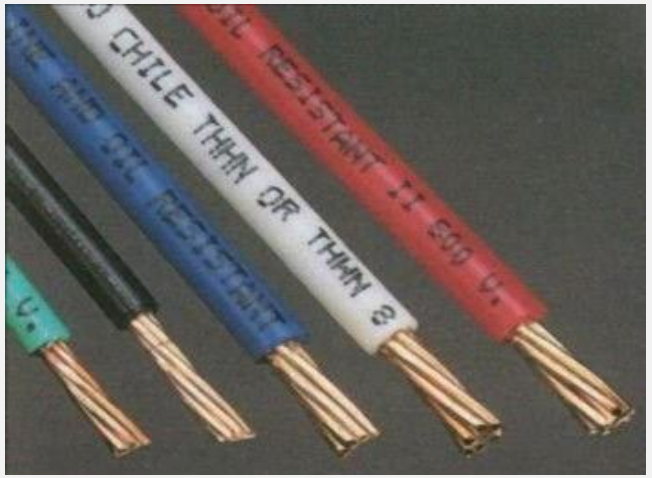
Electric League
of Western Pennsylvania

Article 310
Conductors for General Wiring

Article 310
Conductors for General Wiring

310.3(A) Minimum Size of Conductors.

The minimum size of conductors for voltage ratings up to and including 2000 volts shall be 14 AWG copper or 12 AWG aluminum or copper-clad aluminum, except as permitted elsewhere in this *Code*.



Article 310
Conductors for General Wiring

310.3(B) Conductor Material.

Conductors in this article shall be of aluminum, copper-clad aluminum, or copper unless otherwise specified.

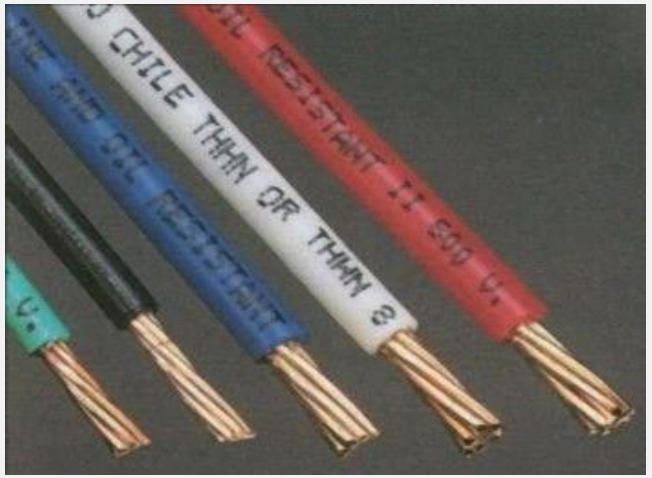


Solid aluminum conductors 8, 10, and 12 AWG shall be made of an **AA-8000** series electrical grade aluminum alloy conductor material. Stranded aluminum conductors 8 AWG through 1000 kcmil marked as Type RHH, RHW, XHHW, THW, THHW, THWN, THHN, service-entrance Type SE Style U, and SE Style R shall be made of an **AA-8000** series electrical grade aluminum alloy conductor material.

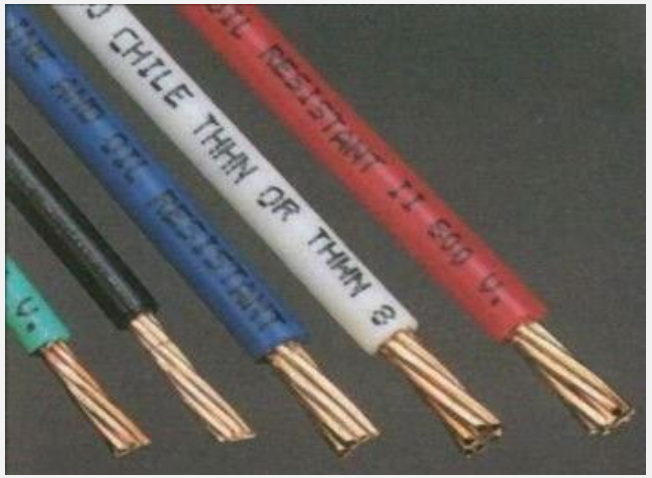
Article 310
Conductors for General Wiring

310.3(C) Stranded Conductors.

Where installed in raceways, conductors 8 AWG and larger shall be stranded, unless specifically permitted or required elsewhere in this *Code* to be solid.



Article 310
Conductors for General Wiring



310.10 Uses Permitted. The conductors described in 310.104 shall be permitted for use in any of the wiring methods covered in Chapter 3 and as specified in their respective tables or as permitted elsewhere in this *Code*.

(A) Dry Locations. Insulated conductors and cables used in dry locations shall be any of the types identified in this *Code*.

(B) Dry and Damp Locations. Insulated conductors and cables used in dry and damp locations shall be Types FEP, FEPB, MTW, PFA, RHH, RHW, RHW-2, SA, THHN, THW, THW-2, THHW, THWN, THWN-2, TW, XHH, XHHW, XHHW-2, XHHN, XHWN, XHWN-2, Z, or ZW.

Article 310
Conductors for General Wiring

310.10 Uses Permitted.

(C) Wet Locations. Insulated conductors and cables used in wet locations shall comply with one of the following:

(1) Be moisture-impervious metal-sheathed

(2)Be types MTW, RHW, RHW-2, TW, THW, THW-2, THHW, THWN, THWN-2, XHHW, XHHW-2, XHWN, XHWN-2 or ZW

(3) Be of a type listed for use in wet locations



Article 310
Conductors for General Wiring

310.10 Uses Permitted.

(D) Locations Exposed to Direct Sunlight. Insulated conductors or cables used where exposed to direct rays of the sun shall comply with (D)(1) or (D)(2):

(1) Conductors and cables shall be listed, or listed and marked, as being sunlight resistant

(2) Conductors and cables shall be covered with insulating material, such as tape or sleeving, that is listed, or listed and marked, as being sunlight resistant



Article 310
Conductors for General Wiring

310.10 (G) Conductors in Parallel. Aluminum, copper-clad aluminum, or copper conductors, for each phase, polarity, neutral, or grounded circuit shall be permitted to be connected in parallel (electrically joined at both ends) only in sizes **1/0 AWG and larger** where installed in accordance with 310.10(G)(2) through (G)(6).

RULES:

(1) Be the same length

(2) Same conductor material

(3) Be the same size in circular mil area

(4) Have the same insulation type

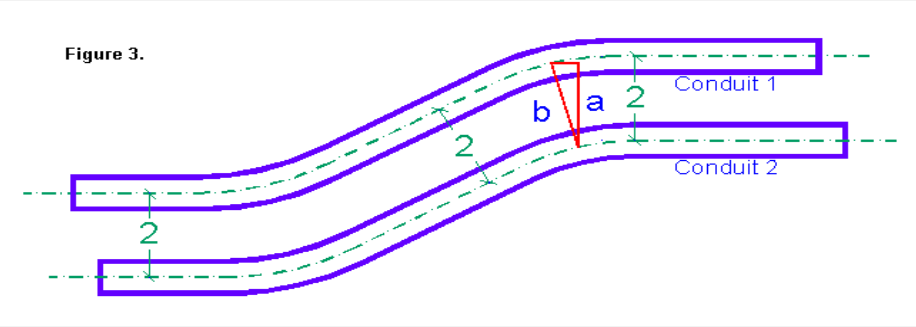
(5) Be terminated in the same manner

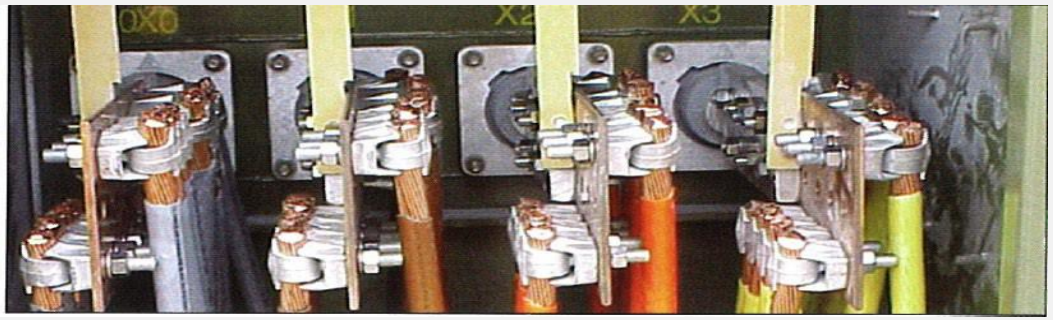
(G)(3): Same number of conductors in each conduit

(G)(4): Derate if Needed

(G)(5): Grounding conductor per 250.122

(G)(6): Bonding conductor per 250.102





Electric League
of Western Pennsylvania

Article 310
Conductor Ampacity

Article 310
Conductors for General Wiring

Table 310.15(B)(2)(a) Ambient Temperature Correction Factors Based on 30°C (86°F)

For ambient temperatures other than 30°C (86°F), multiply the allowable ampacities specified in the ampacity tables by the appropriate correction factor shown below.

Ambient Temperature (°C)	Temperature Rating of Conductor			Ambient Temperature (°F)
	60°C	75°C	90°C	
10 or less	1.29	1.20	1.15	50 or less
11–15	1.22	1.15	1.12	51–59
16–20	1.15	1.11	1.08	60–68
21–25	1.08	1.05	1.04	69–77
26–30	1.00	1.00	1.00	78–86
31–35	0.91	0.94	0.96	87–95
36–40	0.82	0.88	0.91	96–104
41–45	0.71	0.82	0.87	105–113
46–50	0.58	0.75	0.82	114–122
51–55	0.41	0.67	0.76	123–131
56–60	—	0.58	0.71	132–140
61–65	—	0.47	0.65	141–149
66–70	—	0.33	0.58	150–158
71–75	—	—	0.50	159–167
76–80	—	—	0.41	168–176
81–85	—	—	0.29	177–185

310.14(A)(3) Temperature Limitation of Conductors.

No conductor shall be used in such a manner that its operating temperature exceeds that designated for the type of insulated conductor involved. In no case shall conductors be associated together in such a way, with respect to type of circuit, the wiring method employed, or the number of conductors, that the limiting temperature of any conductor is exceeded.

Note: This is the Temperature anywhere along the length

Article 310
Conductors for General Wiring

Size AWG or kcmil	Temperature Rating of Conductor			
	60°C (140°F)	75°C (167°F)	90°C (194°F)	(
	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, USE, ZW	Types TBS, SA, SIS, FEP, FEPB, MI, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, ZW-2	Ty
	COPPER			
18**	—	—	14	
16**	—	—	18	
14**	15	20	25	
12**	20	25	30	
10**	30	35	40	
8	40	50	55	
6	55	65	75	
4	70	85	95	
3	85	100	115	
2	95	115	130	
1	110	130	145	

310.15(A) General.

Ampacities for conductors rated 0 volts to 2000 volts shall be as specified in the Ampacity Table 310.16 through Table 310.21, as modified by 310.15(A) through (F) and 310.12. Under engineering supervision, ampacities of sizes not shown in ampacity tables for conductors meeting the general wiring requirements shall be permitted to be determined by interpolation of the adjacent conductors based on the conductor's area.

Article 310
Conductors for General Wiring

60°C (140°F)	75°C (167°F)	90°C (194°F)
Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, XHWN, USE, ZW	Types TBS, SA, SIS, FEP, FEPB, MI, PFA, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN, Z, ZW-2
COPPER		
18*	—	—
16*	—	—
14*	15	20
12*	20	25
10*	30	35
8	40	50
6	55	65
4	70	85
3	85	100
2	95	115
1	110	130
1/0	125	150
2/0	145	175
3/0	165	200
4/0	195	230

310.15(A) General.

The temperature correction and adjustment factors shall be permitted to be applied to the ampacity for the temperature rating of the conductor, if the corrected and adjusted ampacity does not exceed the ampacity for the temperature rating of the termination in accordance with the provisions of **110.14(C).**

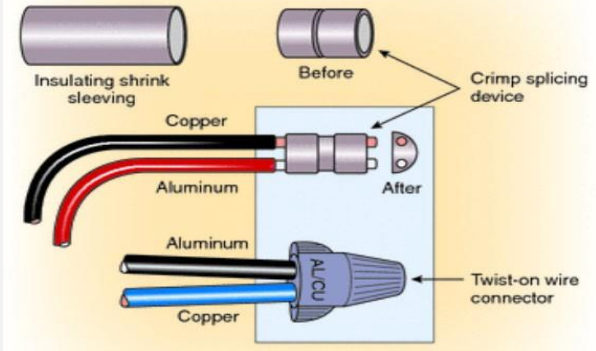


Electric League
of Western Pennsylvania

Article 110.14 – Lug Temperature Limitations

ARTICLE 110 Requirements for Electrical Installations

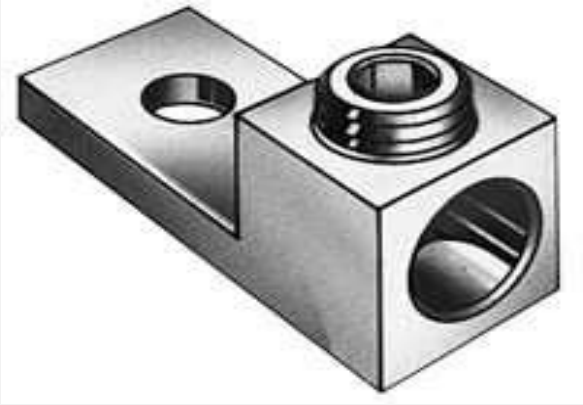


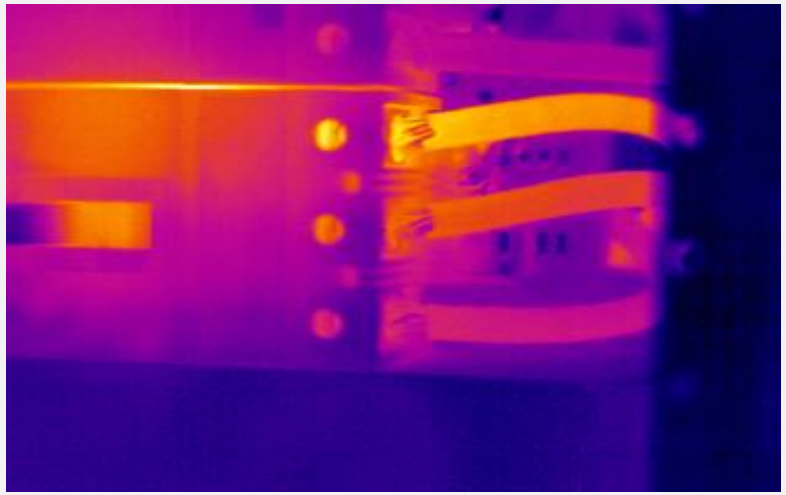


110.14 Electrical Connections.

Because of different characteristics of dissimilar metals, devices such as pressure terminal or pressure splicing connectors and soldering lugs shall be identified for the material of the conductor and shall be properly installed and used. Conductors of dissimilar metals shall not be intermixed in a terminal or splicing connector where physical contact occurs between dissimilar conductors (such as copper and aluminum, copper and copper-clad aluminum, or aluminum and copper-clad aluminum), unless the device is identified for the purpose and conditions of use

ARTICLE 110 Requirements for Electrical Installations



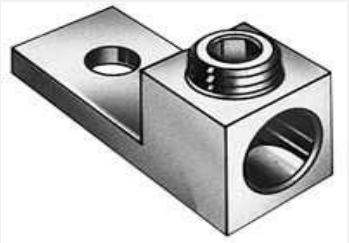


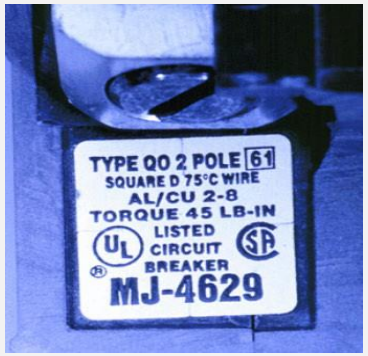
110.14 Electrical Connections.

(C) Temperature Limitations.

The temperature rating associated with the ampacity of a conductor shall be selected and coordinated so as not to exceed the lowest temperature rating of any connected termination, conductor, or device. Conductors with temperature ratings higher than specified for terminations shall be permitted to be used for ampacity adjustment, correction, or both.

ARTICLE 110 Requirements for Electrical Installations





110.14(C)(1) Electrical Connections.

(1) Equipment Provisions. The determination of termination provisions of equipment shall be based on 110.14(C)(1)(a) or (C)(1)(b). Unless the **equipment** is listed and marked otherwise, conductor ampacities used in determining equipment termination provisions shall be based on Table 310.16 as appropriately modified by 310.12.

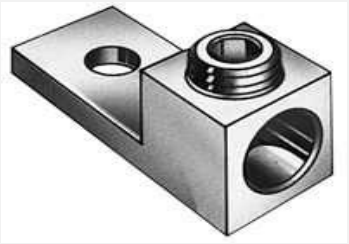
(a) Termination provisions of equipment for circuits rated 100 amperes or less, or marked for 14 AWG through 1 AWG conductors:

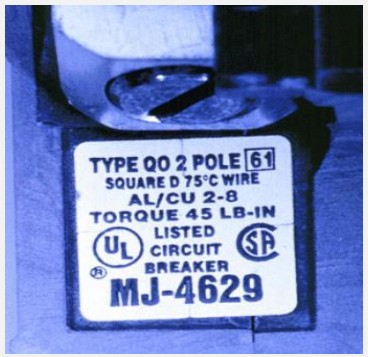
(1) Conductors rated 60°C (140°F)

(2) Conductors with higher temperature ratings provided the ampacity of such is determined based on the 60°C (140°F) ampacity of the conductor size used.

ARTICLE 110 Requirements for Electrical Installations

110.14(C)(1) Electrical Connections (Con't)





(b) Termination provisions of equipment for circuits rated over 100 amperes, or marked for conductors larger than 1 AWG, shall be used only for one of the following:

(1) Conductors rated 75°C (167°F)

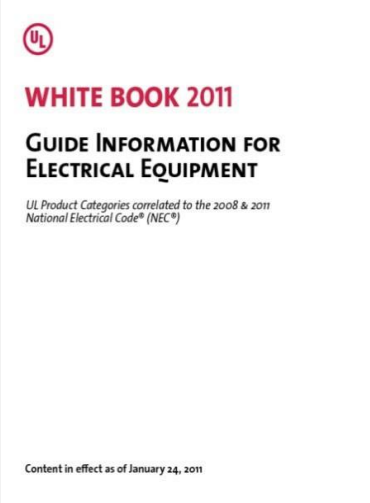
(2) Conductors with higher temperature ratings provided the ampacity of such conductors does not exceed the 75°C (167°F) ampacity of the conductor size used, or up to their ampacity if the equipment is listed and identified for use with such conductors.

ARTICLE 110 Requirements for Electrical Installations

110.14(C)(2) Separate Connector Provisions. Separately installed pressure connectors shall be used with conductors at the ampacities not exceeding the ampacity at the listed and identified temperature rating of the connector.



ARTICLE 110 Requirements for Electrical Installations



Be careful! UL White Book General Information on electrical equipment directory says:

A 75°C conductor temperature marking on a circuit breaker or switch normally intended for wire sizes 14-1 AWG does not in itself indicate that 75°C insulated wire can be used unless:

1) the circuit breaker or switch is used by itself, such as in a separate enclosure, or

2) the equipment in which the circuit breaker or switch is installed is also so marked.

ARTICLE 110 Requirements for Electrical Installations

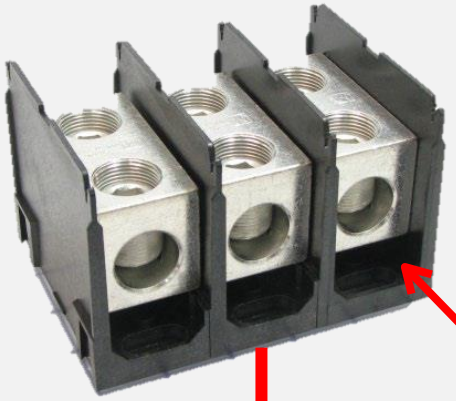


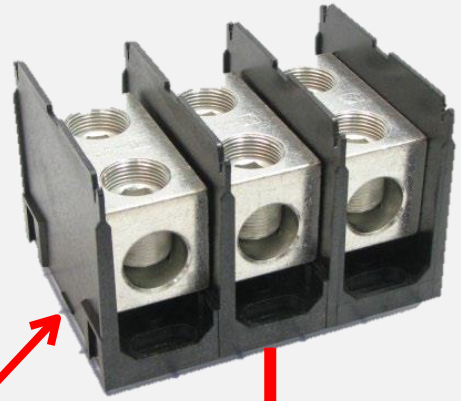
(Continued) …. UL White Book General Information on electrical equipment directory says:

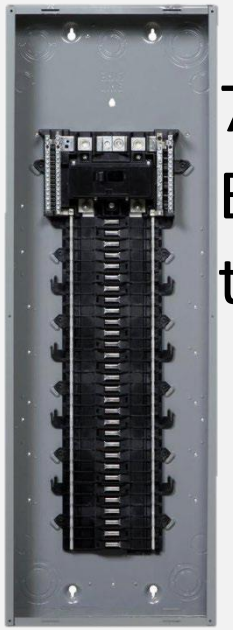
A 75 or 90°C temperature marking on a terminal does not in itself indicate that 75 or 90°C insulated wire can be used unless the equipment in which the terminals are installed is marked for 75 or 90°C.

ARTICLE 110 Requirements for Electrical Installations









90°C
Wire

75°C
Wire

75°C
Wire

90°C
Equipment
termination

75°C
Equipment
termination

75°C
Equipment
termination

ARTICLE 110 Requirements for Electrical Installations

When can I use the 90 degree C column for wiring?



When applying **de-rating factors** for either higher ambient temperature (over 86°F, 30°C)

or

Where more than 3 current carrying conductors are installed in a raceway.

Always begin de-rating using the highest ampacity column in Table 310.16 corresponding to the conductor's insulation temperature rating. Then follow the limitations for the terminations.

Electric League
of Western Pennsylvania

Chapter 2 – The round up rule

Article 240
Overcurrent Protection





240.4 Protection of Conductors.

(B) Overcurrent Devices Rated 800 Amperes or Less. The **next higher standard overcurrent** device rating (above the ampacity of the conductors being protected) shall be permitted to be used, provided all of the following conditions are met:

(1) Not part of a multioutlet branch circuit supplying receptacles

(2) The ampacity of the conductors does not correspond with the standard ampere rating of a fuse or a circuit breaker

(3) The next higher standard rating selected does not exceed 800 amperes. (Art. 240.6)

Article 240
Overcurrent Protection

Table 240.6(A) Standard Ampere Ratings (A) Fuses and Fixed-Trip Circuit Breakers. The standard ampere ratings for fuses and inverse time circuit breakers shall be considered as shown in Table 240.6(A). Additional standard ampere ratings for fuses shall be 1, 3, 6, 10, and 601. The use of fuses and inverse time circuit breakers with nonstandard ampere ratings shall be permitted.





Standard Ampere Ratings				
15	20	25	30	35
40	45	50	60	70
80	90	100	110	125
150	175	200	225	250
300	350	400	450	500
600	700	800	1000	1200
1600	2000	2500	3000	400
5000	6000	—	—	—

Article 240
Overcurrent Protection

240.4 Protection of Conductors.

(C) Overcurrent Devices Rated Over 800 Amperes. Where the overcurrent device is rated over 800 amperes, the ampacity of the conductors it protects shall be equal to or greater than the rating of the overcurrent device defined in 240.6.

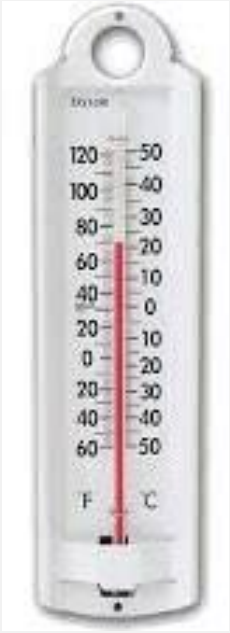


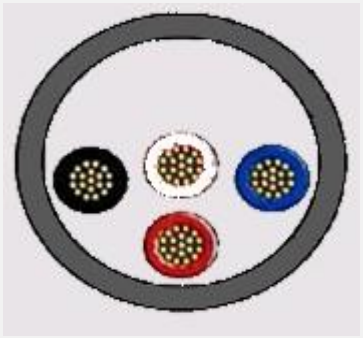


Electric League
of Western Pennsylvania

Now back to Table 310.16…

Article 310
Conductors for General Wiring





310.16 Ampacities of Insulated Conductors in Raceway, Cable, or Earth (Directly Buried).

The ampacities shall be as specified in Table 310.16 where all of the following conditions apply:

(1) Conductors are rated 0 volts through 2000 volts.

(2)Conductors are rated 60°C (140°F), 75°C (167°F), or 90°C (194°F).

(3) Wiring is installed in a 30°C (86°F) ambient temperature.

(4) There are not more than three current-carrying conductors.

Table 310.16 Ampacities of Insulated Conductors with Not More Than Three Current-Carrying Conductors in Raceway, Cable, or Earth (Directly Buried)

Size AWG or kcmil	Temperature Rating of Conductor [See Table 310.4(1)]						Size AWG or kcmil
	60°C (140°F)	75°C (167°F)	90°C (194°F)	60°C (140°F)	75°C (167°F)	90°C (194°F)	
	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, XHWN, USE, ZW	Types TBS, SA, SIS, FEP, FEPB, MI, PFA, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN, Z, ZW-2	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, XHWN, USE	Types TBS, SA, SIS, THHN, THHW, THW-2, THWN-2, RHH, RHW-2, USE-2, XHH, XHHW, XHHW-2, XHWN, XHWN-2, XHHN	
	COPPER			ALUMINUM OR COPPER-CLAD ALUMINUM			
18*	—	—	14	—	—	—	—
16*	—	—	18	—	—	—	—
14*	15	20	25	—	—	—	—
12*	20	25	30	15	20	25	12*
10*	30	35	40	25	30	35	10*
8	40	50	55	35	40	45	8
6	55	65	75	40	50	55	6
4	70	85	95	55	65	75	4
3	85	100	115	65	75	85	3
2	95	115	130	75	90	100	2
1	110	130	145	85	100	115	1
1/0	125	150	170	100	120	135	1/0
2/0	145	175	195	115	135	150	2/0
3/0	165	200	225	130	155	175	3/0
4/0	195	230	260	150	180	205	4/0
250	215	255	290	170	205	230	250
300	240	285	320	195	230	260	300
350	260	310	350	210	250	280	350
400	280	335	380	225	270	305	400
500	320	380	430	260	310	350	500
600	350	420	475	285	340	385	600
700	385	460	520	315	375	425	700

1108

Article 310
Conductors for General Wiring

310.15(B) Ambient Temperature Correction Factors.

310.15(B)(1) General.

Ampacities for ambient temperatures other than those shown in the ampacity tables shall be corrected in accordance with Table 310.15(B)(1)(1) or Table 310.15(B)(1)(2), or shall be permitted to be calculated using Equation 310.15(B)(1).

$$I' = I\sqrt{\frac{T_c - T_a'}{T_c - T_a}}$$

Where:

I' ampacity corrected for ambient temperature

I ampacity shown in the tables

T_c temperature rating of conductor (°C)

T_a' new ambient temperature (°C)

T_a ambient temperature used in the table (°C)

Article 310
Conductors for General Wiring

Note: Table 310.15(B)(1)(1) shall be used with Table 310.16 and Table 310.17 (free air) as required.

Table 310.15(B)(1)(1) Ambient Temperature Correction Factors Based on 30°C (86°F)

For ambient temperatures other than 30°C (86°F), multiply the ampacities specified in the ampacity tables by the appropriate correction factor shown below.

Ambient Temperature (°C)	Temperature Rating of Conductor			Ambient Temperature (°F)
	60°C	75°C	90°C	
10 or less	1.29	1.20	1.15	50 or less
11–15	1.22	1.15	1.12	51–59
16–20	1.15	1.11	1.08	60–68
21–25	1.08	1.05	1.04	69–77
26–30	1.00	1.00	1.00	78–86
31–35	0.91	0.94	0.96	87–95
36–40	0.82	0.88	0.91	96–104
41–45	0.71	0.82	0.87	105–113
46–50	0.58	0.75	0.82	114–122
51–55	0.41	0.67	0.76	123–131
56–60	—	0.58	0.71	132–140
61–65	—	0.47	0.65	141–149
66–70	—	0.33	0.58	150–158
71–75	—	—	0.50	159–167
76–80	—	—	0.41	168–176
81–85	—	—	0.29	177–185

Article 310

Conductors for General Wiring

Note: Table 310.15(B)(1)(2) shall be used with Table 310.18, Table 310.19, Table 310.20, and Table 310.21 as required. (Type Z, FEP, TFE insulations or THHN conductors on a messenger or bare conductors in free air)

Table 310.15(B)(1)(2) Ambient Temperature Correction Factors Based on 40ºC (104ºF)

For ambient temperatures other than 40°C (104°F), multiply the ampacities specified in the ampacity tables by the appropriate correction factor shown below.

Ambient Temperature (°C)	Temperature Rating of Conductor						Ambient Temperature (ºF)
	60°C	75°C	90°C	150°C	200°C	250°C	
10 or less	1.58	1.36	1.26	1.13	1.09	1.07	50 or less
11–15	1.50	1.31	1.22	1.11	1.08	1.06	51–59
16–20	1.41	1.25	1.18	1.09	1.06	1.05	60–68
21–25	1.32	1.2	1.14	1.07	1.05	1.04	69–77
26–30	1.22	1.13	1.10	1.04	1.03	1.02	78–86
31–35	1.12	1.07	1.05	1.02	1.02	1.01	87–95
36–40	1.00	1.00	1.00	1.00	1.00	1.00	96–104
41–45	0.87	0.93	0.95	0.98	0.98	0.99	105–113
46–50	0.71	0.85	0.89	0.95	0.97	0.98	114–122
51–55	0.50	0.76	0.84	0.93	0.95	0.96	123–131
56–60	—	0.65	0.77	0.90	0.94	0.95	132–140
61–65	—	0.53	0.71	0.88	0.92	0.94	141–149
66–70	—	0.38	0.63	0.85	0.90	0.93	150–158
71–75	—	—	0.55	0.83	0.88	0.91	159–167
76–80	—	—	0.45	0.80	0.87	0.90	168–176
81–90	—	—	—	0.74	0.83	0.87	177–194
91–100	—	—	—	0.67	0.79	0.85	195–212
101–110	—	—	—	0.60	0.75	0.82	213–230
111–120	—	—	—	0.52	0.71	0.79	231–248
121–130	—	—	—	0.43	0.66	0.76	249–266
131–140	—	—	—	0.30	0.61	0.72	267–284

Article 310
Conductors for General Wiring

Note: Always use the actual wire insulation rating when derating (not the lug temperature).

Example: a 12 AWG wire insulated with 90 deg C insulation can carry 30 amps according to 310.16, so if this 12 AWG wire was placed in a 120 degree ambient temperature with a .82 derating factor, it would be able to carry 30 amps x .82 = 24.6 amps

Article 310
Conductors for General Wiring





310.15(B)(2) Rooftop.

For raceways or cables exposed to direct sunlight on or above rooftops where the distance above the roof to the bottom of the raceway or cable is less than 23 mm ($^{7}/_{8}$ in.), a **temperature adder of 33°C (60°F)** shall be added to the outdoor temperature to determine the applicable ambient temperature for application of the correction factors in Table 310.15(B)(1) or Table 310.15(B)(2).

Exception: Type XHHW-2 insulated conductors shall not be subject to this ampacity adjustment.

Article 310
Conductors for General Wiring

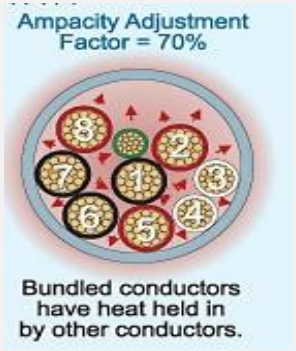


Table 310.15(C)(1) Adjustment Factors for More Than Three Current-Carrying Conductors

Number of Conductors*	Percent of Values in Table 310.16 Through Table 310.19 as Adjusted for Ambient Temperature if Necessary
4–6	80
7–9	70
10–20	50
21–30	45
31–40	40
41 and above	35

310.15(C)(1) More than Three Current-Carrying Conductors.

The ampacity of each conductor shall be reduced as shown in Table 310.15(C)(1) where the number of current-carrying conductors in a raceway or cable exceeds three, or where single conductors or multiconductor cables not installed in raceways are installed without maintaining spacing for a continuous length longer than 600 mm (24 in.). Each current-carrying conductor of a paralleled set of conductors shall be counted as a current-carrying conductor.

Article 310
Conductors for General Wiring



310.15(C)(1) More than Three Current-Carrying Conductors.

(a) Where conductors are installed in cable trays, the provisions of 392.80 shall apply.

(b) Adjustment factors shall not apply to conductors in raceways having a length not exceeding 600 mm (24 in.).

(c) Adjustment factors shall not apply to underground conductors entering or leaving an outdoor trench if those conductors have physical protection in the form of rigid metal conduit, intermediate metal conduit, rigid polyvinyl chloride conduit (PVC), or reinforced thermosetting resin conduit (RTRC) having a length not exceeding 3.05 m (10 ft), and if the number of conductors does not exceed four.

Article 310
Conductors for General Wiring



310.15(C)(1) More than Three Current-Carrying Conductors.

(d) Adjustment factors shall not apply to Type AC cable or to Type MC cable under the following conditions:

(1) The cables do not have an overall outer jacket.

(2) Each cable has not more than three current-carrying conductors.

(3) The conductors are 12 AWG copper.

(4) Not more than 20 current-carrying conductors are installed without maintaining spacing, are stacked, or are supported on “bridle rings.”

Chapter 3 – Article 310 Conductors for General Wiring



310.15(E) Neutral Conductor.

Neutral conductors shall be considered current carrying in accordance with any of the following:

(1) A neutral conductor that carries only the unbalanced current from other conductors of the same circuit shall not be required to be counted when applying the provisions of 310.15(C)(1).

(2) In a 3-wire circuit consisting of two phase conductors and the neutral conductor of a 4-wire, 3-phase, wye-connected system, a common conductor carries approximately the same current as the line-to-neutral load currents of the other conductors and shall be counted when applying the provisions of 310.15(C)(1).

(3) On a 4-wire, 3-phase wye circuit where the major portion of the load consists of nonlinear loads, harmonic currents are present in the neutral conductor; the neutral conductor shall therefore be considered a current-carrying conductor.

Chapter 3 – Article 310 Conductors for General Wiring



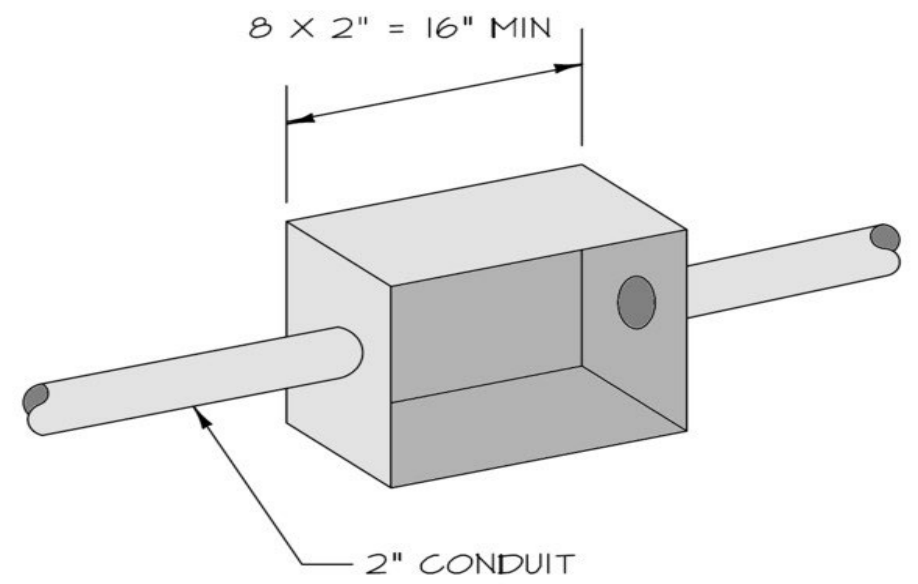
310.15(F) Grounding or Bonding Conductor.

A grounding or bonding conductor shall not be counted when applying the provisions of 310.15(C)(1).

Electric League
of Western Pennsylvania

Article 314 Pull Boxes

Article 314
Pull and Junction Boxes

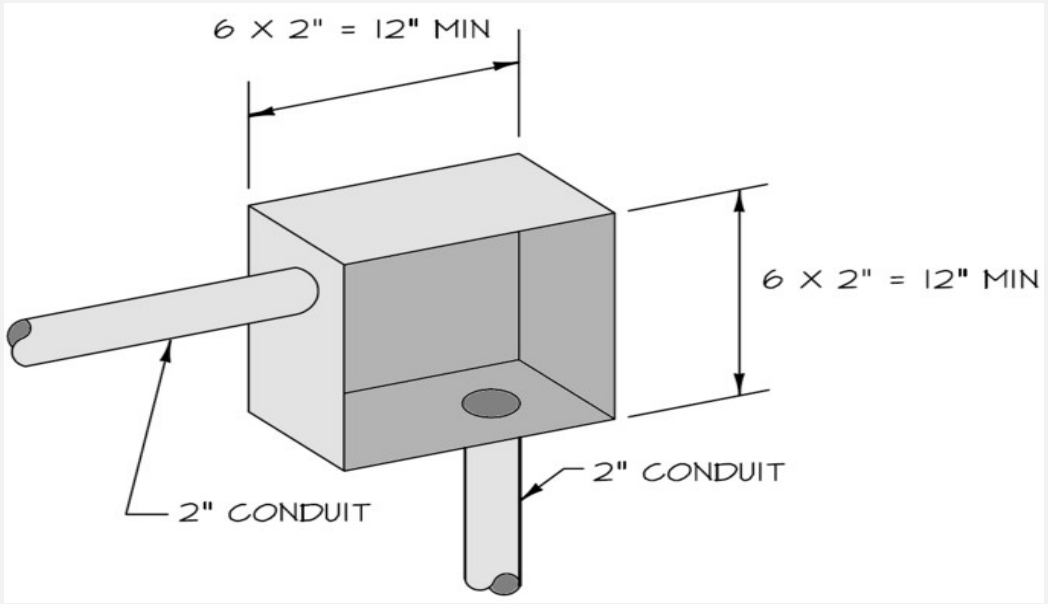


314.28 Pull and Junction Boxes and Conduit Bodies. Boxes and conduit bodies used as pull or junction boxes containing conductors 4 AWG or larger shall comply with the following:

(A) Minimum Size.

(1) Straight Pulls. In straight pulls, the length of the box shall not be less than **eight times** the metric designator (trade size) of the largest raceway.

Article 314
Pull and Junction Boxes



314.28 Pull and Junction Boxes and Conduit Bodies. (A)(2) Angle or U Pulls. Where splices or where angle or U pulls are made, the distance between each raceway entry inside the box and the opposite wall of the box shall not be less than **six times** the metric designator (trade size) of the largest raceway in a row.

Exception for removable wall must comply with conductor deflection table

Article 314
Pull and Junction Boxes

314.28 Pull and Junction Boxes and Conduit Bodies. This distance shall be increased for additional entries by the amount of the sum of the diameters of all other raceway entries in the same row on the same wall of the box. Each row shall be calculated individually, and the single row that provides the maximum distance shall be used.

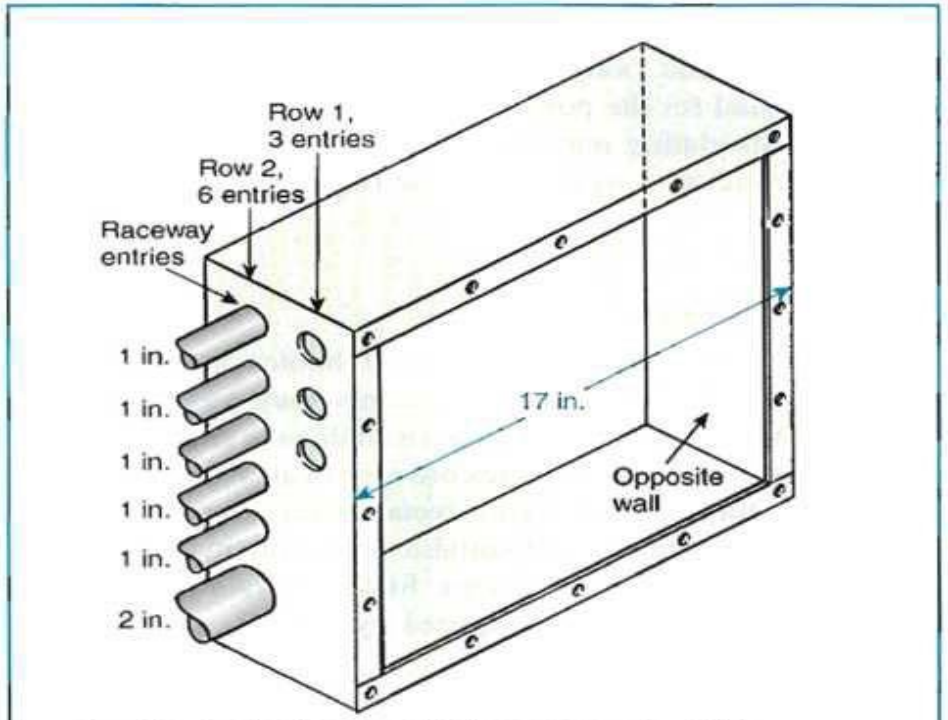


Exhibit 314.10 An example showing calculations required by 314.28(A)(2) for splices, angle pulls, or U pulls.

Article 314
Pull and Junction Boxes

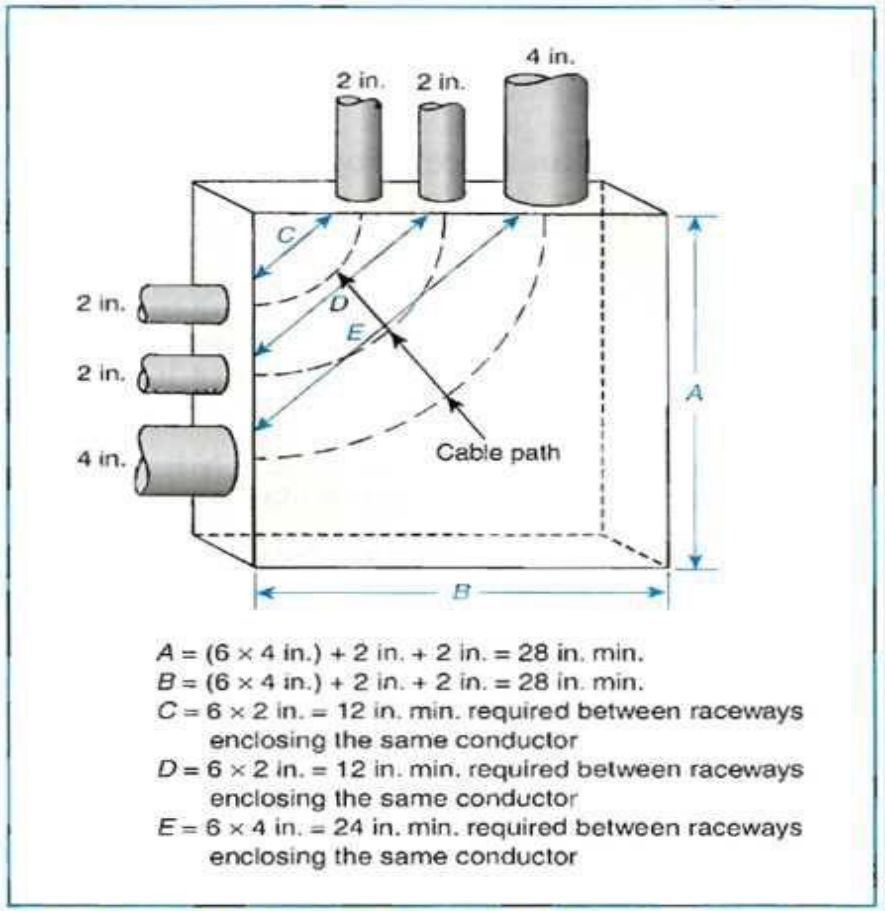


Exhibit 314.11 An example showing calculations required by 314.28(A)(2) for raceways enclosing the same conductor.

314.28 Pull and Junction Boxes and Conduit Bodies.

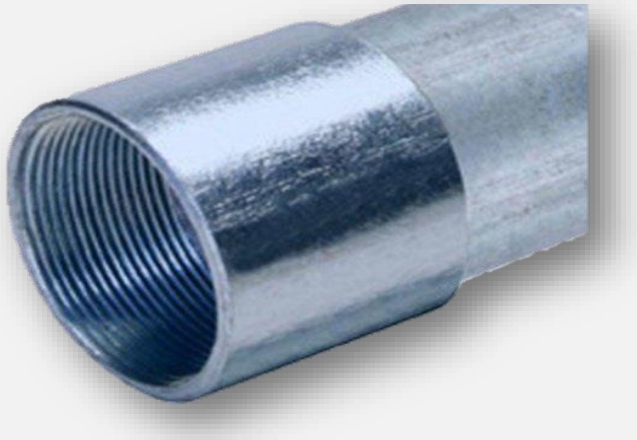
(2) Angle or U Pulls, or Splices.

The distance between raceway entries enclosing the same conductor shall not be less than six times the metric designator (trade size) of the larger raceway.

Electric League
of Western Pennsylvania

Conduit and Tubing Fill Calculations

ARTICLE 342
Intermediate Metal Conduit (IMC)



342.22 Number of Conductors.

The number of conductors shall not exceed that permitted by the percentage fill specified in Table 1, Chapter 9.

Cables shall be permitted to be installed where such use is not prohibited by the respective cable articles. The number of cables shall not exceed the allowable percentage fill specified in Table 1, Chapter 9.

ARTICLE 344
Rigid Metal Conduit (RMC)



344.22 Number of Conductors.

The number of conductors shall not exceed that permitted by the percentage fill specified in Table 1, Chapter 9.

Cables shall be permitted to be installed where such use is not prohibited by the respective cable articles. The number of cables shall not exceed the allowable percentage fill specified in Table 1, Chapter 9.

ARTICLE 348
Flexible Metal Conduit (FMC)



348.22 Number of Conductors.

The number of conductors shall not exceed that permitted by the percentage fill specified in Table 1, Chapter 9, or as permitted in Table 348.22, or for metric designator 12 (trade size 3⁄ 8).

Cables shall be permitted to be installed where such use is not prohibited by the respective cable articles. The number of cables shall not exceed the allowable percentage fill specified in Table 1, Chapter 9.

ARTICLE 348
Flexible Metal Conduit (FMC)

Table 348.22 Maximum Number of Insulated Conductors in Metric Designator 12 (Trade Size 3⁄8) Flexible Metal Conduit (FMC)*

Size (AWG)	Types RFH-2, SF-2		Types TF, XHHW, TW		Types TFN, THHN, THWN		Types FEP, FEBP, PF, PGF	
	Fittings Inside Conduit	Fittings Outside Conduit	Fittings Inside Conduit	Fittings Outside Conduit	Fittings Inside Conduit	Fittings Outside Conduit	Fittings Inside Conduit	Fittings Outside Conduit
18	2	3	3	5	5	8	5	8
16	1	2	3	4	4	6	4	6
14	1	2	2	3	3	4	3	4
12	—	—	1	2	2	3	2	3
10	—	—	1	1	1	1	1	2

ARTICLE 350
Flexible Liquidtite Metal Conduit (FLMC)



348.22 Number of Conductors.

The number of conductors shall not exceed that permitted by the percentage fill specified in Table 1, Chapter 9, or as permitted in Table 348.22, or for metric designator 12 (trade size 3⁄ 8).

Cables shall be permitted to be installed where such use is not prohibited by the respective cable articles. The number of cables shall not exceed the allowable percentage fill specified in Table 1, Chapter 9.

ARTICLE 348
Flexible Liquidtite Metal Conduit (FLMC)

Table 348.22 Maximum Number of Insulated Conductors in Metric Designator 12 (Trade Size 3⁄8) Flexible Metal Conduit (FMC)*

Size (AWG)	Types RFH-2, SF-2		Types TF, XHHW, TW		Types TFN, THHN, THWN		Types FEP, FEBP, PF, PGF	
	Fittings Inside Conduit	Fittings Outside Conduit	Fittings Inside Conduit	Fittings Outside Conduit	Fittings Inside Conduit	Fittings Outside Conduit	Fittings Inside Conduit	Fittings Outside Conduit
18	2	3	3	5	5	8	5	8
16	1	2	3	4	4	6	4	6
14	1	2	2	3	3	4	3	4
12	—	—	1	2	2	3	2	3
10	—	—	1	1	1	1	1	2

ARTICLE 352
Rigid Polyvinyl Chloride Conduit (PVC)



352.22 Number of Conductors.

The number of conductors shall not exceed that permitted by the percentage fill specified in Table 1, Chapter 9.

Cables shall be permitted to be installed where such use is not prohibited by the respective cable articles. The number of cables shall not exceed the allowable percentage fill specified in Table 1, Chapter 9.

Chapter 9 – Table 1

Table 1 Percent of Cross Section of Conduit and Tubing for Conductors and Cables	
Number of Conductors and/or Cables	Cross-Sectional Area (%)
1	53
2	31
Over 2	40

Informational Note No. 1: Table 1 is based on common conditions of proper cabling and alignment of conductors where the length of the pull and the number of bends are within reasonable limits. It should be recognized that, for certain conditions, a larger size conduit or a lesser conduit fill should be considered.

Chapter 9 – Table 1

Table 1 Percent of Cross Section of Conduit and Tubing for Conductors and Cables	
Number of Conductors and/or Cables	Cross-Sectional Area (%)
1	53
2	31
Over 2	40

Informational Note No. 2: When pulling three conductors or cables into a raceway, if the ratio of the raceway (inside diameter) to the conductor or cable (outside diameter) is between 2.8 and 3.2, jamming can occur. While jamming can occur when pulling four or more conductors or cables into a raceway, the probability is very low.

Chapter 9 – Table 1

Notes to Tables

9.0(1) See Informative Annex C for the maximum number of conductors and fixture wires, all of the same size (total cross-sectional area including insulation) permitted in trade sizes of the applicable conduit or tubing.

9.0(2) Table 1 applies only to complete conduit or tubing systems and is not intended to apply to sections of conduit or tubing used to protect exposed wiring and cable from physical damage.

Chapter 9 – Table 1

Notes to Tables

9.0(3) Equipment grounding or bonding conductors, where installed, shall be included when calculating conduit or tubing fill. The actual dimensions of the equipment grounding or bonding conductor (insulated or bare) shall be used in the calculation.

Chapter 9 – Table 1

Notes to Tables

9.0(4) Where conduit or tubing nipples, not including connectors, having a maximum length not to exceed 600 mm (24 in.) are installed between boxes, cabinets, and similar enclosures, the nipples shall be permitted to be filled to **60 percent** of their total cross-sectional area, and 310.15(C)(1) adjustment factors need not apply to this condition.

Chapter 9 – Table 1

Notes to Tables

9.0(5) For conductors not included in Chapter 9, such as multiconductor cables and optical fiber cables, the actual dimensions shall be used.

9.0(6) For combinations of conductors of different sizes, use actual dimensions or Table 5 and Table 5A for dimensions of conductors and Table 4 for the applicable conduit or tubing dimensions.

Chapter 9 – Table 1

Notes to Tables

9.0(7) When calculating the maximum number of conductors or cables permitted in a conduit or tubing, all of the same size (total cross-sectional area including insulation), the next higher whole number shall be used to determine the maximum number of conductors permitted when the calculation results in a decimal greater than or equal to 0.8. When calculating the size for conduit or tubing permitted for a single conductor, one conductor shall be permitted when the calculation results in a decimal greater than or equal to 0.8.

Chapter 9 – Table 1

Notes to Tables

9.0(8) Where bare conductors are permitted by other sections of this Code, the dimensions for bare conductors in Table 8 shall be permitted.

Chapter 9 – Table 1

Notes to Tables

9.0(9) A multiconductor cable, optical fiber cable, or flexible cord of two or more conductors shall be treated as a single conductor for calculating percentage conduit or tubing fill area. For cables that have elliptical cross sections, the cross-sectional area calculation shall be based on using the major diameter of the ellipse as a circle diameter. Assemblies of single insulated conductors without an overall covering shall not be considered a cable when determining conduit or tubing fill area. The conduit or tubing fill for the assemblies shall be calculated based upon the individual conductors.

Chapter 9 – Table 1

Notes to Tables

9.0(10) The values for approximate conductor diameter and area shown in Table 5 are based on worst-case scenario and indicate round concentric-lay-stranded conductors. Solid and round concentric-lay-stranded conductor values are grouped together for the purpose of Table 5. Round compact-stranded conductor values are shown in Table 5A. If the actual values of the conductor diameter and area are known, they shall be permitted to be used.

Example

A contractor is installing 4#2 AWG and 1#6 AWG ground. The wires are THHN/THWN. What size EMT must be used:

1) **Because there are over 2 conductors, the fill is 40%**
2) **Per Table 5 in Chapter 9, a #2 AWG conductor has an area of 0.1158 sq. inches and a #6 AWG conductor has an area of 0.0507 sq. inches. Total Conductor area: 4 x 0.1158 + 1 x 0.0507 = 0.5139**
3) **Look in Chapter 9, Table 4 under EMT conduit and find the area at 40% which is higher than 0.5139.**
4) **Per the table a 1 1/4" EMT conduit has an area of 0.598 and can be used.**

Example (Con't)

A contractor is installing 4#2 AWG and 1#6 AWG ground. The wires are THHN/THWN. What size EMT must be used:

Question: Could the same wire be pulled into a 1 1/4" PVC schedule 80 conduit?

Answer: No….A 1 1/4" PVC schedule 80 conduit only has a 40% area of 0.495. Does not comply!

Electric League
of Western Pennsylvania

Chapter 3
Cables and Raceways
Type AC Cable

ARTICLE 320
Armored Cable: Type AC

320.6 Listing Requirements.

Type AC cable and associated fittings shall be listed.



A listing was added in 2017 NEC as a requirement in each article for cable assemblies

ARTICLE 320
Armored Cable: Type AC



320.30 Securing and Supporting.

(A) General. Type AC cable shall be supported and secured by staples; cable ties listed and identified for securement and support; straps, hangers, or similar fittings; or other approved means designed and installed so as not to damage the cable.

(B) Securing. Unless otherwise permitted, Type AC cable shall be secured within 300 mm (12 in.) of every outlet box, junction box, cabinet, or fitting and at intervals not exceeding 1.4 m (4 1⁄2 ft).

ARTICLE 320
Armored Cable: Type AC



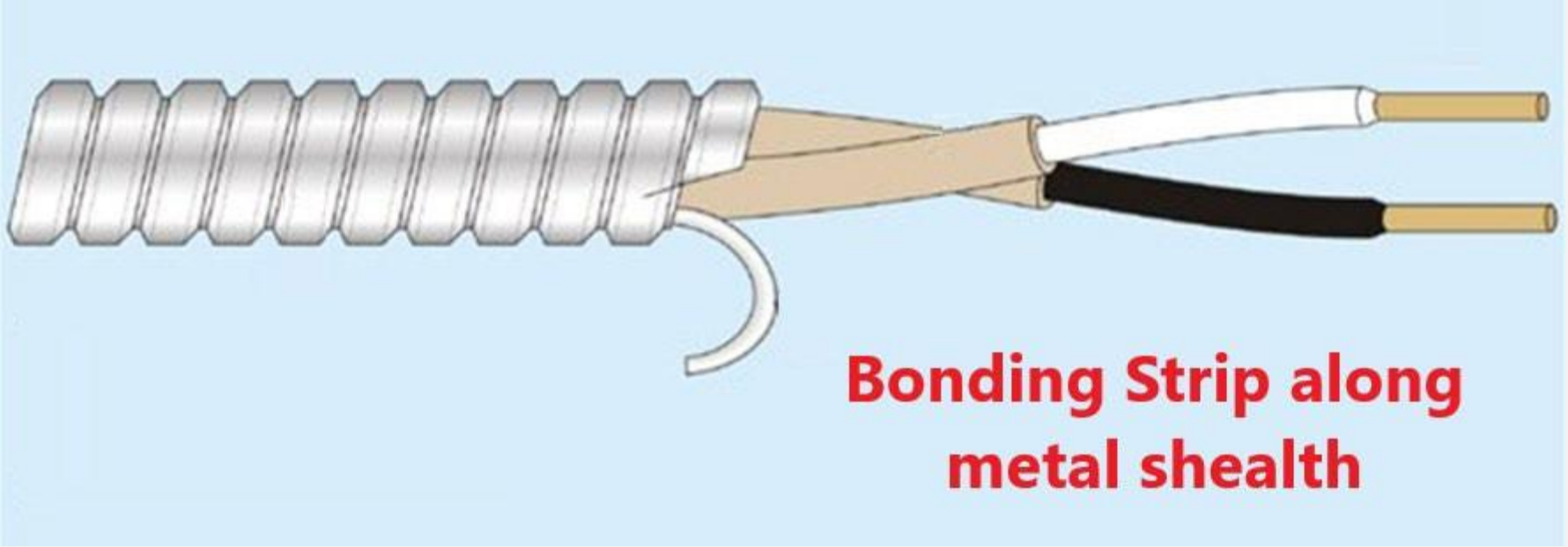
320.30 Securing and Supporting.

(C) Supporting. Unless otherwise permitted, Type AC cable shall be supported at intervals not exceeding 1.4 m (4 1⁄2 ft).

Horizontal runs of Type AC cable installed in wooden or metal framing members or similar supporting means shall be considered supported where such support does not exceed 1.4 m (4 1⁄2 ft) intervals.

ARTICLE 320
Armored Cable: Type AC

320.108 Equipment Grounding Conductor. Type AC cable shall provide an adequate path for fault current as required by 250.4(A)(5) or (B)(4) to act as an equipment grounding conductor.



Electric League
of Western Pennsylvania

Chapter 3
Cables and Raceways
Type MC Cable

ARTICLE 330
Metal-Clad Cable: Type MC



330.10 Uses Permitted.

(A) General Uses. Type MC cable shall be permitted as follows:

(1) For services, feeders, and branch circuits.

(2) For power, lighting, control, and signal circuits.

(3) Indoors or outdoors.

(4) Exposed or concealed.

(5) To be direct buried where identified for such use.

(6) In cable tray where identified for such use.

(7) In any raceway.

(8) As aerial cable on a messenger.

(9) In hazardous (classified) locations where specifically permitted by other articles in this *Code*.

ARTICLE 330
Metal-Clad Cable: Type MC



330.10 Uses Permitted.

(10) In dry locations and embedded in plaster finish on brick or other masonry except in damp or wet locations.

(11) In wet locations where a corrosion-resistant jacket is provided over the metallic covering and any of the following conditions are met:

a. The metallic covering is impervious to moisture.

b. A jacket resistant to moisture is provided under the metal covering.

c. The insulated conductors under the metallic covering are listed for use in wet locations.

(12) Where single-conductor cables are used, all phase conductors and, where used, the grounded conductor shall be grouped together to minimize induced voltage on the sheath.

ARTICLE 330
Metal-Clad Cable: Type MC



330.12 Uses Not Permitted. Type MC cable shall not be used under either of the following conditions:

(1) Where subject to physical damage

(2) Where exposed to any of the destructive corrosive conditions in (a) or (b), unless the metallic sheath or armor is resistant to the conditions or is protected by material resistant to the conditions:

a. Direct buried in the earth or embedded in concrete unless identified for direct burial

b. Exposed to cinder fills, strong chlorides, caustic alkalis, or vapors of chlorine or of hydrochloric acids

ARTICLE 330
Metal-Clad Cable: Type MC



330.15 Exposed Work. Exposed runs of cable, except as provided in 300.11(B), shall closely follow the surface of the building finish or of running boards. Exposed runs shall also be permitted to be installed on the underside of joists where supported at each joist and located so as not to be subject to physical damage.

ARTICLE 330
Metal-Clad Cable: Type MC





330.30 Securing and Supporting.

(A) General. Type MC cable shall be supported and secured by staples, cable ties listed and identified for securement and support; straps, hangers, or similar fittings or other approved means designed and installed so as not to damage the cable.



"listed and identified" was added in 2017 code – type 2s or 21s are listed

ARTICLE 330

Metal-Clad Cable: Type MC





330.30 Securing and Supporting.

(B) Securing. Unless otherwise provided, cables shall be secured at intervals not exceeding 1.8 m (6 ft). Cables containing four or fewer conductors sized no larger than 10 AWG shall be secured within 300 mm (12 in.) of every box, cabinet, fitting, or other cable termination. In vertical installations, listed cables with ungrounded conductors 250 kcmil and larger shall be permitted to be secured at intervals not exceeding 3 m (10 ft).

ARTICLE 330
Metal-Clad Cable: Type MC

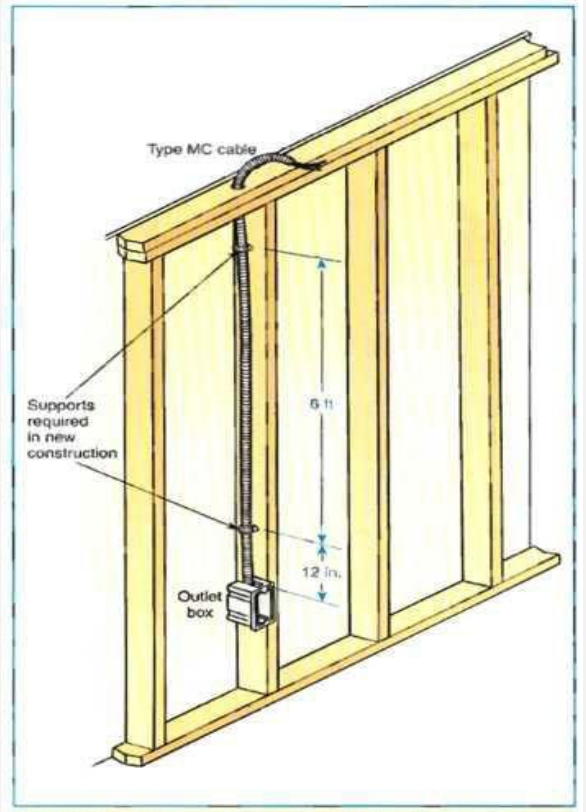


Exhibit 330.2 An application of 330.30(A) and (C), showing Type MC cable supported and secured at intervals not exceeding 6 ft and within 12 in. of the box.

330.30 Securing and Supporting.

(C) Supporting. Unless otherwise provided, cables shall be supported at intervals not exceeding 1.8-m (6-ft)

Horizontal runs of Type MC cable installed in wooden or metal framing members or similar supporting means shall be considered supported and secured where such support does not exceed 1.8-m (6-ft) intervals.

ARTICLE 330
Metal-Clad Cable: Type MC

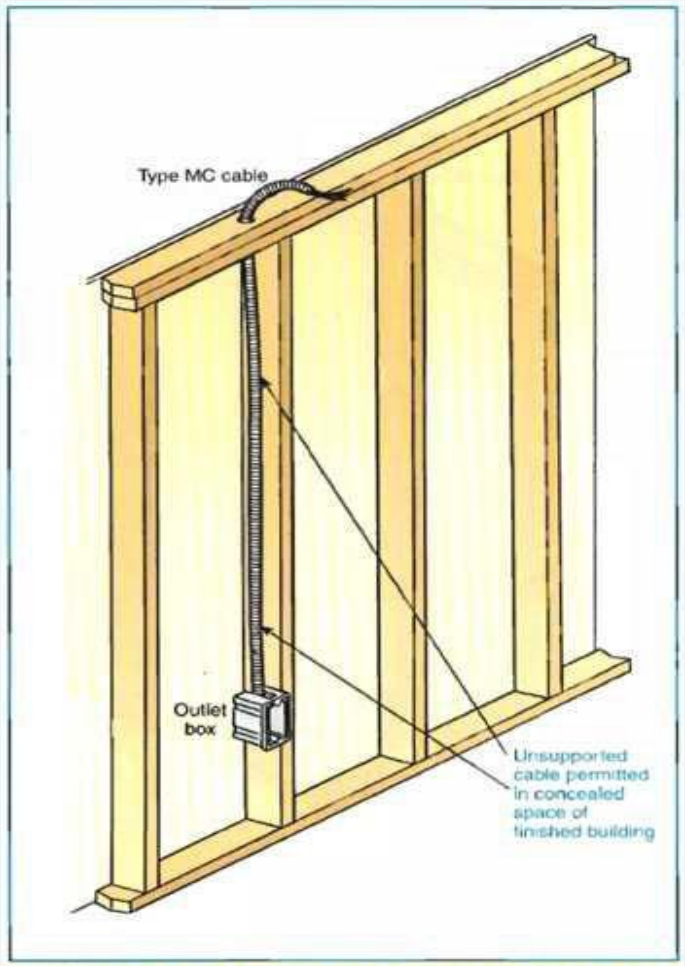


Exhibit 330.3 An application of 330.30(B), which permits Type MC cable to be fished in walls, floors, or ceilings.

330.30 Securing and Supporting.

(D) Unsupported Cables. Type MC cable shall be permitted to be unsupported and unsecured where the cable complies with any of the following:

(1) Is fished between access points through concealed spaces in finished buildings or structures and supporting is impractical; or

(2) Is not more than 1.8 m (6 ft) in length from the last point of cable support to the point of connection to a luminaire (lighting fixture) or other piece of electrical equipment and the cable and point of connection are within an accessible ceiling. For the purpose of this section, Type MC cable fittings shall be permitted as a means of cable support.

Electric League
of Western Pennsylvania

Chapter 3
Article 342
Type IMC Conduit

ARTICLE 342
Intermediate Metal Conduit: Type IMC



342.30 Securing and Supporting. IMC shall be installed as a complete system in accordance with 300.18 and shall be securely fastened in place and supported in accordance with 342.30(A) and (B).

(A) Securely Fastened. IMC shall be secured in accordance with one of the following:

(1) IMC shall be securely fastened within 900 mm (3 ft) of each outlet box, junction box, device box, cabinet, conduit body, or other conduit termination.

(2) Where structural members do not readily permit fastening within 900 mm (3 ft), fastening shall be permitted to be increased to a distance of 1.5 m (5 ft).

(3) Where approved, conduit shall not be required to be securely fastened within 900 mm (3 ft) of the service head for above-the-roof termination of a mast.

ARTICLE 342
Intermediate Metal Conduit: Type IMC

342.30 Securing and Supporting.

(B) Supports. IMC shall be supported in accordance with one of the following:

(1) Conduit shall be supported at intervals not exceeding 3 m (10 ft).

(2) The distance between supports for straight runs of conduit shall be permitted in accordance with Table 344.30(B)(2), provided the conduit is made up with threaded couplings and supports that prevent transmission of stresses to termination where conduit is deflected between supports.

Table 344.30(B)(2) Supports for Rigid Metal Conduit

Conduit Size		Maximum Distance Between Rigid Metal Conduit Supports	
Metric Designator	Trade Size	m	ft
16–21	½–¾	3.0	10
27	1	3.7	12
35–41	1¼–1½	4.3	14
53–63	2–2½	4.9	16
78 and larger	3 and larger	6.1	20



Rigid conduit has farther supports if threaded couplings

ARTICLE 342
Intermediate Metal Conduit: Type IMC



342.30 Securing and Supporting.

(B) Supports. IMC shall be supported in accordance with one of the following:

(3) Exposed vertical risers from industrial machinery or fixed equipment shall be permitted to be supported at intervals not exceeding 6 m (20 ft) if the conduit is made up with threaded couplings, the conduit is supported and securely fastened at the top and bottom of the riser, and no other means of intermediate support is readily available.

(4) Horizontal runs of IMC supported by openings through framing members at intervals not exceeding 3 m (10 ft) and securely fastened within 900 mm (3 ft) of termination points shall be permitted.

ARTICLE 342

Intermediate Metal Conduit: Type IMC

342.100 Construction. IMC shall be made of one of the following:

(1) Steel, with protective coatings

(2) Stainless steel

Added in 2020 code



Electric League
of Western Pennsylvania

Chapter 3
Article 352
Type PVC Conduit

ARTICLE 352
Rigid Polyvinyl Chloride Conduit: Type PVC



358.10 Uses Permitted.

(A) Concealed. (In Walls, floors & Ceilings)

(B) In corrosive Locations

(C) In cinder fill

(D) In wet locations

(E) In dry and Damp locations

(F) Exposed PVC Schedule 80 permitted

(G) Underground

(H) To support conduit bodies

(I) Permitted to contain higher rated temperature cables

ARTICLE 352
Rigid Polyvinyl Chloride Conduit: Type PVC



358.10 Uses Permitted.

(A) Concealed. (In Walls, floors & Ceilings)

(B) In corrosive Locations

(C) In cinder fill

(D) In wet locations

(E) In dry and Damp locations

(F) Exposed PVC Schedule 80 permitted

(G) Underground

(H) To support conduit bodies

(I) Permitted to contain higher rated temperature cables

ARTICLE 352
Rigid Polyvinyl Chloride Conduit: Type PVC



352.12 Uses Not Permitted.

(A) Hazardous Locations.

(B) Support of Luminaires or other equipment

(C) Where subject to physical damage unless identified for such use (Schedule 80).

(D) Ambient Temperatures. Where subject to ambient temperatures in excess of 50°C (122°F) unless listed otherwise.

(E) Theaters and Similar Locations.

ARTICLE 352
Rigid Polyvinyl Chloride Conduit: Type PVC

Table 352.30 Support of Rigid Polyvinyl Chloride Conduit (PVC)

Conduit Size		Maximum Spacing Between Supports	
Metric Designator	Trade Size	mm or m	ft
16–27	½–1	900 mm	3
35–53	1¼–2	1.5 m	5
63–78	2½–3	1.8 m	6
91–129	3½–5	2.1 m	7
155	6	2.5 m	8

352.30 Securing and Supporting.

(B) Supports. PVC conduit shall be supported as required in Table 352.30. Conduit listed for support at spacings other than as shown in Table 352.30 shall be permitted to be installed in accordance with the listing. Horizontal runs of PVC conduit supported by openings through framing members at intervals not exceeding those in Table 352.30 and securely fastened within 900 mm (3 ft) of termination points shall be permitted.

Electric League
of Western Pennsylvania

Chapter 3
Article 352
Type EMT Conduit

ARTICLE 358
Electrical Metallic Tubing: Type EMT





358.10 Uses Permitted.

(A) Exposed and Concealed. The use of EMT shall be permitted for both exposed and concealed work for the following:

(1) In concrete, in direct contact with the earth or in areas subject to severe corrosive influences where installed in accordance with 358.10(B)

(2) In dry, damp, and wet locations

(3) In any hazardous (classified) location as permitted by other articles in this Code

ARTICLE 358
Electrical Metallic Tubing: Type EMT





358.10 Uses Permitted.

(B) Corrosive Environments.

(1) Galvanized Steel and Stainless Steel EMT, Elbows, and Fittings. Galvanized steel and stainless steel EMT, elbows, and fittings shall be permitted to be installed in concrete, in direct contact with the earth, or in areas subject to severe corrosive influences where protected by corrosion protection and approved as suitable for the condition.

ARTICLE 358
Electrical Metallic Tubing: Type EMT





358.10 Uses Permitted.

(B) Corrosive Environments.

(2) Supplementary Protection of Aluminum EMT. Aluminum EMT shall be provided with approved supplementary corrosion protection where encased in concrete or in direct contact with the earth.

(C) Cinder Fill. Galvanized steel and stainless steel EMT shall be permitted to be installed in cinder concrete or cinder fill where subject to permanent moisture when protected on all sides by a layer of noncinder concrete at least 50 mm (2 in.) thick or when the tubing is installed at least 450 mm (18 in.) under the fill.

ARTICLE 358
Electrical Metallic Tubing: Type EMT





358.12 Uses Not Permitted. EMT shall not be used under the following conditions:

(1) Where subject to severe physical damage

(2) For the support of luminaires or other equipment except conduit bodies no larger than the largest trade size of the tubing

ARTICLE 358
Electrical Metallic Tubing: Type EMT





358.14 Dissimilar Metals. Where practicable, dissimilar metals in contact anywhere in the system shall be avoided to eliminate the possibility of galvanic action. Aluminum fittings and enclosures

shall be permitted to be used with galvanized steel EMT, and galvanized steel fittings and enclosures shall be permitted to be used with aluminum EMT where not subject to severe corrosive influences. Stainless steel EMT shall only be used with stainless steel fittings and approved accessories, outlet boxes, and enclosures.

ARTICLE 358
Electrical Metallic Tubing: Type EMT





358.20 Size.

(A) Minimum. EMT smaller than metric designator 16 (trade size 1⁄2) shall not be used.

Exception: For enclosing the leads of motors as permitted in 430.245(B).

(B) Maximum. The maximum size of EMT shall be metric designator 103 (trade size 4).

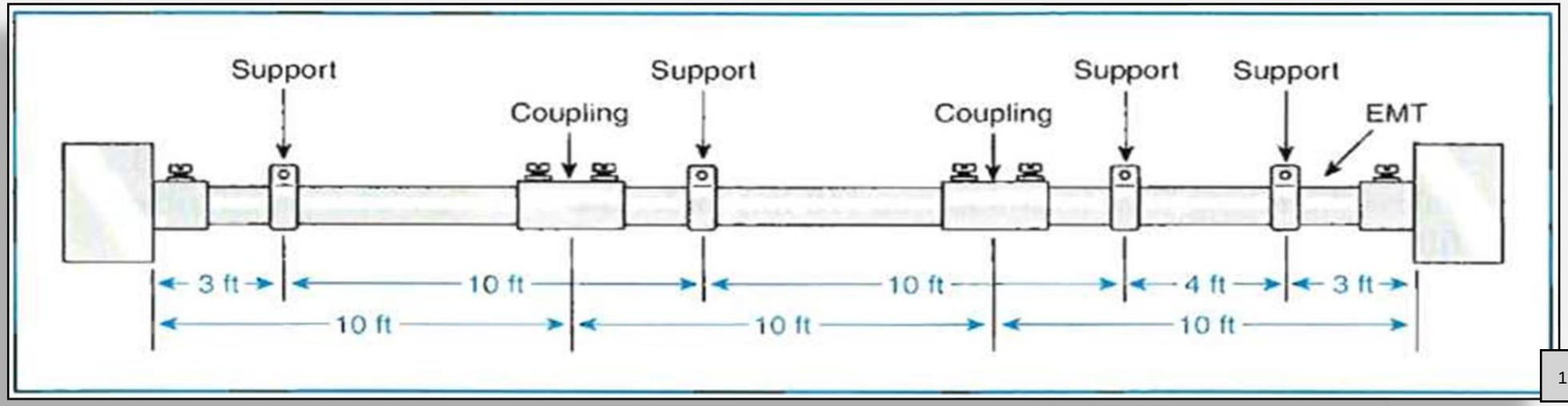
Informational Note: See 300.1(C) for the metric designators and trade sizes. These are for identification purposes only and do not relate to actual dimensions.

ARTICLE 358

Electrical Metallic Tubing: Type EMT

358.30(A) Securely Fastened. EMT shall be securely fastened in place at intervals not to exceed 3 m (10 ft). In addition, each EMT run between termination points shall be securely fastened within 900 mm (3 ft) of each outlet box, junction box, device box, cabinet, conduit body, or other tubing termination.

Exception to 5' where structural members do not allow ready fastening



ARTICLE 358
Electrical Metallic Tubing: Type EMT

358.30 (B) Supports. Horizontal runs of EMT supported by openings through framing members at intervals not greater than 3 m (10 ft) and securely fastened within 900 mm (3 ft) of termination points shall be permitted.



ARTICLE 358

Electrical Metallic Tubing: Type EMT

358.60 Grounding. EMT shall be permitted as an equipment grounding conductor.



ARTICLE 358

Electrical Metallic Tubing: Type EMT

Part III. Construction Specifications

358.100 Construction. EMT shall be made of one of the following:

(1) Steel with protective coatings

(2) Aluminum

(3) Stainless steel





Added in 2020 Code

Electric League
of Western Pennsylvania

Chapter 3
Article 366
Auxiliary Gutters

ARTICLE 366.20
Auxiliary Gutters



366.20 Conductors Connected in Parallel. Where single conductor cables comprising each phase, neutral, or grounded conductor of an alternating-current circuit are connected in parallel as permitted in 310.10(H), the conductors shall be installed in groups consisting of not more than one conductor per phase, neutral, or grounded conductor to prevent current imbalance in the paralleled conductors due to inductive reactance.

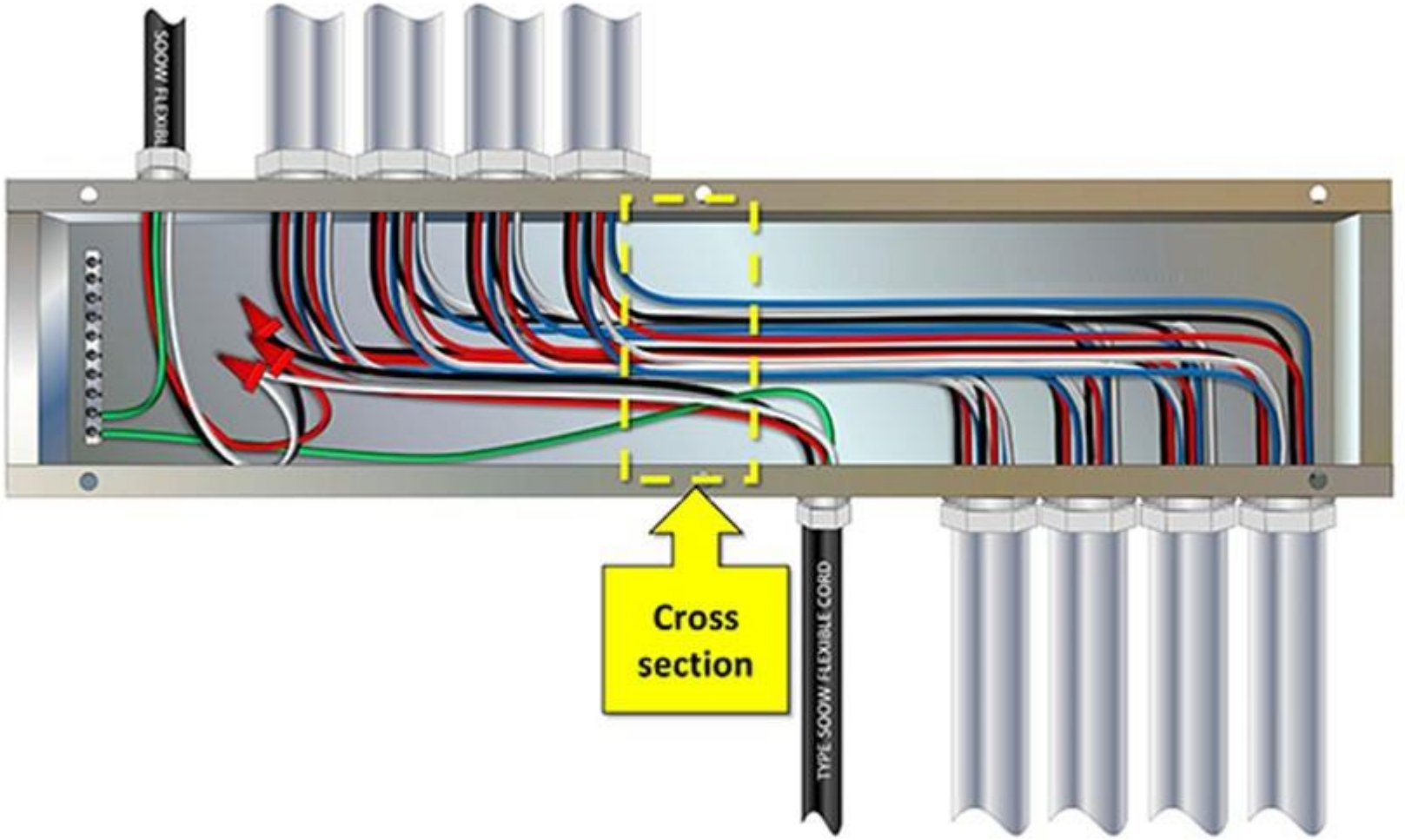
ARTICLE 366.20
Auxiliary Gutters

366.23(A) Sheet Metal Auxiliary Gutters.

The adjustment factors in 310.15(C)(1) shall be applied only where the number of current-carrying conductors, including neutral conductors classified as current-carrying under 310.15(E), exceeds 30 at any cross section of the sheet metal auxiliary gutter. Conductors for signaling circuits or controller conductors between a motor and its starter and used only for starting duty shall not be considered as current-carrying conductors. The current carried continuously in bare copper bars in sheet metal auxiliary gutters shall not exceed 1.55 amperes/mm2 (1000 amperes/in.2) of cross section of the conductor. For aluminum bars, the current carried continuously shall not exceed 1.09 amperes/mm2 (700 amperes/in.2) of cross section of the conductor.

Electric League
of Western Pennsylvania

ARTICLE 366.20
Auxiliary Gutters



ARTICLE 366.20
Auxiliary Gutters

366.23(B) Nonmetallic Auxiliary Gutters.

The adjustment factors specified in 310.15(C)(1) shall be applicable to the current-carrying conductors up to and including the **20 percent fill** specified in 366.22(B).

Electric League
of Western Pennsylvania

End of Class
Wire and Raceway Sizing for Electrical Systems

Questions?

Thank-you !!!

Tim Pool

File Attachments for Item:

EC-10 NEC 2020 Soares Grounding and Bonding Fundamentals (Ohio Division of Industrial Compliance)

All certifications (three six-hour sessions)

Ohio Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: Department of Industrial Compliance

Organization: STATE OF OHIO

Address: 6606 Tussing

E-mail: michael.thompson@com.ohio.gov Telephone: 614-728-5293

Website: com.ohio.gov

Conference Sponsor (if applicable)_____ Conference Email:_____

Check here if Course Renewal:_____ Prior course number _____ (*i.e. BBS2018-429*)

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: NEC 2020 Soares Grounding and Bonding Fundamentals Presented by The IAEI Association

Course instructor: Michael Thompson

Course description: We will study and go through the IAEI 3part Power point presentation on grounding and bonding course study to help with the inspection and plan review processes Part 1

Instructional hours per session: 6 hrs Number of Sessions: 1 each

Course Date(s) and Location: Department of Commerce in Reynoldsburg

Special Content:

Code Administration: X
Existing Buildings: X
Electrical Instruction: X
Plumbing Instruction:_____

Conference Course: _____
Conference Name: _____
Conference location:_____

Course to be offered online? X **On Demand**_____ **Webinar**_____

Course Website: Might use Microsoft TEAMS on course if travel becomes a issue

Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation)*:
Microsoft Teams attendance

Course applicable for the following certifications

Residential Certifications Only: _____ Commercial Certifications: X

Administrative Course, All Certifications: X

Application materials included:

X Course Outline or Course Learning Objectives
X Presentation Materials/Slides (not required for roundtable courses)
_____ Assessment Materials (for online courses)
X Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

2020 NEC Soares Grounding Part I.

7:30 – 8:00- Greetings.

Chapter 1The Language of Grounding and Bonding-Definitions

Chapter2General Fundamentals

Chapter3To Ground or Not to Ground the System

Chapter4Grounding Electrical Systems

Chapter5Clearing Ground Faults and Short Circuits

Chapter6Ground Fault Protection

8:00 am 8:10 am – To go over purpose of this class and go over the process and give everyone the PDF book of Soares Grounding.

8:10 -9:20 - Chapter 1 The Language of Grounding and Bonding-Definitions

9:20 – 9:30 break

9:30- 10:30 – Chapter 2 General Fundamentals

10:30 – 12-00 – Chapter 3 To Ground or Not to Ground the System

12:00- 1:00 Lunch

1:00 pm– 2:00 pm - Chapter 4 Grounding Electrical Systems

2:00 -2:30 – Chapter 5 Clearing Ground Faults and Short Circuits

2:30 -2:45 Break

2:30 -3:30 Chapter 6 Ground Fault Protection

SOARES Grounding and Bonding

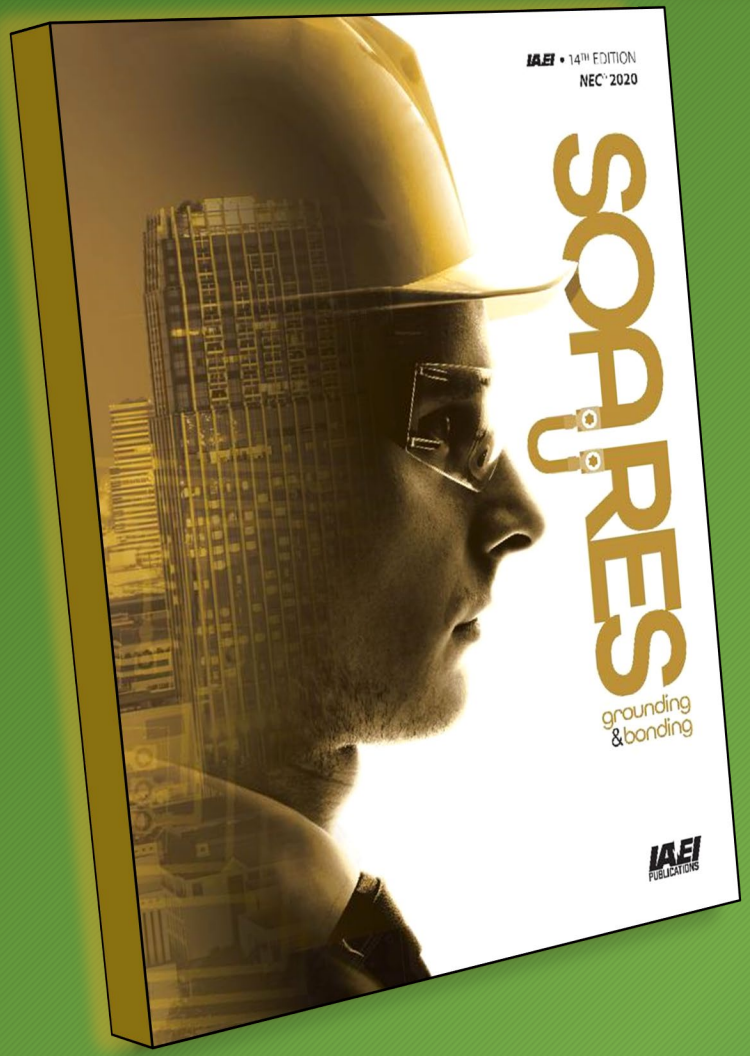
Based on the 2020 NEC®

Part I of III - Grounding and Bonding Fundamentals

International Association Of Electrical Inspectors

Presented by the International Association of Electrical Inspectors

Soares Grounding and Bonding



- IAEI's *Soares Grounding and Bonding*
- 14th Edition
- Based on the requirements of the ***2020 National Electrical Code***
- Dedicated to the memory of Eustace Soares

Soares Chapter Index Links - Part I

Chapter 1 The Language of Grounding and Bonding-Definitions

Chapter 2 General Fundamentals

Chapter 3 To Ground or Not to Ground the System

Chapter 4 Grounding Electrical Systems

Chapter 5 Clearing Ground Faults and Short Circuits

Chapter 6 Ground Fault Protection

Click on any chapter to link directly to that chapter

Seminar and Course Objectives

- Provide basic fundamental information on electrical circuits, electric shock, and overcurrent device operation
- Cover the subject of grounding of electrical systems and equipment for safety in a concise, yet thorough, manner
- Present information on the fundamentals of grounding for systems, services, feeders, branch circuits, and equipment
- Provide information for sizing bonding and grounding conductors and equipment, grounding electrodes and grounding electrode conductors

Seminar and Course Objectives *(cont.)*

- Cover requirements for grounding separately derived systems
- Grounding at additional buildings or structures
- Provide information on grounding special systems, such as for hazardous *(classified)* locations, agricultural buildings, health care facilities, swimming pools, and electric signs
- Provide information on electronic equipment and limited energy system grounding and bonding requirements
- Provide basic fundamentals on lightning protection

CHAPTER ONE

THE LANGUAGE OF GROUNDING AND BONDING DEFINITIONS

Taking the Mystery Out of Grounding

- In the first edition of ***Grounding Electrical Distribution Systems for Safety*** published by **Eustace Soares**, his main themes were getting past the "traditions" from hand me down training and the understanding and using of proper terminology to ensure clear communication
- Quote from Soares: "For many years the subject of "Grounding" has been considered one of the most controversial chapters in the *National Electrical Code*. But there is no real reason why the subject should be treated as a mystery and given so many different interpretations."
- *"…Tradition has been the nemesis of the progress of civilization for centuries"*
- **Essential to use proper terminology**
- The following slides provides definitions for a majority of the terms used in grounding and bonding

Basic Electrical Terms

- The following terms are not in alphabetical order
- Instead, they are sequenced on how the concepts are taught in logic starting with:
  - What pushes current
  - What current is
  - What impedes that current flow for dc circuits then for ac circuits
- Most of the following definitions are found in **Article 100** of the ***National Electrical Code***
- Others are taken from the **IEEE Dictionary of Terms**, or **Webster's Dictionary** as noted

Basic Electrical Terms

- ***Voltage (Electromotive Force).*** Electromotive force is a difference in potential from an electrical source of energy that will cause electrons to move when a circuit is established. A "volt" is the unit of measure of the electromotive force (EMF). Volts or Voltage is the unit of measure of the force required to establish and maintain electric currents that can be measured. By international agreement 1 volt is the amount of EMF that will establish a current flow of 1 amp through a resistance of 1 ohm.
- ***Current (Amperes).*** Current, measured in amperes, consists of the movement or flow of electricity in a circuit. In most cases, the current of a circuit consists of the motion of electrons, negatively charged particles of electricity, going from the source and back to the source.

Basic Electrical Terms

- ***Resistance (Ohms).*** Resistance is the name given to the opposition to current offered by the internal structure of the particular conductive material to the movement of electricity through it, i.e., to the maintenance of current in them. The amount of current in the circuit is limited by the total resistance in the circuit. This opposition results in the conversion of electrical energy into heat. Resistance is measured in ohms.

- ***Impedance (Ohms).*** The term *resistance* is often used to define the opposition to current in both ac and dc systems. The correct term for opposition to current in ac systems is *impedance*. Resistance, inductive reactance, and capacitive reactance all offer opposition to current in alternating-current circuits. The three elements are added together vectorially (phasorially), not directly. This results in the total impedance or opposition to current of an ac circuit. Impedance is measured in ohms.

Basic Electrical Terms

- ***Capacitance.*** A capacitor basically consists of two conductors that are separated by an insulator. A capacitor stores electrical stress. Capacitive reactance is the opposition to current due to capacitance of the circuit. The Institute of Electrical and Electronics Engineers (IEEE) defines *capacitance* as, “The property of a system of conductors and dielectrics which permits the storage of electricity when potential differences exists between the conductors. Its value is expressed as the ratio of a quantity of electricity to a potential difference. A capacitance is always positive.”

Basic Electrical Terms

- ***Inductance.*** Inductance is the ability to store magnetic energy. Inductance is caused by the magnetic field created by an alternating-current circuit as a result of the alternating current changing directions. This causes the magnetic lines of force that surround the conductor to rise and fall. Induction is measured as inductive reactance. As the magnetic lines of force rise and fall, they work to oppose the current in the conductor and induce a voltage directly opposite the applied voltage. This induced voltage is called *counter-electromotive force* or counter EMF. Induction is the current effect of an ac circuit. Where there is an alternating magnetic field there will be induction. This induction will result in inductive reactance, which opposes the current.

Definitions of Basic Electrical Terms

- **IAEI's *Soares Book on Grounding and Bonding*** places a huge emphasis on definitions of words and terms used for proper application of *Code* rules relating to the subject of grounding and bonding
- Using a common language of communication is imperative to understanding grounding and bonding and applying the *Code* to installations and systems in the field
- It is important that words and terms related to this subject mean what they imply by definition for all *NEC* users

Definitions of Basic Electrical Terms

- A major effort was completed between the 2005 and 2008 *NEC* cycle by a diverse task group of interested parties to look at all the terminology related to grounding and bonding
- This **Grounding and Bonding Task Group**'s mission was to:
  - Revise and simplify definitions
  - Revise text throughout the *NEC* for consistency
- While the majority of this effort was completed in the 2008 *NEC*, there have been some definition and other changes made as needed for the 2011, 2014, 2017 and 2020 *NEC*

Definitions of Basic Electrical Terms

- ***Available Fault Current [Fault Current, Available]*** - The largest amount of current capable of being delivered at a point on the system during a short-circuit condition.
  - ***Informational Note:*** A short-circuit can occur during abnormal conditions such as a fault between circuit conductors or a ground fault. See Informational Note Figure 100.1
- ***Bonded (Bonding)*** - Connected to establish electrical continuity and conductivity.
- ***Bonding Jumpers [Bonding Conductor or Jumper]*** - A reliable conductor to ensure the required electrical conductivity between metal parts required to be electrically connected.

Definitions of Basic Electrical Terms

- ***Covered Conductor [Conductor, Covered]*** - conductor encased within material of composition or thickness that is not recognized by this *Code* as electrical insulation.
- ***Effective Ground Fault Current Path*** - An 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 and that facilitates the operation of the overcurrent protective device or ground-fault detectors.
- ***Equipment Bonding Jumper [Bonding Jumper, Equipment]*** - The connection between two or more portions of the equipment grounding conductor.

Definitions of Basic Electrical Terms

- ***Equipment Grounding Conductor [Grounding Conductor, Equipment] (EGC)*** – A conductive path(s) that is part of an effective ground-fault current path and connects normally non-current-carrying metal parts of equipment together and to the system grounded conductor or to the grounding electrode conductor, or both.
  - **Informational Note No. 1**: It is recognized that the equipment grounding conductor also performs bonding.
  - **Informational Note No. 2**: See 250.118 for a list of acceptable equipment grounding conductors.
- ***Fault Current*** - The current delivered at a point on the system during a short-circuit condition.

Definitions of Basic Electrical Terms

- ***Ground*** – The earth
- ***Grounded (Grounding)*** – Connected (connecting) to ground or to a conductive body that extends the ground connection.
- ***Grounded Conductor*** – A system or circuit conductor that is intentionally grounded.
  - **Informational Note:** Although an equipment grounding conductor is grounded, it is not considered a grounded conductor.
- ***Grounding Electrode*** – A conducting object through which a direct connection to earth is established.
- ***Grounding Electrode Conductor (GEC)*** - A conductor used to connect the system grounded conductor or the equipment to a grounding electrode or to a point on the grounding electrode system.

Definitions of Basic Electrical Terms

- ***Ground Fault*** - An unintentional, electrically conductive connection between an ungrounded conductor of an electrical circuit and the normally non-current-carrying conductors, metallic enclosures, metallic raceways, metallic equipment, or earth.
- ***Ground Fault Current Path*** - An electrically conductive path from the point of a ground fault on a wiring system through normally non-current-carrying conductors, grounded conductors, equipment, or the earth to the electrical supply source.
  - **Informational Note:** Examples of ground-fault current paths are any combination of equipment grounding conductors, metallic raceways, metallic cable sheaths, electrical equipment, and any other electrically conductive material such as metal, water, and gas piping; steel framing members; stucco mesh; metal ducting; reinforcing steel; shields of communications cables; grounded conductors; and the earth itself.

Definitions of Basic Electrical Terms

- ***Ground-Fault Circuit Interrupter (GFCI)*** **-** A device intended for the protection of personnel that functions to deenergize a circuit or portion thereof within an established period of time when a current to ground exceeds the values established for a Class A device.
  - **Informational Note**: Class A ground-fault circuit interrupters trip when the current to ground is 6 mA or higher and do not trip when the current to ground is less than 4 mA. For further information, see UL 943, Standard for Ground-Fault Circuit Interrupters.
- ***Ground-Fault Protection of Equipment*** **-** A system intended to provide protection of equipment from damaging line-to-ground fault currents by operating to cause a disconnecting means to open all ungrounded conductors of the faulted circuit. This protection is provided at current levels less than those required to protect conductors from damage through the operation of a supply circuit overcurrent device.

Definitions of Basic Electrical Terms

- ***Guarded*** - Covered, shielded, fenced, enclosed, or otherwise protected by means of suitable covers, casings, barriers, rails, screens, mats, or platforms to remove the likelihood of approach or contact by persons or objects to a point of danger
- ***Insulated*** – Equipment or materials that are covered with an insulating material.
- ***Insulated Conductor [Conductor, Insulated]*** - A conductor encased within material of composition and thickness that is recognized by this *Code* as electrical insulation.
- ***Intersystem Bonding Termination (IBT)*** - A device that provides a means for connecting intersystem bonding conductors for communications systems to the grounding electrode system.

Definitions of Basic Electrical Terms

- ***Interactive System*** – An electric power production system that is operating in parallel with and capable of delivering energy to an electric primary source supply system.
- ***Interactive Inverter*** - An inverter intended for use in parallel power source(s) such as an electric utility to supply common loads and capable of delivering power to the utility.
- ***Isolated (as applied to location)*** - Not readily accessible to persons unless special means for access are used.
- ***Main Bonding Jumper [Bonding Jumper, Main] (MBJ)*** - The connection between the grounded circuit conductor and the equipment grounding conductor, or the supply side bonding jumper, or both at the service.

Definitions of Basic Electrical Terms

- ***Neutral Conductor*** - The conductor connected to the neutral point of a system that is intended to carry current under normal conditions.

- ***Neutral Point*** - The common point on a wye-connection in a polyphase system or midpoint on a single-phase, 3-wire system, or midpoint of a single-phase portion of a 3-phase delta system, or a midpoint of a 3-wire, direct-current system.

    - **Informational Note:** At the neutral point of the system, the vectorial sum of the nominal voltages from all other phases within the system that utilize the neutral, with respect to the neutral point, is zero potential.

Definitions of Basic Electrical Terms

- ***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.
  - **Informational Note**: A current in excess of rating may be accommodated by certain equipment and conductors for a given set of conditions. Therefore, the rules for overcurrent protection are specific for particular situations.
- ***Overload*** - Operation of equipment in excess of normal, full load rating, or of a conductor in excess of rated ampacity that, when it persists for a sufficient length of time, would cause damage or dangerous overheating. A fault, such as a short circuit or ground fault, is not an overload.

Definitions of Basic Electrical Terms

- ***Short Circuit (IEEE – Power Switchgear)*** – An abnormal connection (including an arc) of relatively low impedance, whether made accidentally or intentionally, between two points of different potential. *(IEEE Dictionary of Terms)*
  - *Note: The term fault or short-circuit fault is used to describe a short circuit.*
- ***Separately Derived System (SDS)*** - An electrical source, other than a service, having no direct connection(s) to circuit conductors of any other electrical source other than those established by grounding and bonding connections.

Definitions of Basic Electrical Terms

- ***Service*** - The conductors and equipment connecting the serving utility to the wiring system of the premises served.
- ***Solidly Grounded [Grounded, Solidly]*** - Connected to ground without inserting any resistor or impedance device.
- ***Stand-Alone System*** - A system that is capable of supplying power independent of an electric power production and distribution network.
- ***Supply Side Bonding Jumper [Bonding Jumper, Supply Side]*** - A conductor installed on the supply side of a service or within a service equipment enclosure(s), or for a separately derived system, that ensures the required electrical conductivity between metal parts required to be electrically connected.

Definitions of Basic Electrical Terms

- ***System Bonding Jumper [Bonding Jumper, System] (SBJ)*** - The connection between the grounded circuit conductor and the supply-side bonding jumper, or the equipment grounding conductor, or both, at a separately derived system.

- ***Ungrounded*** - Not connected to ground or to a conductive body that extends the ground connection.

The Foundation of Grounding

- The first and most vital element of a sound, safe structure is a **solid footing or foundation** on which to build the building
- If the building or structure does not sit on a solid foundation, there can be continuous structural problems that might lead to unsafe conditions
- Likewise, the **electrical grounding system** serves as one of the foundations for an electrical service or distribution system supplying electrical energy to the structure
- Often the grounding of a system or metal objects is referred to as *earthing (being connected to the earth)*

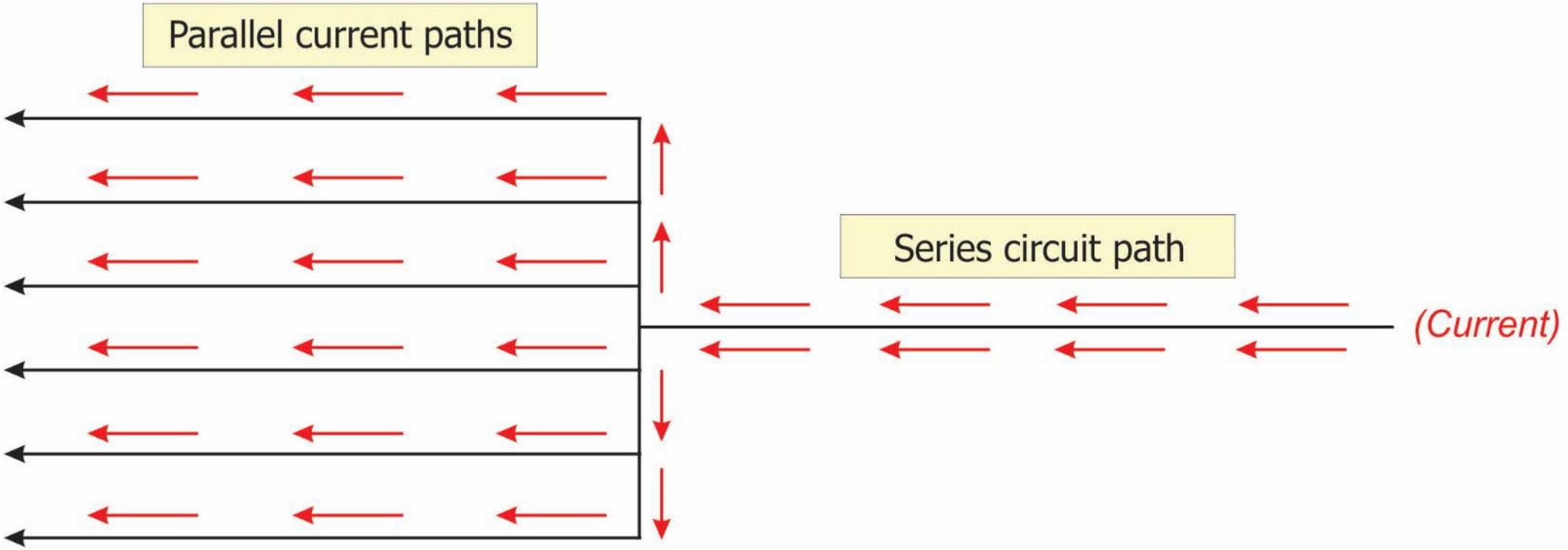
The Foundation of Grounding *(cont.)*

- When solidly grounded, electrical systems must be connected to a dependable grounding electrode or grounding electrode system *(without adding any intentional impedance)*
- Grounding electrode(s) supports the entire grounding system that makes the earth connection
- Must be effective and all grounding paths needing connection to earth must be connected to it
- This serves as the foundation of the electrical system
- See Chapter Seven of this Soares publication for in-depth coverage of the grounding electrode(s) system

Electrical Circuitry Basics

- "Electricity takes the path of least resistance"
- Current will take all paths or circuits that are available
- Where more than one path exists, current will divide among the paths
- Current will divide in opposite proportion to the **resistance** (dc) or **impedance** (ac)
- Lower impedance path or circuit will carry more current than the higher impedance path(s)
- The study of grounding and bonding is vital to apply these basic rules
- Important to review some **basic principles** and the fundamental elements of electricity and how current and the various possible current paths relate to **electrical safety**

Series and Parallel Paths for Current



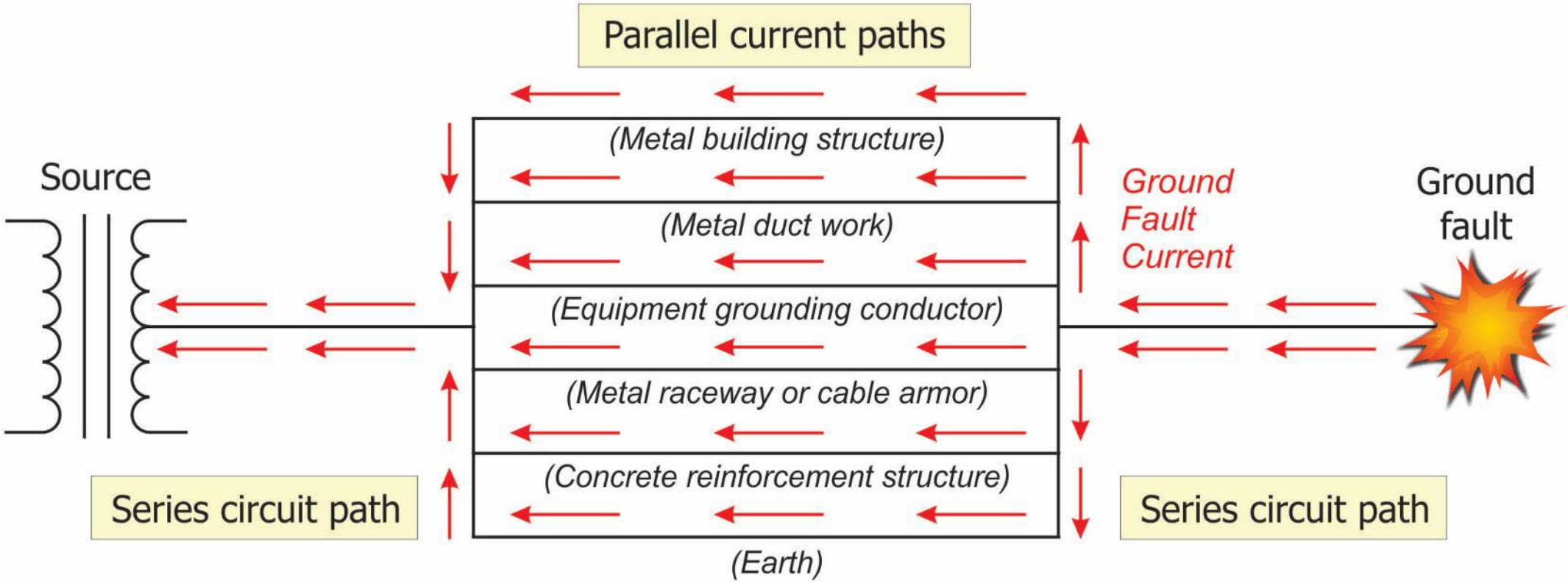
Current will always try to return to the source

Current will return on as many paths that are available to it

Amount of current on a particular path depends on the impedance of that path

Copyright © IAEI 2020

Series and Parallel Paths for Current



Current will always try to return to the source

Current will return on as many paths that are available to it

Amount of current on a particular path depends on the impedance of that path

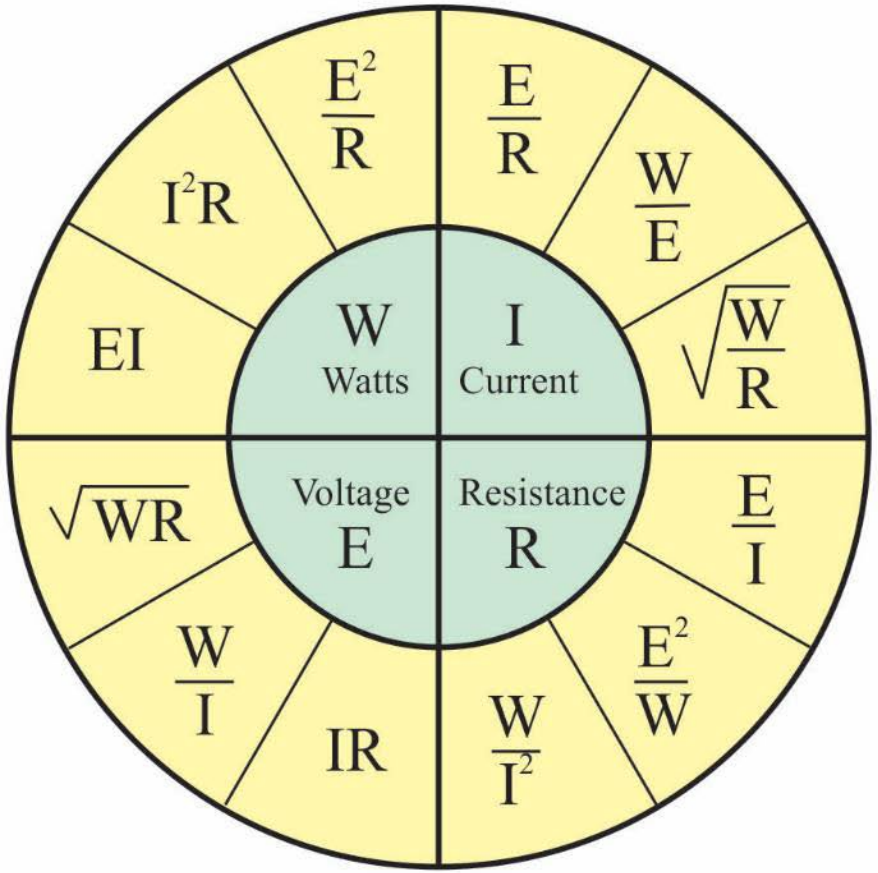
Copyright © IAEI 2020

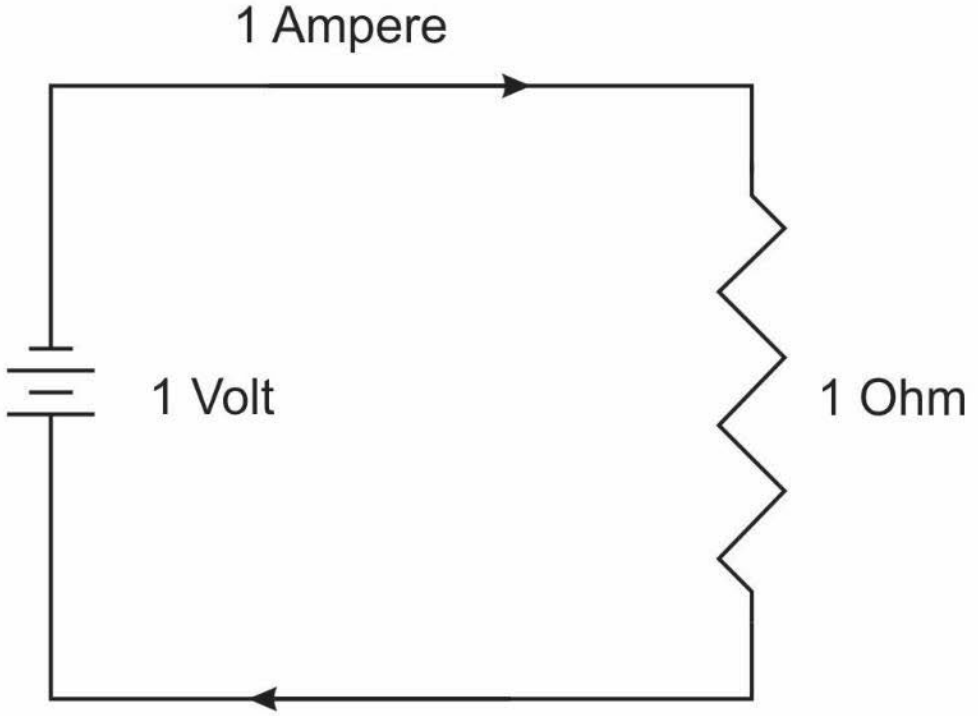
Ohm's Law – The Basics

- E – Electromotive Force *(Voltage)*
- I – Intensity in Amperes *(Current)*
- R – Resistance in Ohms *(Resistance)*
- Z – Impedance *(Total opposition to flow of current in ac circuits)*

- <u>Example of using Ohm's Law</u>:
  - 120-volt circuit is connected to a circuit that has a resistance of 6 ohms
  - The amount of current in the circuit is equal to 120 volts divided by 6 ohms = 20 amperes

Watt's Wheel- Ohm's Law





Ω = Ohm
1,000 Ohms = 1 Kilohm (K)
1,000,000 Ohms = 1 Megohm (Meg)
1,000 Kilohms (K) = 1 Megohm (Meg)

Copyright © IAEI 2020

Resistance Compared to Impedance

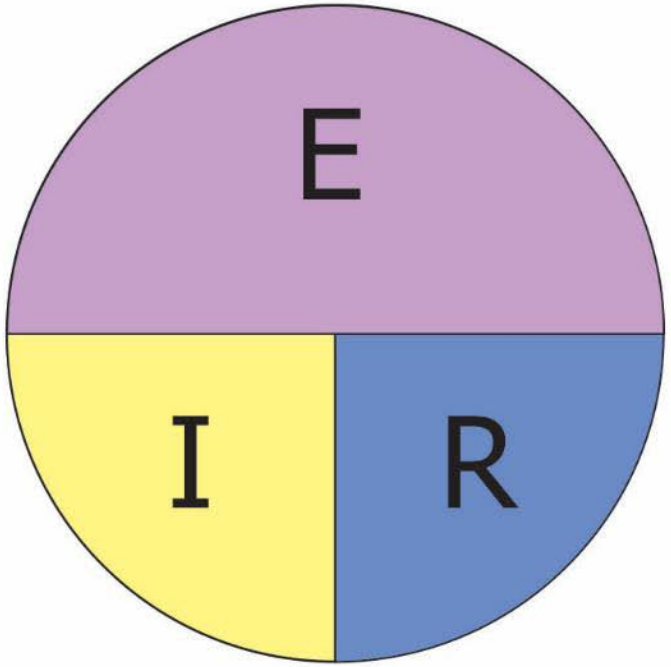
- For **direct current (dc) systems and circuits**, ***resistance*** **(R)** is properly used to describe the opposition to current
- Typical to use the term ***ohms*** to relate to the resistance of the circuit, such as 35 ohms
- Ohm's law in a dc circuit can be summarized as follows:
  - Current is directly proportional to the voltage and inversely proportional to the resistance **(I = E/R)**
- As voltage is increased, current will increase through a **fixed resistance**
- As resistance is reduced, current will increase if the voltage stays the same
- A pressure (voltage) of **one volt** will cause **one ampere** of current through a resistance of **one ohm**

Resistance Compared to Impedance *(cont.)*

- For **alternating-current (ac) systems and circuits**, ***impedance*** **(Z)** is the proper term to describe the total opposition to current
- Impedance consists of three components:
  - Inductive reactance
  - Capacitive reactance
  - Resistance
- Impedance, rather than resistance, is used most often throughout this text since, for the most part, ac electrical systems and circuits are being considered
- See Chapter Three of this Soares publication for a detailed discussion of the importance of keeping impedance as low as possible

Basic Electrical Theory Terms

Ohm's Law



Voltage = (E) or Pressure that pushes

Resistance = (R) or Resistance in ohms

Current = (I) or Amperes that flow

Opposition to current in an ac circuit is made up of three components:

R Resistance

X_L Inductive reactance

X_C Capacitive reactance

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

(Impedance formula)

Resistance = Opposition to current in a dc circuit

Impedance (Z)= total opposition to current in an ac circuit

Copyright © IAEI 2020

Alternating Current Basics

- In a **60-cycle ac circuit**, alternating current changes in amplitude and direction **120 times per second**
- It develops a **magnetic field** that results from the inductive reactance of the circuit
- **Capacitance** is inherent to ac circuits as they are built, because capacitors are basically two conductors separated by an insulator
- **Resistance** is, generally, the load in ohms connected to the circuit
- These same elements all exist in the grounding and bonding circuits as well as in the normal electrical circuits

Alternating Current Basics *(cont.)*

- Minimizing the amount of the overall **opposition *(impedance)* to current** in the grounding and bonding circuits is very important
- These grounding and bonding circuits can be looked upon as **silent servants**
- Waiting to perform the important function of carrying enough current so overcurrent protective devices can operate to clear a fault
- This is one reason ***NEC 300.3*** requires all conductors of a circuit to be closely installed together minimizing the overall impedance

Current in an Electrical Circuit

- In any available complete circuit or path, **current** *(be it normal current or fault current)* will always try to **return to its source**
- In order for there to be current, there must be a complete circuit
- Current will take **any and all available paths or circuits** to it to return to the source
- The amount of current in each path is directly related to the amount of opposition *(impedance or resistance)* of that particular path
- The same care that is given to constructing the electrical circuits *(phase conductors and neutral conductors)* must also be given to the grounding and bonding circuits of the system

Current in an Electrical Circuit *(cont.)*

- The equipment grounding (safety) circuits must be complete and must meet three important criteria:
  - (1) The path for ground-fault current must be **electrically continuous**
  - (2) Must have **adequate capacity** to conduct safely any ground-fault current likely to be imposed on it
  - (3) Must be of **low impedance**
- When the phrase "***low-impedance path***" is used in the *Code*, it refers to a path that offers **little opposition to current** *(whether it is normal current or fault current)*
- During ground fault conditions, this "low impedance path" allows sufficient current flow so that overcurrent or ground fault device can operate quickly

Overcurrent Device Operation

- Overcurrent devices require amperes to operate
- Lower resistance or opposition means increased amperes
- Circuits operating normally with current below the overcurrent device ratings will continue to operate normally
- Current levels in electrical circuits above the overcurrent device rating cause the overcurrent device to open
- The higher the current, the quicker the device will operate
- Inverse time as applied to overcurrent devices means the more current, the faster the device opens

Amperages Operate Overcurrent Devices

E = Voltage		R = Ohms		I = Amperes
Voltage (E)	=	*Resistance (R)	x	**Current (I)
120	=	60	x	2
120	=	40	x	3
120	=	20	x	6
120	=	10	x	12
120	=	5	x	24
120	=	2	x	60
120	=	1	x	120

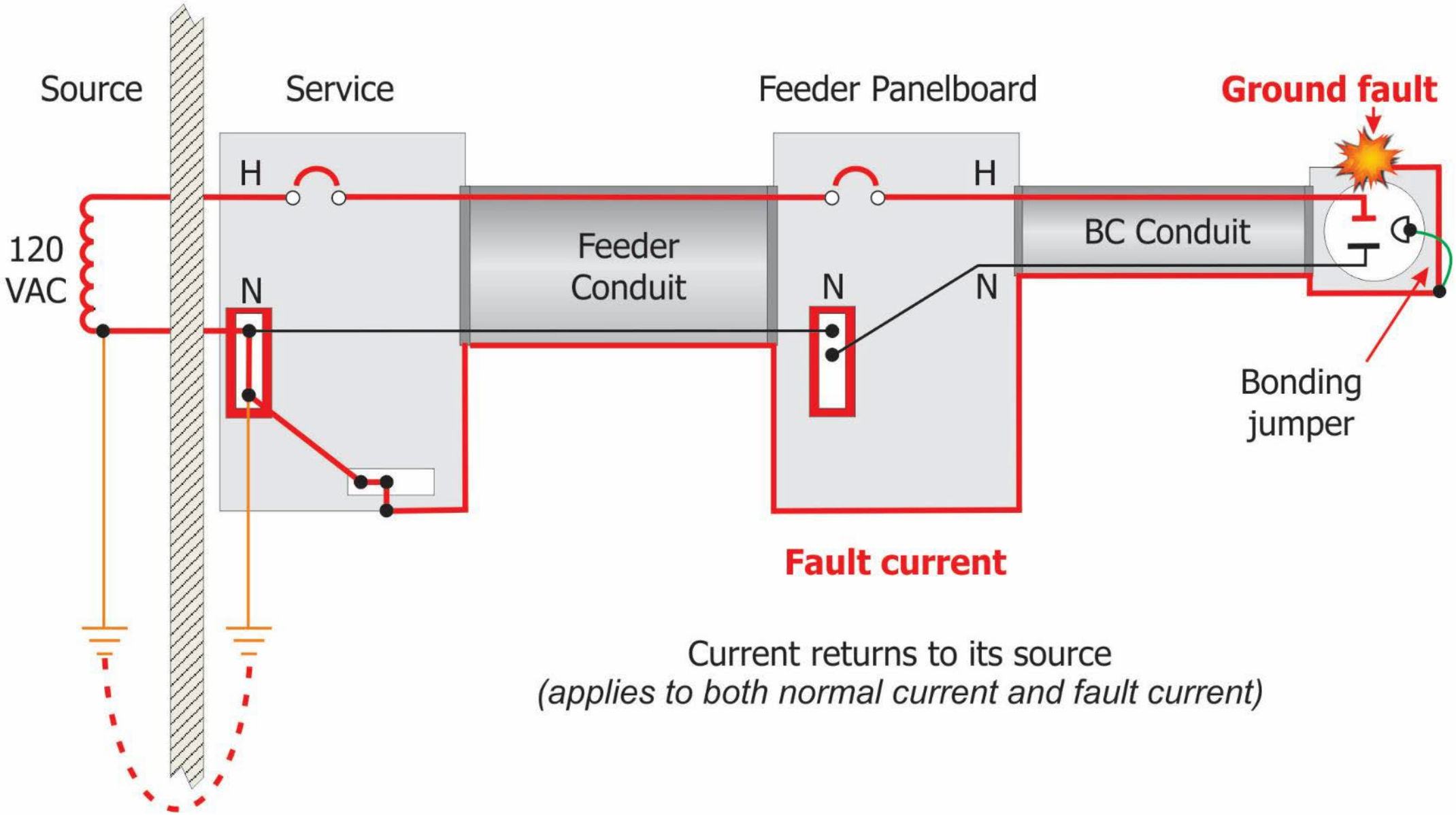
* As the resistance or opposition to current increases, the current in the circuit decreases.

** As the resistance or opposition to current decreases, the current in the circuit increases.

Note: A 15 ampere circuit breaker needs 75 amperes (5 x 15) or more amperes to be in the "instantaneous" trip range to open under short circuit or ground fault conditions.

Copyright © IAEI 2020

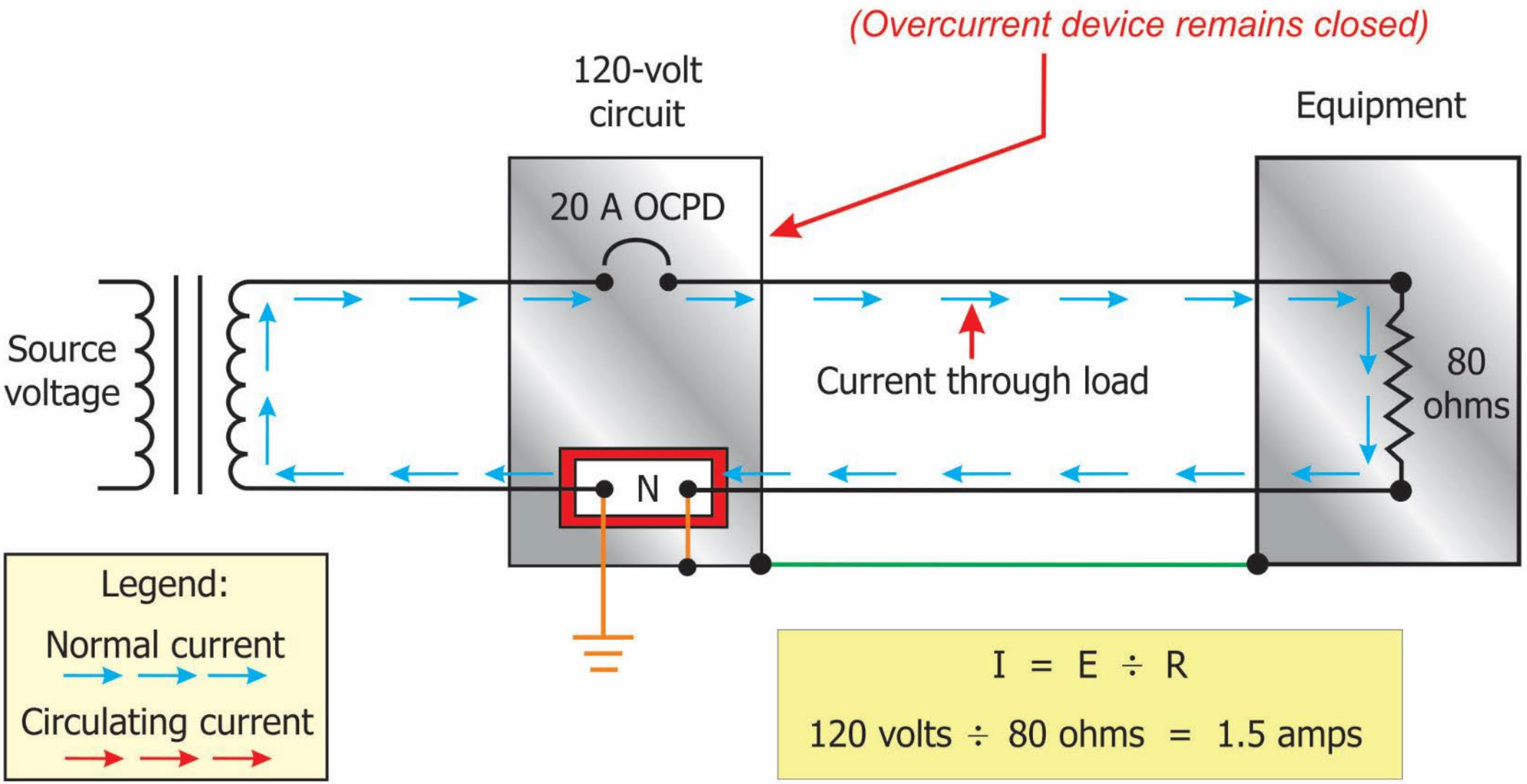
Overcurrent Device Operation



Current returns to its source
(applies to both normal current and fault current)

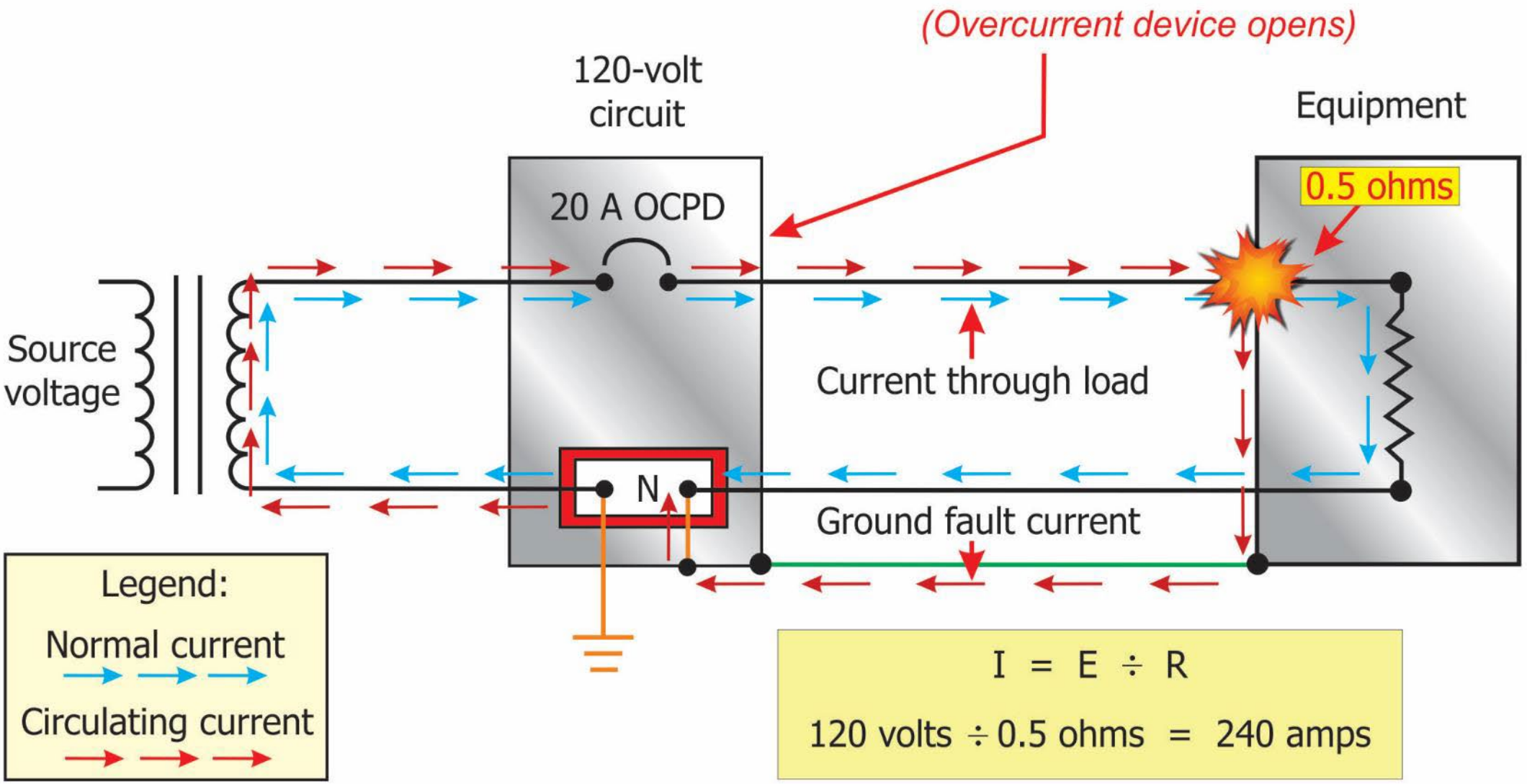
Copyright © IAEI 2020

Normal Current in the Circuit



Copyright © IAEI 2020

Ground-Fault Current in the Circuit



Note: Unless ungrounded conductors are totally severed *(broken)*, a certain amount of load current in the normal circuit will be present *(under ground- fault conditions)*

Copyright © IAEI 2020

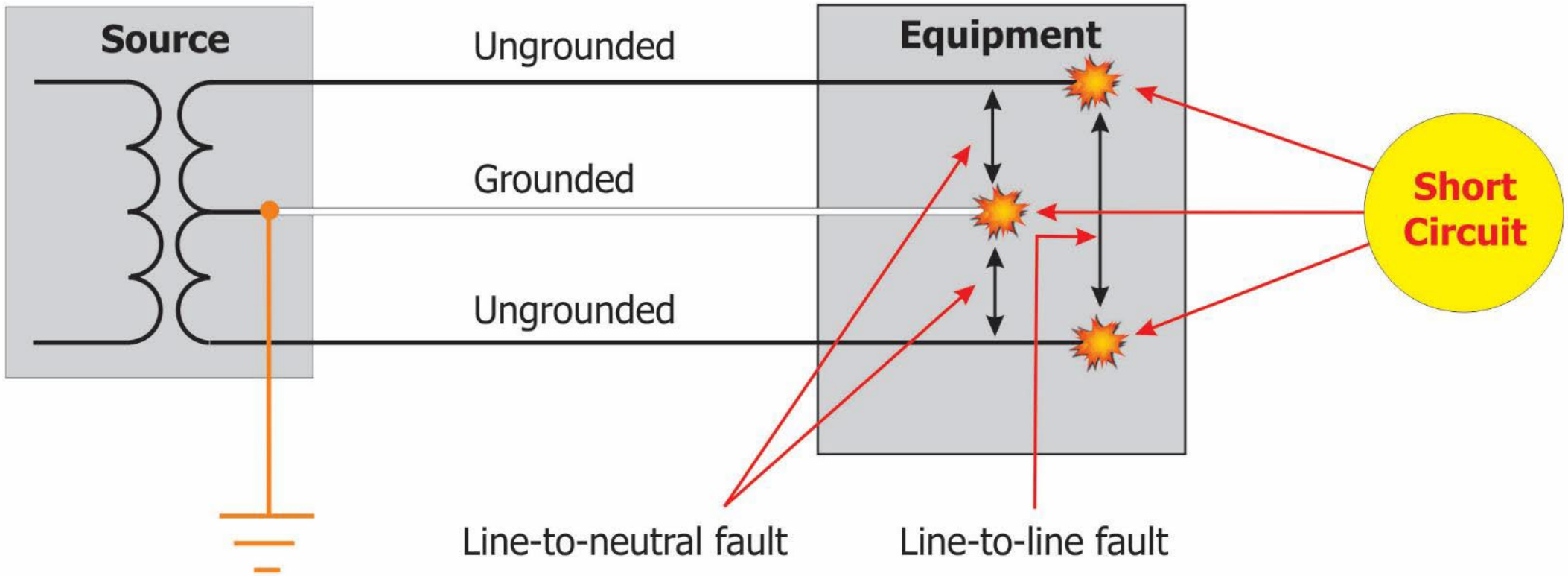
Differentiate Between a Short Circuit and a Ground Fault

- A **short circuit** and a **ground fault** are different, although they both stem from insulation failure
- Common practice to call all faults or failures in the electrical system insulation a short circuit
- This can lead to misunderstanding *(and has done so)* when the terms are not used properly
- A short circuit can be a solid or bolted connection, or it can be an arcing fault completing the path through a short air space

Differentiate Between a Short Circuit and a Ground Fault *(cont.)*

- For a **short circuit**, the failure can be from one phase conductor to another phase conductor or from one phase conductor to the grounded conductor or neutral
- For either condition, the maximum value of fault current is dependent on the available capacity the system can deliver to the point of the fault and the impedance path of the two faulted conductors
- Maximum value of short-circuit current from line-to-neutral will vary depending upon the single-phase source impedance and the distance from the source to the fault and the impedance of the path
- In both cases the available short-circuit current is further limited by the dynamic impedance of the arc, where one is established, plus the impedance of the conductors to the point of short circuit

Definition: Short Circuit



Short circuit. A conducting connection, whether intentional or accidental, between any of the conductors of an electrical system whether it is from line-to-line or from line to the grounded conductor.

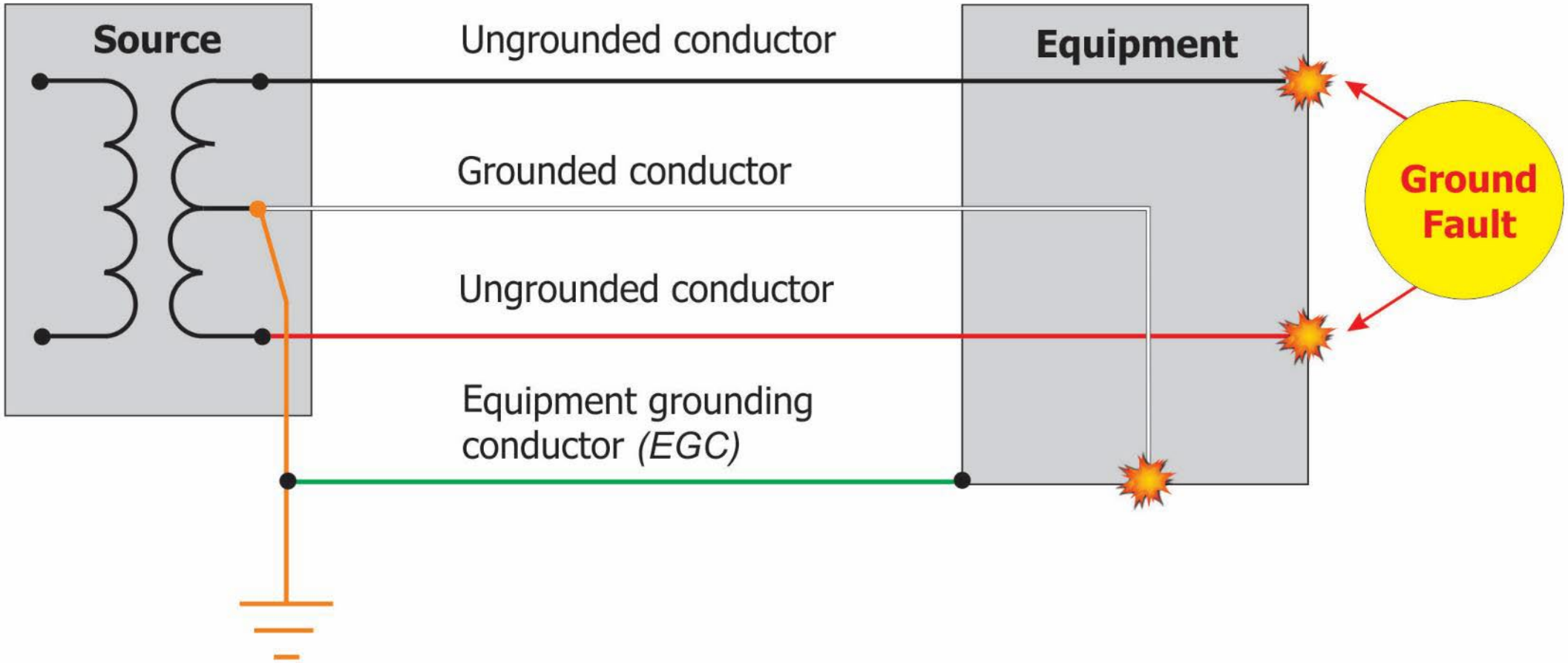
Copyright © IAEI 2020

Differentiate Between a Short Circuit and a Ground Fault *(cont.)*

- For a **ground fault**, there is **unintentional contact** between an ungrounded phase *(hot)* conductor and the conductor enclosure or from the grounded phase conductor to the conductor enclosure *(wire-to-conduit, wire-to-motor frame, and so forth)*
- Not a common practice to refer to a conductor that is intentionally grounded *[such as a grounded phase conductor or system grounded (neutral) conductor]* as being in a ground-fault condition
- However, a grounded system conductor *(such as a neutral conductor)* that is generally not permitted to be grounded again past the service disconnecting means can be considered a ground fault
- This condition is particularly important with equipment ground-fault protection systems for equipment (GFPE) and GFCI devices

Definition: Ground Fault

Ground Fault. An unintentional, electrically conductive connection between an ungrounded conductor of an electrical circuit and the normally non-current-carrying conductors, metallic enclosures, metallic raceways, metallic equipment, or earth.



Copyright © IAEI 2020

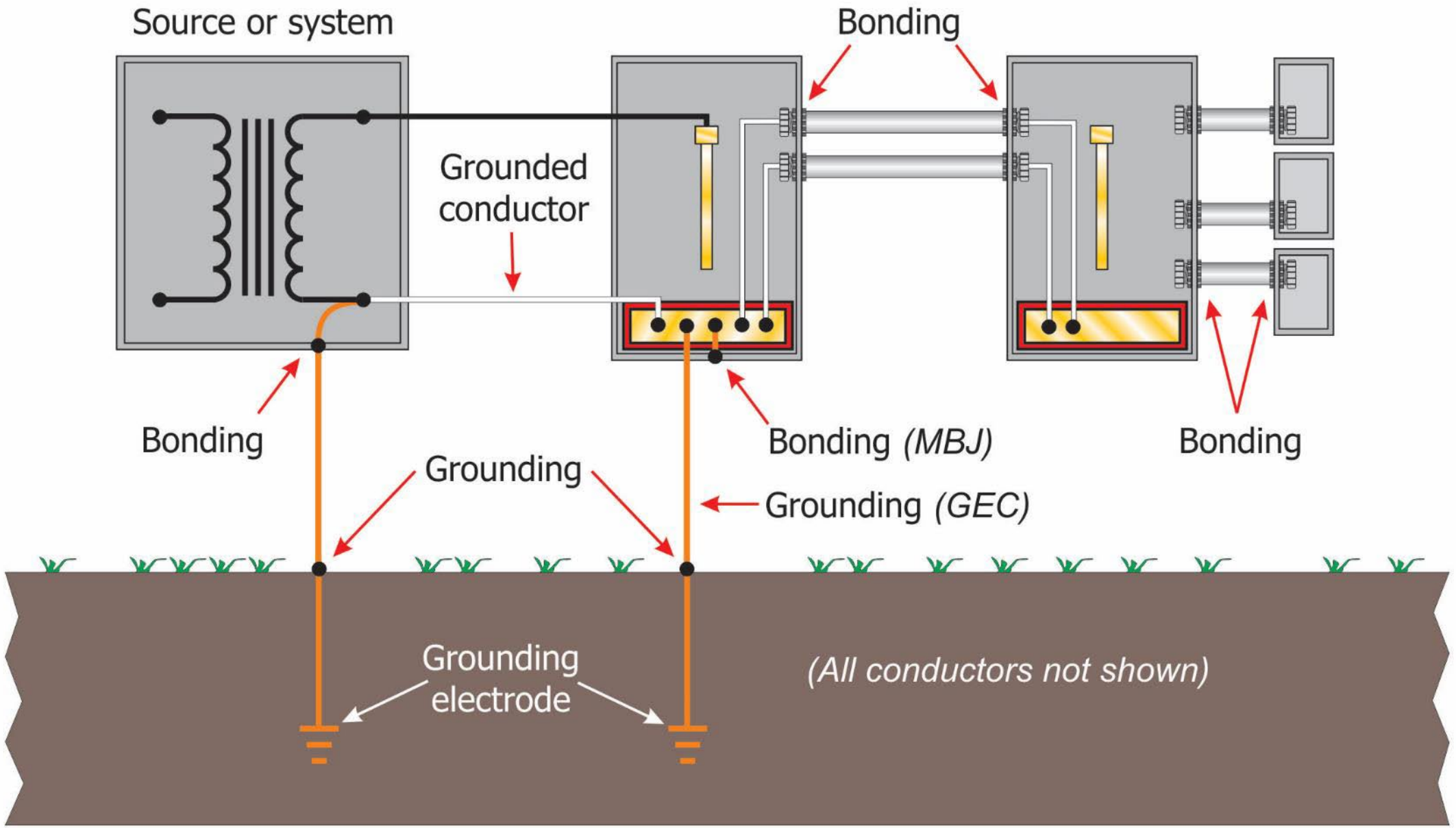
Differentiate Between a Short Circuit and a Ground Fault *(cont.)*

- A fault can easily involve both a **short circuit** and **ground fault** condition
- The fault can start as a ground fault or line-to-ground fault and escalate into a short circuit or phase-to-phase fault
- A fault can also begin as a short circuit and expand to a ground fault
- For electrical systems of **120-volts-to-ground**, the circuit overcurrent protective devices will typically clear the fault or it will be extinguished when the alternating voltage passes through a voltage zero in the cycle
- For **277-volts-to-ground** systems, destructive arcing faults can be more easily sustained by the higher system voltage
- Equipment ground-fault protection systems have been designed to address this issue

Purposes of Grounding and Bonding

- Grounding ***(Connecting to earth)***
  - Limit the voltages due to lightning, line surges or unintentional contact with higher voltage lines
  - Stabilize voltage to ground during normal operation
- Bonding ***(Connecting together)***
  - Bonding shall be provided where necessary to ensure electrical continuity
  - Must have the capacity to conduct safely any fault current likely to be imposed

Grounding Compared to Bonded



Copyright © IAEI 2020

Grounded Conductors

- Grounded conductors *(many times neutrals)* are intended to carry return currents from circuits to the source in normal operation *(amount of current can vary)*
- The conductor is referred to as grounded because this is the action required at the service or separately derived system
- The term ***grounded*** is a ***past tense term*** meaning the action has already happened
- It is generally not permitted to use the grounded conductor *(neutral)* for grounding or in making grounding connections on the load side of the service or separately derived system *[see 250.4(A)(5)]*
- The goal is to keep current on the path intended for it

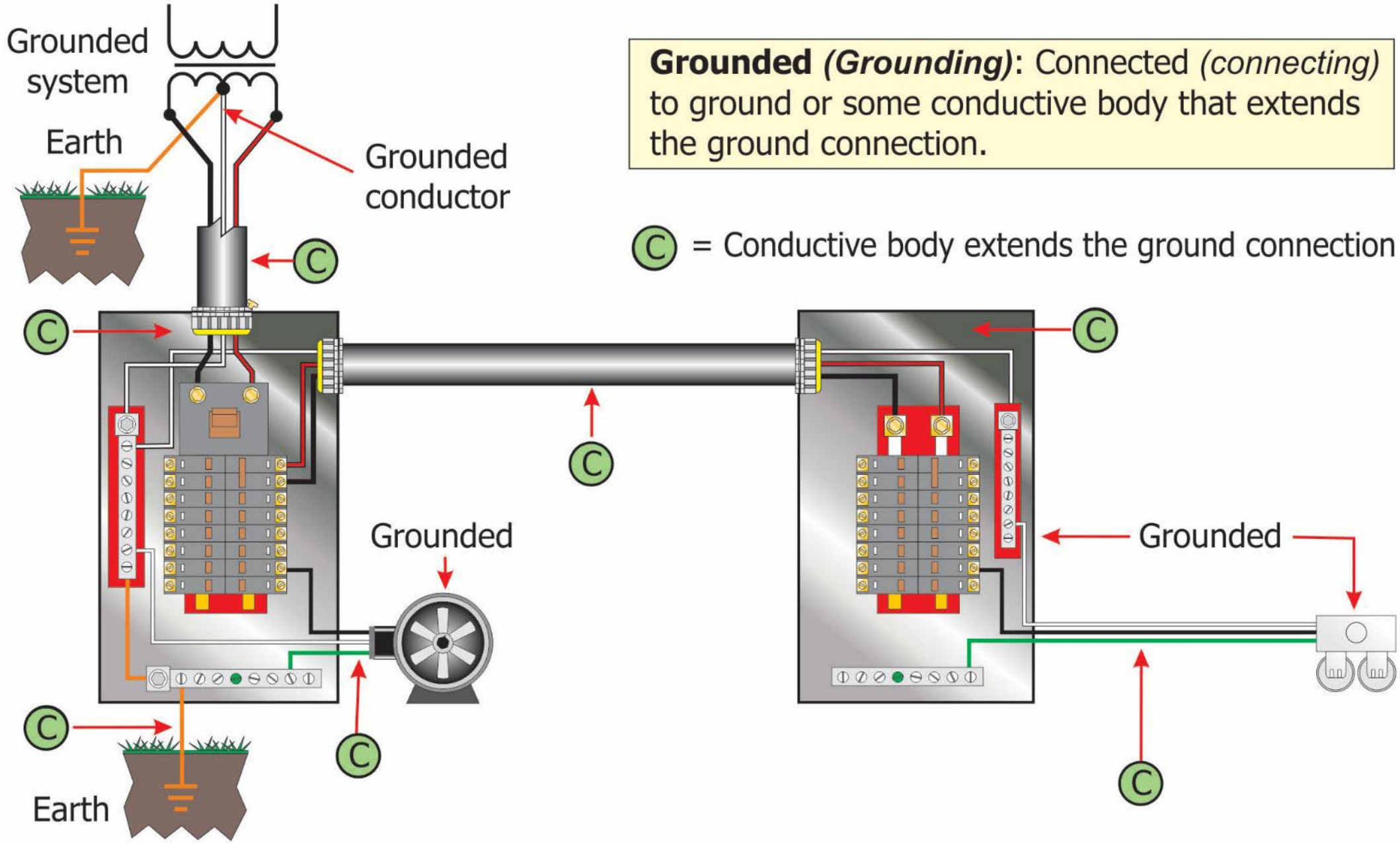
Grounding – Equipment Grounding Conductor

- ***Grounding*** is a ***present tense*** word
- Grounding indicates a process that is ongoing
- Grounding is an action required at enclosures and equipment in electrical circuits from the source or service to the final outlet(s) on the circuit
- It is accomplished by using an equipment grounding conductor of any type specified in 250.118
- The equipment grounding conductor of a circuit serves to put all metal enclosures at earth potential along the circuit
- It also serves as the low-impedance path *(safety circuit)* to carry ground-fault current to the source to facilitate the operation of overcurrent devices in ground-fault conditions
- Chapter Fourteen covers equipment grounding conductors

Definitions - Grounding as Compared to Bonding

- ***Ground:*** The earth.
- ***Grounded (Grounding):*** Connected *(connecting)* to ground or to a conductive body that extends the ground connection.
- ***Bonded (Bonding):*** Connected to establish electrical continuity and conductivity.

Grounded *(Grounding)*



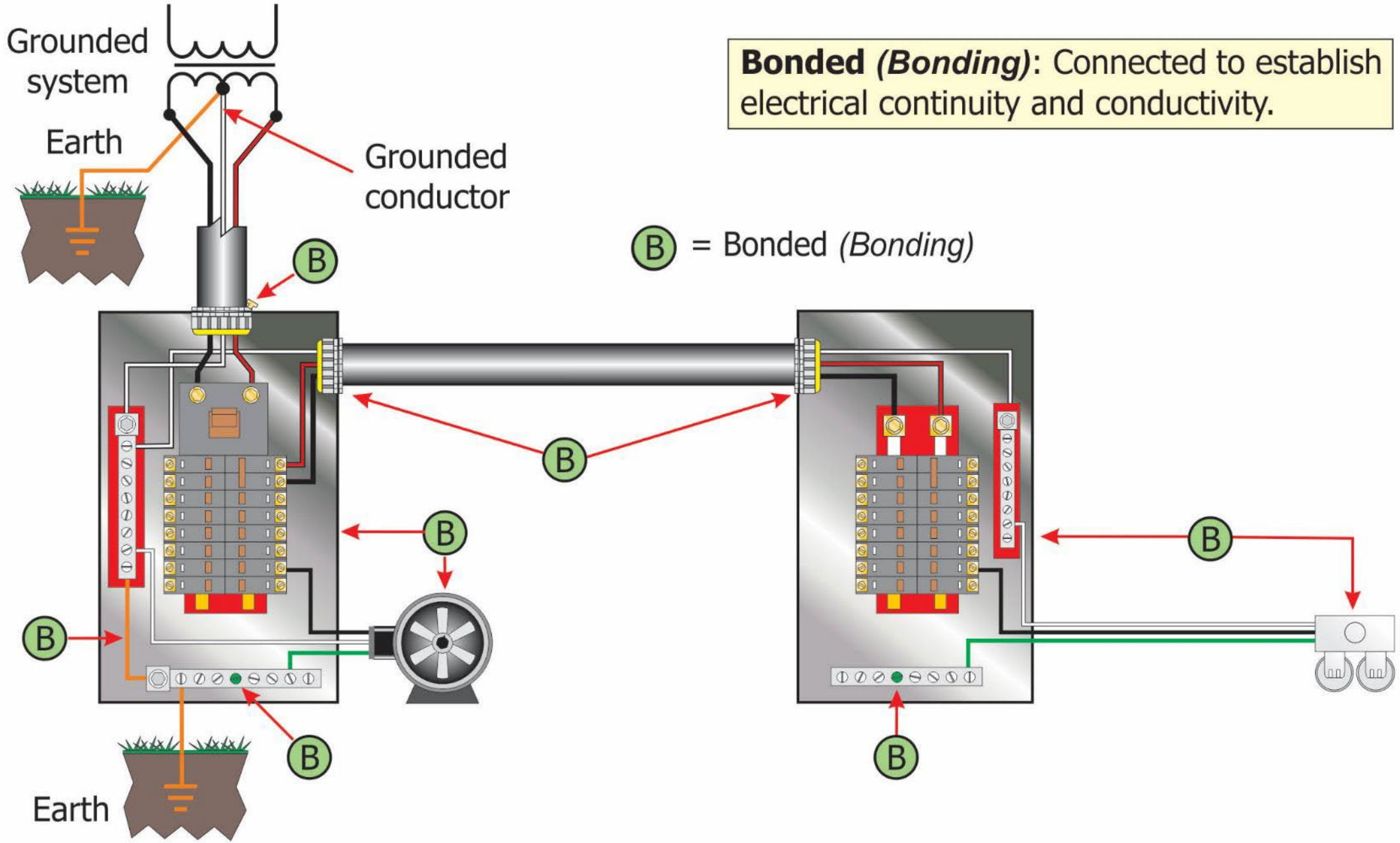
Grounded *(Grounding)*: Connected *(connecting)* to ground or some conductive body that extends the ground connection.

C = Conductive body extends the ground connection

Copyright © IAEI 2020

Bonded *(Bonding)*

Bonded *(Bonding)*: Connected to establish electrical continuity and conductivity.



Copyright © IAEI 2020

Effective Grounding and Bonding

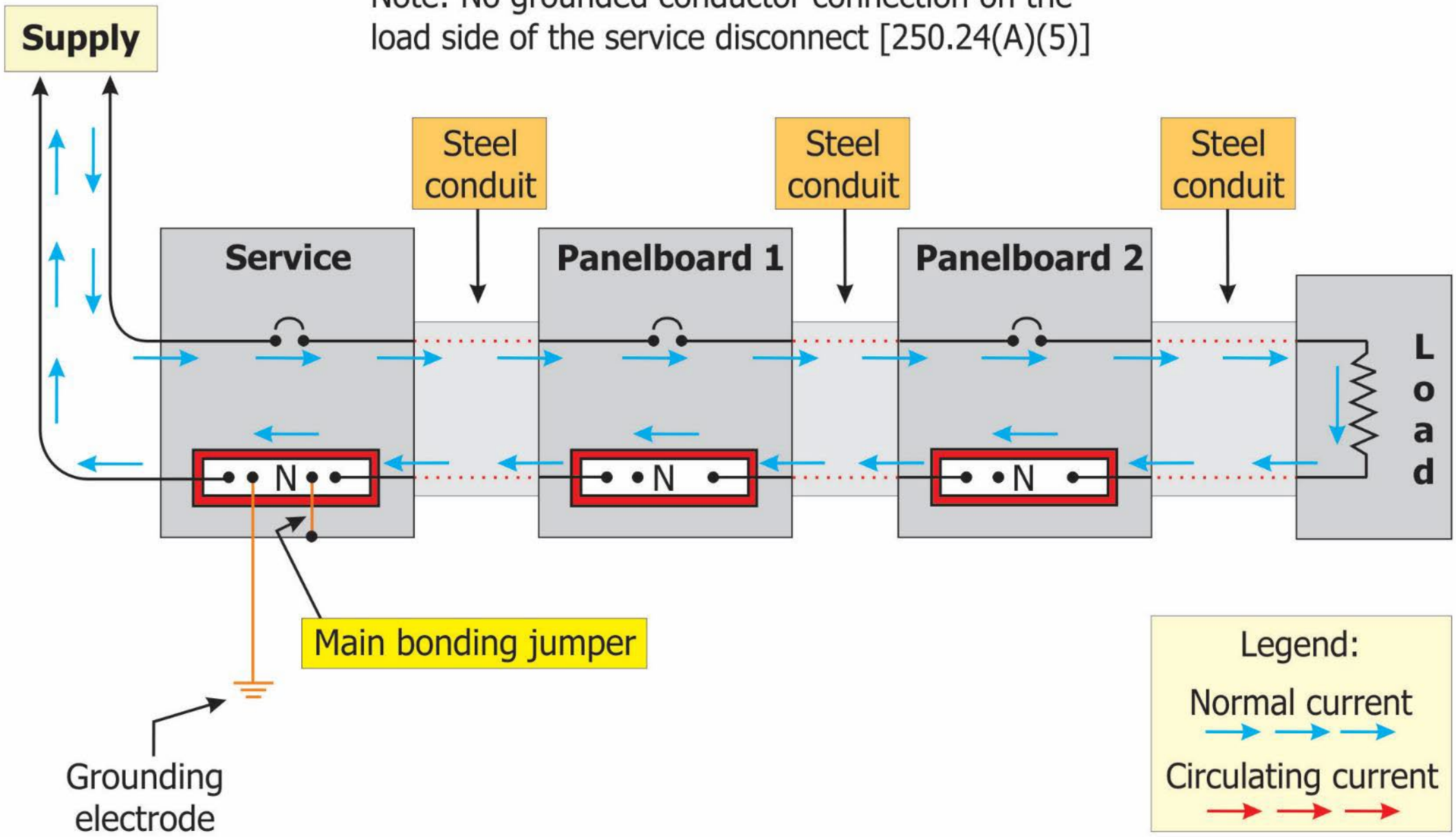
- Grounding and bonding must be effective
- These are the safety circuits of the electrical system
- The safety circuit *(bonding)* path must have the following characteristics for effectiveness anticipated by the *NEC*
  - Electrically continuous path
  - Have adequate capacity for fault currents imposed
  - Have lowest possible impedance
- See definitions in Article 100

Circulating Currents

- Keep current on the path intended for it
- Multiple grounding connections to a grounded conductor on the downstream side of a main bonding jumper at the service or bonding jumper at a derived system can lead to ***circulating currents*** in normal operation
- It is important that care be taken to keep the grounding connections to grounded *(neutral)* conductors limited to those allowed by the *Code* rules

Proper Current Flow

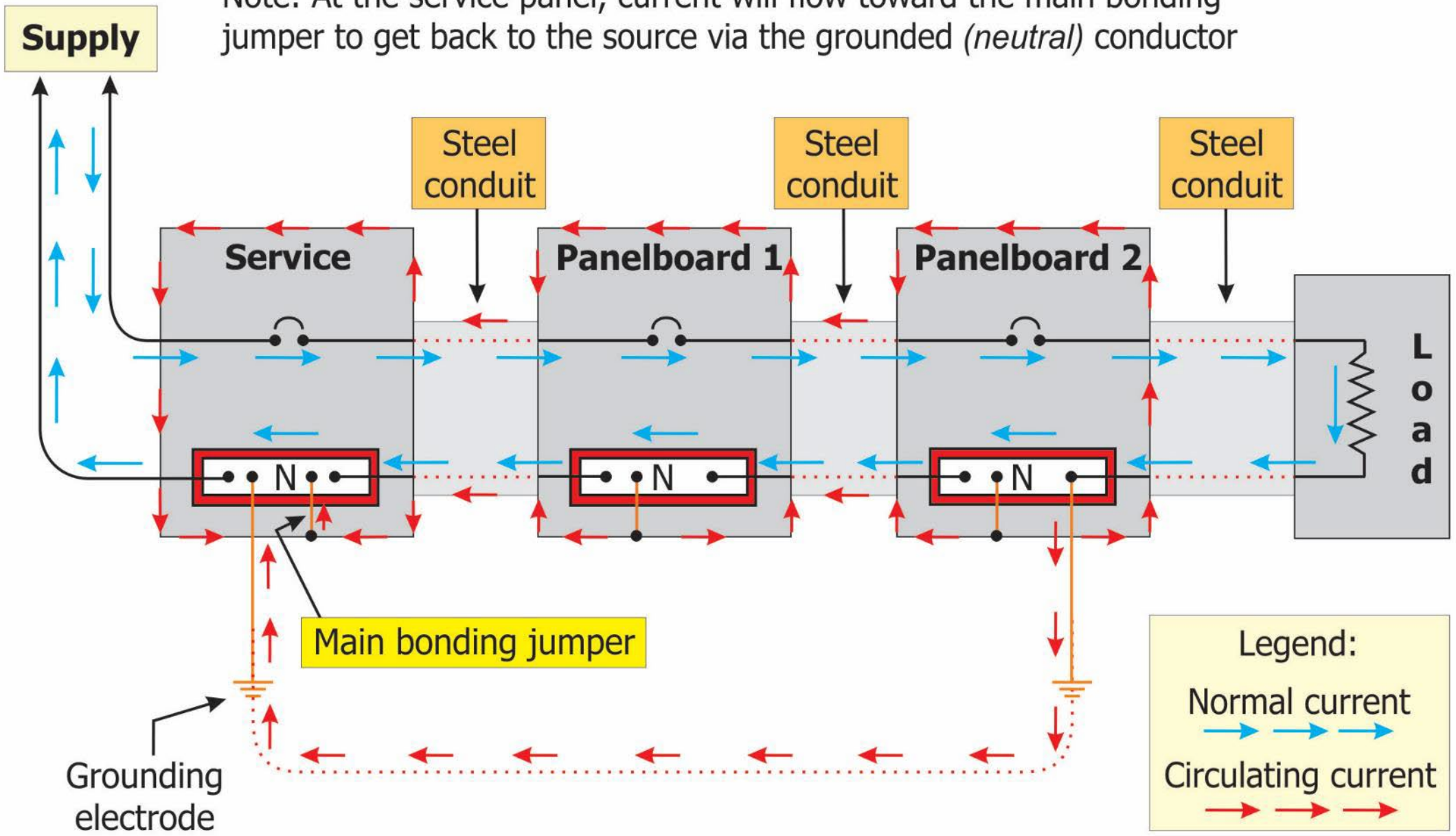
Note: No grounded conductor connection on the load side of the service disconnect [250.24(A)(5)]



Copyright © IAEI 2020

Circulating Currents on all Paths Available

Note: At the service panel, current will flow toward the main bonding jumper to get back to the source via the grounded *(neutral)* conductor

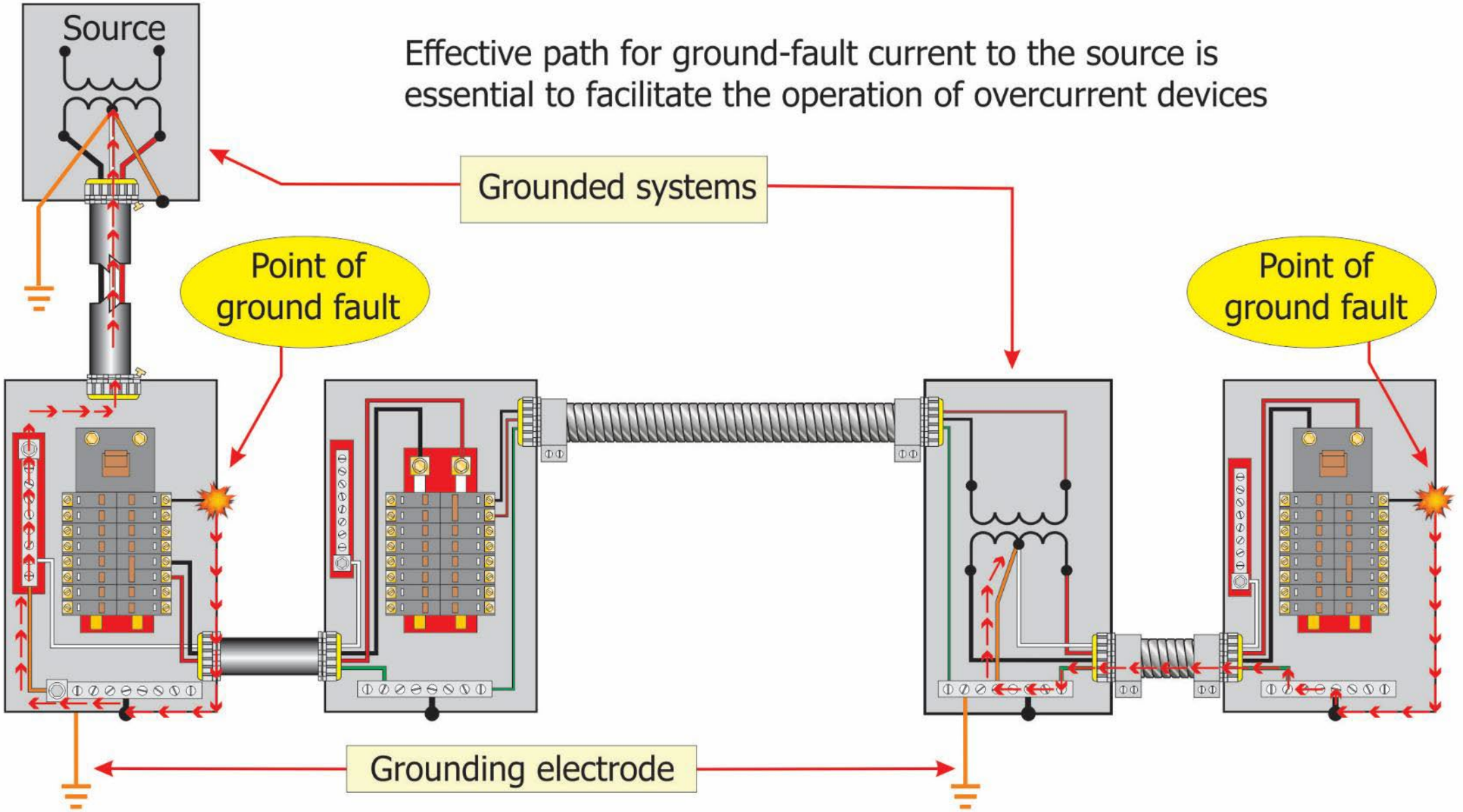


Copyright © IAEI 2020

Definitions - Current on the Proper Path

- Three Article 100 definitions describe important terms used in Article 250:
- ***Effective Ground-Fault Current Path:*** An 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 and that facilitates the operation of the overcurrent device or ground fault detectors.

Effective Ground-Fault Current Path



See 250.4(A)(5) and definition in Article 100 *(Effective Ground-Fault Current Path)*

Copyright © IAEI 2020

Definitions - Current on the Proper Path

- Three Article 100 definitions describe important terms used in Article 250 *(cont.)*:
- ***Ground Fault:*** An unintentional, electrically conductive connection between an ungrounded conductor of an electrical circuit and the normally non-current-carrying conductors, metallic enclosures, metallic raceways, metallic equipment, or earth.

Definitions - Current on the Proper Path

- Three Article 100 definitions describe important terms used in Article 250 *(cont.)*:
- ***Ground-Fault Current Path:*** An electrically conductive path from the point of a ground fault on a wiring system through normally non-current-carrying conductors, grounded conductors, equipment, or the earth to the electrical supply source.
- *Informational Note:* ***Examples of ground-fault current paths*** *are any combination of equipment grounding conductors, metallic raceways, metallic cable sheaths, electrical equipment, and any other electrically conductive material such as metal, water, and gas piping; steel framing members; stucco mesh; metal ducting; reinforcing steel; shields of communications cables; grounded conductors; and the earth itself.*

CHAPTER TWO

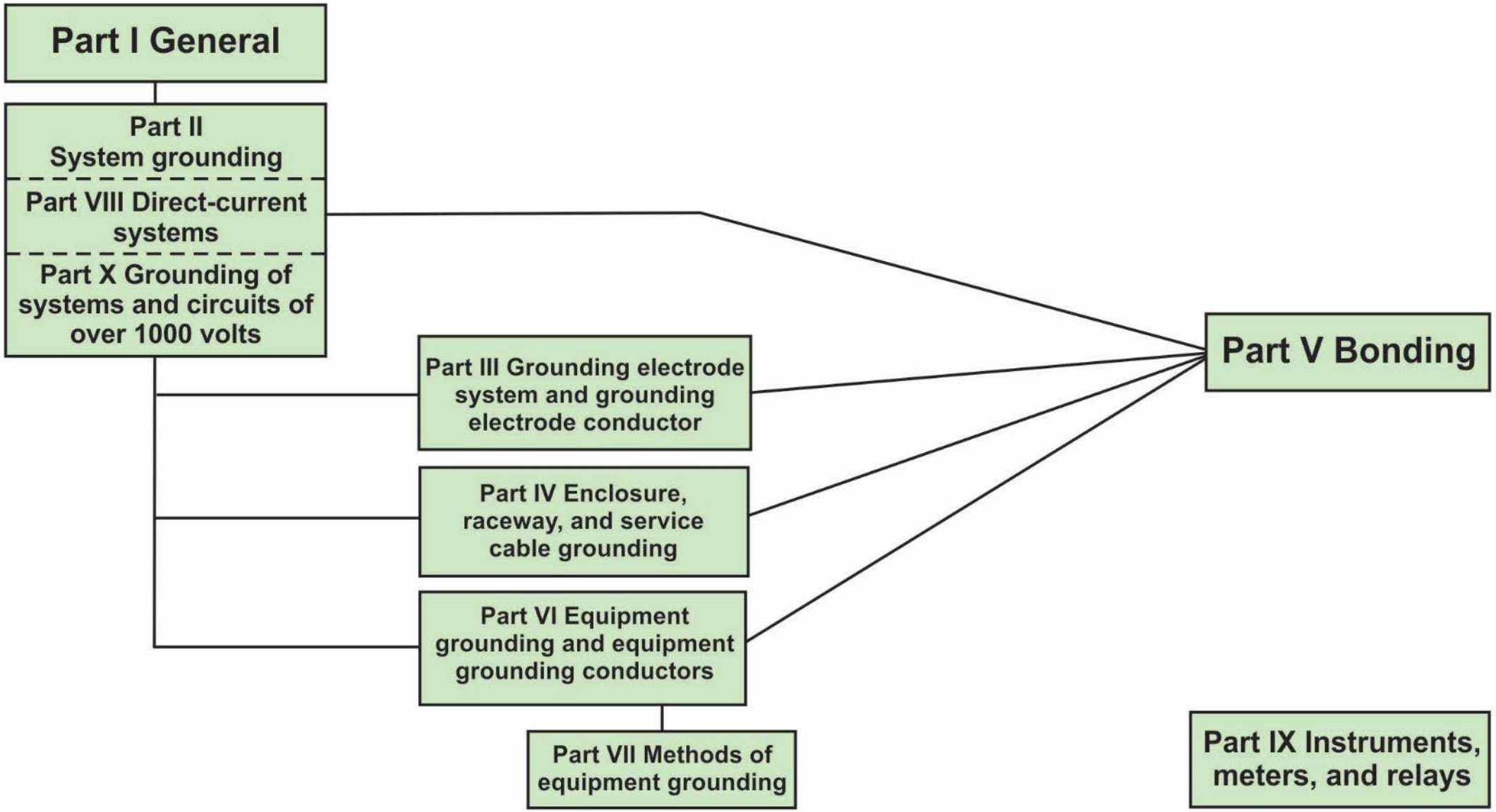
GERERAL FUNDAMENTALS



Overview of NFPA 70 Article 250

- Article 250 is located in Chapter Two of the *NEC* which is accurately titled "Wiring and Protection"
- Part I of Article 250 includes general requirements and some important performance requirements that are vital to understanding and applying prescriptive requirements found in the latter parts of the article
- The parts in Article 250 are very much interlocking
- Parts must be used together to understand and properly apply the rules
- Figure 250.1 is included in Article 250 and serves as a built-in map or guide which serves to enhance usability issues

NEC Figure 250.1



Reproduction of *NEC* Figure 250.1 Grounding and Bonding

Copyright © IAEI 2020

Scope of Article 250

- Systems, circuits, and equipment required, permitted, or not permitted to be grounded
- Circuit conductor to be grounded on grounded systems
- Location of grounding connections
- Types and sizes of grounding and bonding conductors and electrodes
- Methods of grounding and bonding
- Conditions under which **guards**, **isolation**, or **insulation** may be used as a substitute for grounding

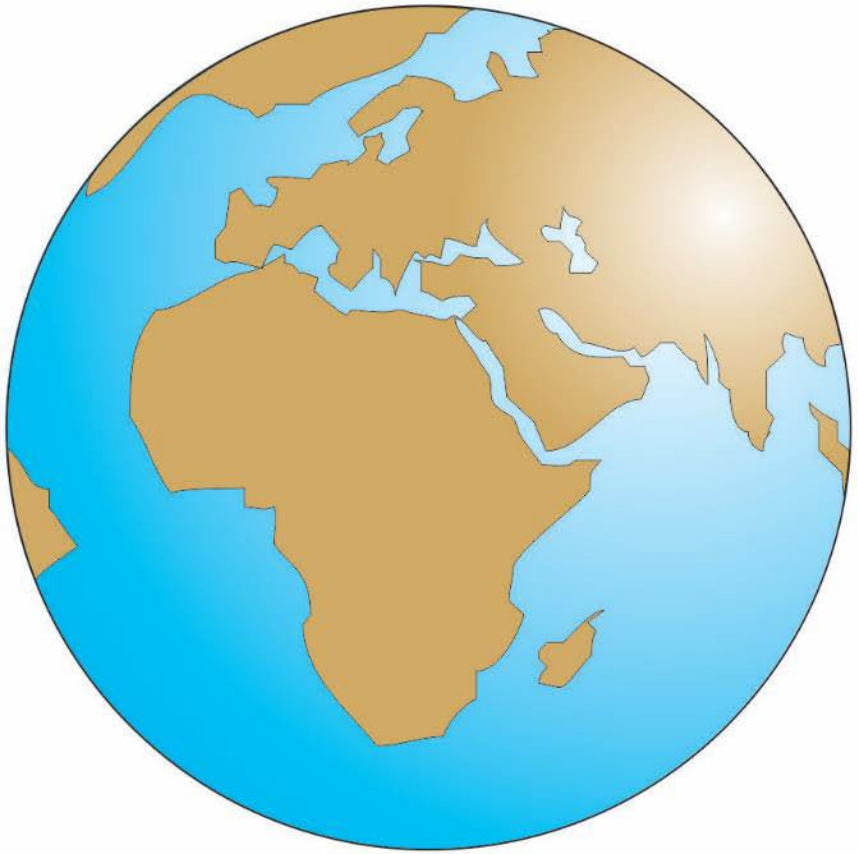
Alternatives to Grounding

- ***Guarded:*** Covered, shielded, fenced, enclosed, or otherwise protected by means of suitable covers, casings, barriers, rails, screens, mats, or platforms to remove the likelihood of approach or contact by persons or objects to a point of danger. *(see Article 100)*

- ***Isolated (as applied to location):*** Not readily accessible to persons unless special means for access are used. *(see Article 100)*

- ***Insulated Conductor [Conductor, Insulated]:*** A conductor encased within material of composition and thickness that is recognized by this *Code* as electrical insulation.

The Earth as a Conductor





Grounded: "Connected (connecting) to ground or to a conductive body that extends the ground connection"

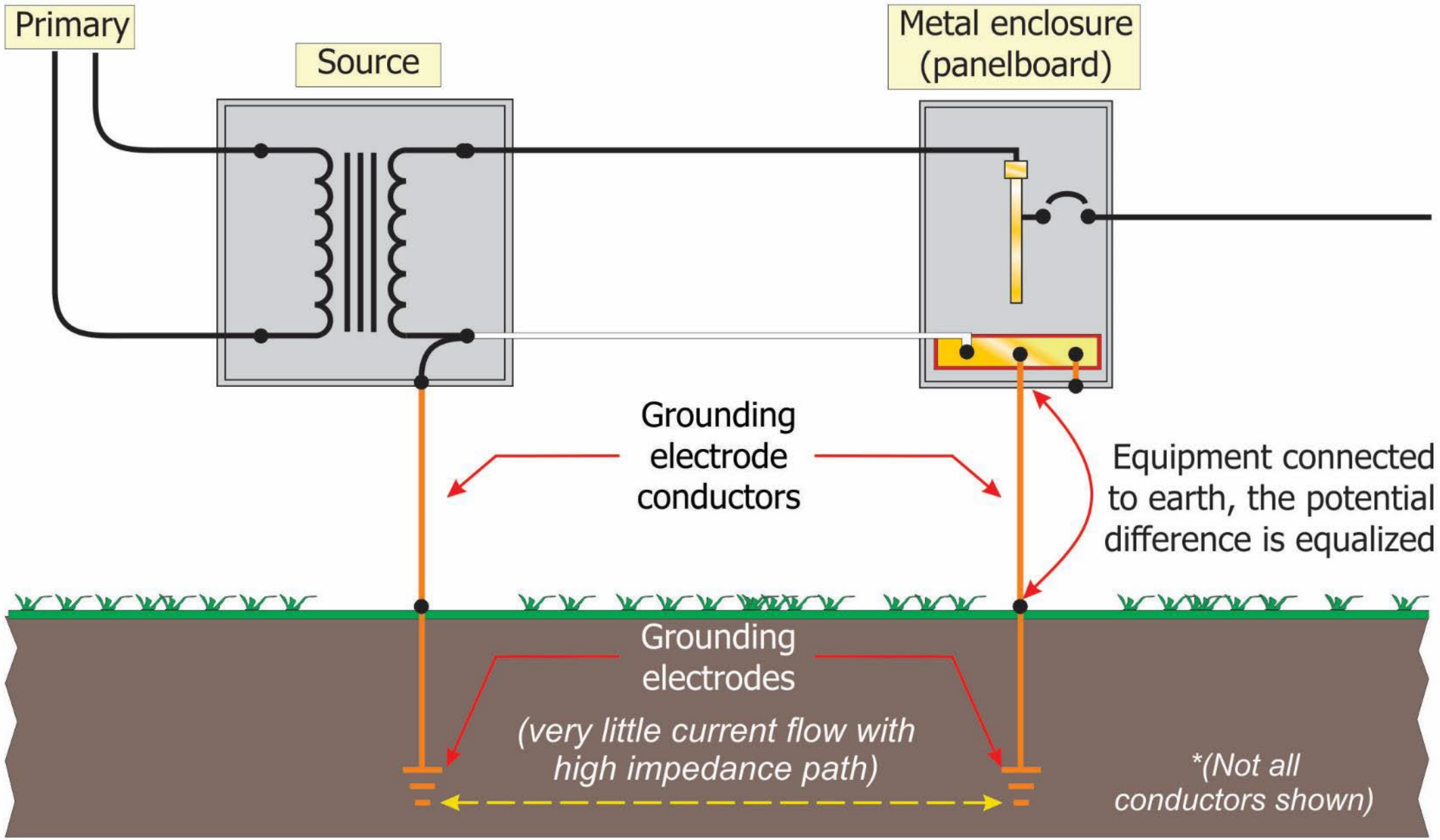
The earth as a conductor is assumed to have a voltage potential to conduct electricity of "zero"

Copyright © IAEI 2020

Grounding Fundamentals

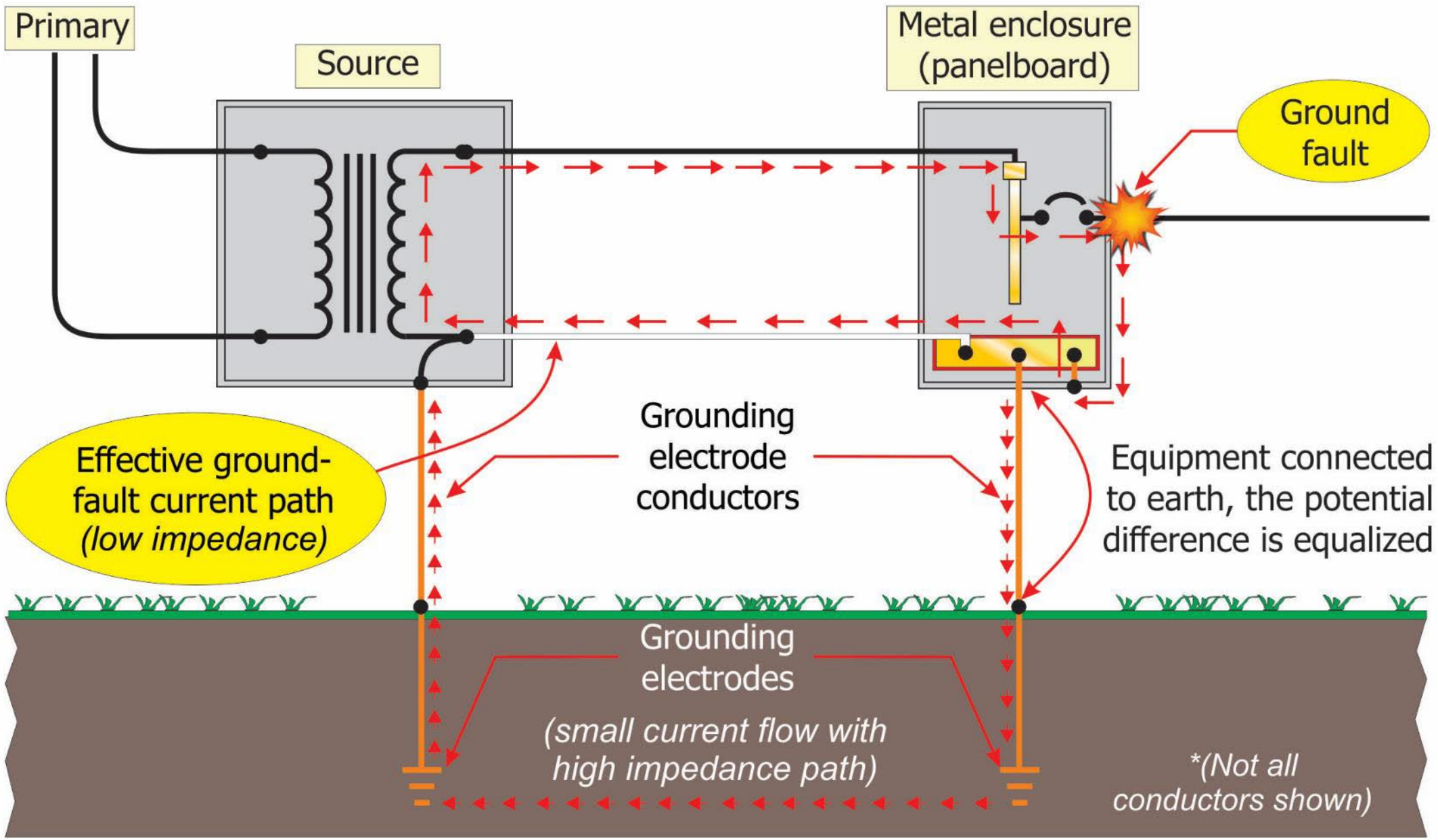
- A metal object *(metal box or other metal equipment enclosure, etc.)* that is grounded by connecting *(bonding)* it to the ground *(earth)* is forced theoretically to take the same **zero potential** as the earth
- This connection to earth is typically established by means of a grounding electrode, grounding electrode conductor, and/or equipment grounding conductor
- Slight **differences in potential** can exist due to differences in impedance of the conductor materials, long conductor length, or poor connections

Grounding Fundamental



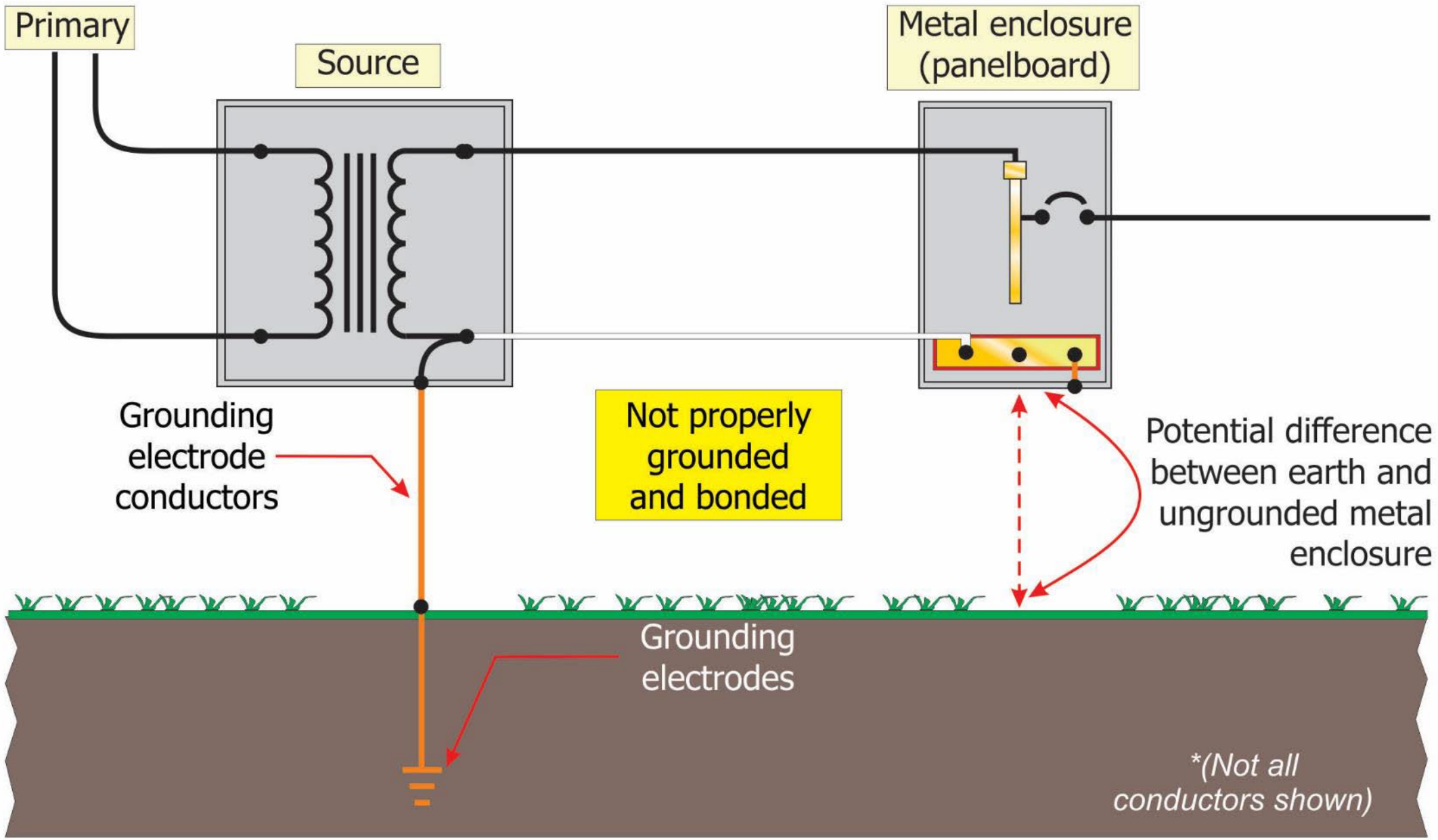
Copyright © IAEI 2020

Grounding Fundamental



Copyright © IAEI 2020

Grounding Fundamental



Copyright © IAEI 2020

Electrical Shock and the Human Body

- Electrical equipment *(supplied by a grounded system)* left ungrounded/unbonded or that has a poorly connected equipment grounding path becomes a **silent and often lethal source of electrical shock** when a ground fault occurs
- Hazards can occur where two separate pieces of electrical equipment are supplied from a grounded system and both are within reach of a person
- If one piece is not properly connected or poorly connected to the EGC path and becomes energized through a failure of the insulation system *(ground fault)*, the person is now in a circuit *(path)* for fault current to pass through their body as the current tries to find its way back to its source ***(person will receive a mild shock)***
- In other cases, the **shock can be fatal** *(even though the impedance of the human body can be relatively high)* as approximately **100 milliamp (mA) of current can be lethal**
- A **milliamp** is equal to **one thousandth of an ampere**

Effects of Electricity on Humans

It doesn't take much current to cause injury or death to people



(Measured in milliamperes)

1000	- 1 ampere *(1000 milliamps)*
900	- Severe burns
833	- Will light a 100-watt bulb
300	- Breathing stops
200	
100	- Heart stops beating
90	
60	
30	- Suffocation possible
20	- Muscle contraction
10	- "Let-go" threshold
5	- GFCI will trip
2	- Mild shock
1	- Threshold of sensation

Copyright © IAEI 2020

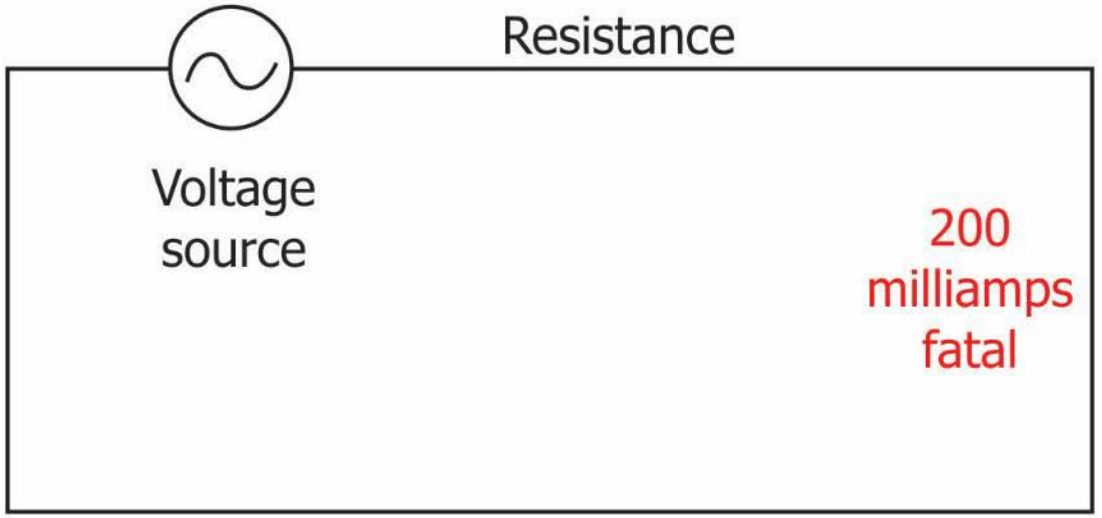
Severity of Electrical Shock

- Like the bird on an electric wire, the human body is immune to electric shock as long as it is not part of the electric circuit
- When a person becomes a path for electricity, he or she will experience an **electrical shock**
- The **intensity** and **damage** done to the body by the shock determined by:
  - Current level (amount through the person)
  - How long the current exists (duration)
  - Person's size
  - Pathway the current takes through the body
  - Circuit frequency

Severity of Electric Shock

The severity of electric shock is related to **four elements**

(1) Amount of current
(2) Length of time current is present
(3) Path of current through the body
(4) Frequency of the current *(Hz)*



Amount of time current is allowed to pass through the body



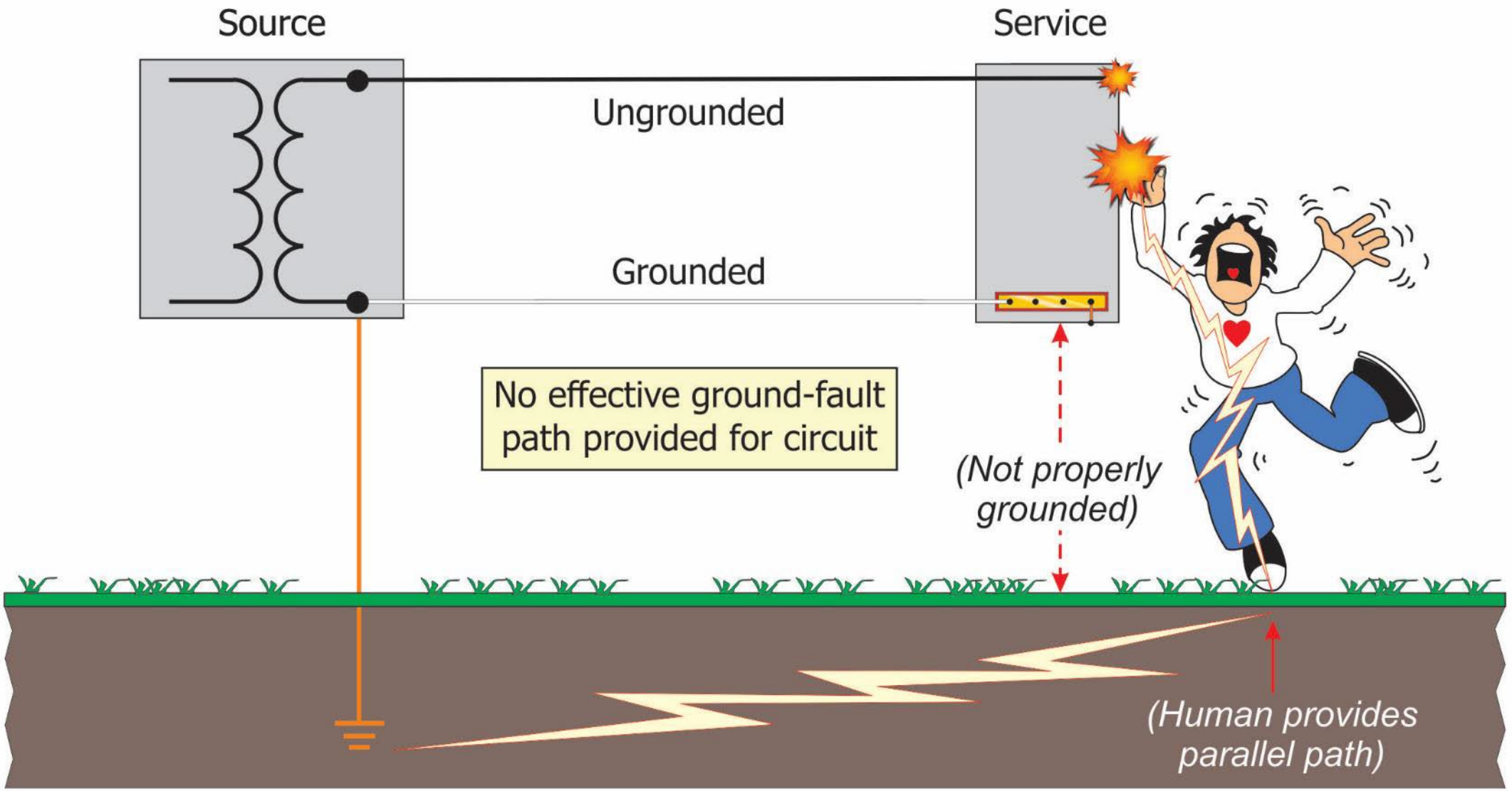
If the combination of these four elements is just right, the shock can be severe or lead to electrocution

Copyright © IAEI 2020

Effects of Electricity on the Human Body

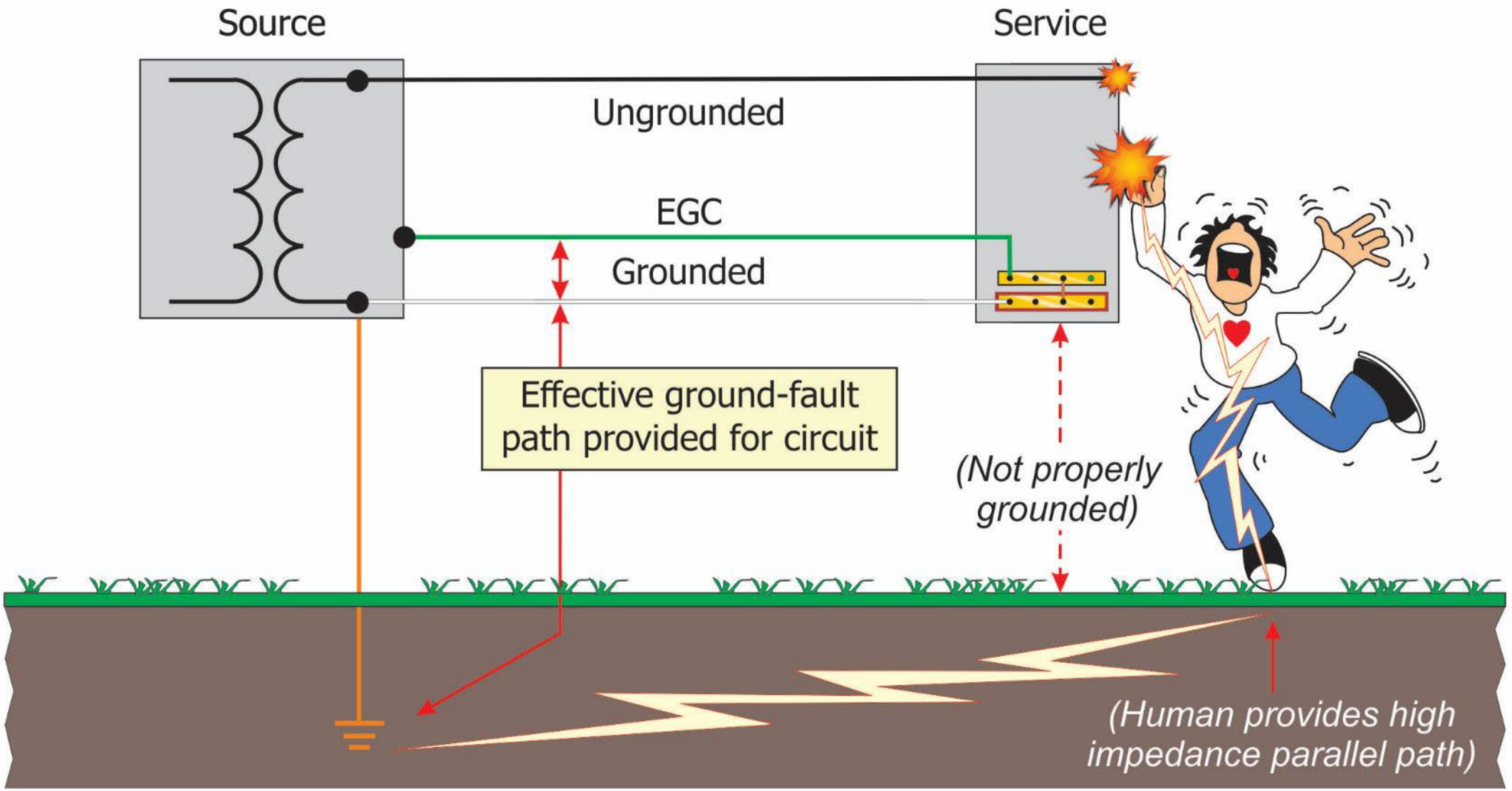
- A person can become a pathway to ground or between conductors in one of two ways:
  - Series circuit
  - Parallel circuit
- In a **series circuit**, the person is the only path through which the current can attempt to return to its source
- In a **parallel circuit**, the human body and one or more other paths *(equipment grounding conductor, metal enclosures of equipment, or other metallic paths, etc.)* each provide a path for current at the same time

Human Completing Grounding Path



Copyright © IAEI 2020

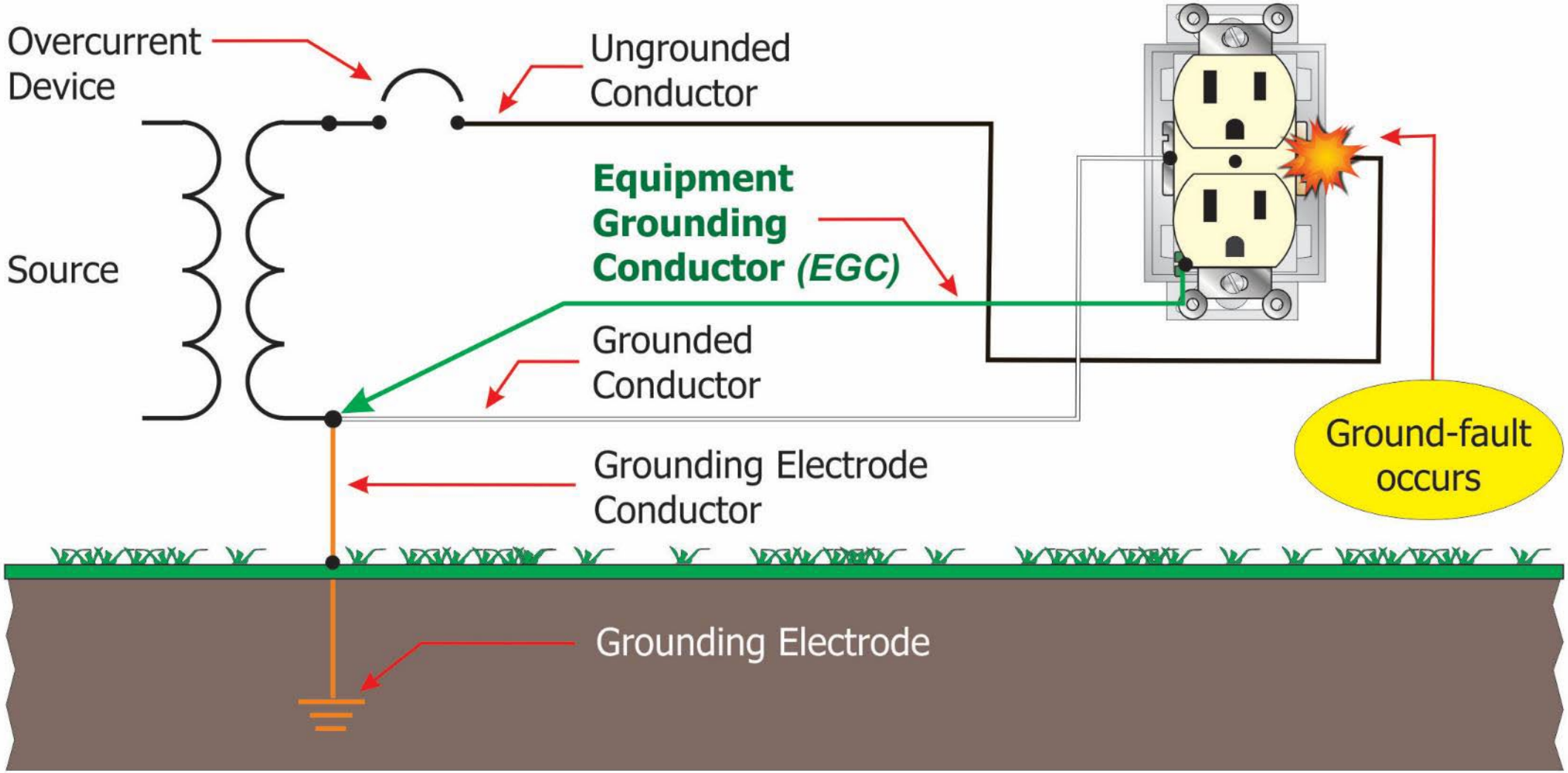
Human Completing Grounding Path



Copyright © IAEI 2020

Purpose of Equipment Grounding Conductor *(EGC)*

1. Extends the ground *(earth)* connection to the equipment
2. Provides an effective return path for ground-fault current

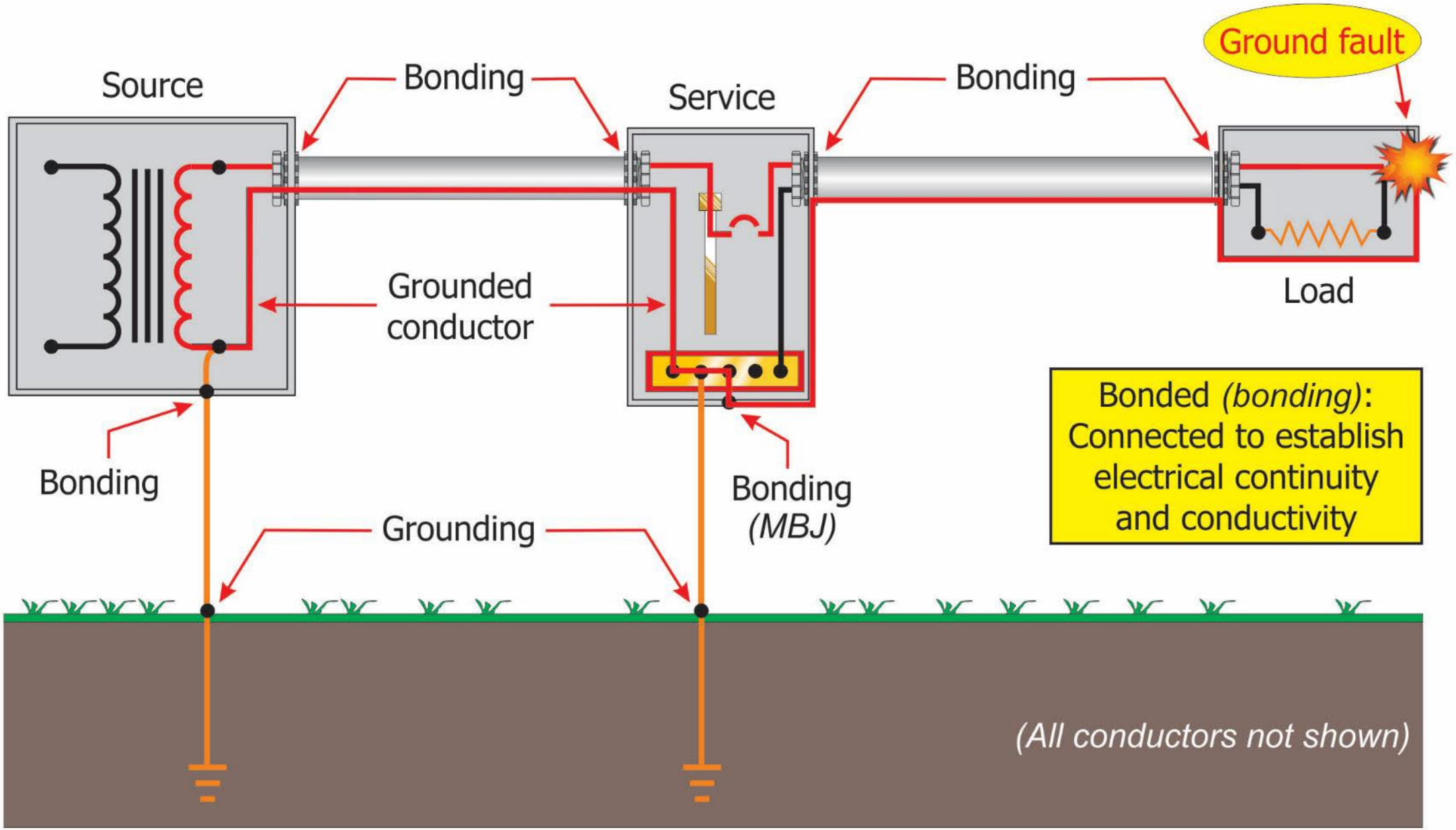


Copyright © IAEI 2020

Bonding of Electrical Equipment

- Normally non-current carrying metallic enclosures, raceways and other parts of the electrical system need to be **bonded together** *(direct connection or to bonding jumpers)* forming a **low impedance path** to **carry ground-fault current** when a ground fault occurs
- For **grounded systems**, parts are to be connected together and to the supply source to form an **effective ground-fault current path**
- See 250.4(A)(3)

Purpose of Bonding Equipment and Enclosures



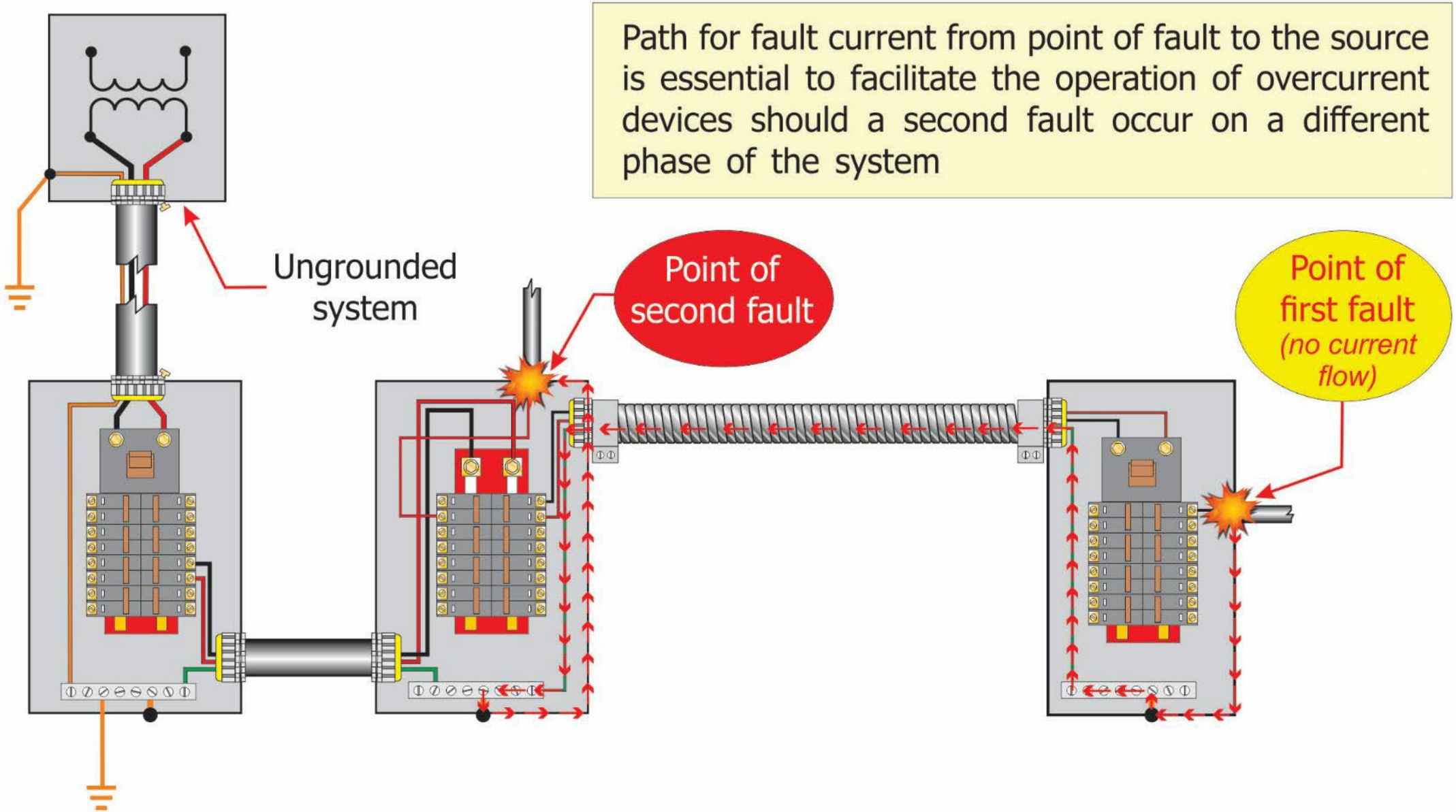
Copyright © IAEI 2020

Bonding of Electrical Equipment *(cont.)*

- Normally non-current carrying metallic enclosures, raceways and other parts of the electrical system need to be **bonded together** *(direct connection or to bonding jumpers)* forming a **low impedance path** to **carry ground-fault current** when a ground fault occurs *(cont.)*
- For **ungrounded systems**, parts are connected together and to the supply source grounded equipment to form a **low-impedance ground-fault current path** capable of carrying the **maximum fault current likely to be imposed**
  - This typically occurs where a second ground fault occurs before the first one is cleared
- For **ungrounded systems**, fault current can be essentially a **line-to-line fault** passing through the equipment grounding system from the first fault point to the second
- See 250.4(B)(2)

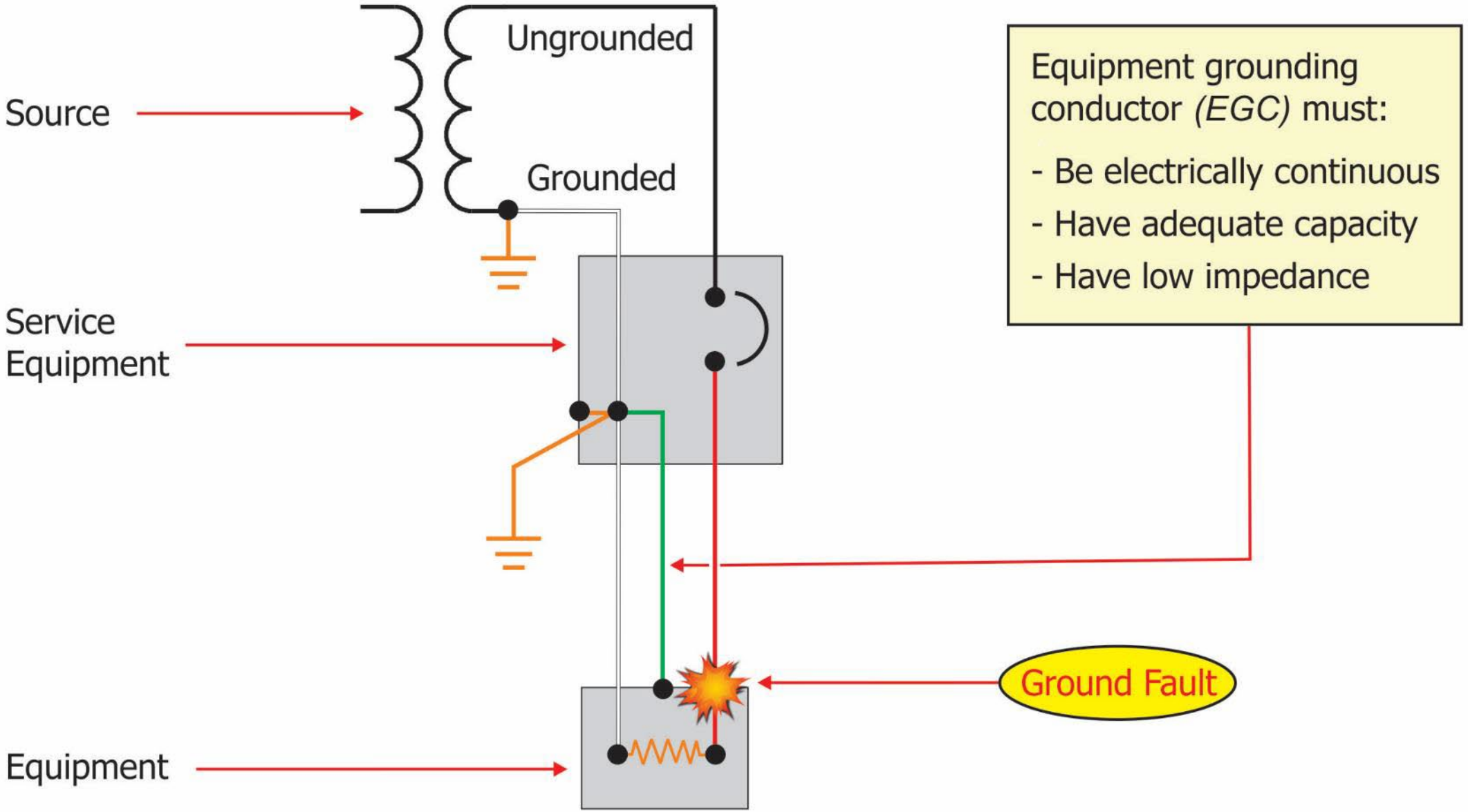
Effective Ground-Fault Current Path on Ungrounded Systems

Path for fault current from point of fault to the source is essential to facilitate the operation of overcurrent devices should a second fault occur on a different phase of the system



Copyright © IAEI 2020

Effective Ground-Fault Current Path



Copyright © IAEI 2020

Performance Criteria in 250.4

- Understanding how and why things work the way they do makes it easier to understand and apply *Code* rules to electrical installations
  - 250.4(A) Grounded Systems
  - 250.4(B) Ungrounded Systems

250.4(A)
Grounded System Performance

- Grounded systems include an **intentionally grounded system** or circuit conductor
- The performance criteria for grounded systems is included as performance language in 250.4(A)
  - Electrical system grounding
  - Grounding of electrical equipment
  - Bonding of electrical equipment
  - Bonding of electrically conductive materials and other equipment
  - Effective ground-fault current path

250.4(B) Ungrounded System Performance

- Ungrounded systems **do not include a conductor of the system that is intentionally grounded**
- There are grounding requirements for enclosures and equipment for ungrounded systems
- The performance criteria for ungrounded systems are included in 250.4(B)
  - Grounding of electrical equipment
  - Bonding of electrical equipment
  - Bonding of electrically conductive materials and other equipment
  - Path for fault current

Electrical System Design

- Electrical systems are designed with capacity for the load
- A goal of the electrical system must include a design that is safe and free of short circuits and ground faults as required by 110.7
- Ungrounded system conductors are separated from grounded conductors and grounded parts by insulation
- Insulation mediums can be in a variety of forms including thermoplastic, rubber, or, even, air
- Electrical wiring installations *(including conductors)* should be tested to verify insulation integrity prior to energizing the circuits
- Testing equipment is available for this purpose

Insulation Resistance

- Basic knowledge of and the need for **insulation-resistance testing** are important
- Measurements of insulation resistance can best be made with a **megohm-meter insulation tester**, commonly called a "**megger**"
- These instruments typically available from several manufacturers and vary in cost and features
- As measured with such an instrument, insulation resistance is the resistance to direct current *(usually at 500, 1000, or 1500 volts for systems of 1000 volts or less)* through or over the surface of the insulation in electrical equipment
- Insulation resistance is a measurement of not only the solid dielectric but also the dielectric provided by air when measuring from conductor to metal enclosure or raceway

Insulation Resistance Testing



Courtesy of Electro-Test, Inc.

- Insulation-resistance *(hi-potential)* testing in progress

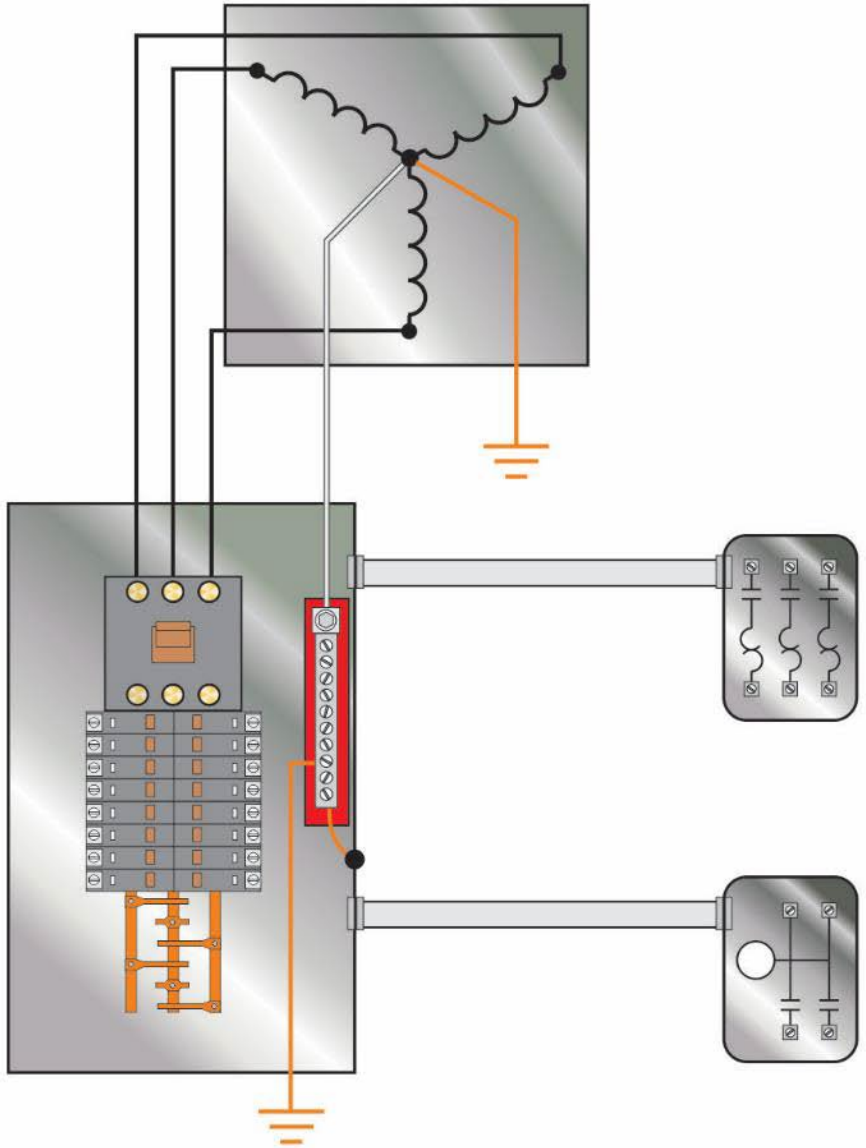


Courtesy of Megger

Circuit Impedance and Other Characteristics

- Equipment must have adequate **short-circuit current ratings** for the amount of fault current at its line terminals
- Overcurrent devices intended to interrupt current at fault levels must do so **without extensive damage** being caused to the equipment
- Extensive damage is not defined in the *Code*
- Passive devices must **withstand fault current** until upstream overcurrent devices clear the fault or short circuit
- The overcurrent devices and other characteristics of the circuit(s) to be protected must be **selected and coordinated** to provide protection for damage that might result from ground-fault, or short-circuit currents

110.9 Interrupting Ratings

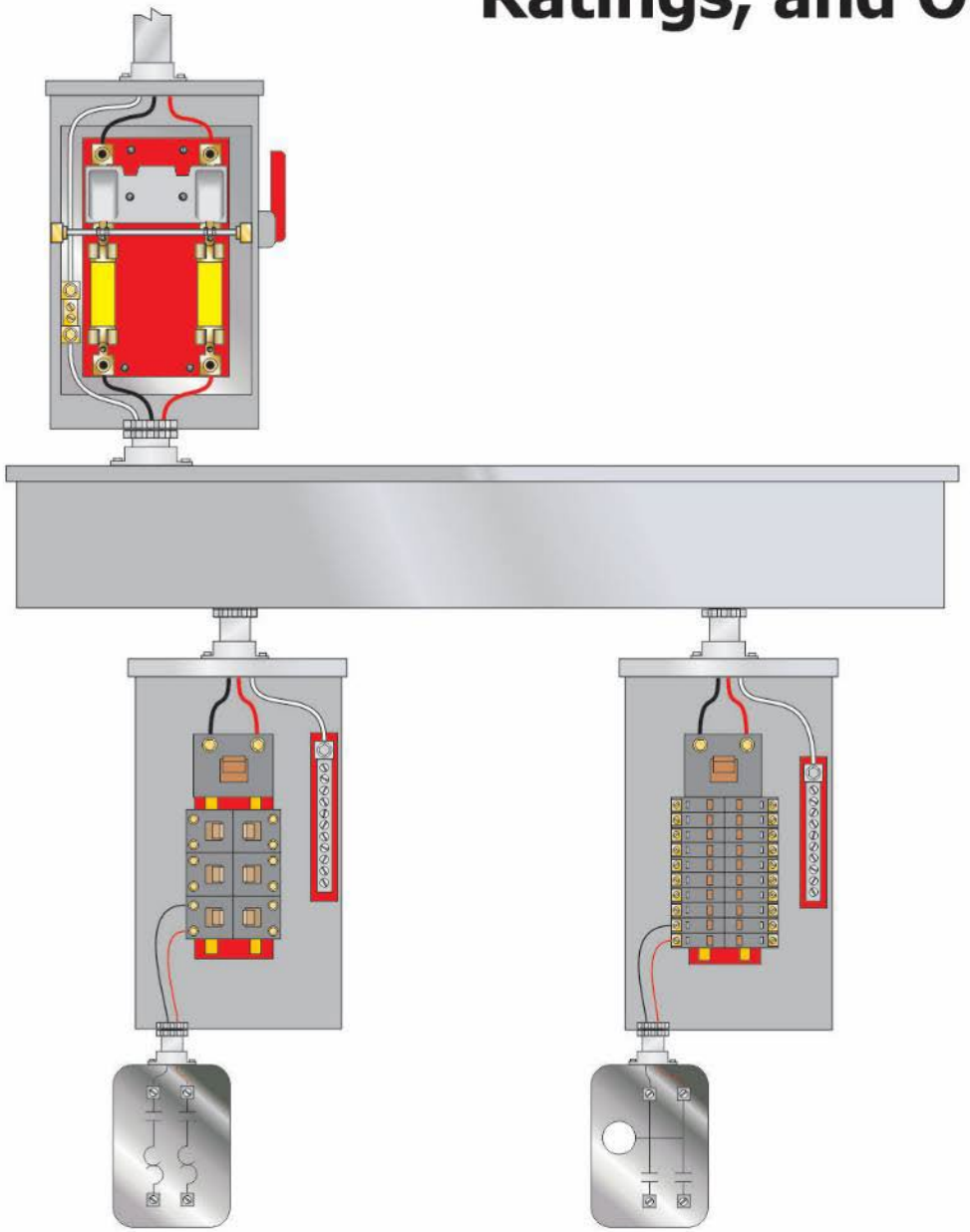


Equipment intended to interrupt current at fault levels shall have an interrupting rating at normal circuit voltage sufficient for the *(fault)* current that is available at the line terminals of the equipment

Equipment intended to interrupt current at other than fault levels shall have an interrupting rating at nominal circuit voltage sufficient for the current that must be interrupted

Copyright © IAEI 2020

110.10 Circuit Impedance, Short-Circuit Ratings, and Other Characteristics



- Overcurrent protective devices
- Total impedance
- Component short-circuit current rating
- Other characteristics of circuit

The above shall be selected and coordinated to permit circuit protective devices to clear fault without extensive damage to the electrical equipment of the circuit

Listed products applied in accordance with their listing are considered to meet requirements of *NEC* 110.10

Fault assumed to be between:

- Two or more of the circuit conductors
- Any circuit conductor and the grounding conductor or enclosing metal raceway

Copyright © IAEI 2020

1287

CHAPTER THREE

TO GROUND OR NOT TO GROUND THE SYSTEM

Electrical Systems

- **Electrical system** generally refers to the distribution system from a source having specific voltage *(potential)* and often amperage and power *(current or capacity in KW or KVA)* characteristics
- Example:
  - 480Y/277-volts, 3-phase, 4-wire at some capacity such as 1600 amperes or 1500 KVA

Article 100: Definitions

- ***Ground Fault:*** "An unintentional, electrically conductive connection between an ungrounded conductor of an electrical circuit and the normally non-current-carrying conductors, metallic enclosures, metallic raceways, metallic equipment, or earth."

Article 100: Definitions

- ***Ground-Fault Current Path:*** "An electrically conductive path from the point of a ground fault on a wiring system through normally non-current-carrying conductors, grounded conductors, equipment, or earth to the electrical supply source."
- **Informational Note:** Examples of ground-fault current paths are any combination of equipment grounding conductors, metallic raceways, metallic cable sheaths, electrical equipment, and any other electrically conductive material such as metal, water, and gas piping; steel framing members; stucco mesh; metal ducting; reinforcing steel; shields of communications cables; grounded conductors; and the earth itself.

Article 100: Definitions

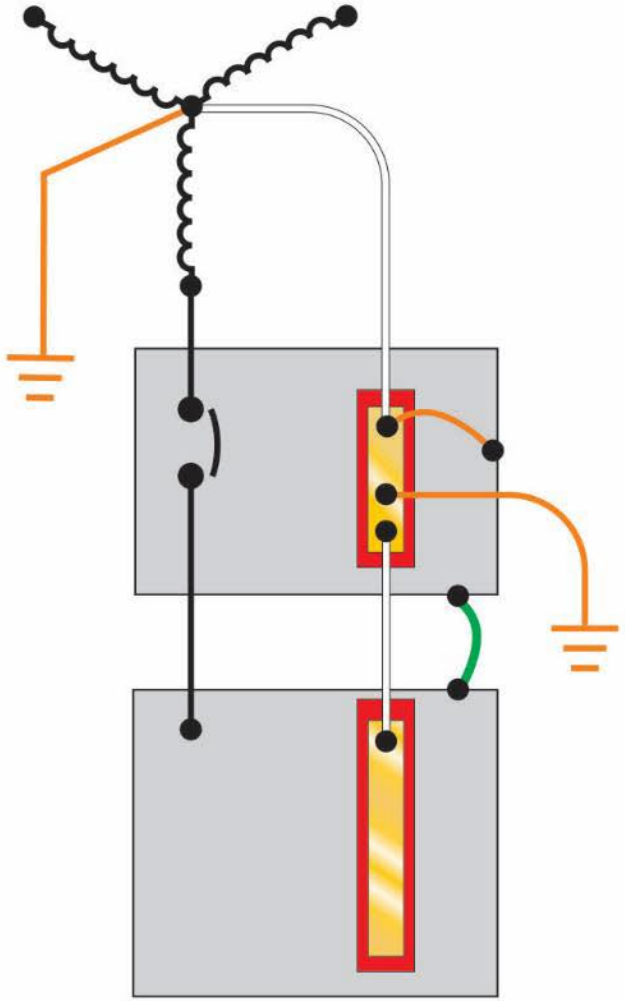
- ***Effective Ground-Fault Current Path:*** "An intentionally constructed, low-impedance electrically conductive path designed and intended to carry current under ground-fault conditions from the point of a ground fault on a wiring system to the electrical supply source and that facilitates the operation of the overcurrent protective device or ground-fault detectors."

250.4 General Requirements for Grounding and Bonding

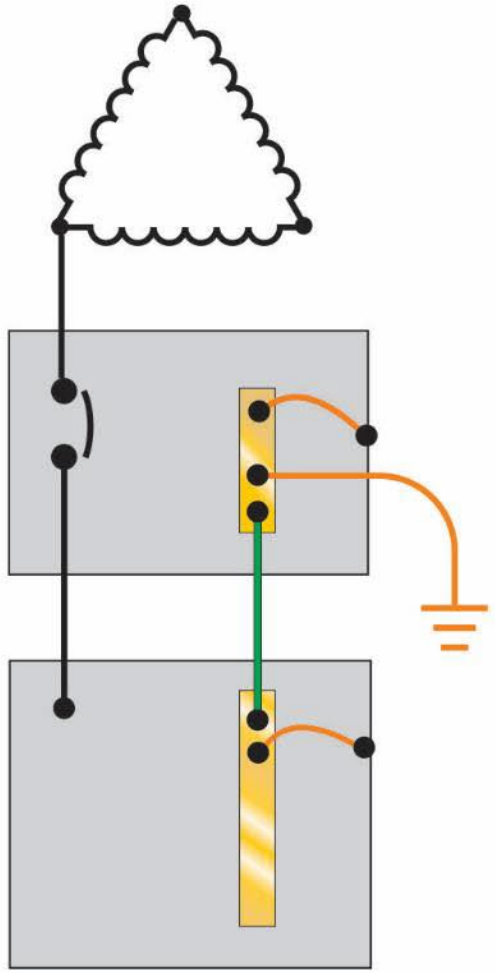
- Section 250.4 is divided into two main parts
  - **250.4(A)** includes the performance requirements for ***Grounded Systems***
    - (1) Electrical System Grounding
    - (2) Grounding of Electrical Equipment
    - (3) Bonding of Electrical Equipment
    - (4) Bonding of Electrically Conductive Materials and Other Equipment
    - (5) Effective Ground-Fault Current Path
  - **250.4(B)** includes the performance requirements for ***Ungrounded Systems***
    - (1) Grounding Electrical Equipment
    - (2) Bonding of Electrical Equipment
    - (3) Bonding of Electrically Conductive Materials and Other Equipment
    - (4) Path for Fault Current

NEC 250.4(A) and (B)

250.4(A) - Grounded Systems



250.4(B) - Ungrounded Systems



The performance requirements of the fault-current paths for each system are provided in each part

Copyright © IAEI 2020

250.4(A)(1) Informational Notes

- Informational Note No. 1 at 250.4(A)(1) indicates that important considerations for limiting imposed voltages are to minimize **excessive lengths** and to avoid **unnecessary bends and loops** in grounding and bonding conductors
- Informational Note No. 2 gives direction to **NFPA 780** for guidance on installation of **lightning protection systems**
  - Note: The *NEC* does not provide installation requirements for lighting protection system other than the bonding of the two grounding electrode systems together
- Note that this is a recommendation and not a requirement as provided for in the text to 90.5(C)

System Grounding – To Ground or Not to Ground?

- Great debates have occurred over the merits of grounding electrical systems versus ungrounded systems
- Certain electrical systems falling within the parameters of **250.20** are **required to be grounded**
- Other electrical systems are **permitted to be grounded** *(see **250.21**)*
- Some systems are **not permitted to be grounded** due to special conditions *(see **250.22**)*
- Whether the system is required to be grounded, or is grounded by choice, the applicable grounding rules for grounded systems must be followed *(see 250.20)*

Systems Required to be Grounded

- As specified in 250.20(A) through (D), these alternating-current (ac) systems must be grounded:
  - AC circuits of less than 50 volts [250.20(A)]
  - AC systems of 50 volts to 1000 volts [250.20(B)]
  - AC systems of over 1000 volts [250.20(C)]
  - Impedance grounded neutral systems [250.20(D)]

AC Circuits of Less than 50 Volts

- Three conditions where ac circuits of **less than 50 volts** are **required to be grounded**:

  1. Where supplied by transformers, if the transformer supply system exceeds 150 volts to ground

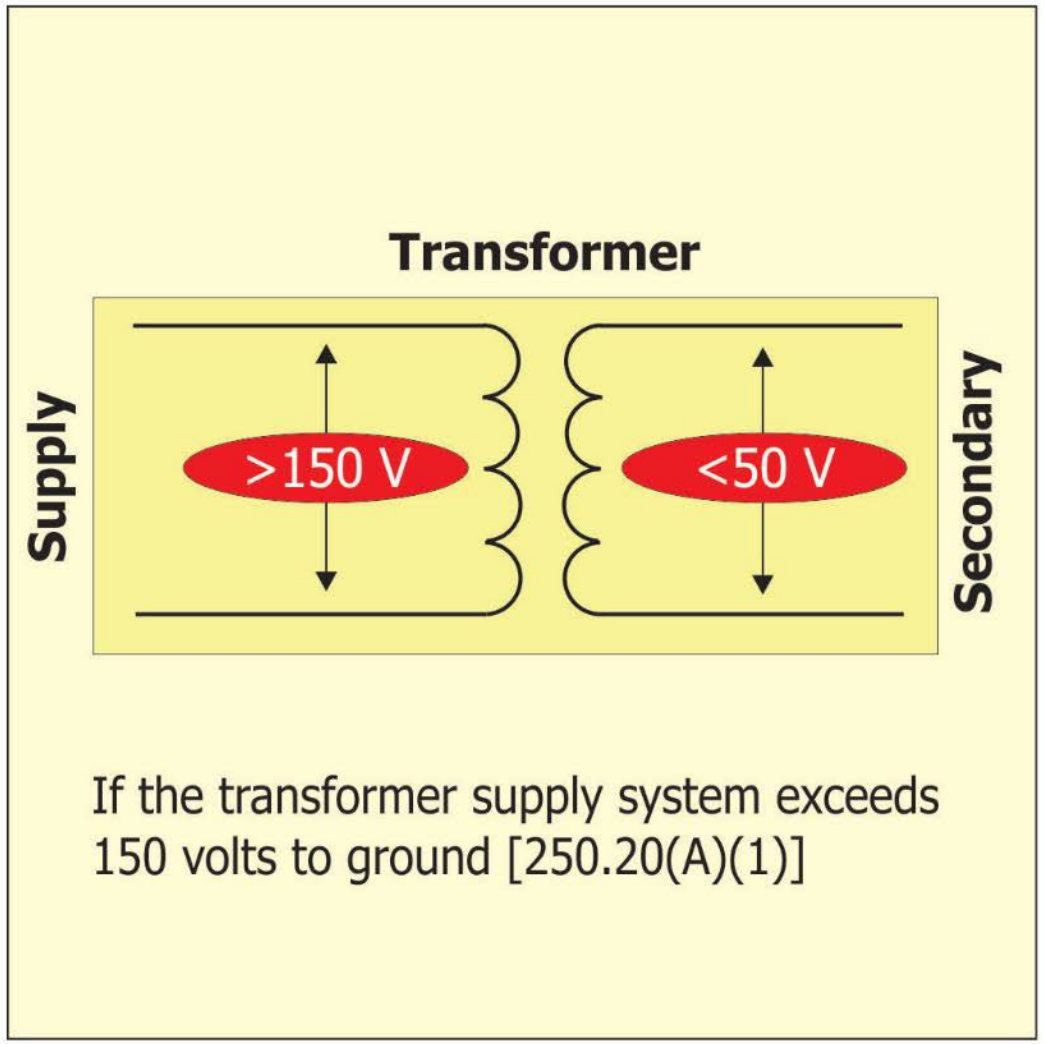
  2. Where supplied by transformers, if the transformer supply system is ungrounded

  3. Where installed outside as overhead conductors

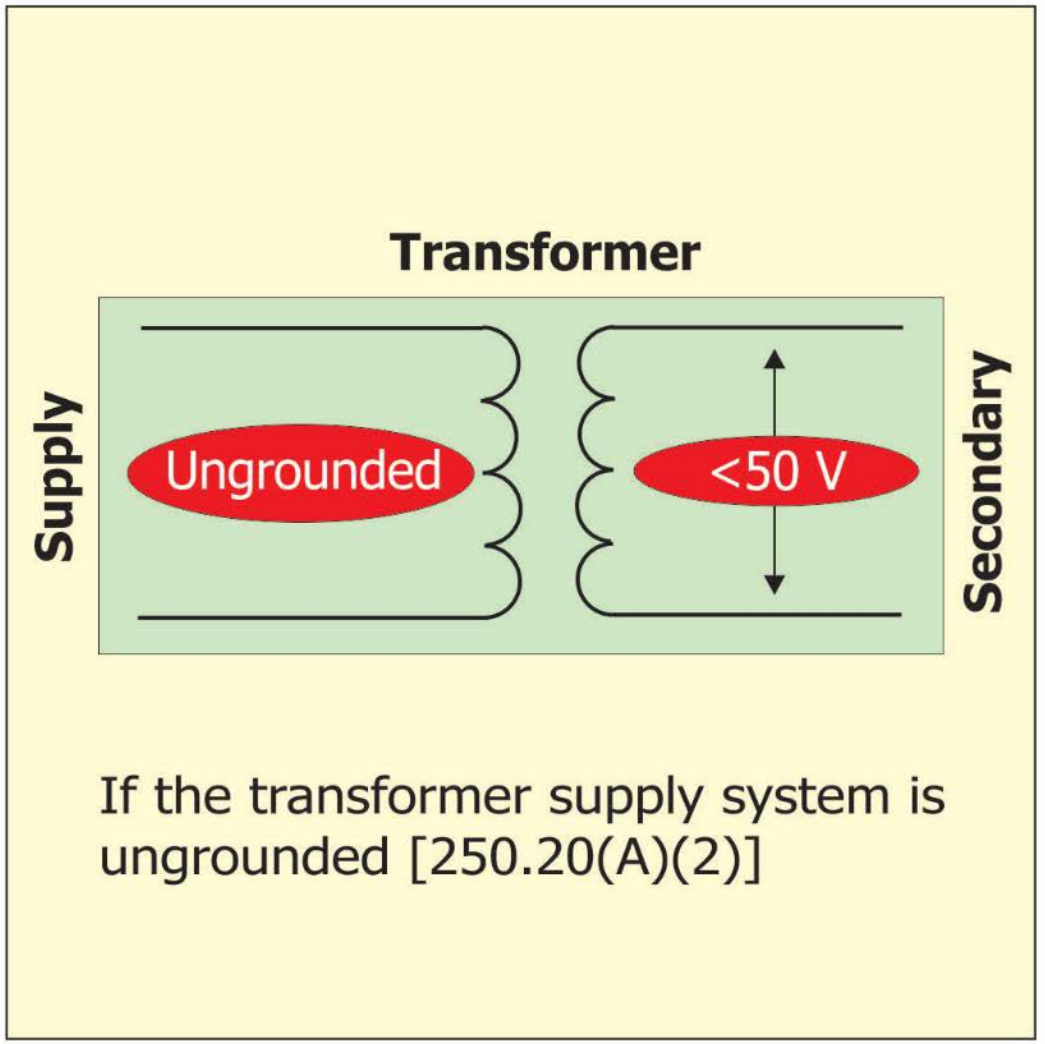
- See 250.20(A)

250.20(A) Grounding of AC Systems of Less Than 50 Volts

Alternating-current (ac) systems of less than 50 volts are required to be grounded where supplied by a transformer under the following conditions:



If the transformer supply system exceeds 150 volts to ground [250.20(A)(1)]

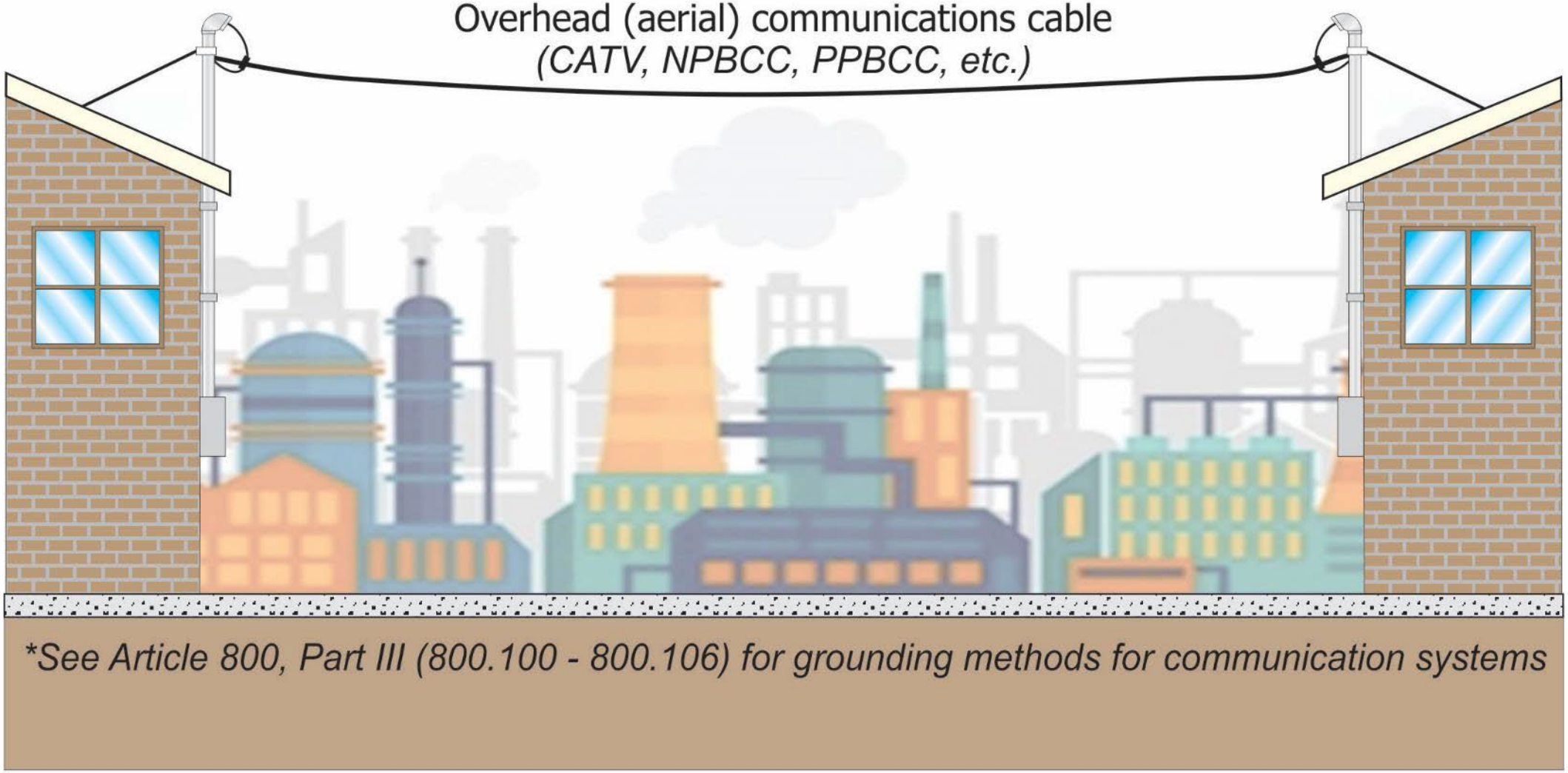


If the transformer supply system is ungrounded [250.20(A)(2)]

Copyright © IAEI 2020

250.20(A) Grounding of AC Systems of Less Than 50 Volts

Alternating-current (ac) systems of less than 50 volts are required to be grounded where installed outside as overhead conductors [250.20(A)(3)]



Copyright © IAEI 2020

AC Systems of 50 Volts to 1000 Volts

- Three conditions where these systems of **50 volts to 1000 volts** are **required to be grounded**:

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

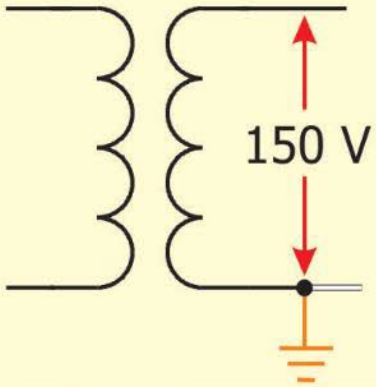
  2. Where the system is 3-phase, 4-wire, wye-connected in which the neutral conductor is used as a circuit conductor

  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

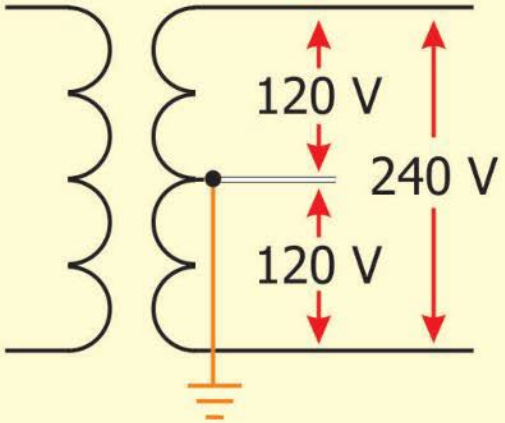
- See 250.20(B)

250.20(B) Grounding of AC Systems 50 to 1000 Volts

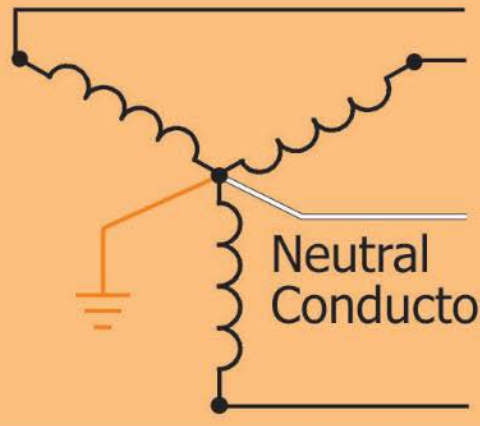
Alternating-current systems of 50 volts to 1000 volts that supply premises wiring and premises wiring systems is required to be grounded where the system can be or is:



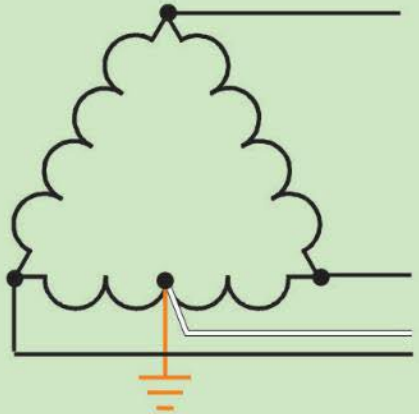
Grounded so the maximum voltage to ground does not exceed 150 volts [250.20(B)(1)]



Example: 120/240-volt single-phase, 3-wire system



3-phase, 4-wire wye systems where neutral conductor is used as circuit conductor [250.20(B)(2)]



3-phase, 4-wire delta systems where the midpoint of one phase winding is used as circuit conductor [250.20(B)(3)]

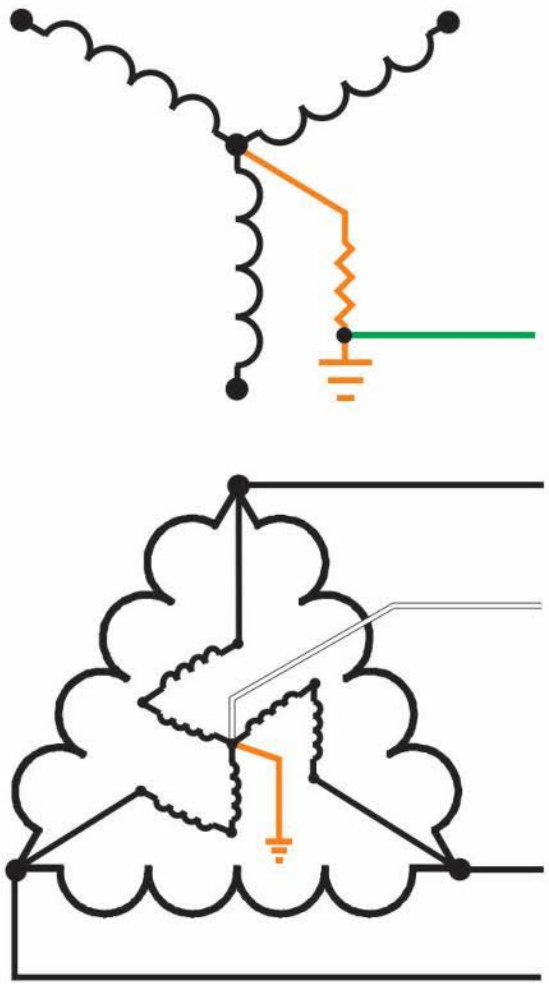
Copyright © IAEI 2020

AC Systems of Over 1000 Volts

- AC systems supplying mobile or portable equipment **shall be grounded** as specified in 250.188
- Where systems of over 1000 volts supply equipment **other than mobile or portable types**, the systems are **permitted to be grounded** but not required to be grounded
- See 250.20(C)

250.20(C) Grounding of AC Systems Over 1000 Volts

Alternating-current (ac) systems supplying mobile or portable equipment over 1000 volts required to be grounded as specified in 250.188



- Shall be supplied from system having its neutral conductor grounded through impedance [250.188(A)]
- Where delta-connected system is used, must have system neutral point and associated neutral conductor derived [250.188(A)]
- Exposed-non-current-carrying metal parts required to be connected to EGC where system neutral impedance is grounded [250.188(B)]
- Ground-fault current not to exceed 100 volts [250.188(C)]
- Ground-fault detection & relaying provided to de-energize components of system [250.188(D)]
- Grounding electrode isolated by at least 10 m (20 ft) from other systems [250.188(E)]

Where supplying other than mobile or portable equipment, such systems permitted to be grounded

Copyright © IAEI 2020

Impedance Grounded Systems

- **Impedance grounded systems** are often considered in electrical designs where the facility operation **cannot tolerate electrical system disruption** from the first ground fault
- **Impedance grounded systems** has:
  - All the advantages of an ungrounded system *(as far as operation of the plant or system with one phase faulted to ground is concerned)*
  - With none of the disadvantages of an ungrounded system
- Depending on system voltage and design, impedance may be a "**low impedance**" system or a "**high impedance**" system
- See **250.36** for **1000-volt and below** systems and to **250.187** for **over 1000-volt** systems [250.20(D)]

Systems Permitted but Not Required to be Grounded

- Electrical systems not required to be grounded *[250.20(A), (B), (C) or (D)]* and are not prohibited from being grounded *(250.22)*, may or may not be grounded
- These systems are usually found in industrial or agricultural applications
- Often are either 240-volt or 480-volt, three-phase, three-wire systems *(some higher voltage systems are also used in heavy-industrial applications)*
- Ungrounded systems are often installed where an additional degree of reliability is desired while providing equal and effective means for safety of equipment by the use of ground-fault indicator equipment *(ground detectors)*

Systems Permitted to be Grounded

- As specified in 250.21(A)
  1. Electrical systems used exclusively to supply industrial furnaces for melting, refining, tempering, etc.
  2. Separately derived systems used exclusively for rectifiers supplying only adjustable speed industrial drives
  3. Separately derived systems supplied by transformers having a primary voltage rating of 1000 volts or less with all the following conditions:
     a. Used exclusively for control circuits
     b. Conditions of maintenance and supervision (qualified persons)
     c. Continuity of power is required
  4. Other systems that are not required to be grounded in accordance with the requirements of 250.20(B)

Systems Permitted to be Grounded

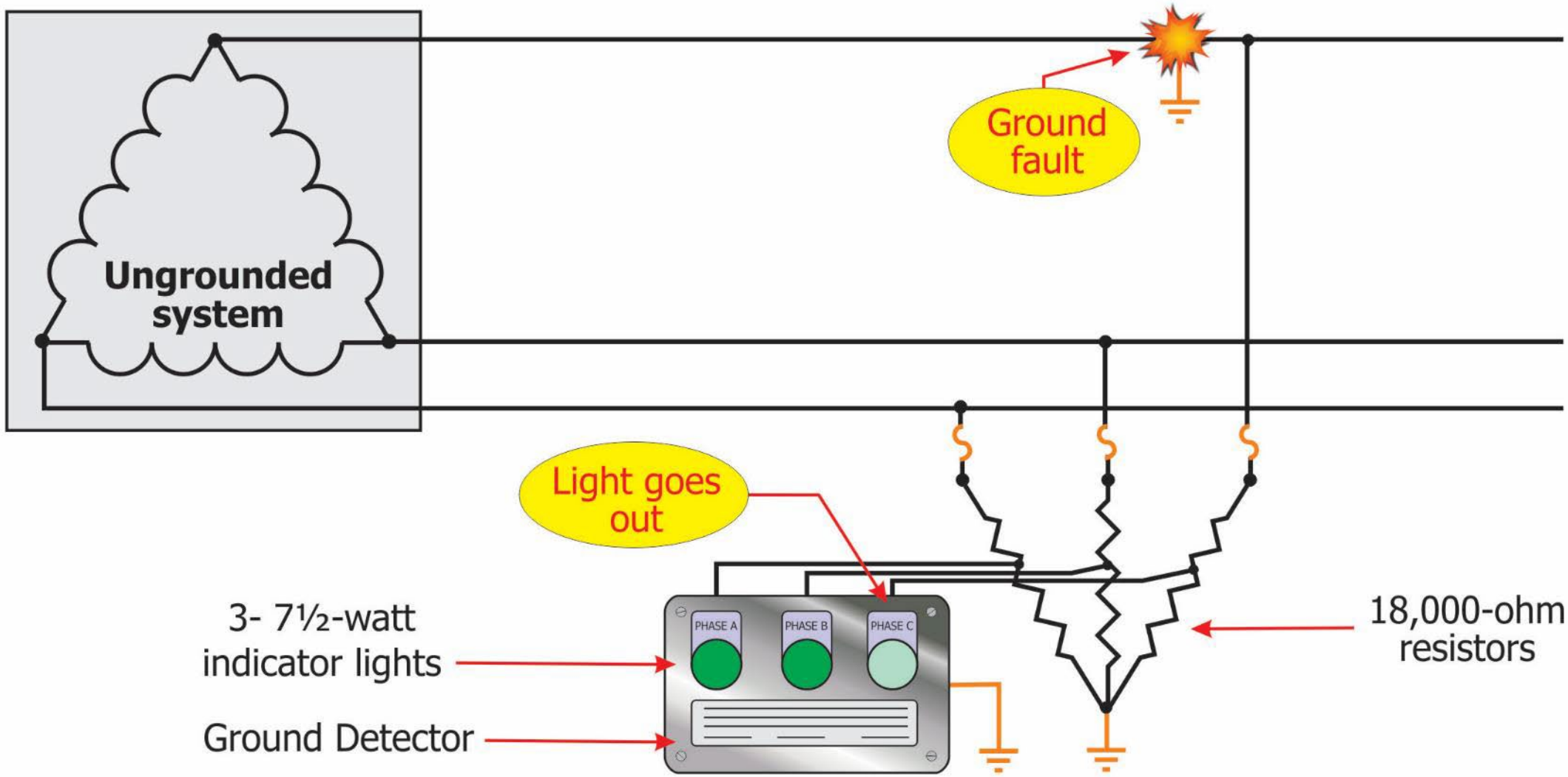
- ***Ground Detectors:*** Ungrounded ac systems as permitted in 250.21(A)(1) through (A)(4) operating at not less than 120 volts and at 1000 volts or less shall have ground detectors installed on the system [250.21(B)(1)]
- Ground detectors are to be connected as close as practicable to where the system receives its supply

Ground Detectors

- In the past, **ground detector lights** or neutralizer or “potentializer” plugs were installed to indicate that a **ground fault had occurred on the ungrounded system**
- Typical for 7 ½-watt indicator lights connected to the lines through 18,000-ohm resistors
- Tap made to each resistor to give 120 volts to the lamp
- Lamp burns until its phase goes to ground
  - At which time there is no or little potential across the lamp and it stops glowing, thus identifying the faulted phase

250.21(B) Ground Detectors for Ungrounded Systems

Ungrounded ac systems operating at not less than 120 volts and at 1000 volts or less shall have ground detectors installed on the system and connected as close as practicable to where the system receives its supply

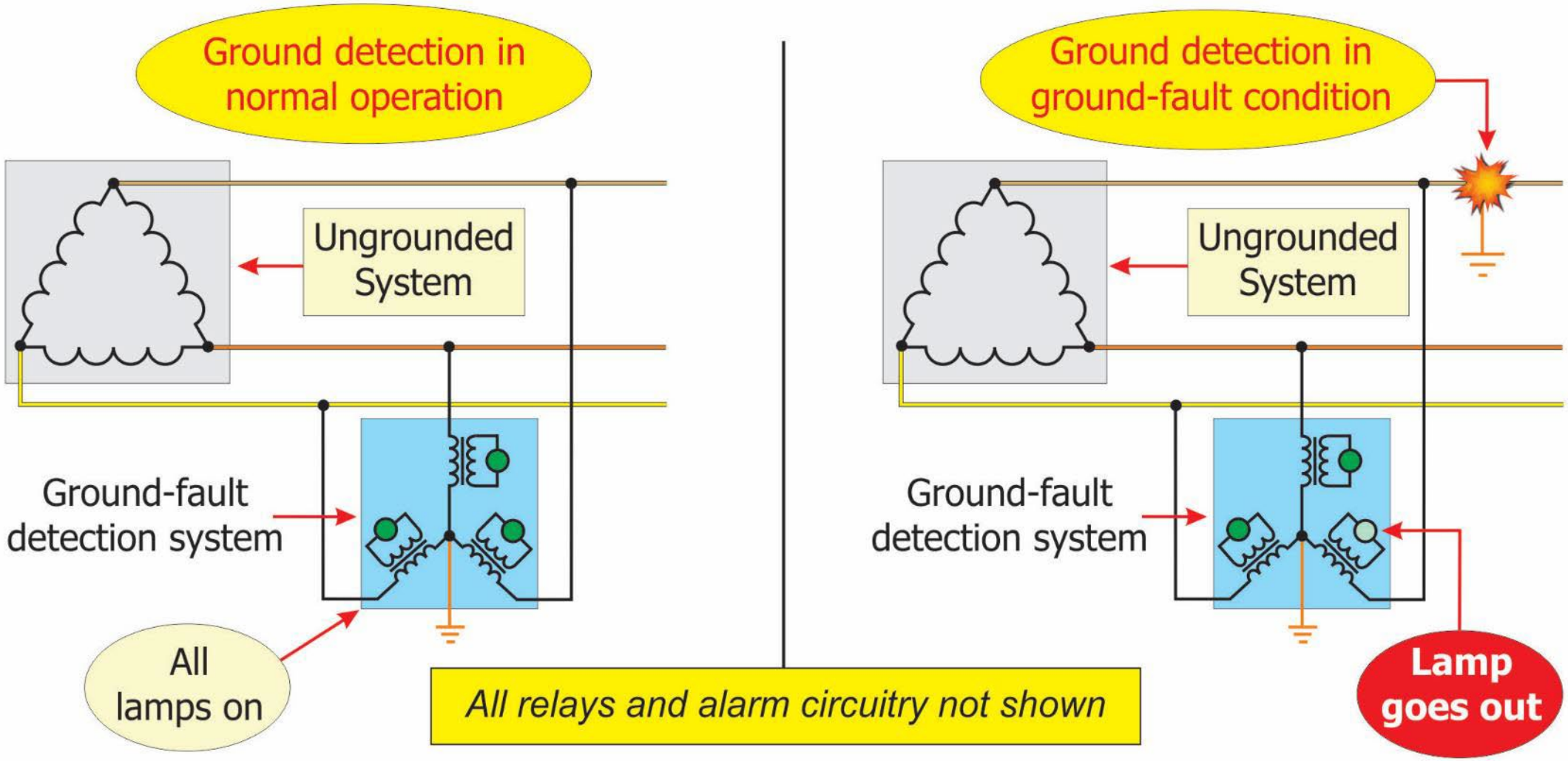


Copyright © IAEI 2020

Ground Detectors *(cont.)*

- More modern types of **ground detection indication** equipment are available
- Offers added benefits of **no system ground connection** *(not even through a resistor as was the case in the older ground detection light systems)*
- Ground detection is required on ungrounded systems

Ground-Fault Detection System



In a ground detection system, the lamp typically burns until its phase goes to ground, at which time there is no or little potential across the lamp and it stops glowing, thus identifying the faulted phase

Copyright © IAEI 2020

Circuits That Shall Not Be Grounded

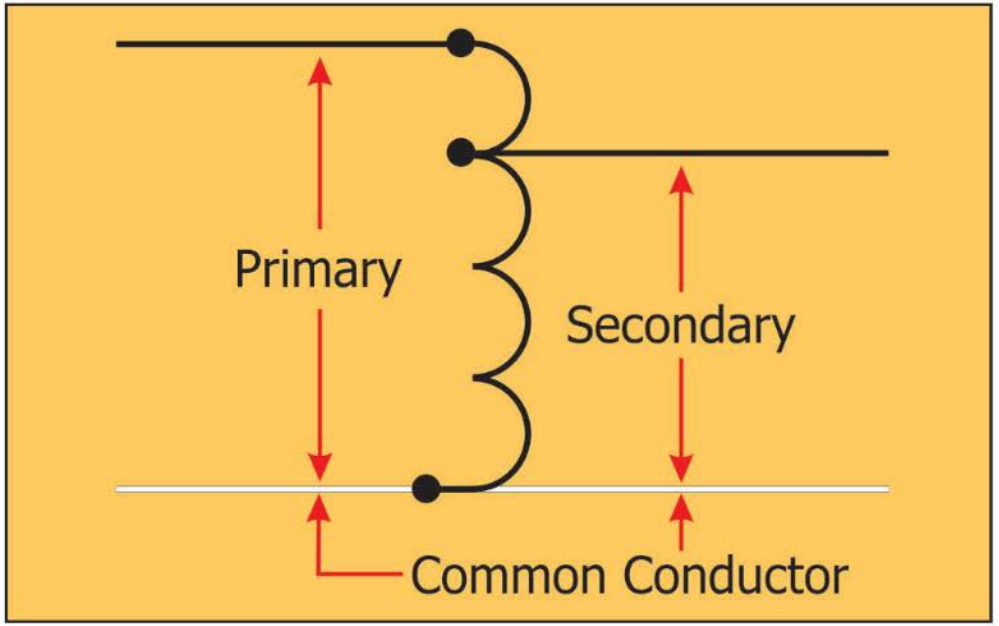
- Six types of circuits are **not permitted to be grounded** *(see 250.22)*
  1. **Cranes** that operate over combustible fibers in Class III locations *[503.155]*
  2. **Health care facilities** *(Isolated power systems and circuits in Article 517)*
  3. **Electrolytic Cells** *(Article 668)*
  4. **Low-voltage lighting systems** *[411.6(A)]*
  5. **Secondary circuits** of lighting systems *[680.23(A)(2)]*
  6. Class 2 load side circuits for **suspended ceiling low-voltage power grid distribution systems** *[393.60(B)]*

Electrical Systems That Are Not Separately Derived Systems

An alternate ac power source (such as an on-site generator) is not a separately derived system if the grounded conductor is solidly interconnected to a service-supplied system grounded conductor

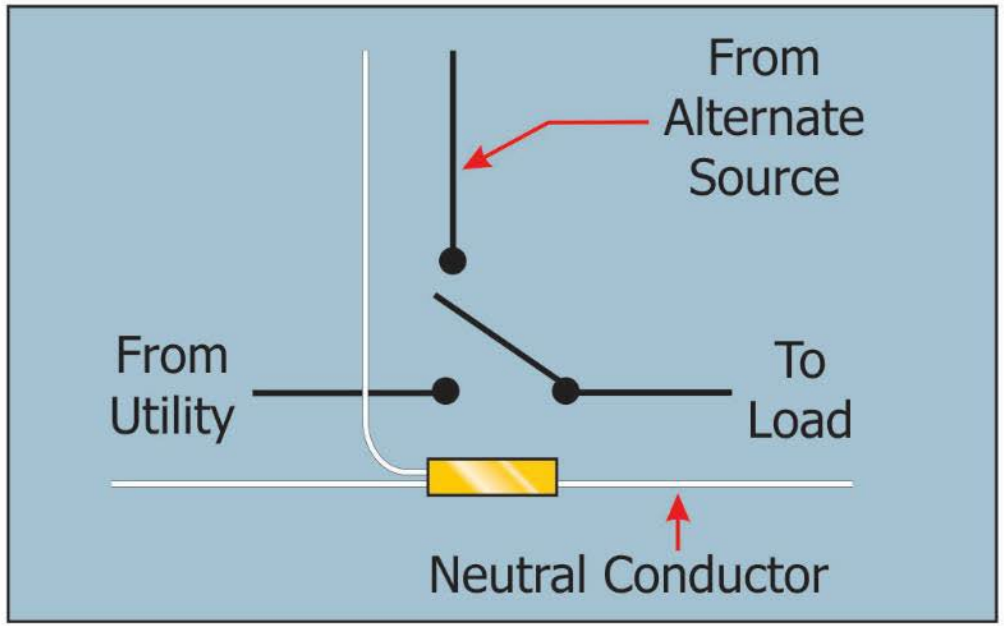
Example: Alternate source transfer equipment that does not include a switching action in the grounded conductor and allows it to remain solidly connected to the service-supplied grounded conductor when the alternate source is operational and supplying the load served

Autotransformer



Not separately derived as the systems have one common conductor

Alternate Source Transfer Equipment

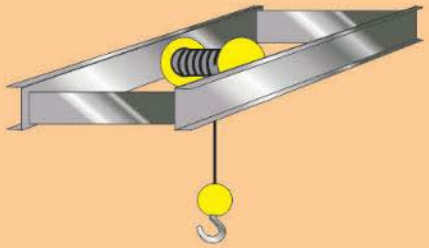


Not separately derived as the neutral conductor is not switched in the transfer switch

Copyright © IAEI 2020

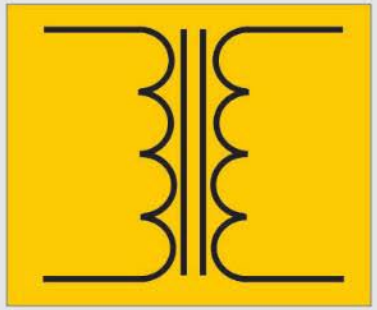
Examples of Circuits That Are Not Permitted To Be Grounded

Cranes



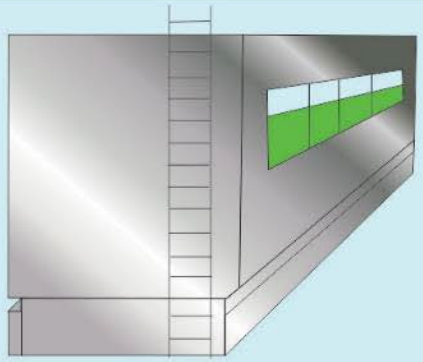
Cranes that operate over combustible fibers in Class III locations [250.22(1)]

Isolated power systems



Isolated power systems in health care facilities for hazardous inhalation anesthetizing and wet locations [250.22(2)]

Electrolytic cells



Circuits for electrolytic cells as provided for in Article 668 [250.22(3)]

Copyright © IAEI 2020

Article 100 Definitions

- ***Ungrounded:*** Not connected to ground or to a conductive body that extends the ground connection.

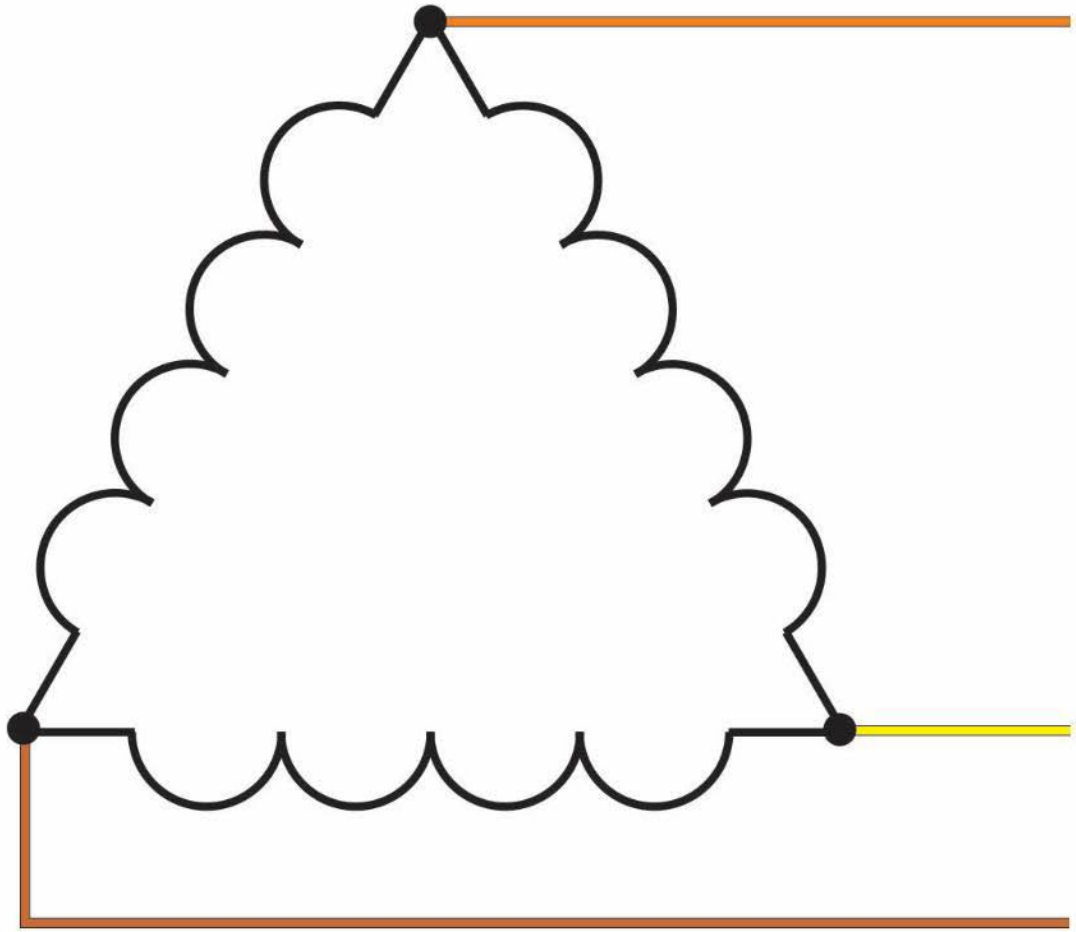
- *Note: What is missing from an "Ungrounded" system is the grounded conductor, an ungrounded system is still grounded through the grounding electrode system.*

Electrical Systems Permitted to be Ungrounded

- Electrical systems **not required to be grounded** *[250.20(A), (B), (C) or (D)]* and are **not prohibited from being grounded** *(250.22)*, may or may not be grounded
- It should be noted that whether the system is required to be grounded or is grounded by choice, **all grounding and bonding requirements for grounded systems must be followed** *(see 250.20)*
- These systems are usually found in **industrial or agricultural** applications
- Typically either 240-volt or 480-volt, three-phase, three-wire systems *(some higher voltage systems are also used in heavy-industrial applications)*
- **Ungrounded systems** typically installed where an additional degree of reliability is desired while providing equal and effective means for safety of equipment by the use of ground-fault indicator equipment *(ground detectors)*

Systems Permitted to be Ungrounded

250.21(A) describes four ac systems of 50 volts to 1000 volts that are permitted to be grounded but not required to be grounded



Typical Ungrounded Systems Voltages

- 240-volt, 3-phase, 3-wire
- 480-volt, 3-phase, 3-wire
- 2300-volt, 3-phase, 3-wire
- 4600-volt, 3-phase, 3-wire
- 13.8-kV, 3-phase, 3-wire

Copyright © IAEI 2020

Marking of Ungrounded Systems

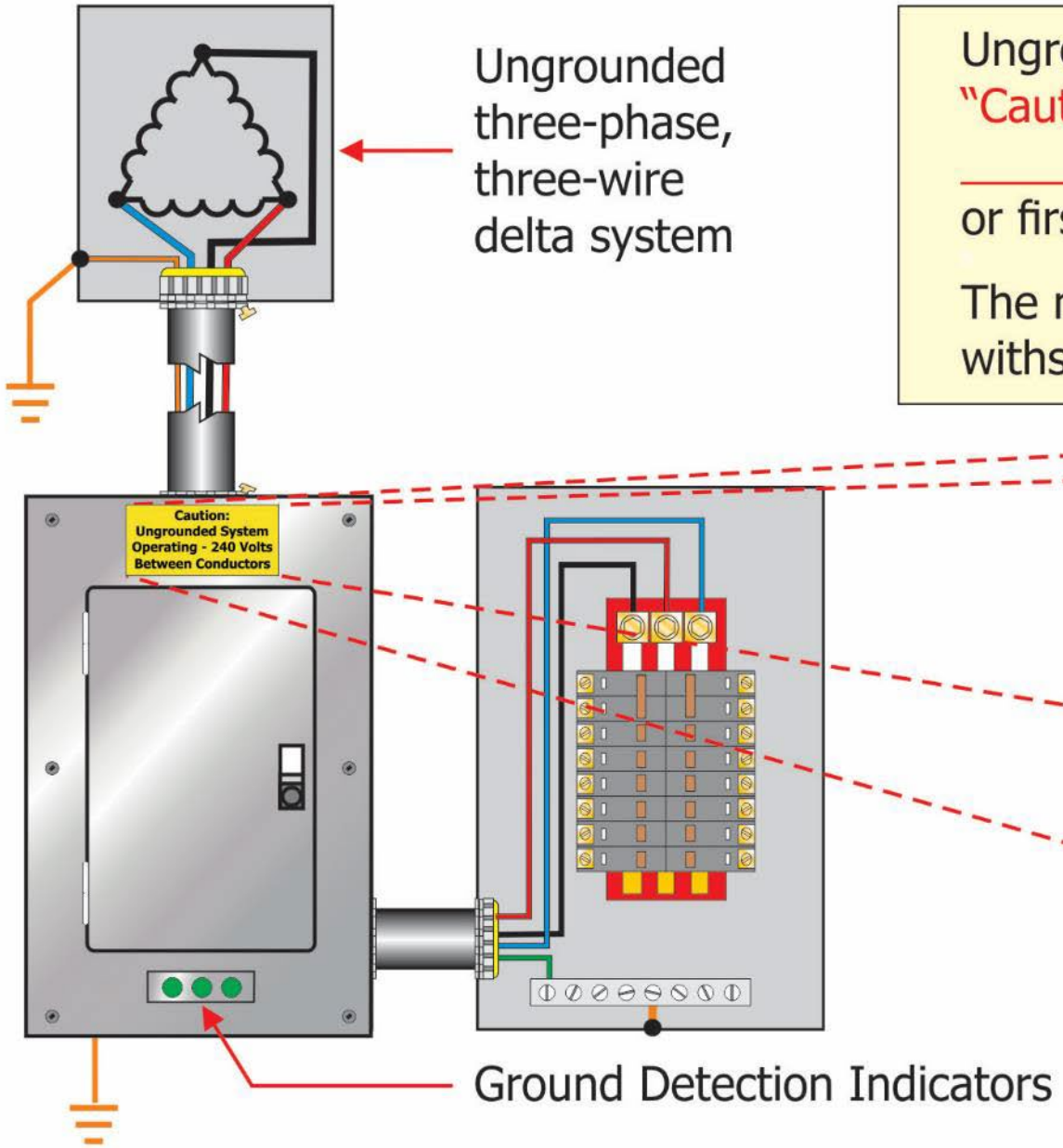
- Ungrounded systems are required to be legibly marked, with a label or some other identifying means

CAUTION UNGROUNDED SYSTEM

OPERATING – _____VOLTS BETWEEN CONDUCTORS

- This marking shall be located at the source or first disconnection means of the system
- Marking must be of “sufficient durability” to withstand the surrounding environment (such as an outdoor wet location)
- See 250.21(C)

250.21(C) Marking - Ungrounded Systems



Ungrounded systems shall be legibly marked "Caution Ungrounded System Operating - _____ Volts Between Conductors" at the source or first disconnecting means of the system

The marking shall be of sufficient durability to withstand the environment involved

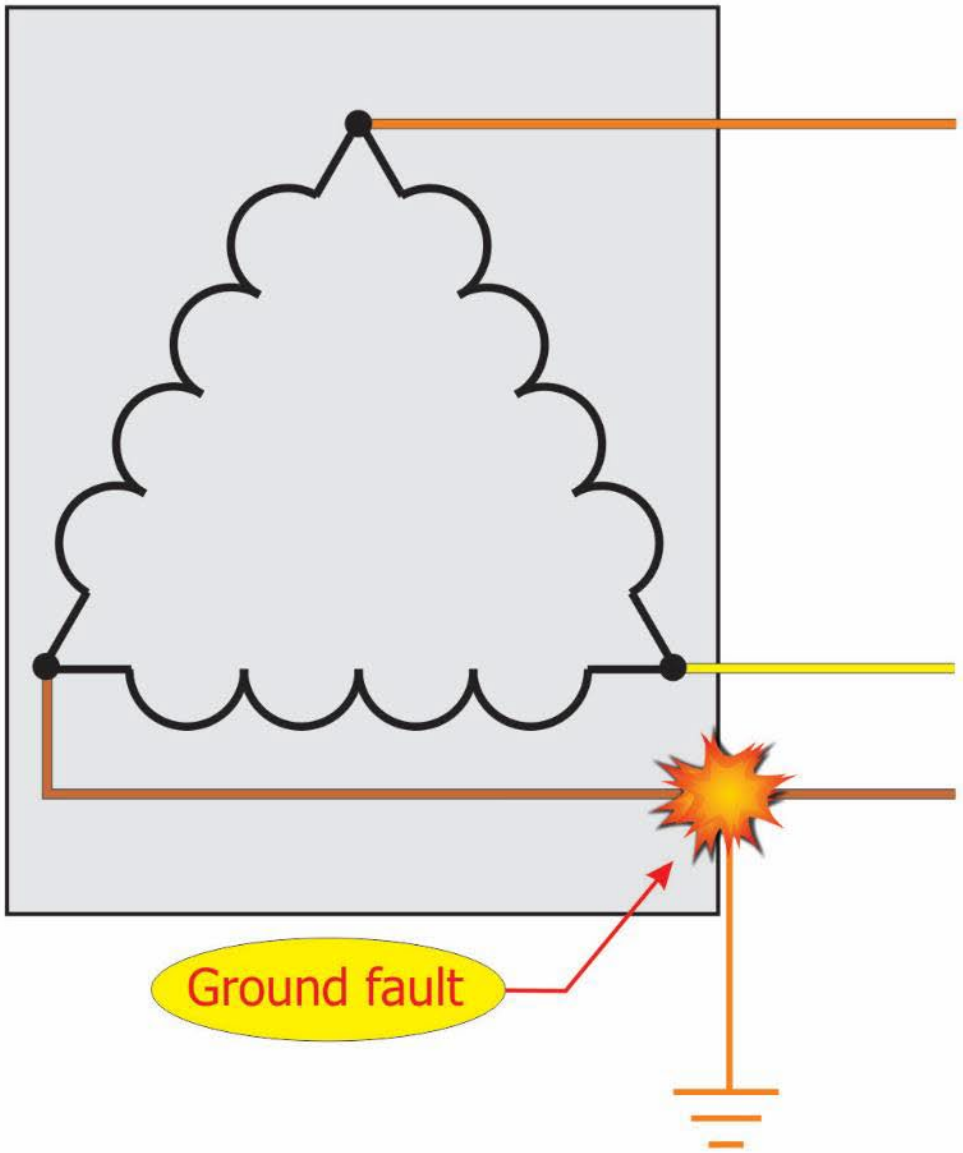
Caution:
Ungrounded System
Operating - 240 Volts
Between Conductors

Copyright © IAEI 2020

Issues to Consider with an Ungrounded System

- The occurrence of the **first ground fault** *(not a short circuit or line-to-line fault)* on an ungrounded system **will not open an overcurrent protective device** for the service, feeder, or branch circuit
- Overcurrent device open or operates with **elevated current above its rating**, where the first ground fault in an ungrounded system will see **very little ground fault current**
- First fault does “ground” the system but usually accidentally and through ineffective means *(higher impedance)* and in unspecified and uncontrolled locations

First Ground Fault on Ungrounded System

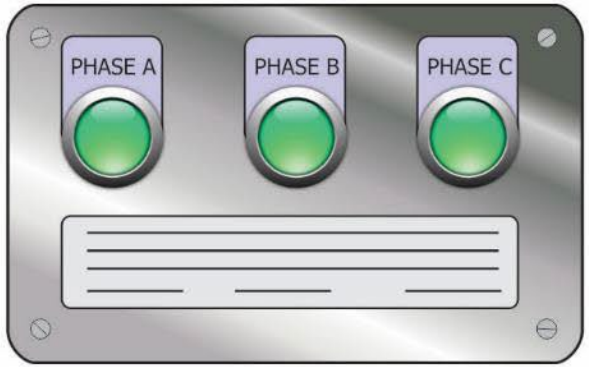


First ground fault on an ungrounded system accidentally grounds the system

Second ground fault on another phase is not only a ground fault, but a phase-to-phase short circuit

Ground detection indicators are important to indicating the first ground fault in an ungrounded system

Ground detectors are required for ungrounded systems *[250.21(B)]*



Typical Ground-Detection Indicators

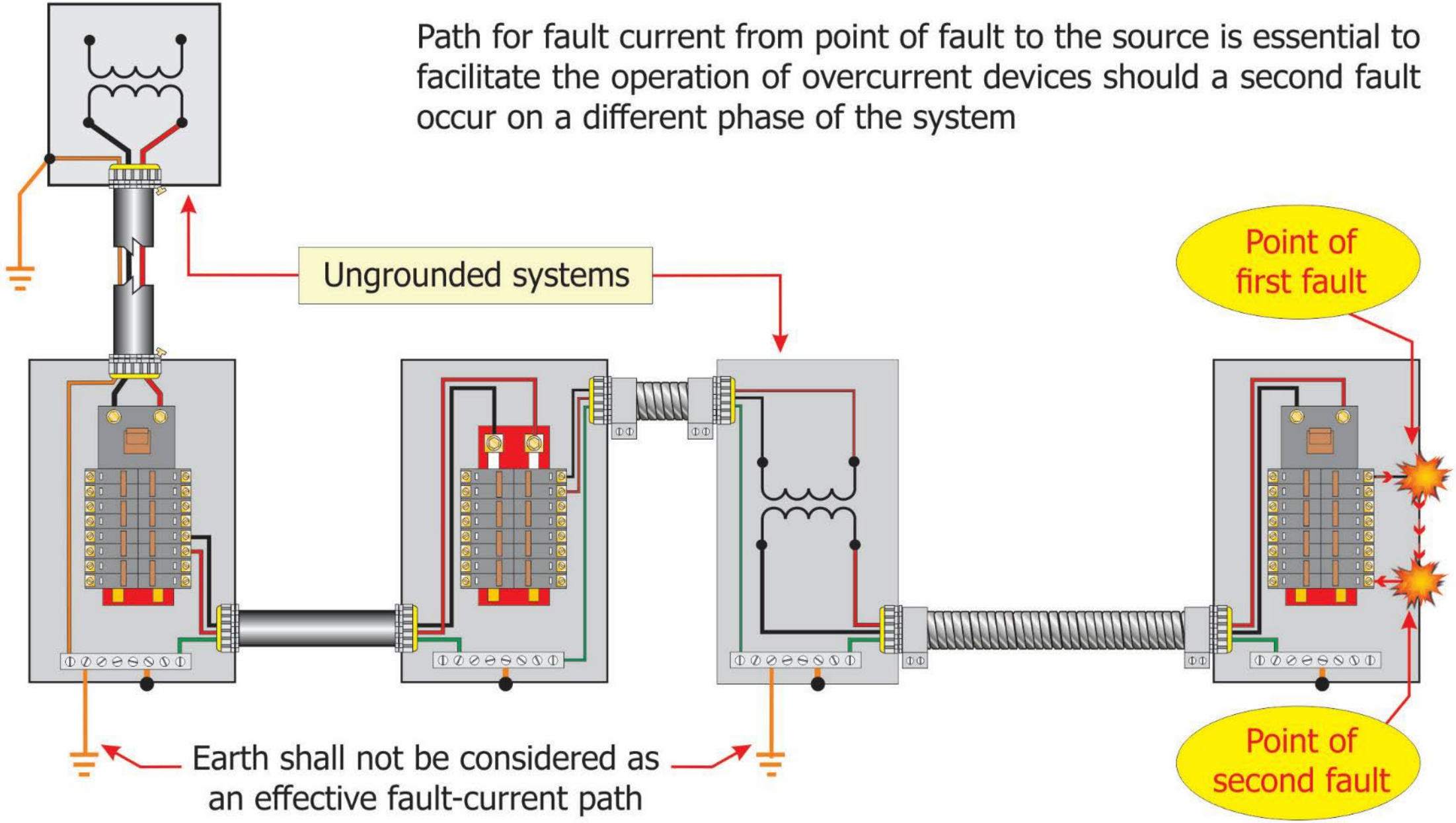
Copyright © IAEI 2020

Issues to Consider with an Ungrounded System *(cont.)*

- When an ungrounded system with one ground fault experiences a **second ground fault** on a different phase, the result is a **phase-to-phase fault** on the system through the **equipment grounding conductor path(s)**
- Typically causes one or more **over-current protective devices to open or operate**, provided there is adequate current in this path
- Major concern for this type of system happens where the first and second faults are located some distance apart
- Important for safety reasons and for system continuity that maintenance personnel locate and eliminate ground faults when first identified on ungrounded systems *(should be done as soon as practical before the second ground fault on a different phase occurs on the system)*

First and Second Faults on Ungrounded Systems

Path for fault current from point of fault to the source is essential to facilitate the operation of overcurrent devices should a second fault occur on a different phase of the system



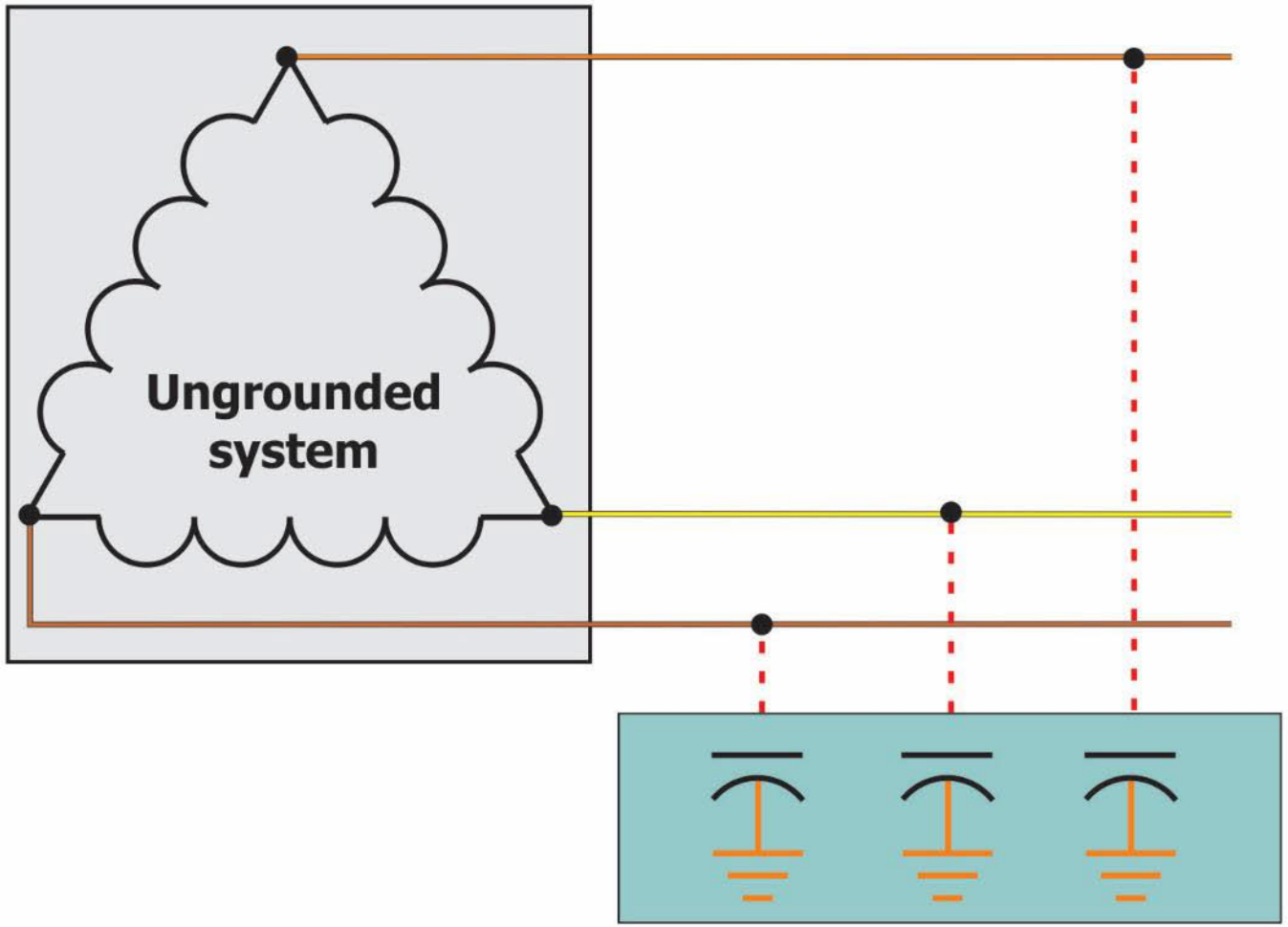
Copyright © IAEI 2020

Issues to Consider with an Ungrounded System *(cont.)*

- Ungrounded systems **exists only in theory**, in a laboratory or at the electrical distribution transformers hanging on the pole before connection to the plant electrical system
- In the real world, ungrounded systems having insulated conductors installed in metallic enclosures are **grounded to varying degrees** through the distributed leakage capacitance of the system
- Physically, a capacitor exists whenever an insulating material separates two conductors that have a difference of potential between them

Actual Ungrounded Delta System

Ungrounded delta system is grounded through capacitance



Distributed leakage capacitance

Ungrounded systems having insulated conductors installed in metallic enclosures are grounded to varying degrees through the distributed leakage capacitance of the system

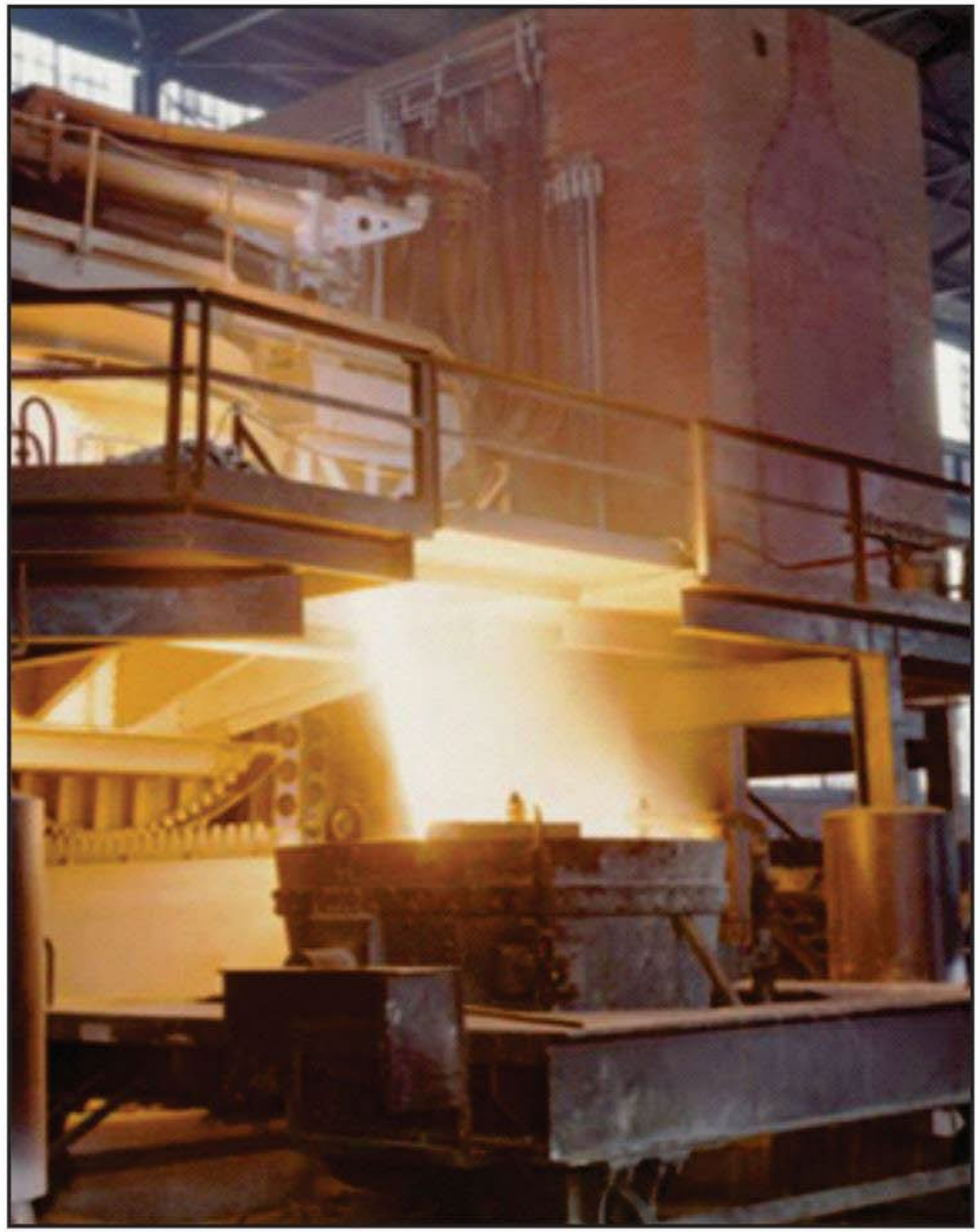
A capacitor exists whenever an insulating material separates two conductors that have a difference of potential between them

Copyright © IAEI 2020

Ground Detection

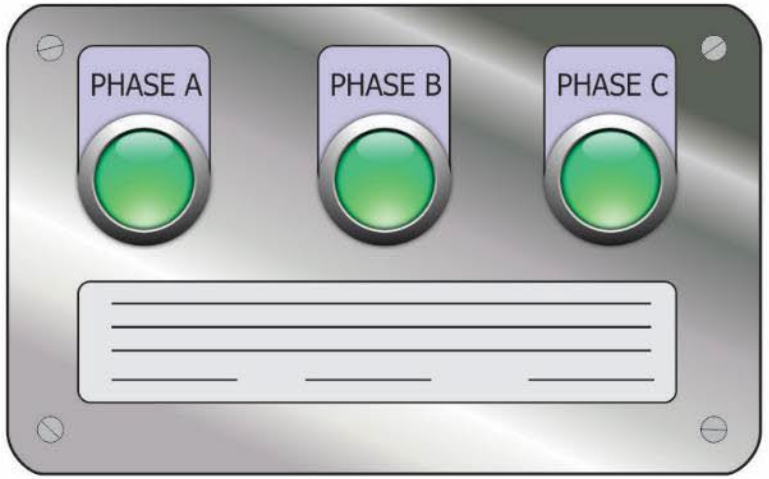
- Ground detection is required on ungrounded systems [250.21(B)]
- Ground-fault indication is intended to alert the maintenance personnel to the problem so the ground fault can be corrected during hours when the plant is not operating or that part of the plant can be shut down
- The plant can continue to operate with one-phase grounded, thus preventing costly production downtimes
- In some cases, downtime in production plants can cost thousands of dollars per minute
- While the plant can continue to operate with one ground-fault, this condition cannot be ignored for long due to the risk of a second ground fault on another phase occurring with possibly catastrophic damage

Ground Detectors Required on Ungrounded Systems



Ungrounded systems are often utilized with industrial electric furnaces where continuity of the service is critical and an outage due to a ground-fault cannot be tolerated

Ground detectors are required on these systems to monitor the system for ground faults that can be cleared prior to a second ground-fault on the system



Copyright © IAEI 2020

Bolted Faults

- Bolted faults (either short circuits or ground faults) rarely occur
- Common myth is that ground-faults are always bolted or solidly connected
- Sparking, intermittent or arcing faults are really the more common fault condition
- Arcing faults produce a great deal of heat in the vicinity of the fault and can lead to destructive burndowns of electrical switchboards, motor control centers, or other equipment


G
N
A
B
C

Considerations Regarding System Grounding

- Consider the pros and cons carefully, if the system is not required to be grounded
  - In grounded systems, the faults are generally isolated to the offending equipment or circuit (local), which can be a disadvantage if the equipment is critical to a process
  - Consider high-impedance grounded system for the “best of both worlds”

Disadvantages of Ungrounded Systems

- Power system overvoltages are not controlled
- Transient overvoltages are not controlled
- System voltages above ground are not controlled
- Potential arcing burndown if second ground fault occurs
- Locating the first fault can be difficult

CHAPTER FOUR

GROUNDING ELECTRICAL SYSTEMS



Grounding Electrical Systems

- Section 250.20 requires that many electrical systems be grounded
- Important to understand that one is dealing with the **electrical system** and not the service equipment, disconnecting means, or non-current-carrying metal parts or enclosures at this point
- System grounding is where one of the circuit conductors, many times the neutral point or neutral conductor, is **purposefully connected to ground**

Grounding Electrical Systems *(cont.)*

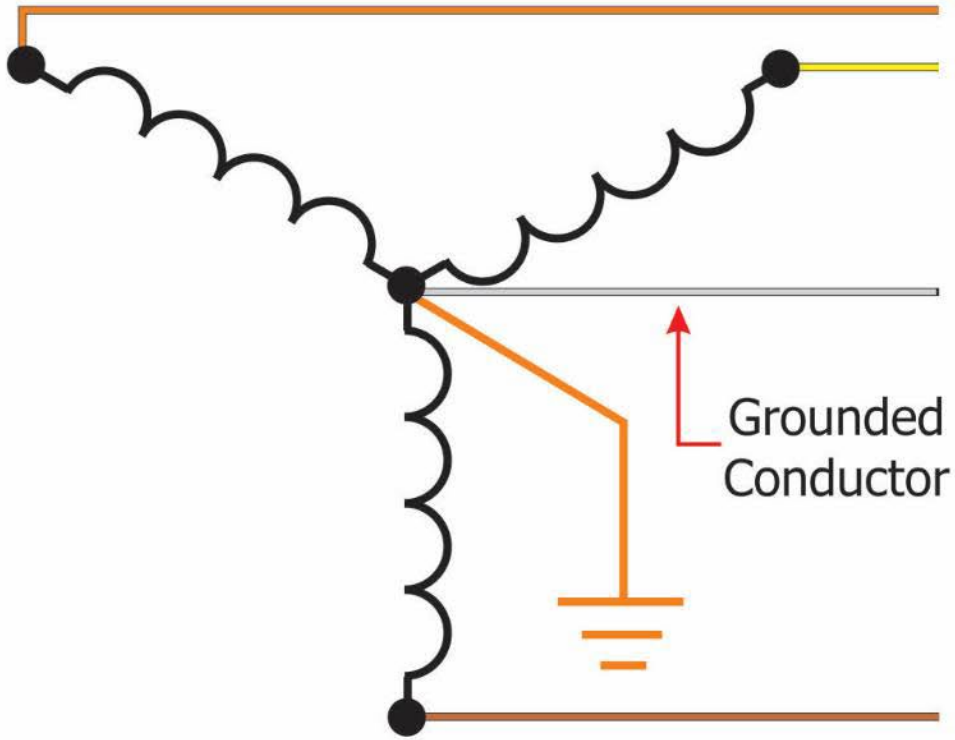
- When system grounding is being addressed, one of the circuit conductors is **purposefully connected to ground** *(typically the neutral point or neutral conductor)*
- For a service from the serving utility, the "system" grounding is determined by the utility
- For "system" grounding for other than the service, the grounding is determined by the *NEC*

Article 100 Definitions

- ***Ground:*** The earth.
- ***Grounded (Grounding):*** Connected (connecting) to ground or to a conductive body that extends the ground connection.
- ***Grounded Conductor:*** A system or circuit conductor that is intentionally grounded.
    - **Informational Note:** Although an equipment grounding conductor is grounded, it is not considered a grounded conductor.

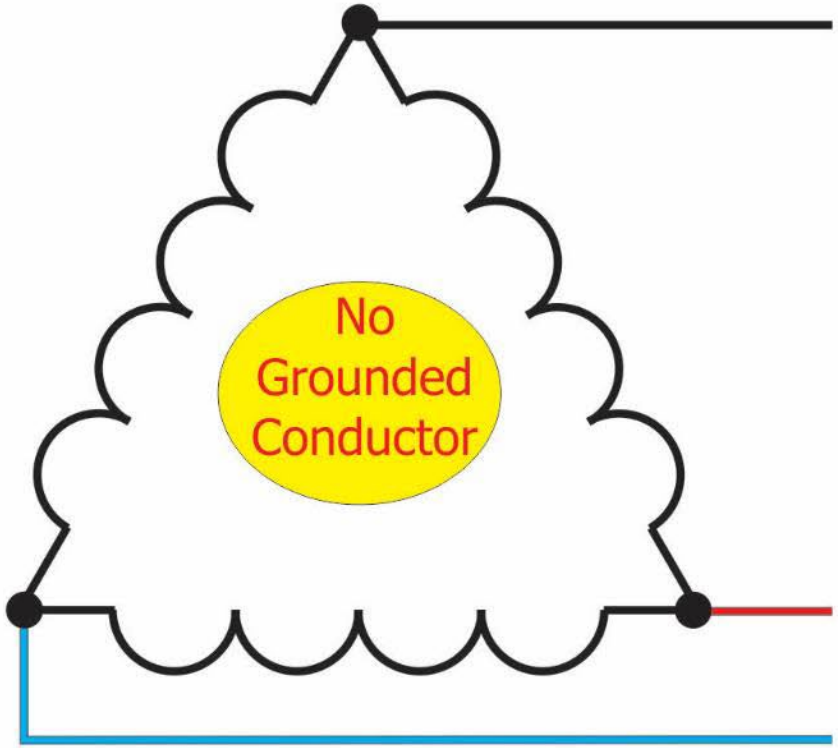
Electrical Systems *(Typical)*

Grounded Electrical System



Grounded wye 3-phase, 4-wire

Ungrounded Electrical System



Ungrounded delta 3-phase, 3-wire

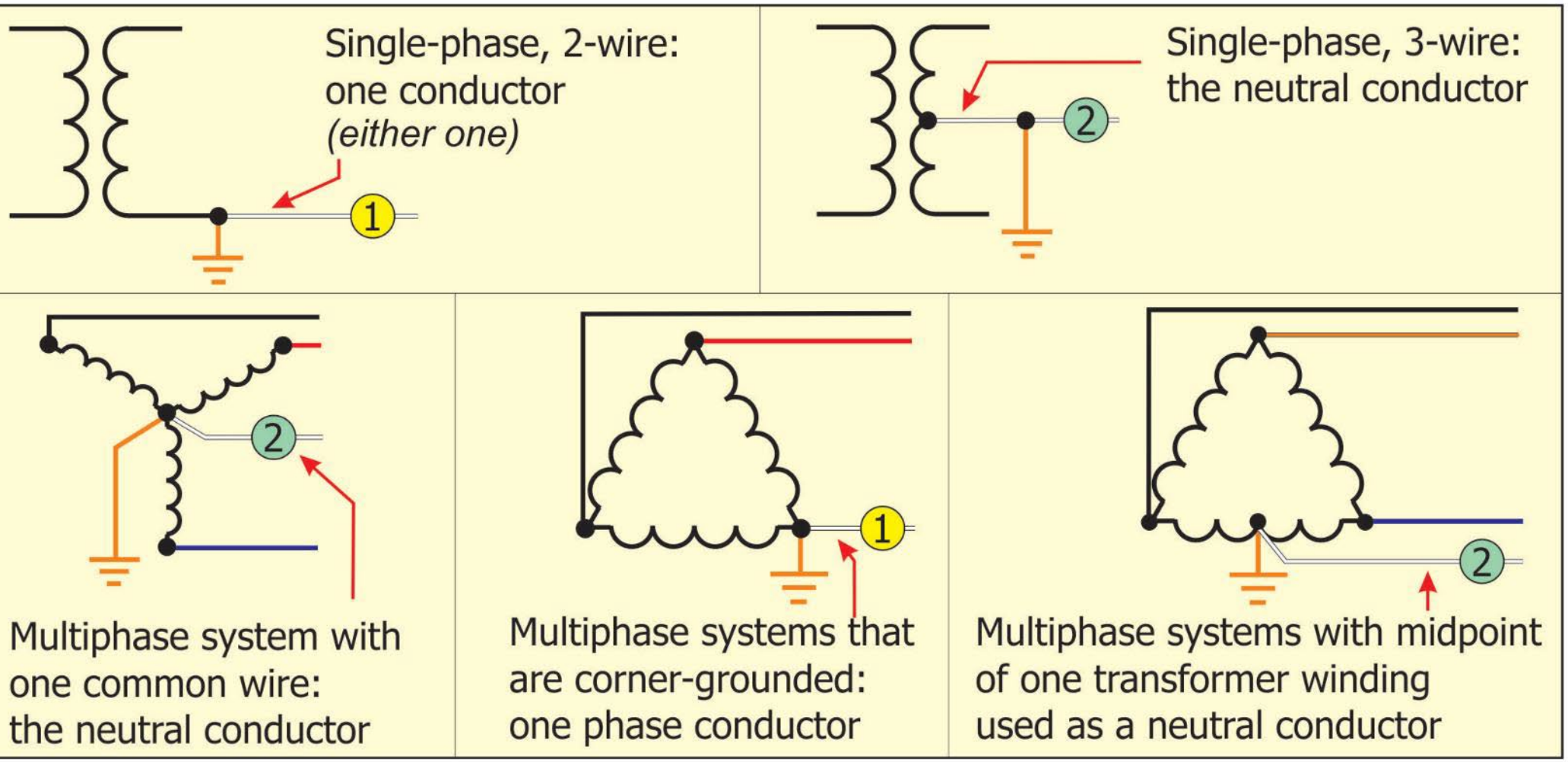
Copyright © IAEI 2020

Conductor to Be Grounded

- Where the electrical system is grounded *[either as required by the NEC or by choice (250.20 and 250.21)]*, 250.26 specifies which conductor in an alternating-current system is to be grounded
- Conductor required to be grounded:
  - Single-phase, 2-wire: one conductor *(either one)*
  - Single-phase, 3-wire: the neutral conductor
  - Multiphase systems having one wire common to all phases: the neutral conductor
  - Multiphase systems where one phase is grounded: one phase conductor
  - Multiphase systems in which one phase is used as a single-phase, 3-wire system: the neutral conductor

250.26 Conductor to be Grounded

For ac premises wiring systems, the grounded conductor shall be as specified in the follows:



1 A grounded conductor but ***not*** a neutral conductor

2 A grounded conductor ***and*** a neutral conductor

Copyright © IAEI 2020

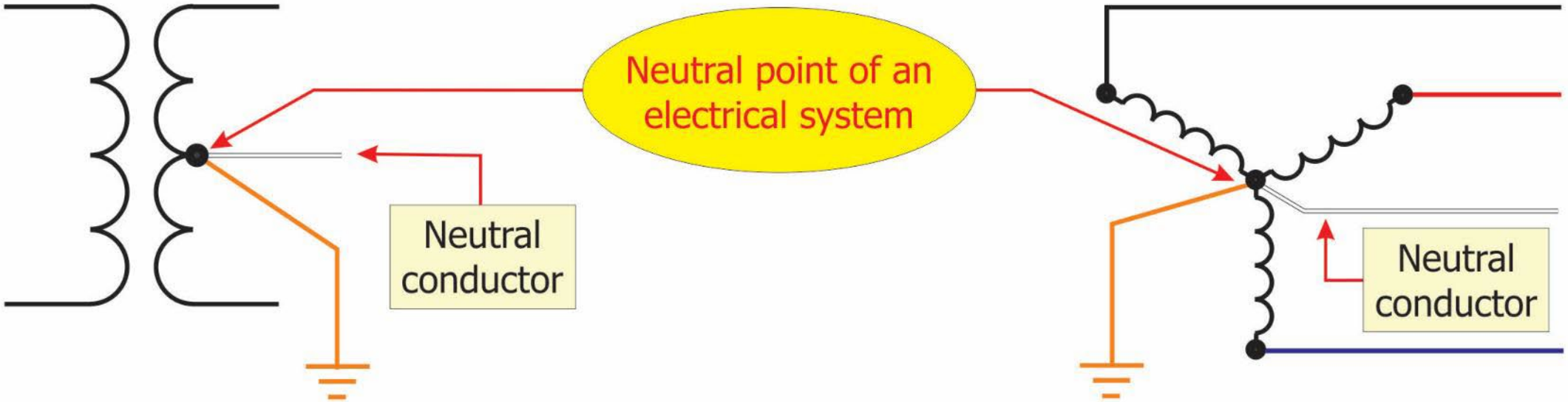
Neutral Conductor and Neutral Point

- The *NEC* provides a clear differentiation between a ***neutral conductor*** of a system and a ***neutral point*** of a system
- These two terms are appropriately used in each *NEC* rule where only the term "*neutral*" was used in previous editions of the *Code*
- An important aspect of these terms is that a **clear differentiation** is established between the neutral conductor and the point on the system where they are connected
- While most neutral conductors of an electrical system are grounded, **not all grounded conductors are neutral conductors**

Article 100 Definitions

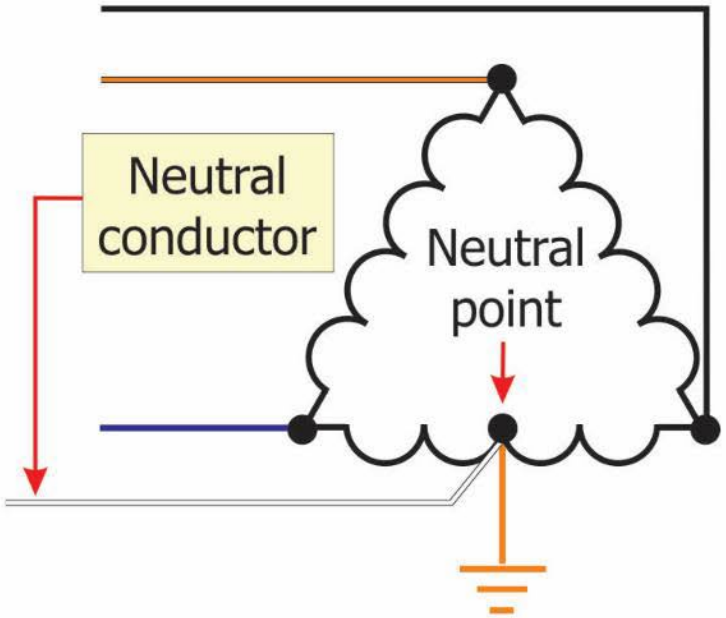
- ***Neutral Conductor:*** The conductor connected to the neutral point of a system that is intended to carry current under normal conditions.
- ***Neutral Point:*** The common point on a wye-connection in a polyphase system or midpoint on a single-phase, 3-wire system, or midpoint of a single-phase portion of a 3-phase delta system, or a midpoint of a 3-wire, direct-current system.
  - **Informational Note:** At the neutral point of the system, the vectorial sum of the nominal voltages from all other phases within the system that utilize the neutral, with respect to the neutral point, is zero potential.

Definition: Neutral Conductor and Neutral Point



Neutral Conductor: The conductor connected to the neutral point of a system that is intended to carry current under normal conditions.

Neutral Point: The common point on a wye-connection in a polyphase system or midpoint on a single-phase, three-wire system, or mid-point of a single-phase portion of a three-phase delta system, or a midpoint of a three-wire, direct-current system.

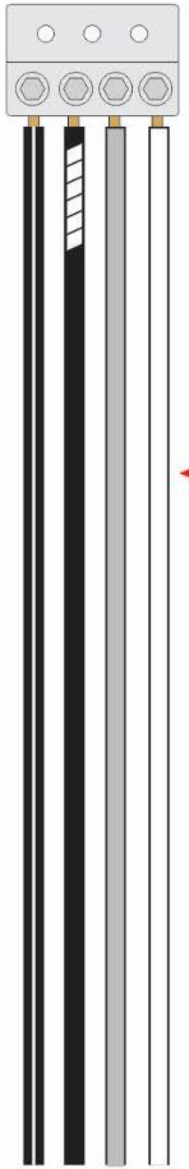


Copyright © IAEI 2020

Identification of the Grounded Conductor

- Grounded conductors are required to be identified by the means specified in **200.6**
- Requirements are provided for **identification of grounded conductors** for:
  - Conductors 6 AWG or smaller
  - Conductors 4 AWG and larger
  - Grounded conductors in flexible cords
  - Grounded conductors of different systems
  - Grounded conductors of multiconductor cables

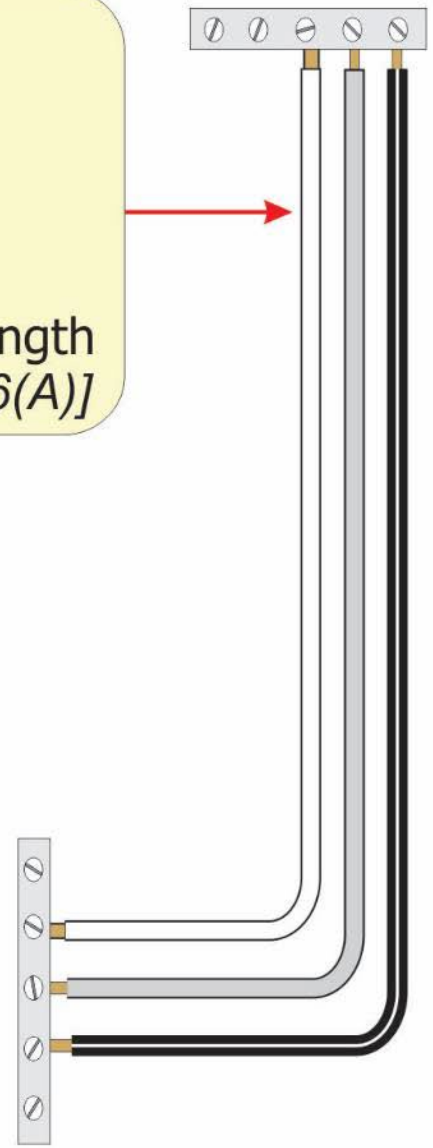
Identification of Insulated Grounded Conductors



Sizes 6 AWG or smaller identify as follows:

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

[200.6(A)]

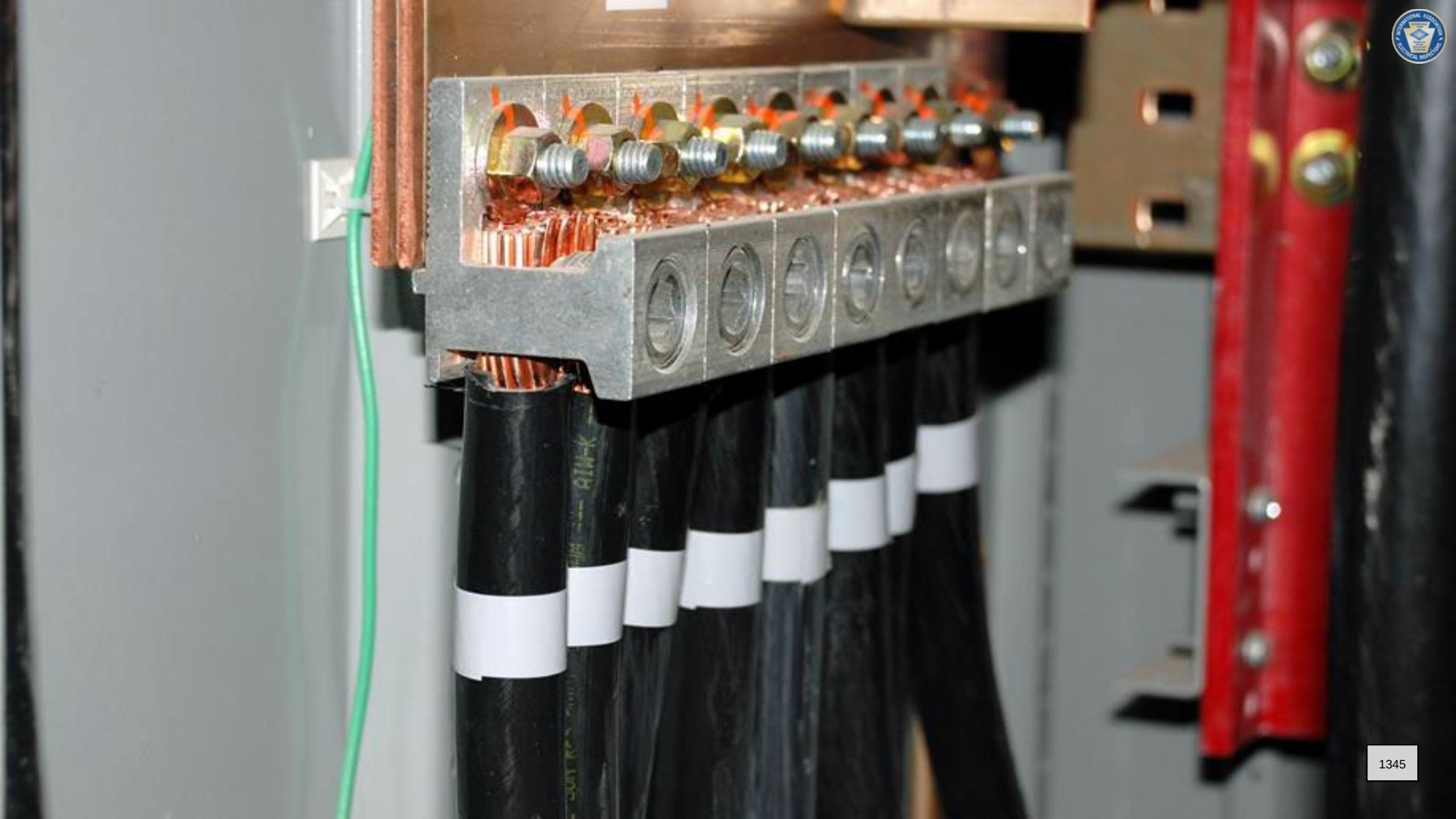


Sizes 4 AWG and larger identify as follows:

- By a continuous white outer finish or...
- By a continuous gray outer finish or...
- By three continuous white or gray stripes on other than green insulation along its entire length or...
- At the time of installation, by a distinctive white or gray marking at the terminations that encircles the conductor

[200.6(B)]

Copyright © IAEI 2020



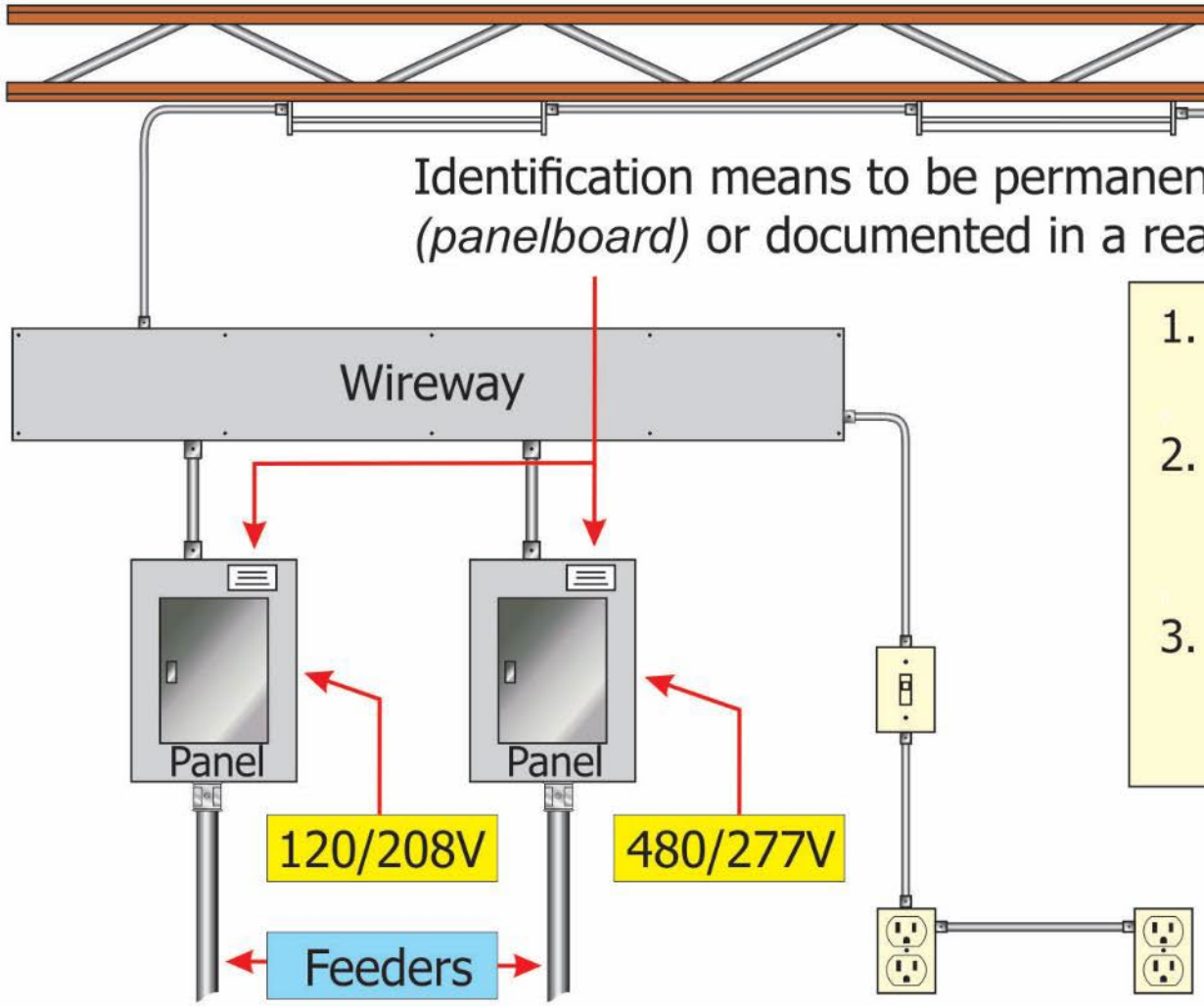
1345

Grounded Conductors of Different Systems

- Larger electrical installations commonly have **more than one electrical system** provided in the facility
- This may result in the grounded *(neutral)* conductors from the **different systems** being installed in the **same enclosure**, such as raceways, wireways, pull boxes and cables
- **Example**: Grounded conductors from both a **480Y/277-volt**, three-phase, four-wire system and a **120/208-volt**, three-phase, four-wire system may be in the same raceway or other enclosure
- First grounded (neutral) conductors to be identified in accordance with the requirements stated in **200.6(A) or (B)**
- Second system grounded (neutral) conductor of the other systems required to be **identified differently** by one of the **other means** provided for conductors in **200.6(A) or (B)**

200.6(D) ID of Grounded Conductors of Different Systems

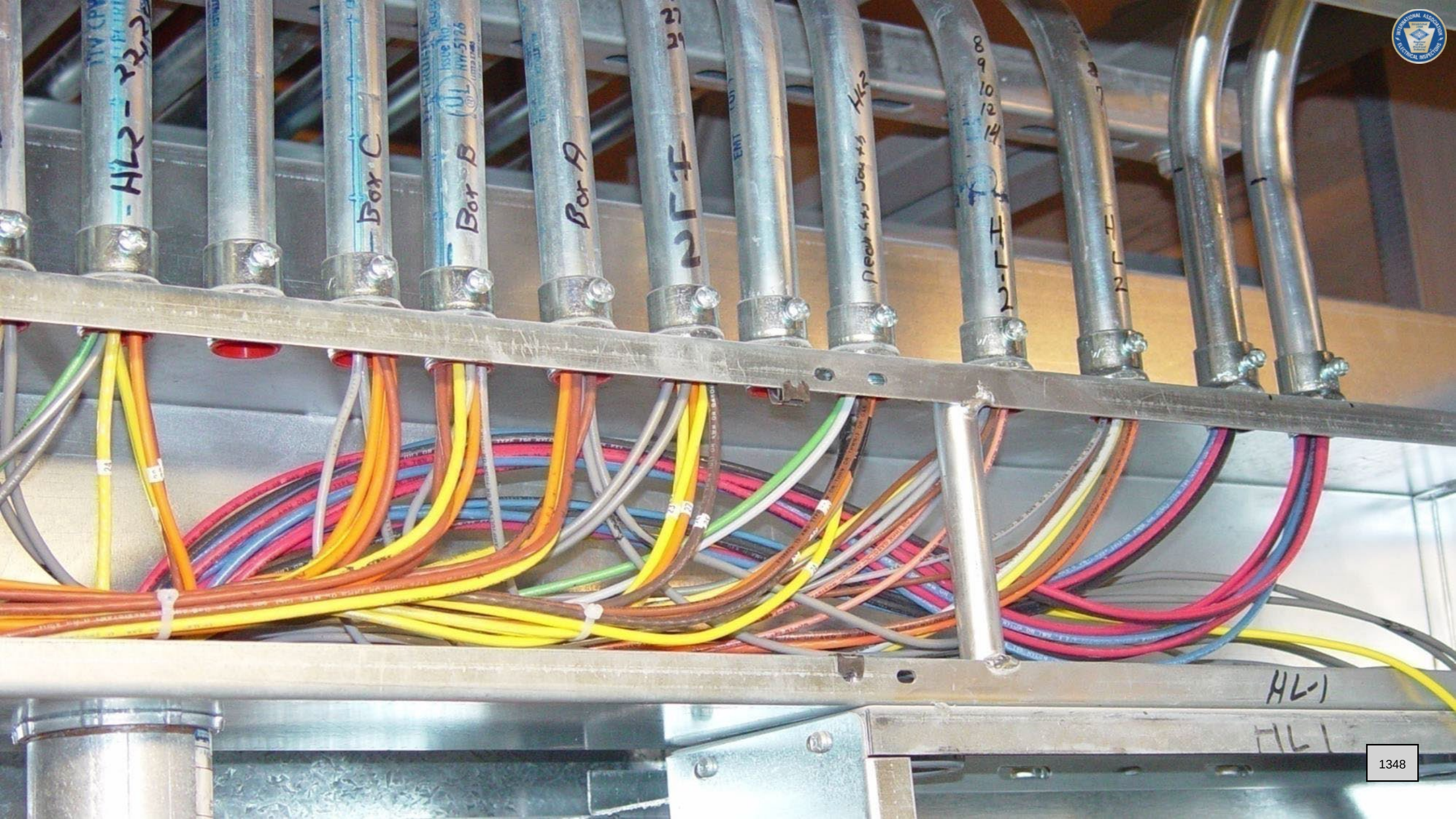
Where grounded conductors of different systems are installed in same raceway, wireway, etc., grounded conductors to be identified by system in a manner that distinguishes the grounded conductors of different systems from one another



1. Grounded conductor to be identified by 200.6(A) or 200.6(B)
2. Other system grounded conductor to have a different identification conforming to either 200.6(A) or 200.6(B)
3. Other means as allowed by 200.6(A) or 200.6(B) that will distinguish each grounded conductor

Note: Different systems does not mean or require different voltages

Copyright © IAEI 2020


HL2 - 22,24
Box C
Box B
Box A
HL2
HL1

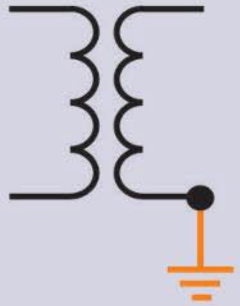
Methods of Grounding Electrical Systems

- A variety of methods are used to ground electrical *systems (if they are to be grounded)*
- These methods fall into three broad categories:
  - Solidly grounded
  - Impedance grounded
  - Ungrounded
- Method chosen will vary, depending upon:
  - System voltage
  - Code requirements
  - Facility owner specifications
  - Engineer's philosophy
  - Utility practices

Methods of Grounding Electrical Systems

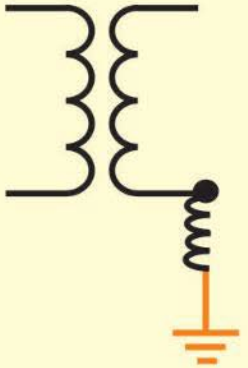
- Various methods commonly used are as follows:
  - *Solidly grounded*
  - *Reactance grounded*
  - *Resistance grounded*
  - *High-resistance grounded*
  - *Ungrounded*

Methods of System Grounding



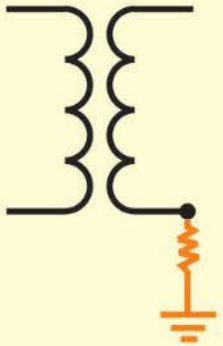
1. Solidly grounded

(No intentional grounding impedance)



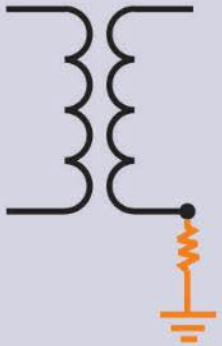
2. Reactance grounded

(Grounded through an inductor)



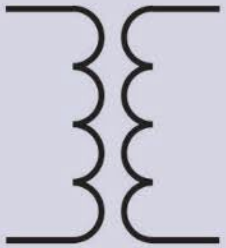
3. Resistance grounded

[Grounded through a resistor (typically 200 to 400 amperes ground-fault current)]



4. High-resistance grounded

[Grounded through the highest permissible resistance (typically 1 to 10 amperes ground-fault current)]



5. Ungrounded

(No intentional system grounding connection)

A variety of methods are used to ground electrical systems *(if they are to be grounded)*

These methods fall into three broad categories
– Solidly grounded,
– Impedance grounded
– Ungrounded

Copyright © IAEI 2020

Surge Arrester Applications

- Surge arresters applied on **grounded systems** permit the use of reduced rated *(80 percent rate voltage)* surge arresters
- Surge arresters must be rated near *(but not less than)* 80 percent of line-to-line voltage
- Reduced rated arresters must be used on a grounded system
- Surge arresters applied on **ungrounded systems** must be fully rated for the line-to-line voltage *(even though they are connected in a wye configuration and the arrester neutral point is grounded)*
- On an ungrounded system, when one phase is unintentionally grounded, the arrestor(s) on the other two phases will have full line-to-line voltage across them

Delta Transformer Bank Grounding

- Where (3) single-phase transformers that have center taps *(such as 240/120 single phase 3-wire)* are connected in a **delta bank**…
  - Only one transformer of bank is to have **midpoint grounded**
- One phase will have a higher voltage to ground *(phase to phase ÷ 2 x 1.73 = high-leg voltage to ground)*
- Mark high leg **orange color** or other effective means *[110.15 and 230.56]*
- This identification may be in addition to any other identification of phase conductors as required by 210.5 and 215.12(C)

Delta Transformer Bank Grounding *(cont.)*

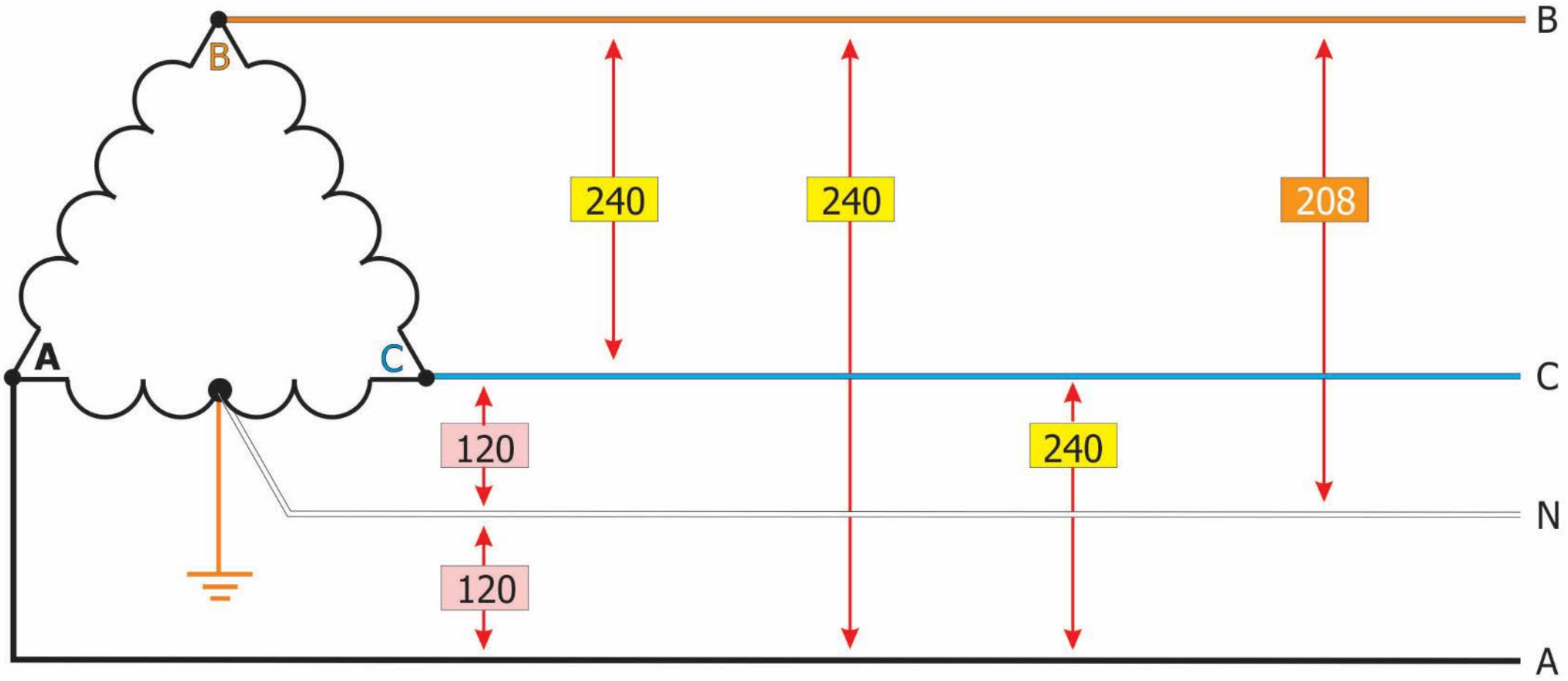
- Comply with location of higher voltage to ground phase conductor in equipment *(B phase having higher voltage to ground)* *[408.3(E)]*
- Switchboard, switchgear, and panelboard enclosures containing high-leg systems shall be provided with a permanent field-applied label as follows: *[408.3(F)(1)]*

“ Caution _____ Phase Has _____ Volts to Ground “

- Label to comply with 110.21(B) *(Field-Applied Hazard Markings)*

120/240 Volt Delta Bank Voltages

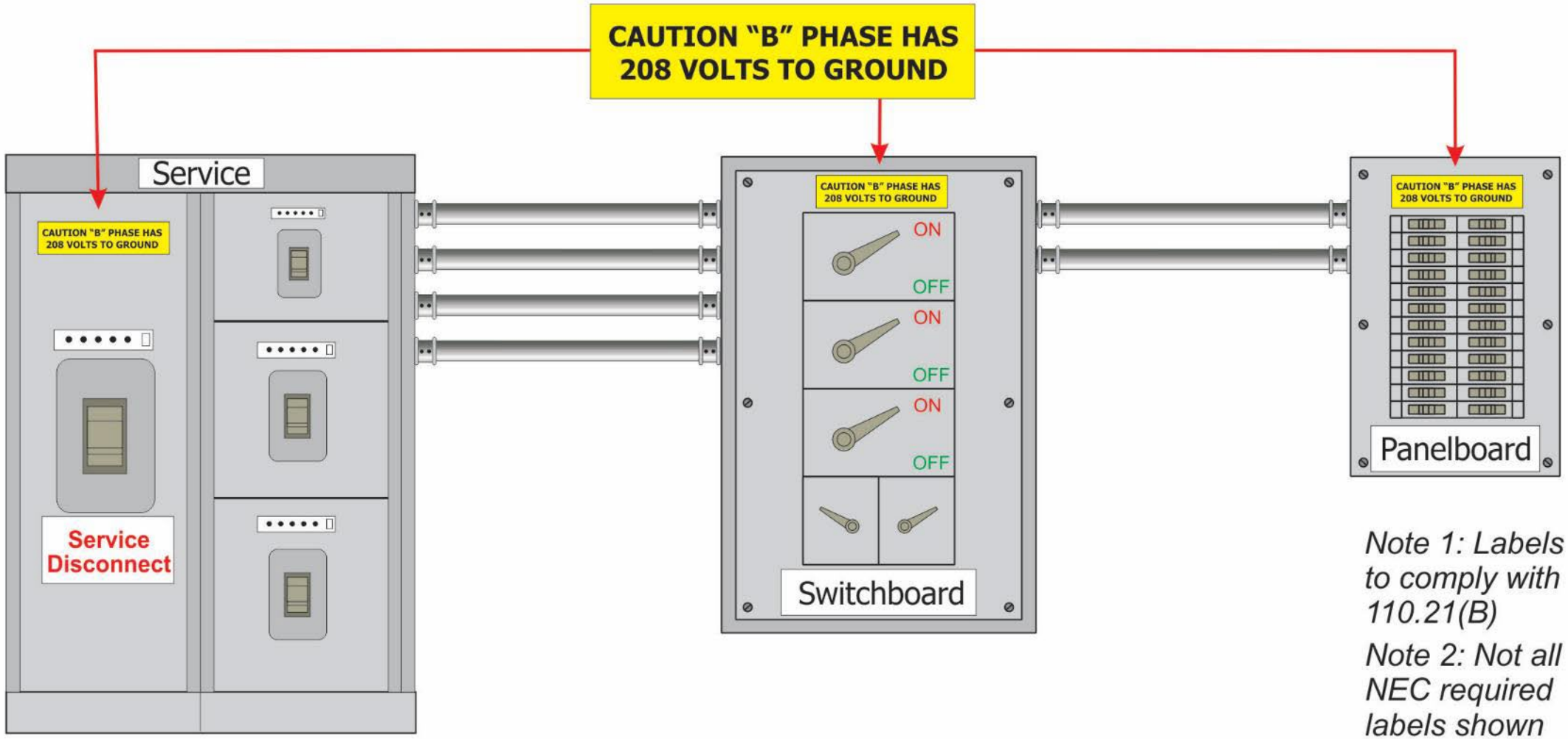
High-leg delta system voltages



240 V / 2 = 120 V
120 V X 1.73 = 207.6 V
High Leg = 208 V

Copyright © IAEI 2020

408.3(F)(1) High-Leg Identification



Note 1: Labels to comply with 110.21(B)

Note 2: Not all NEC required labels shown

Switchboards, switchgear, or panelboards containing a 4-wire, delta-connected system where the midpoint of one phase winding is grounded shall be marked:

CAUTION _____ PHASE HAS _____ VOLTS TO GROUND

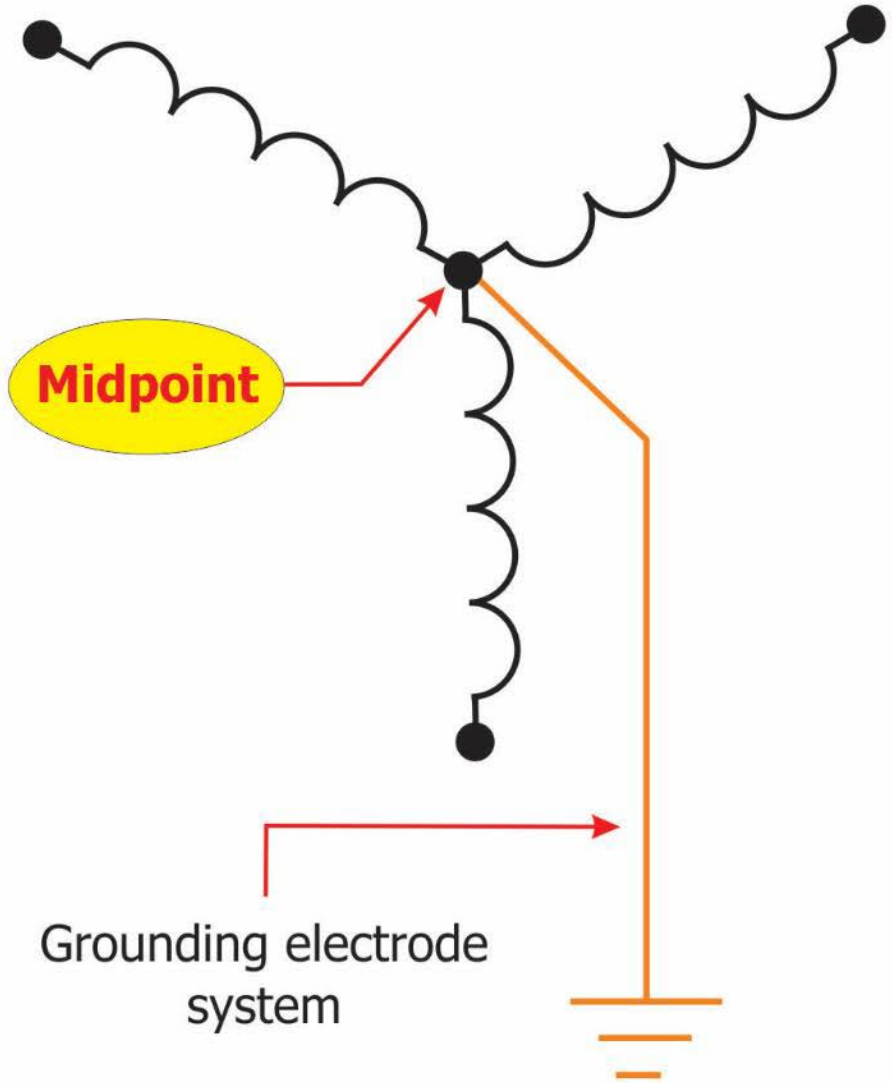
Copyright © IAEI 2020

Grounding the Neutral of Wye-Connected Secondary Windings of a Transformer

- Most universal and commonly used method of grounding a system
- 208Y/120 and 480Y/277 — most commonly used today in the United States
- Growing trend in favor of the 480Y/277-volt system
- Industrial trend toward more use of 575Y/332 volt systems that are now commonly found in Canada
- Primary windings of the transformers serving those wye systems are delta-connected

Grounding Wye-Connected Bank

The connection from the neutral point of the wye-connected transformer to grounding electrode makes this a solidly grounded system



Common voltages:

208Y/120

480Y/277

575Y/332

600Y/346

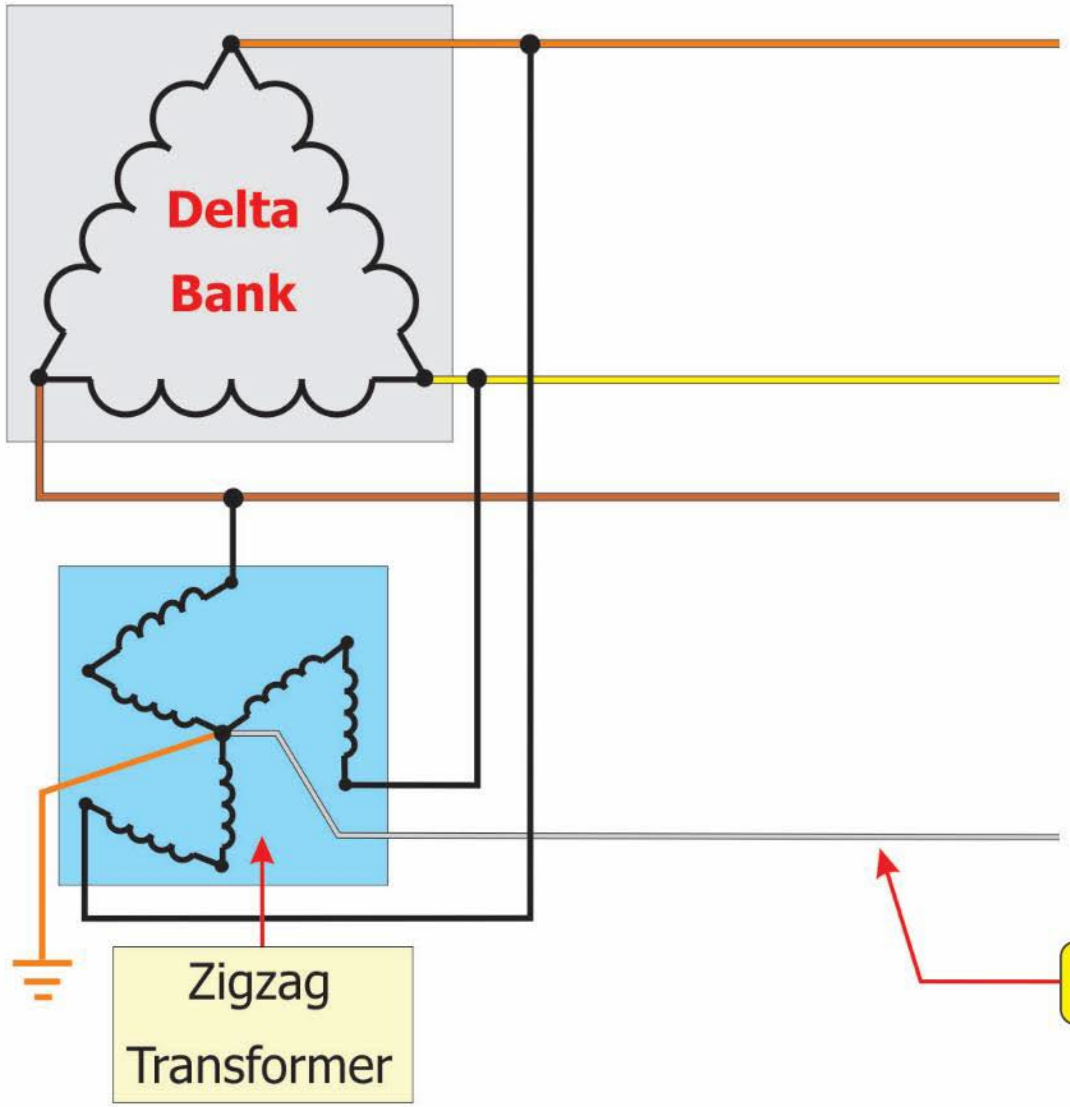
Note: 208Y/120 V and 480Y/277 V are the most commonly use systems in USA

Copyright © IAEI 2020

Grounding a Delta Bank with a Zigzag Grounding Transformer

- Best adapted to an existing 3-wire, 3-phase delta-connected distribution system that is ungrounded
- Used where desired to ground the system to obtain the advantages gained through operating the system grounded while retaining the continuity of service the ungrounded system provides
- Overall delta system is impedance grounded by use of the transformer winding impedance between the original system and the earth connection of the zigzag transformer
- Connection to earth for the zigzag transformer establishes a solidly grounded secondary system

Grounding Delta Bank with Zigzag Transformer



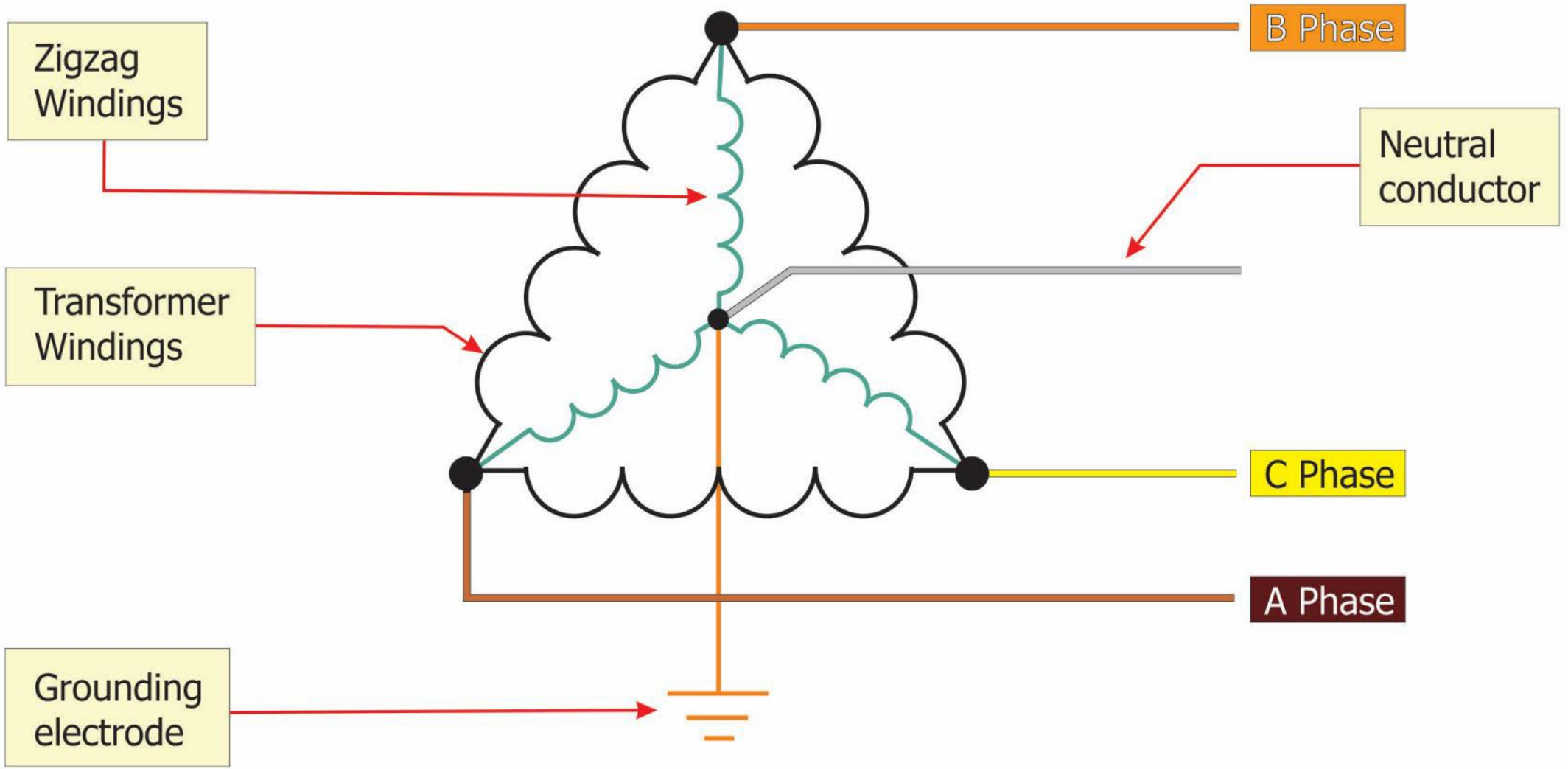
Creates neutral reference for grounding purposes

Not intended to carry neutral loads unless sized properly in accordance with 220.61

Creates a low-impedance path to the source for facilitating the operation of overcurrent devices

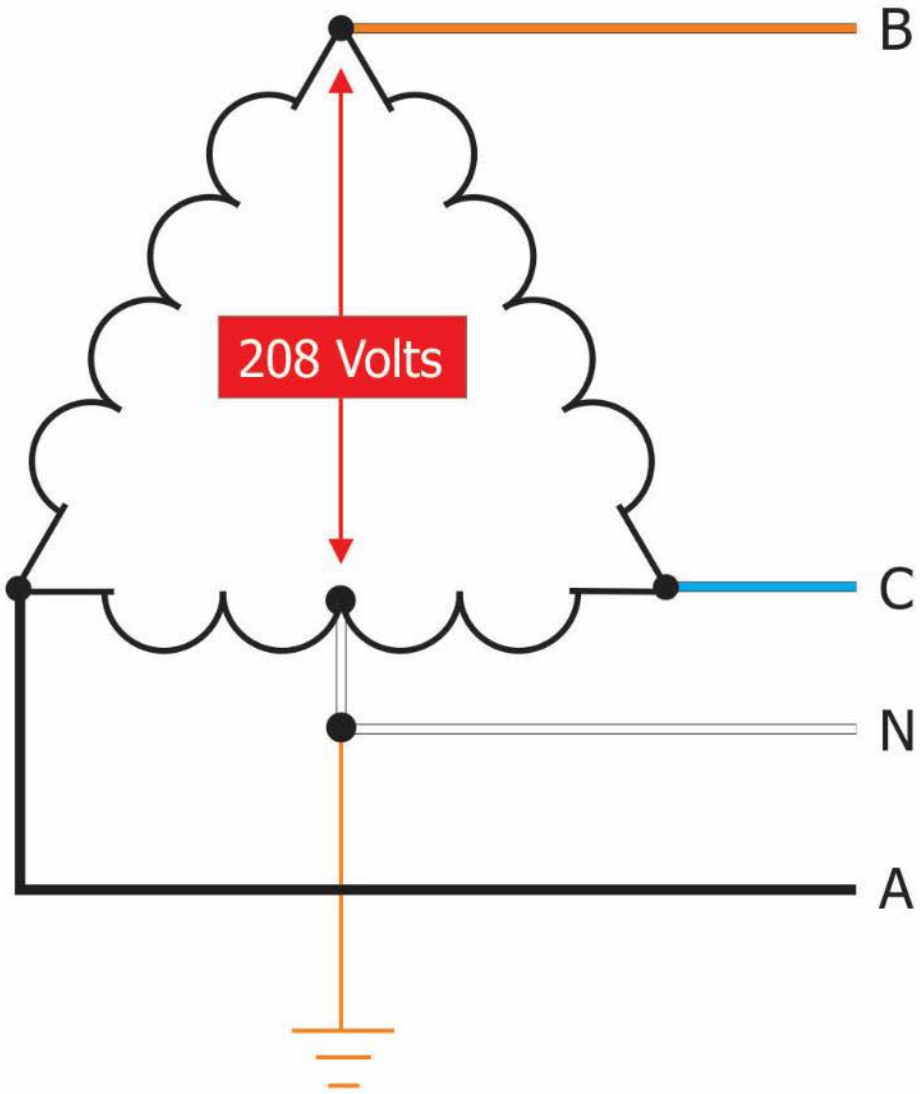
Copyright © IAEI 2020

Relationship of Zigzag Transformer to Delta System



Copyright © IAEI 2020

Grounding Delta Transformer Banks



Grounding midpoint of one transformer in the bank creates high-leg delta system

High-leg delta system must comply with:

- 110.15 *[high-leg marking (orange)]*
- 230.56 *[service conductor high-leg marking (orange)]*
- 408.3(E) *[phase arrangement]*
- 408.3(F) *[high-leg identification label]*

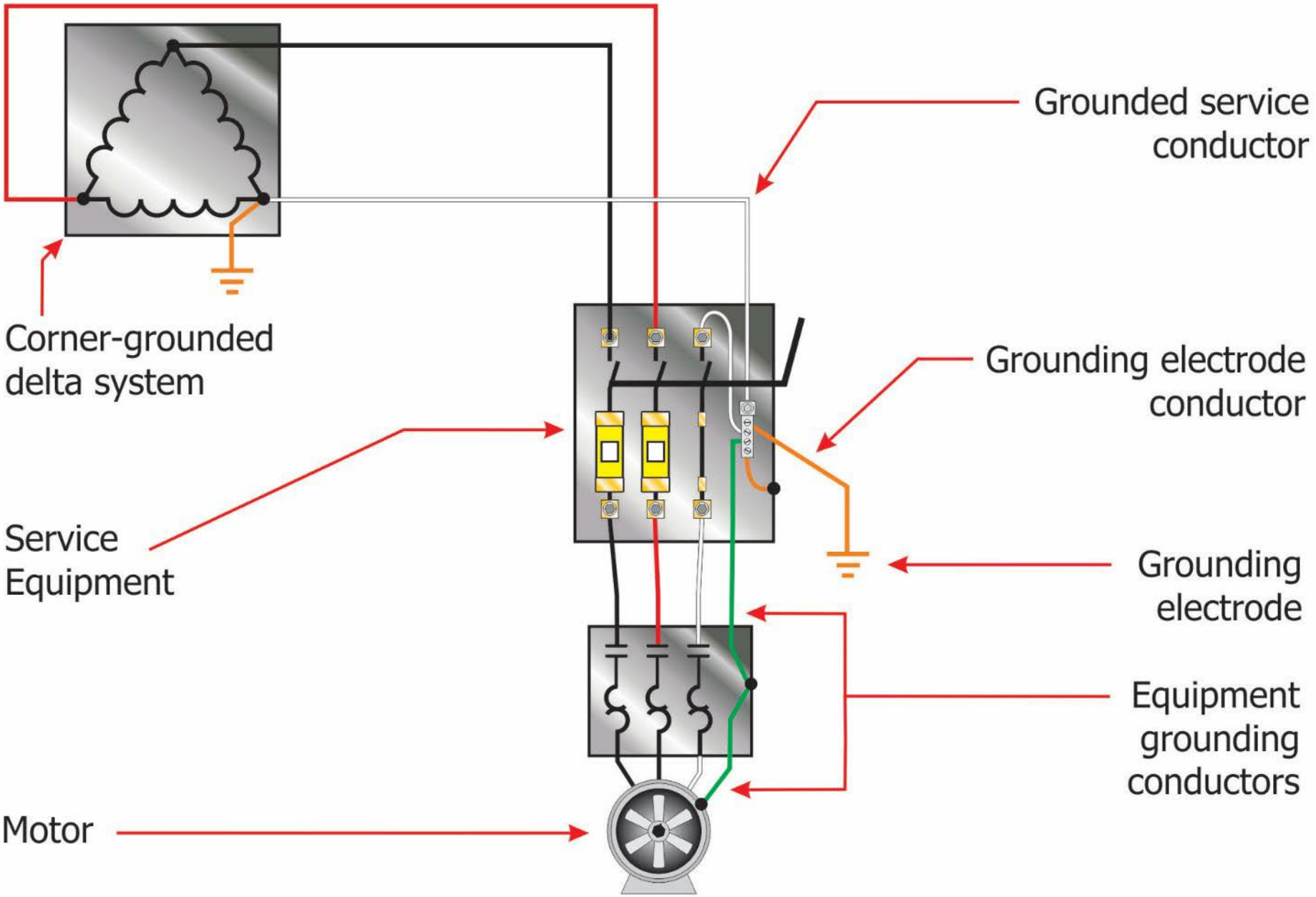
Note: *Phase B to Neutral = 208 volts*

Copyright © IAEI 2020

Grounding of Existing Ungrounded Systems

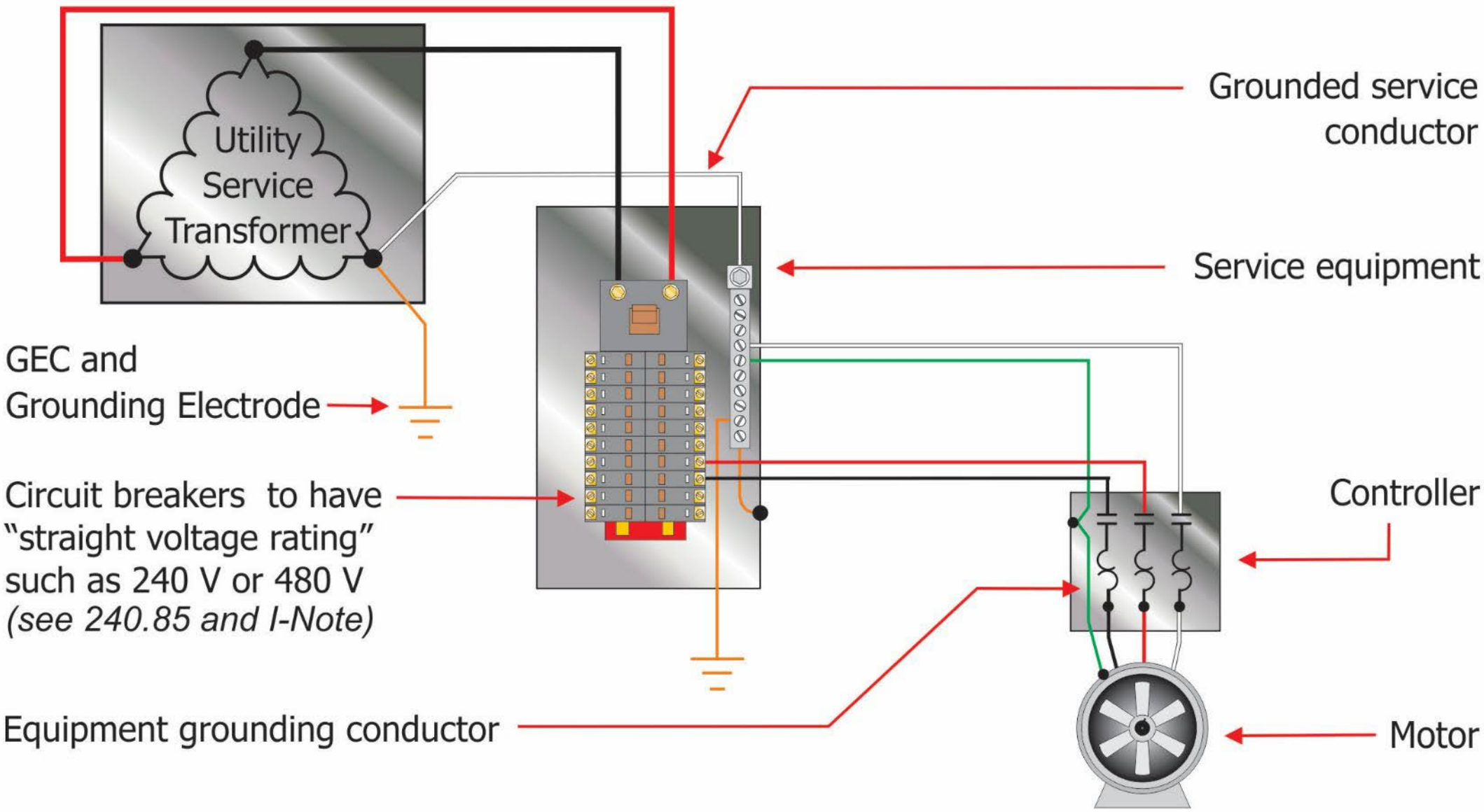
- Overcurrent devices are generally not permitted in grounded conductors as provided in 240.22
- Two conditions permit an overcurrent device in the grounded conductor *(see 240.22)*
  - Where the overcurrent device opens all of the conductors of the circuit *(including the grounded conductor)*
  - Where required by 430.36 or 430.37 for motor overload protection

Fusible Switch for Corner-Grounded Delta System



Copyright © IAEI 2020

Corner-Grounded Delta System



Copyright © IAEI 2020

Circuit Breakers Used as Disconnecting Means for Corner-Grounded Systems

- Where circuit breakers are used as the disconnecting means for corner-grounded systems, they must be marked with a voltage rating suitable for the system voltage and will have a **straight voltage rating** *(such as 240 V or 480 V)*
- **Slash-rated** circuit breakers provide two voltage ratings *(such as 120/240 or 480Y/277)*
- Slash-rated circuit breaker is only listed to interrupt **lower voltage** on any one pole *(not suitable to interrupt the line-to-line voltage)*
- Two-pole circuit breakers that are **suitable for a corner-grounded delta system** are marked "**1-phase/3-phase**"
- See 240.85


OFF
150
TO ANY METAL SURFACE.
TYPE CC
150 AMP
240 VAC
40 °C
CAT. NO. CC3150
CURRENT INTERRUPTING
RATING
MAX. RMS SYM
10,000 AMPS @ 240VAC
USE ANY TWO POLES FOR
SINGLE PHASE APPLICATIONS
WIRE CONNECTOR DATA
CAT No. TA150CC
TORQUE TO 180 LB-IN
#6-4/0 AWG
AL-CU
SUITABLE FOR USE WITH WIRE RATED
75°C OR ABOVE, SIZED PER THE
AMPACITY OF 75°C CONDUCTORS.
CIRCUIT BREAKER
3 POLE UNIT
ISSUE NE-6206
LISTED
Cutler-Hammer
MADE IN

Cutler-Hammer
Circuit Breaker
CSR 25k
2 Pole
200 Amp
120/240 VAC
60 Hz
40°C
Cat. CSR2200
Style 7803C07G83
Interrupting Capacity
RMS Sym. Amps
Volts
Amps
120/240
25k
Terminal
Wire
CU/AL
Wire
Size
2 - 300
Torque
Lb. In.
250
7803
C10
H82
Cutler-Hammer
200
TRIP
OFF
MAIN
DISCONNECT
INTERRUPTOR

CHAPTER FIVE

CLEARING SHORT CIRCUITS AND GROUND FAULTS

Ground Faults and Circuit Impedance

- Conductors generally required to be insulated *[310.106(D)]*
- Bare conductors are allowed where specifically permitted in the *Code*
- Ungrounded *(phase or hot)* conductors must be insulated for the applied voltage
- Install conductors with good insulation and ensure they are not damaged when installed
- De-energize faulted circuits as quickly as possible to reduce damage to conductors and equipment
- Examine circuit to be certain low-impedance path is obtained
- Lower impedance in the grounding circuit results in higher amounts of ground-fault current for overcurrent device operation

Voltage Ratings of Conductors

- Typical **voltage ratings** of conductors are:

300	600	1000	2000
5000	15,000	25,000	35,000

- Conductors available with much higher rated insulations
- Conductors with higher rated insulations typically used for primary distribution of electrical energy rather than for premises wiring

Article 100 Definitions

- ***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.”
  - ***Informational Note:*** “A current in excess of rating may be accommodated by certain equipment and conductors for a given set of conditions. Therefore, the rules for overcurrent protection are specific for particular situations.”
- ***Short Circuit (IEEE – Power Switchgear):*** – An abnormal connection (including an arc) of relatively low impedance, whether made accidentally or intentionally, between two points of different potential. *(IEEE Dictionary of Terms)*
  - *Note: The term fault or short-circuit fault is used to describe a short circuit.*

Article 100 Definitions *(cont.)*

- ***Ground Fault:*** "An unintentional, electrically conductive connection between an ungrounded conductor of an electrical circuit and the normally non-current-carrying conductors, metallic enclosures, metallic raceways, metallic equipment, or earth."

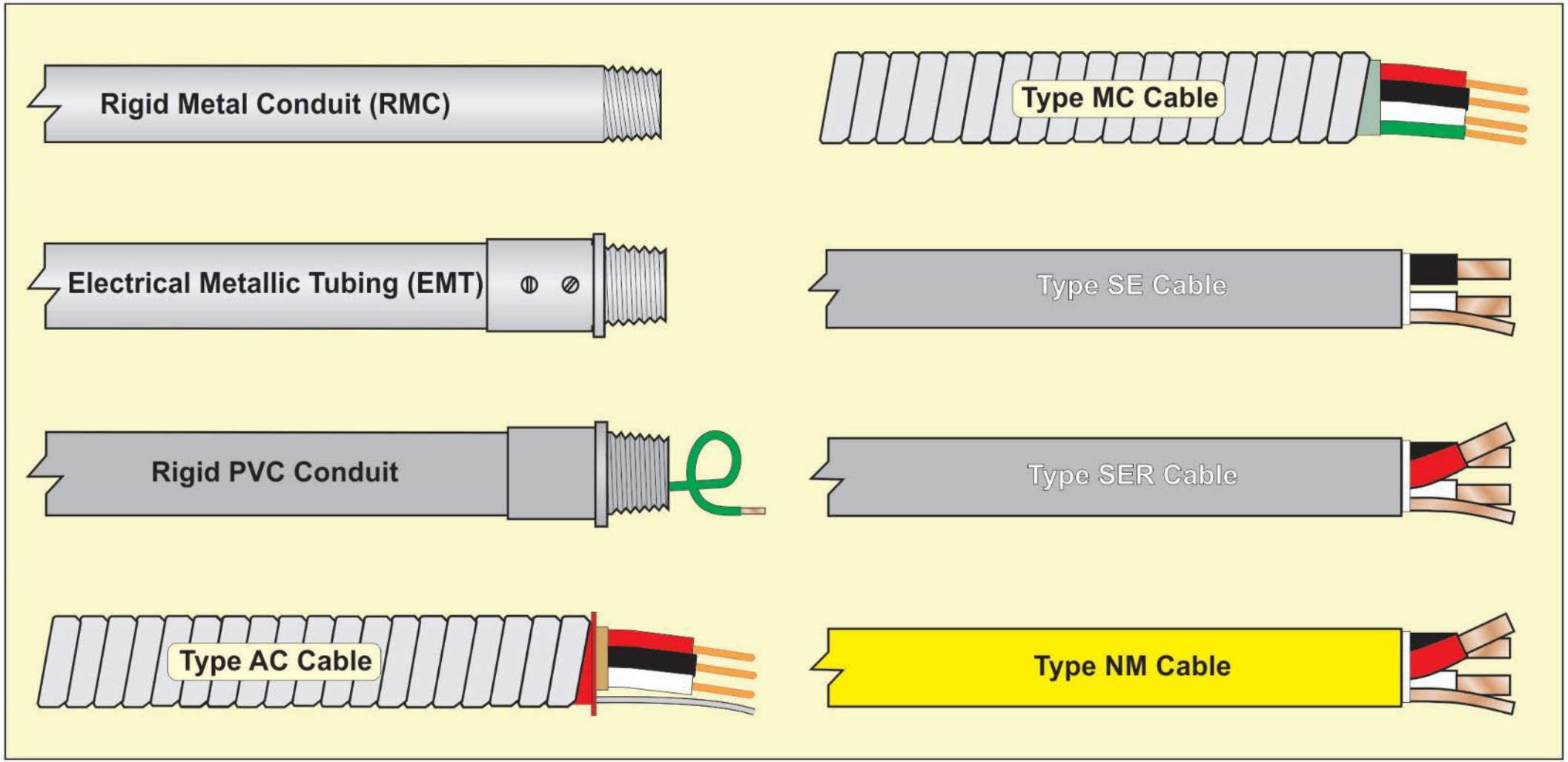
- ***Overload:*** "Operation of equipment in excess of normal, full-load rating, or of a conductor in excess of rated ampacity that, when it persists for a sufficient length of time, would cause damage or dangerous overheating. A fault, such as a short circuit or ground fault, is not an overload."

Fundamentals of Equipment Grounding Circuit Design

- To get **low impedance** of the equipment grounding system in an ac system, the circuit conductors and the equipment grounding conductor (EGC) must generally be **kept together** at all times *[see 250.134(2) and 300.3(B)]*
- EGC may be a copper or aluminum conductor
- EGC may also be the **metal enclosure** of the conductors such as conduit, cable armor or wireways *(qualifying as EGC in accordance with 250.118 for such use)*

All Conductors Generally Required to be Installed Together

All conductors of the same circuit and, where used, the grounded conductor and all wire-type equipment grounding conductors and bonding conductors are generally required to be contained within the same raceway, auxiliary gutter, trench, cable, etc. *[300.3(B), 250.134(2)]*



Copyright © IAEI 2020

Fundamentals of Equipment Grounding Circuit Design *(cont.)*

- In an ac electrical distribution system *(whether grounded or ungrounded)* the overall **impedance consists of resistance and inductive reactance**
- The resistance is from the physical properties of the conductor, such as material, size, and length
- The **inductive reactance** is a key influence in directing the return current to a path closely paralleling the outgoing power conductor feeding the ground fault
- Inductive reactance *(expressed in ohms)* increases as the spacing between the conductors or the circuit is increased
- Inductive reactance will be the predominate factor in determining current division in parallel ground return paths in high capacity or larger circuit constructions

Fault-Current Test Procedures

- As illustrated in the next illustration, a special installation of 65 mm (2½-inch) rigid steel conduit and 4/0 AWG copper conductors was made for a fault-current investigation
- The next illustration is an illustration to show how the test model was built for this testing
- The test data first appeared in the **5th edition of *Soares***
- Test data was derived from a IEEE study entitled, ***"Some Fundamentals of Equipment-Grounding Circuit Design"*** by R. H. Kaufmann, Paper 54-244 presented at the AIEE *(IEEE)* Summer and Pacific General Meeting, Los Angeles, California, **June 24-25, 1954**

Fault-Current Test Procedures *(cont.)*

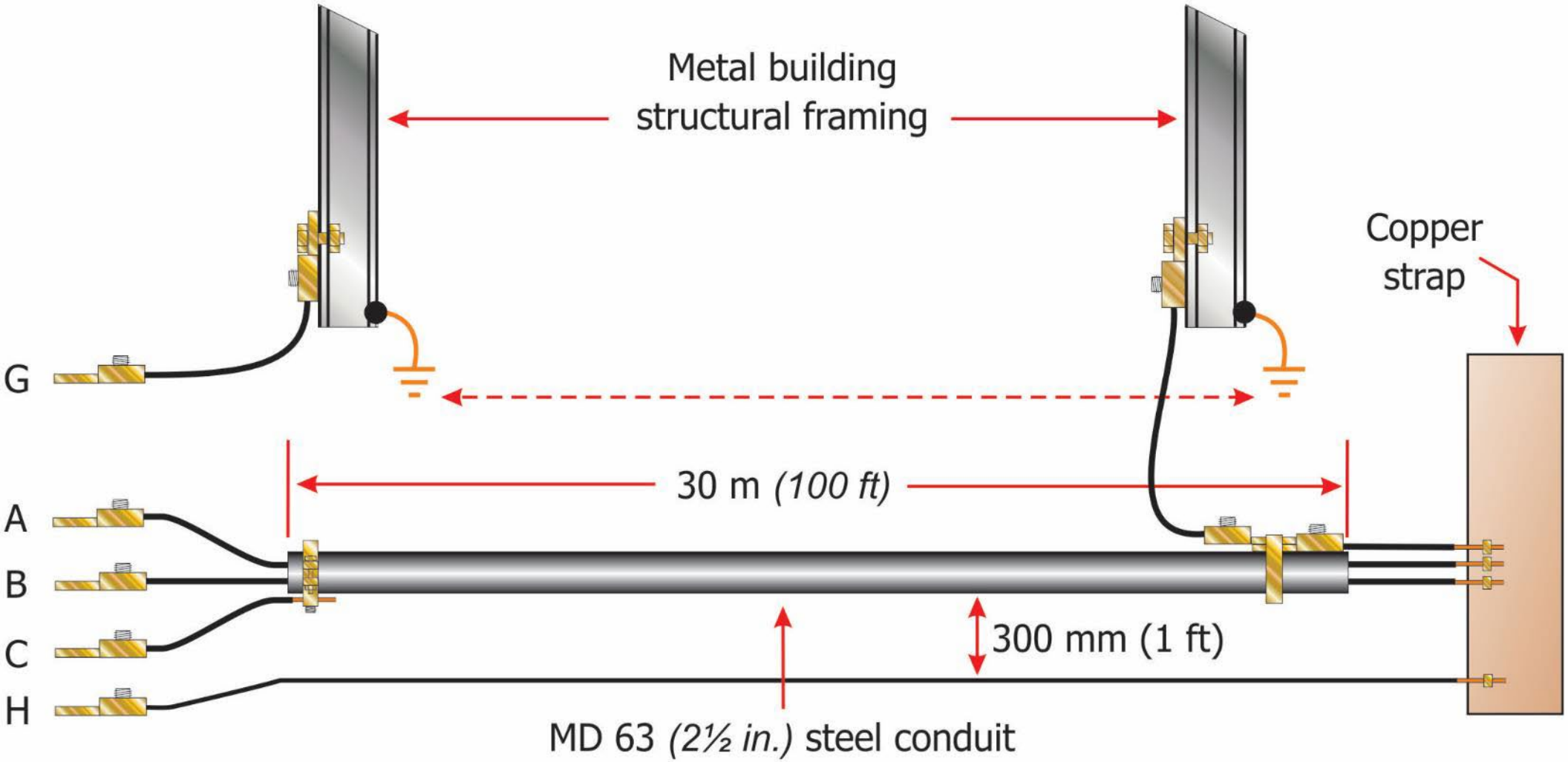
- Installed in a building previously used for short-circuit testing because the building had heavy steel column construction, and all columns were tied to an extensive grounding mat composed of 250-kcmil bare copper conductors
- Conduit was supported on insulators throughout the 30 m (100 ft) length
- Conduit was about 1.5 m (5 ft) from a line of building columns
- External 4/0 AWG conductor was spaced about 300 mm (1 ft) from the conduit on the side opposite the building columns
- Setup was intended to simulate a typical electrical feeder circuit *(found in many commercial and industrial plants)*

Fault-Current Test Procedures *(cont.)*

- Test allowed a wide variety of equipment grounding arrangements
- In every case, the **supply current** was through the **"A" conductor** run through the conduit
- **"B" conductor** served as an **internal EGC**
- **"C" conductor** was connected to the run of **steel metal conduit**
- **"G" conductor** was connected to the **steel building columns**
- **"H" conductor** was the **external EGC** spaced about 300 mm (1 ft) away from and parallel to the conduit
- Copper shorting bar was used at the far end of the conduit
- Arrangement allowed simulation of various fault conditions at the right end and to verify various fault-current return paths

Grounding Current Test Procedure

*See Soares text "Fault-Current Test Procedure" in Chapter 5



Note: All conductors - 4/0 AWG copper

Copyright © IAEI 2020

Fault-Current Test Results

- Results of the tests performed are shown on next table slide
- Test number *(for example, A2)* is for reference purposes
- Next two columns *(Current Flow)* show conductor connections used to determine current path *(for example, out on A and return on C)*
- Next, the current values are shown, first the total input current through conductor A (350), and next the return current through the conduit (350) and its percentage of the total (100)
- The other columns with an “I” heading, along with a subscript indicating the circuit, show the amount of current returning over other possible paths

Fault-Current Test Results *(cont.)*

- The analysis conclusively confirms that only by the use of an internal equipment grounding conductor can any sizable fraction of the return current be diverted from the raceway
- In spite of the extremely low resistance of the building structural frame, it was ineffective in reducing the magnitude of the return current in the conduit *(see tests A6, A7, B6 and B7)*

Current Magnitudes

Test No.	Current Flow: Out On	Current Flow: Return On	IA Total	Ic: Amperes	Ic: Percent of Total	Voltage Magnitudes: I_B	I_H	I_G	E_{AC}	E_{CG}	E_{AB}	E_{AH}	E_{AG}	E_{GB}
Low-Current Tests														
A1	A	B	350	0	0	350	0	0	2.47	0	4.85	0	0	0
A2	A	C	350	350	100	0	0	0	15.9	0.45	2.50	0	0	0
A3	A	C	200	200	100	0	0	0	9.05	0.15	1.51	0	0	0
A4	A	CH	350	340	97	0	12	0	16.0	0.05	2.55	0	0	0
A5	A	CH	200	190	95	0	8	0	9.13	nil	1.55	0	0	0
A6	A	CG	350	340	97	0	0	12	14.6	0	2.54	14.4	0	0
A7	A	CG	200	180	90	0	0	8	9.5	0	1.50	9.4	0	0
A8	A	CB	350	62	18	290	0	0	4.55	nil	4.55	0	0	0
A9	A	CB	200	40	20	150	0	0	2.68	nil	2.68	0	0	0
A10	A	GH	350	0	0	0	160	160	14.0	12.5	2.50	26.4	26.4	24.6
A11	A	GH	200	0	0	0	98	98	9.2	8.1	1.50	17.1	17.1	15.1
High-Current Tests														
B2	A	C	11,200	11,200	100	0	0	0	168	36*	0	0	0	0
B3	A	C	11,070	11,070	100	0	0	0	173	38*	0	0	0	0
B4	A	CH	11,070	11,200	101	0	1,140	0	173	18*	0	0	0	0
B5	A	CH	11,080	11,090	100	0	1,220	0	173	17*	0	0	0	0
B6	A	CG	10,830	10,770	99	0	0	1,080	168	0	71	0	0	0
B7	A	CG	10,910	10,780	99	0	0	1,145	173	9*	0	0	0	0
B8	A	CB	11,620	5,810	50	5,660	0	0	0	27*	0	0	155	0
B9	A	CB	11,380	6,070	53	5,620	0	0	146	25*	0	0	0	0
B10	A	GH	8,710	0	0	0	4,300	4,500	0	146	0	0	268	0

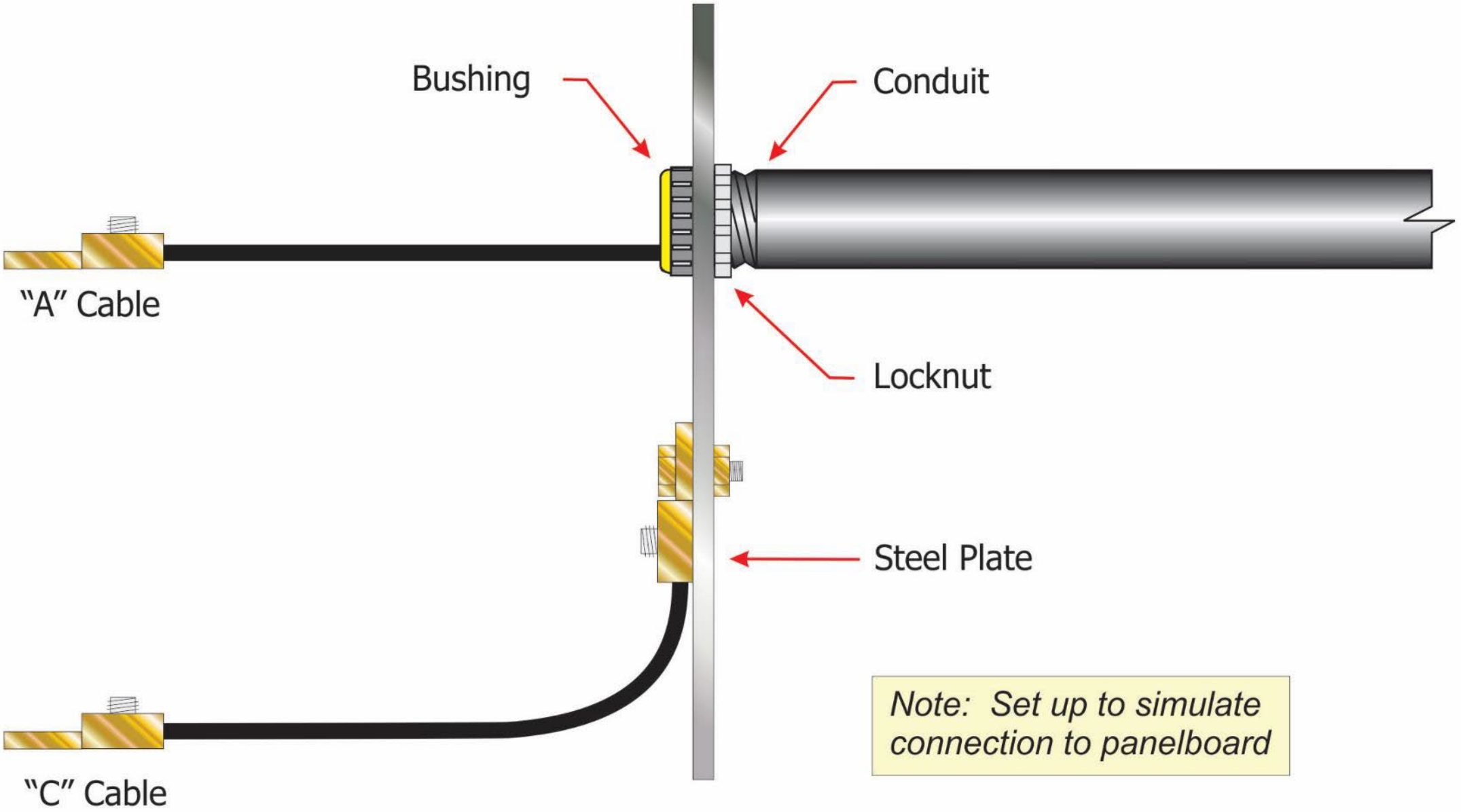
*Distorted wave shape. Tabulated values are crest / $\sqrt{2}$

Copyright © IAEI 2020

Alternate Termination of “C” Cable

- In one high-current test, the conduit termination was altered to simulate a connection to a steel cabinet or junction box
- The bushing was applied finger-tight
- In one test, with about 11,000 amperes for about ¼ second, a fan-shaped shower of sparks occurred parallel to the plate
- In the process, a weld resulted and the parts were separated only with considerable difficulty, with the use of wrenches and a hammer
- This suggested that a repeat shot *(of current)* would have produced no disturbance *(shower of sparks)*
- See next slide

Alternate Termination of "C" Cable



Note: Set up to simulate connection to panelboard

Copyright © IAEI 2020

Maximum Impedance of Ground-Fault Circuit

- The *Code* gives no prescriptive maximum impedance of the ground-fault circuit for grounded or ungrounded systems
- However, 250.4(A)(5) states that an effective ground-fault current path *"shall be installed in a manner that creates a low-impedance circuit facilitating the operation of the overcurrent device"*
- This path should have impedance no greater than the level which allows the circuit breaker or fuse to reach its instantaneous pickup operating range

Maximum Impedance of Ground-Fault Circuit *(cont.)*

- The next slide provides some examples for the maximum impedance for the full ground-fault circuit assuming a system of **120 volts to ground** and a trip level **five times** the overcurrent device rating
- This will cause the overcurrent device to operate quickly to remove the fault from the system *(assuming the overcurrent device will be in the instantaneous trip range at five time the device rating)*
- Any fault current less than the instantaneous operating value will extend or delay, by some value, the opening time of the overcurrent device
- See next slide

Maximum Impedance of Ground-Fault Circuit

Overcurrent Device *(Amps)*	Maximum Z of Ground-Fault Circuit in Ohms Includes Fault Impedance
60	0.4
100	0.24
200	0.12
400	0.06
600	0.04
800	0.03
1200	0.02
1600	0.015
2000	0.012
2500	0.0096
3000	0.008
4000	0.006

Values based on the maximum impedance for the full ground-fault circuit assuming a 120 volts to ground system and a trip level 5 times the overcurrent device rating

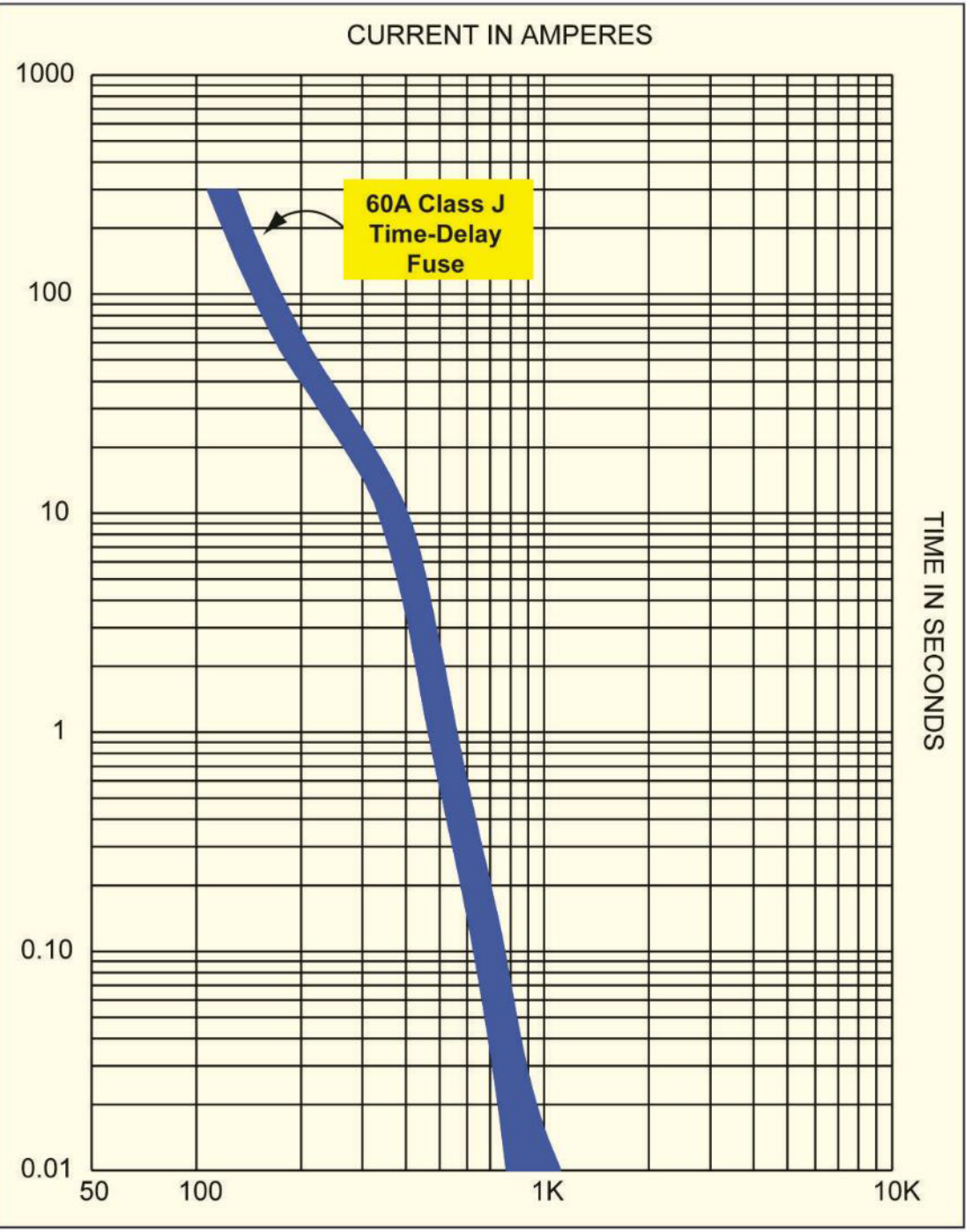
Copyright © IAEI 2020

Time-Current Curves

- Every manufacturer of circuit breakers and fuses publishes operating characteristic or **time-current curves** for their products
- These trip curves should be carefully reviewed to be certain the ground-fault path has an impedance low enough to allow the overcurrent device to operate quickly to reduce thermal damage to the circuit and equipment
- See next slide

Fuse Curve Graph

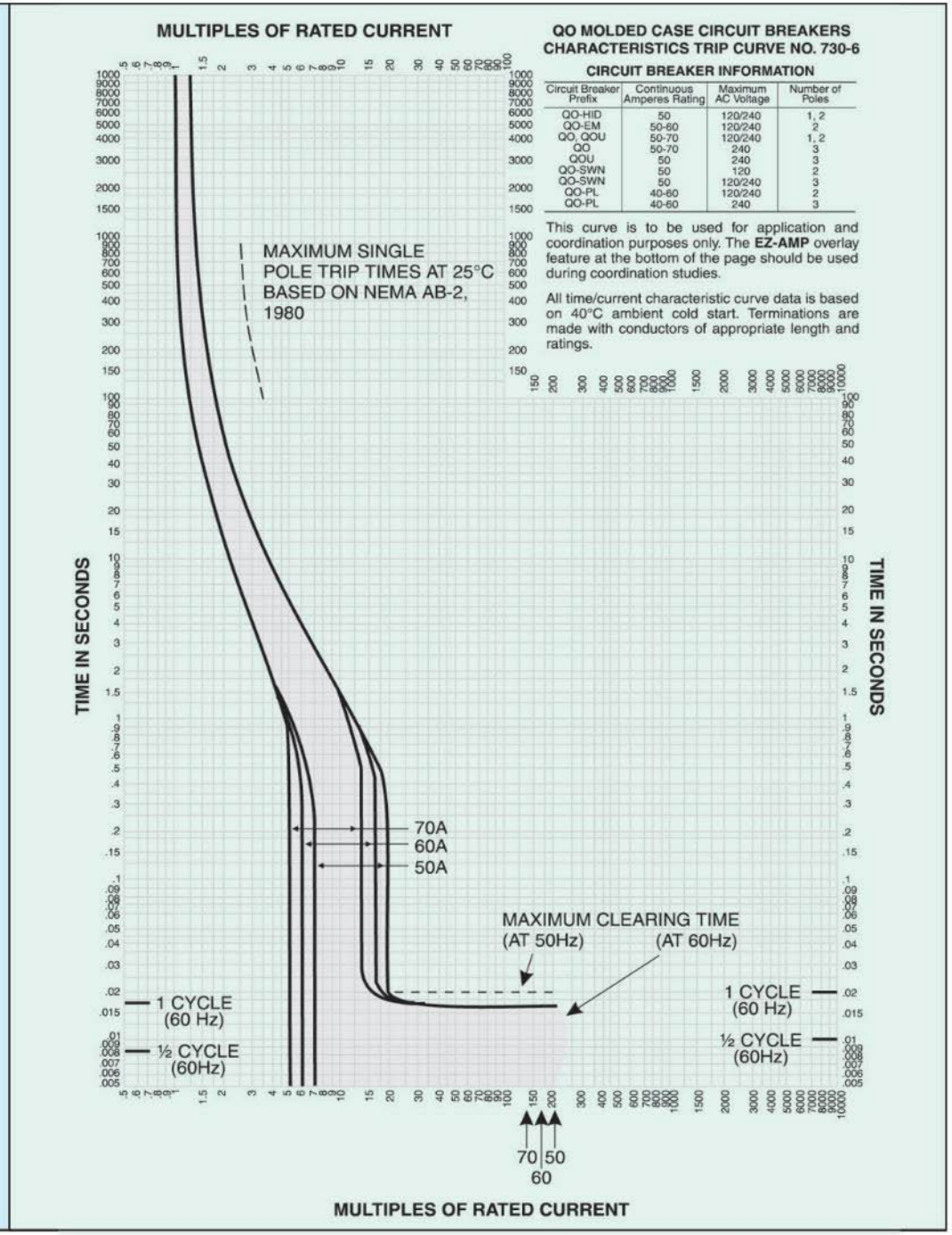
Courtesy of Cooper Bussmann



Copyright © IAEI 2020

Circuit Breaker Let-Through Chart

Courtesy of Schneider Electric



Copyright © IAEI 2020

Effective Ground-Fault Current Path

- To have an effective path for fault current *(for both grounded systems and ungrounded systems)*, the fault-current path must:
  - Be a continuous path
  - Have ample current-carrying capacity
  - Have lowest possible impedance
- The *Code* does not give minimum or maximum values of impedance because this will be different for each circuit
- Current **five times** the rating of the overcurrent device is generally adequate to operate the overcurrent device in a reasonable time so as not to cause extensive damage
- See 250.4(A)(5)

Clearing Short Circuits

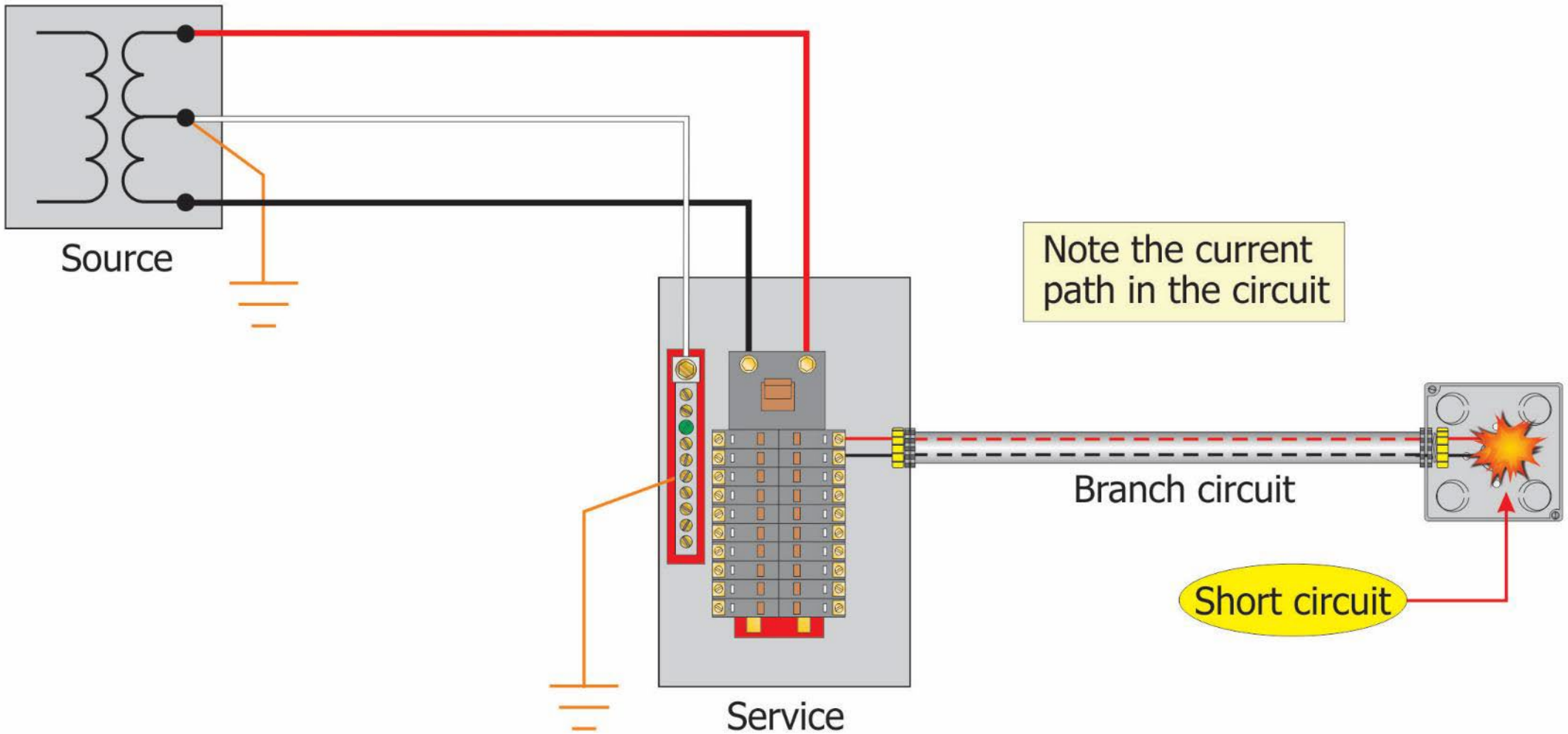
- Method employed for **clearing a short circuit** is the same regardless of whether system is grounded or ungrounded
- Essentially, it involves placing an overcurrent device in series with each ungrounded circuit conductor
- In the event of a ***short circuit*** *(fault from conductor to conductor)* the words **"as quickly as is practical"** means a very short period of time down to as low as a **fraction of a cycle** *(4 to 8 milliseconds)* depending on the amount of short-circuit current and the characteristics of the overcurrent device

Clearing Short Circuits *(cont.)*

- Short circuits typically have fault paths with very low impedance
- Rating of overcurrent device typically based on requirements of 240.4(A) through (G)
- Must consider the **length of the circuit**
- May require larger conductors for long runs to reduce voltage-drop and have low impedance

Clearing Short Circuits

Short circuits are cleared by the overcurrent device in series with the faulted circuit conductor



Copyright © IAEI 2020

Series Combination Ratings

- Some installations of fuses or circuit breakers are installed in a **series combination configuration** *(two or more fuses or circuit breakers are in series)* for the circuit that open together under short circuit conditions
- Devices that have been tested for their operating compatibility may be marked by the manufacturers with a ***series-combination rating***
- Typically, downstream overcurrent device interrupt rating is **below** the fault current that is available at its line terminals, while the overcurrent device closest to the source has an interrupting rating **at or above** the fault current that is available at its line terminals

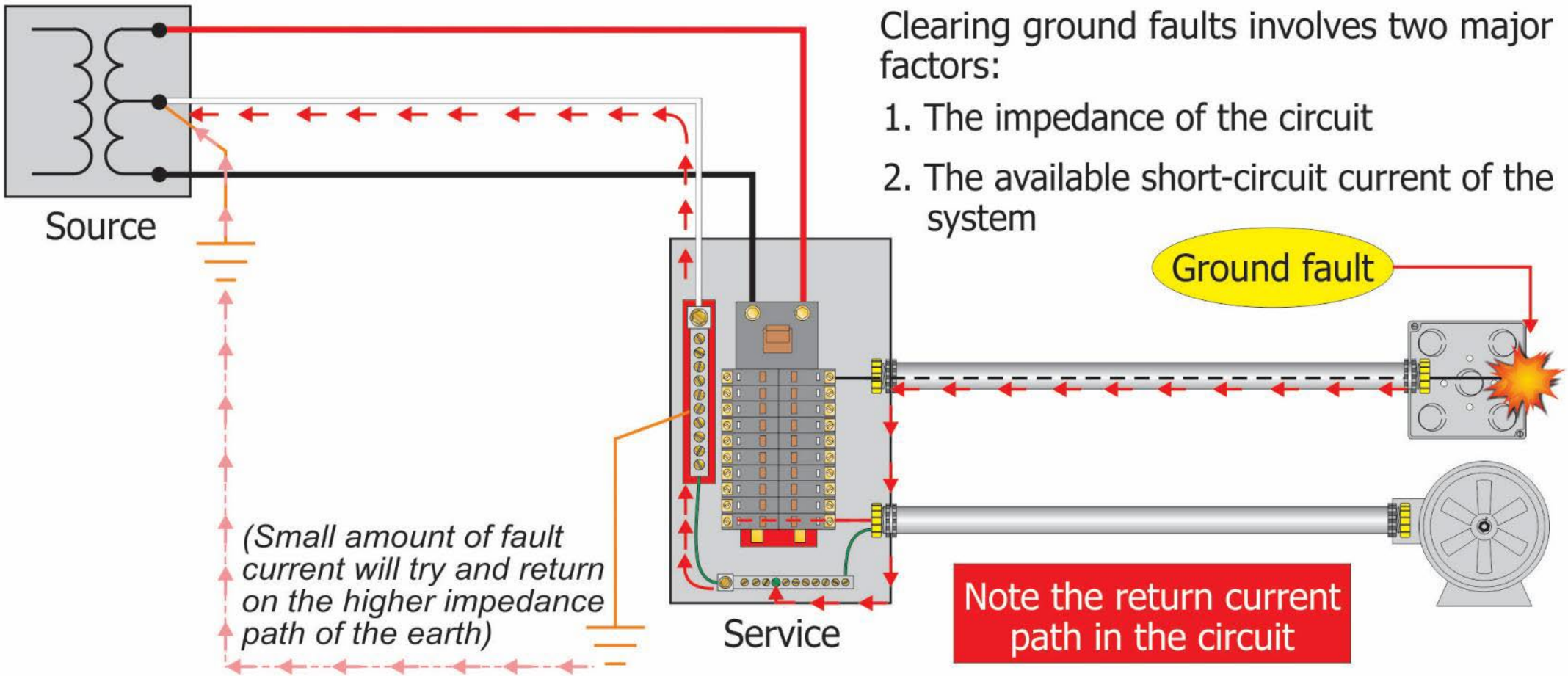
Clearing Ground Faults

- Ground-faults are different than short circuits
  - Short circuit:
    - Two or more ungrounded circuit conductor or an ungrounded and the grounded (neutral) circuit conductor
  - Ground fault:
    - One ungrounded conductor and a ground fault return path
- Ground fault return path can be:
  - A wire
  - Metal raceway
  - Other conductive metal
  - Even the earth itself

Clearing Ground Faults *(cont.)*

- In a **ground fault**, there can be a very **high impedance** component of the faulted circuit that the controlling factor of current is the impedance of the ground-fault circuit
- Ground fault is an arcing fault with a high impedance in the arc itself or for circuits of larger ampacity
- The biggest part of this impedance is the ground-fault return path(s)
- In this case, the only part the available short-circuit capacity plays is in its ability to maintain voltage
- In some circuits, the amount of current in a ground-fault circuit is not dependent on the available capacity of the system, other than its ability to maintain full voltage during a ground fault

Clearing Ground Faults



Clearing ground faults involves two major factors:

1. The impedance of the circuit
2. The available short-circuit current of the system

Consider the impedance of the total circuit to allow enough current to operate the overcurrent protective device

Review the operating or trip curves of the overcurrent device applied in the circuit

Copyright © IAEI 2020

Overcurrent Device Operation

- A low-impedance path is vital to fast operation of overcurrent protective devices
- Symbol for impedance is “Z”
- Symbol for current (amperes) is “I”
- The following can be concluded simply:

  Big “Z” *(impedance)* = Low “I” *(amperes)*

  Low “Z” *(impedance)* = Big “I” *(amperes)*
- Amperes operate overcurrent devices *(fuses and circuit breakers)*

Selective Coordination

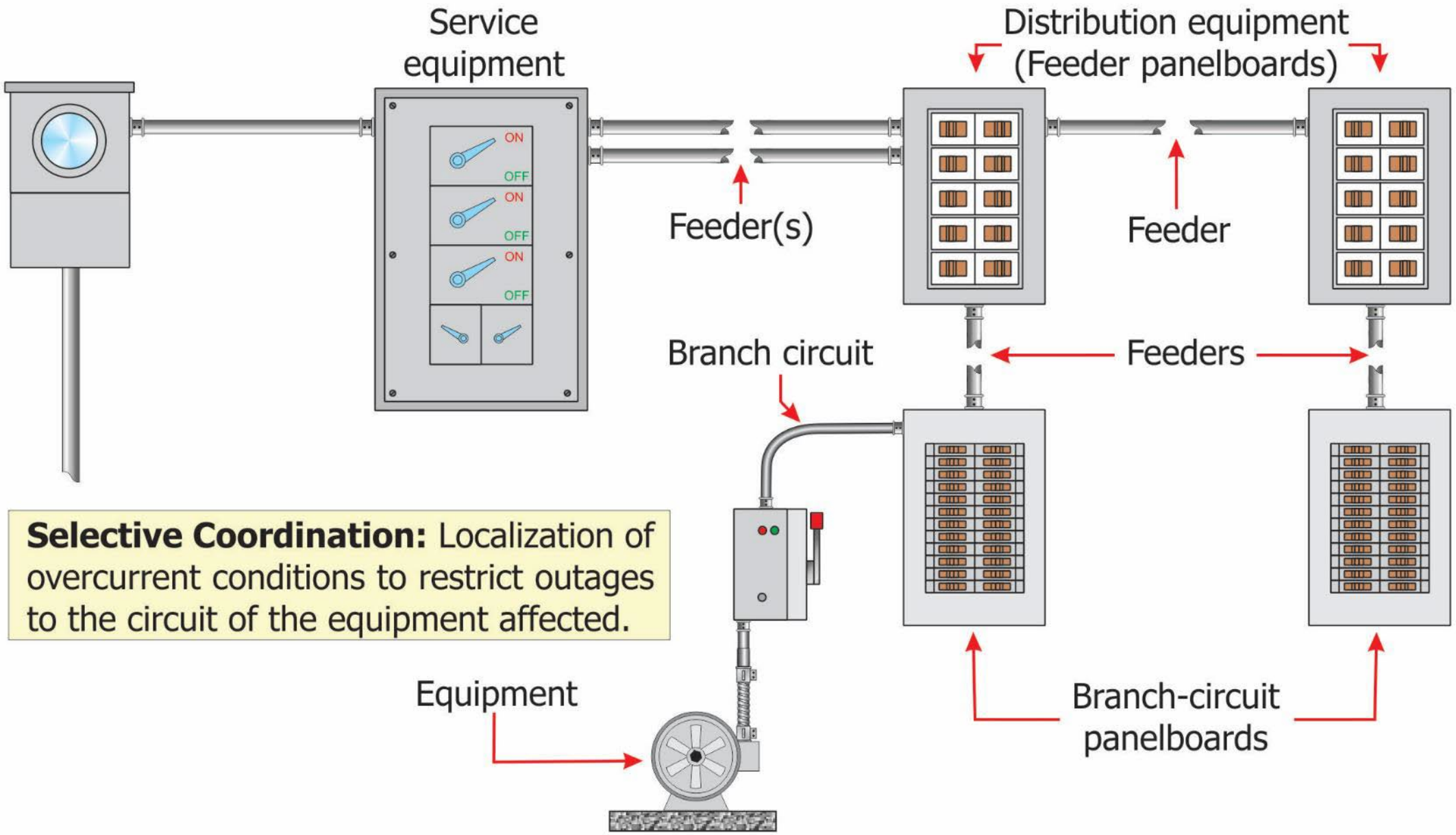
- ***Coordination (Selective):*** "Localization of an overcurrent condition to restrict outages to the circuit or equipment affected, accomplished by the selection and installation of overcurrent protective devices and their ratings or settings for the full range of available overcurrents, from overload to the maximum available fault current, and for the full range of overcurrent protective device opening times associated with those overcurrents."

- Definition from Article 100 of the *NEC*

Selective Coordination *(cont.)*

- Good electrical system designs generally involve good coordination between all levels of overcurrent protection to localize overcurrent or ground-fault conditions to the offending circuit
- The *Code* specifically requires selective coordination of the overcurrent devices in some locations *(see 240.12, 700.32)*
- Other requirements for selective coordination found in Articles 620, 645, 695, 701 and 708
- When applying selective coordination, it will generally be necessary to consider separately coordination of **short circuit** conditions, **ground fault** conditions, and **overload** conditions

Selective Coordination of Overcurrent Devices



Selective Coordination: Localization of overcurrent conditions to restrict outages to the circuit of the equipment affected.

Copyright © IAEI 2020

Clearing Faults in Service Equipment

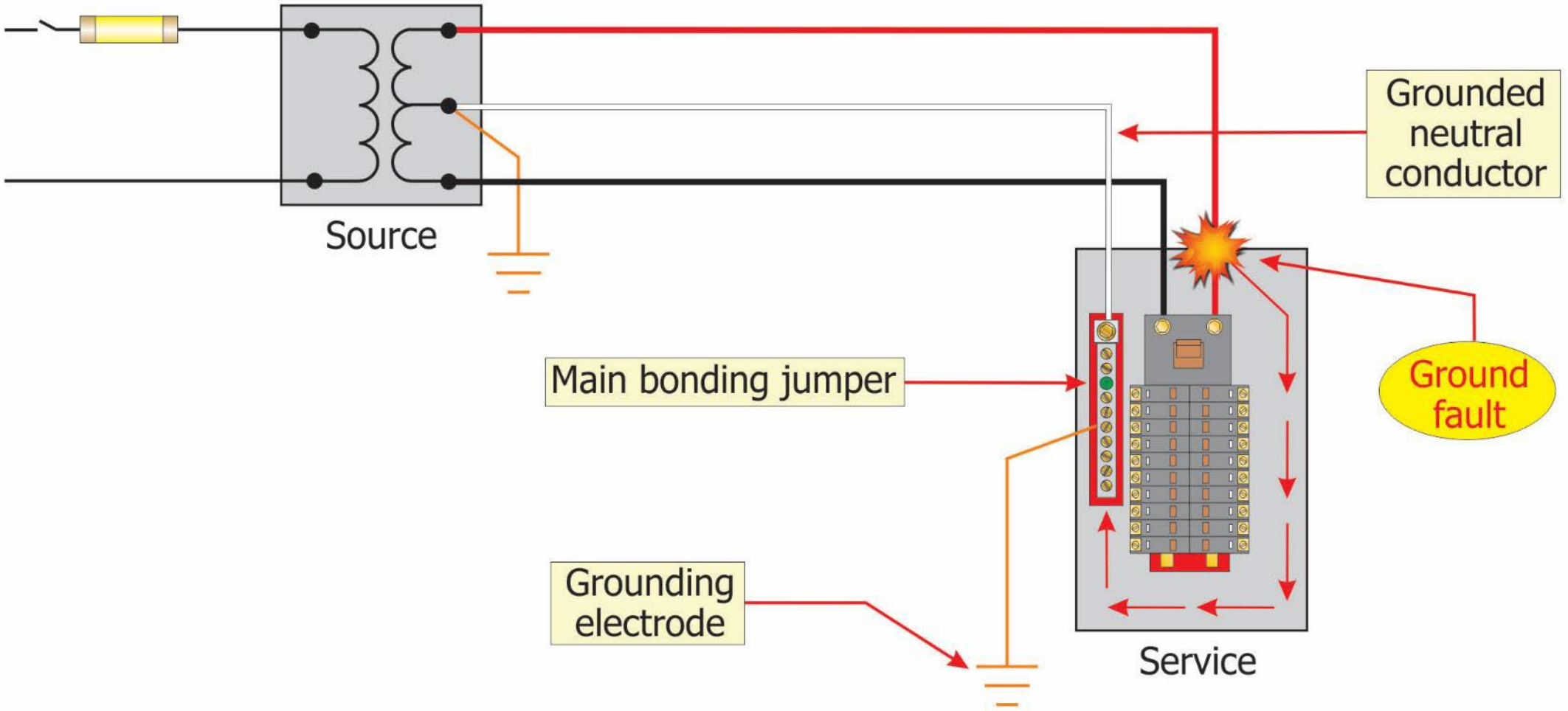
- Service equipment enclosures are one of the most vulnerable locations for ground faults to occur
- No overcurrent protection for the service conductors on the line side of the service disconnect *(only short-circuit protection by the serving utility's transformer primary overcurrent protection)*
- Overload protection is provided by the service overcurrent device in series with the service-entrance conductors
- Service disconnecting means required to be located outside of the building *(or inside, nearest the point of entrance)* limits the length of service conductors without typical overcurrent protection inside the building

Clearing Faults in Service Equipment *(cont.)*

- If a ground fault develops at a point on the **line side** of the service overcurrent device, fault can only be cleared by the **primary overcurrent device on the supply side** of the utility transformer
- If the electrical equipment on the line side of the service is **not properly bonded** and a properly sized **main bonding jumper** installed, it is highly unlikely that there will be enough current in the path to clear the ground fault through the overcurrent devices on the line side of the utility transformer

Clearing Faults in Service Equipment

The main bonding jumper is the vital link to clearing a ground-fault that may occur in the service equipment *(connection between grounding components at the service)*



The grounding electrode and the grounding electrode conductor have little effect in clearing a fault in the service equipment *(high impedance path)*

Copyright © IAEI 2020

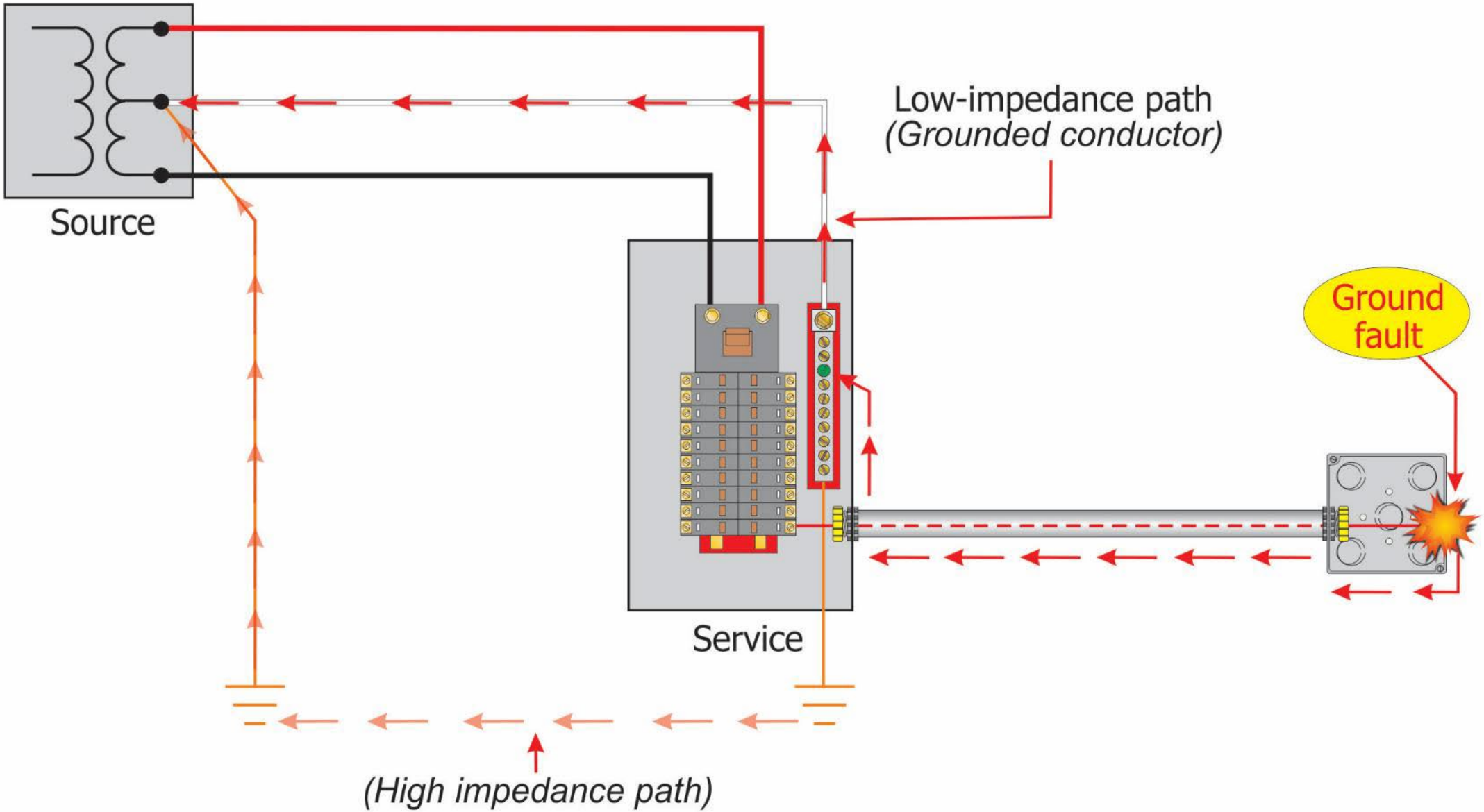
Grounded Conductor to Service Equipment

- For maximum safety, the neutral conductor or grounded conductor must be installed from a grounded system power supply source *(transformer)* to all services and be bonded to each service disconnecting means enclosure *(see 250.24(C) and 250.186)*
- Required even though the service might supply only line-to-line loads *[see 250.24(C) and 250.28]*
- The grounded *(neutral)* conductor of any grounded system serves **two main purposes**:
  - Serves as a current-carrying conductor to carry any unbalanced current back to the source
  - Provides low-impedance path for ground-fault currents to facilitate the operation of the overcurrent devices in the circuit

Analysis of Clearing Ground Faults

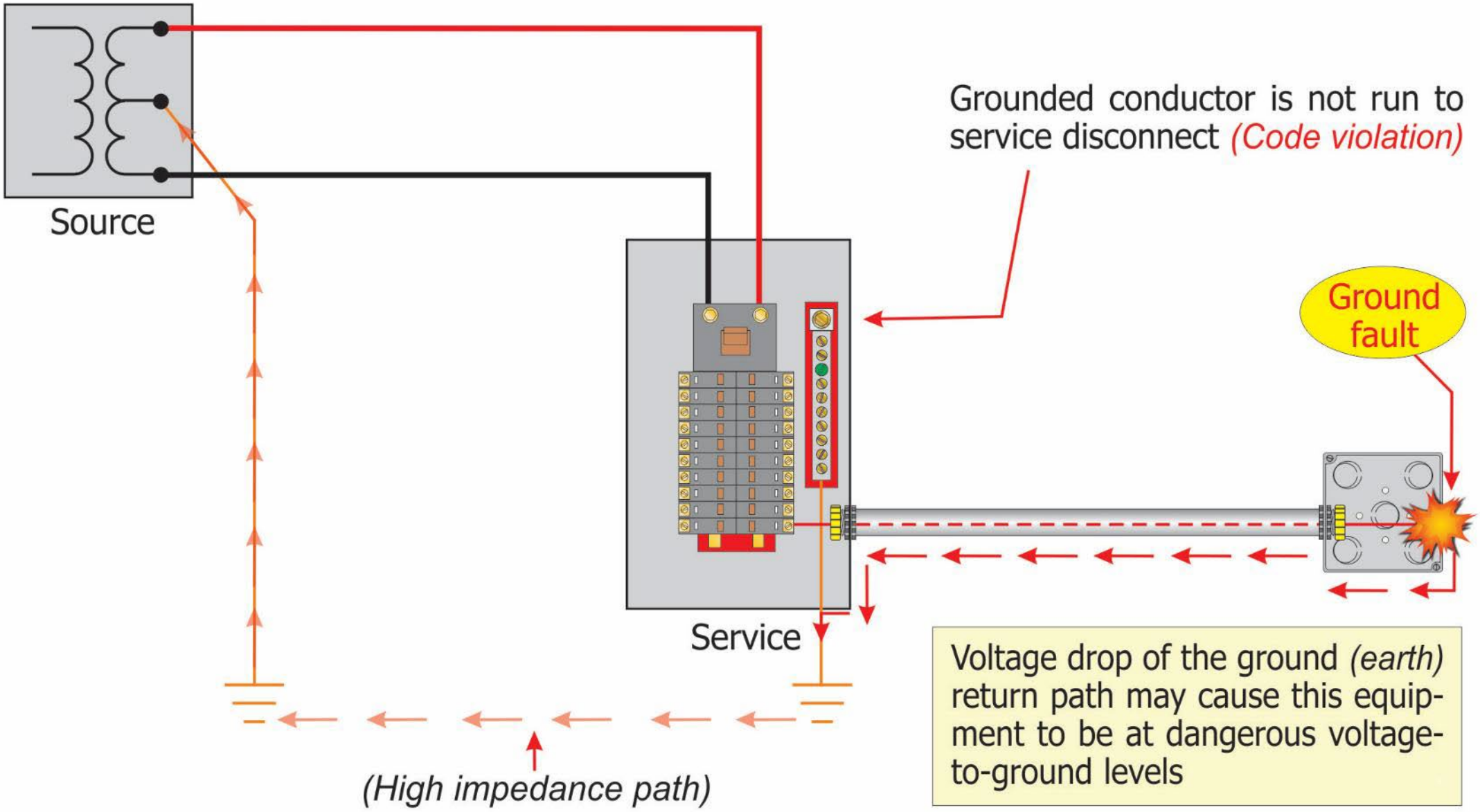
- Two conditions reviewed on the next two slides:
  - Grounded conductor *(neutral conductor)* **installed** from grounded system to service disconnecting means and bonded to enclosure as required by 250.24(C) and 250.186
  - Grounded conductor *(neutral conductor)* **not installed** from grounded system to service disconnecting means and bonded to enclosure *(Code violation)*

250.24(C) Grounded Conductor Run to Service



Copyright © IAEI 2020

250.24(C) Grounded Conductor Not Run to Service



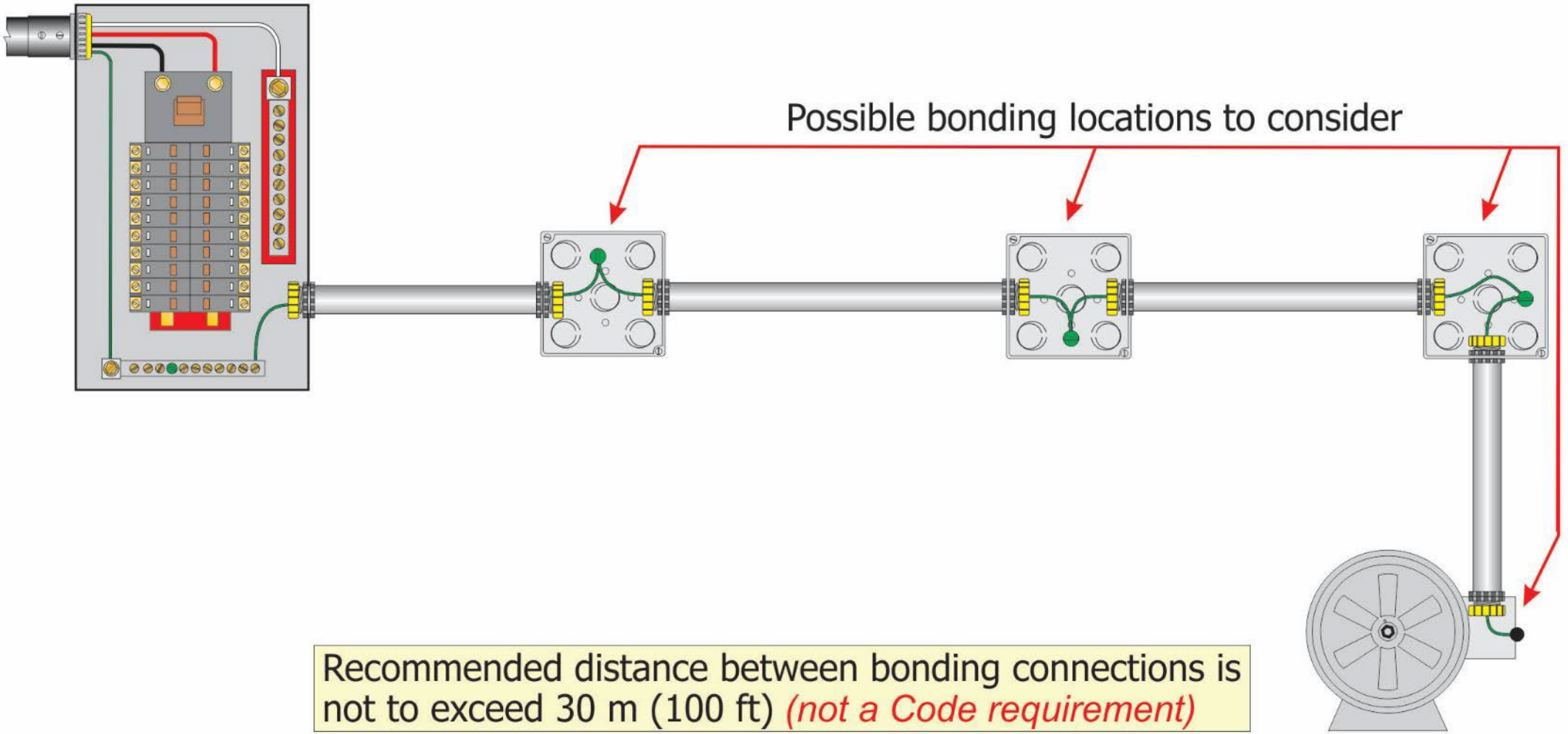
Copyright © IAEI 2020

Long Conduit Runs

- No **minimum size** or **maximum length** given in NEC
- Conduit or tubing, as all conductors, has impedance which must be considered
- Maintain low-impedance path to be effective in clearing faults
- May need to increase conduit or tubing size on longer lengths
- May require supplementary EGC of the wire type installed in the conduit or tubing
- Software available for calculating maximum effective length

Conduit Installed in Excessive Lengths

Where necessary for voltage drop, etc., increase the size of the conduit or tubing or install a wire-type equipment grounding conductor and bond to the raceway as often as practicable



Recommended distance between bonding connections is not to exceed 30 m (100 ft) *(not a Code requirement)*

Copyright © IAEI 2020

Impedance Values for Metal Conduit

- Impedance values for conduit can be obtained from manufacturers
- A reasonable value for the amount of fault current in the circuit can be determined by:
  - Using impedance values
  - Adjusting for the couplings
  - Estimating a 50-volt drop across the fault
- Table III *(Table 5.3 in Soares textbook)* is a reprint of DC resistance and impedance values of rigid steel conduit from the Eustace Soares' first edition grounding book *(see next three slides)*

TABLE III

(Part 1 of 3)

DC Resistance and Impedance Values of Rigid Steel Conduit *

Col. 1 Size of Conduit Inch	Col. 2 Area of Wall in Sq. In.	Col. 3 DC Resistance Ohms per M Ft.	Col. 4 Current in Amperes	Col. 5 Current Density Amps per Sq. In.	Col. 6 AC Impedance Ohms per M Ft.	Col. 7 + "K" factor
** ½	0.254	0.3200	51	200	1.570	4.90
			127	500	1.050	3.28
			254	1000	0.672	2.10
** ¾	0.337	0.2420	67	200	1.190	4.92
			169	500	0.775	3.20
			337	1000	0.508	2.10
1	0.530	0.1540	200	378	0.625	4.07
			500	944	0.352	2.29
			1000	1890	0.213	1.39
1¼	0.680	0.1200	200	294	0.528	4.42
			500	735	0.329	2.76
			1000	1470	0.204	1.71
1½	0.790	0.1030	200	253	0.611	4.96
			500	634	0.317	3.08
			1000	1270	0.197	1.92

Copyright © IAEI 2020

TABLE III

(Part 2 of 3)

DC Resistance and Impedance Values of Rigid Steel Conduit *

Col. 1 Size of Conduit Inch	Col. 2 Area of Wall in Sq. In.	Col. 3 DC Resistance Ohms per M Ft.	Col. 4 Current in Amperes	Col. 5 Current Density Amps per Sq. In.	Col. 6 AC Impedance Ohms per M Ft.	Col. 7 + "K" factor
2	1.030	0.0790	200	194	0.435	5.52
			500	486	0.285	3.62
			1000	970	0.186	2.36
** 2½	1.710	0.0476	342	200	0.290	6.10
			855	500	0.186	3.90
			1710	1000	0.117	2.45
3	2.310	0.0352	200	86.6	0.330	9.38
			500	216	0.234	6.65
			1000	433	0.157	4.47
			2000	866	0.099	2.81
			3000	1300	0.073	2.07
			4000	1730	0.055	1.56
** 3½	2.700	0.0301	540	200	0.214	7.10
			1350	500	0.123	4.10
			2700	1000	0.077	2.55
			5400	2000	0.044	1.45

Copyright © IAEI 2020

TABLE III

(Part 3 of 3)

DC Resistance and Impedance Values of Rigid Steel Conduit *

Col. 1 Size of Conduit Inch	Col. 2 Area of Wall in Sq. In.	Col. 3 DC Resistance Ohms per M Ft.	Col. 4 Current in Amperes	Col. 5 Current Density Amps per Sq. In.	Col. 6 AC Impedance Ohms per M Ft.	Col. 7 + "K" factor
4	3.400	0.0239	680	200	0.170	7.10
			1720	500	0.101	4.20
			3400	1000	0.061	2.55
			6800	2000	0.035	1.45
** 5	4.300	0.0189	860	200	0.136	7.20
			2150	500	0.083	4.40
			4300	1000	0.051	2.70
			8600	2000	0.028	1.50

* The values given are approximate and are based on actual test values. They are sufficiently accurate for all practical purposes. See Table II which gives manufacturing tolerances for conduit. The permissible tolerances may increase the values given in this table by about 15 percent or more.

** Calculated data. All other values are measured test values.

\+ DC resistance times "K" factor = AC impedance.

Table 5.3 is a reprint of DC resistance and impedance values of rigid steel conduit from the Eustace Soares' first edition grounding book (1968).

Copyright © IAEI 2020

Adequate Size of Wire Type Equipment Grounding Conductor (EGC)

- Minimum sizes for wire type equipment grounding conductors are provided in Table 250.122
- Rule of thumb, the minimum should be roughly 25% of the capacity of the phase conductors
- Will allow overcurrent protective devices to clear faults in reasonable time without extensive damage
- See note to Table 250.122 and 250.4(A)(5) and 250.4(B)(4)
- Wire type equipment grounding conductors may need to be increased in size for several reasons including due to circuit length

Conductor Withstand Ratings

- Equipment intended to interrupt current at fault levels is required to have an interrupting rating "**sufficient for the nominal circuit voltage and the current which is available at the line terminals of the equipment**" *(See 110.9)*
- Equipment grounding conductors, circuit conductors, busbars, bonding jumpers, etc. are not intended to break current
- Conductors must be large enough to safely carry any short-circuit and ground-fault current for the time it takes the overcurrent protective device to clear the fault
- See 110.10, 240.1 Informational Note, 250.4, 250.90, 250.96, and 310.10

Conductor Withstand Ratings *(cont.)*

- Table 250.122 “Minimum Size”
- EGC must be large enough to carry fault current
- Must not burn off while carrying fault current
- Limit the current and time to one ampere for five seconds for every 42.25 circular mils of conductor (I^2t) for **insulated conductors**
- Limit the current and time to one ampere for five seconds for every 29.1 circular mils of conductor (I^2t) for **bare EGC**
- Limitations on where uninsulated conductors are permitted without compromising the system

Conductor Withstand Ratings- Bolted Connections

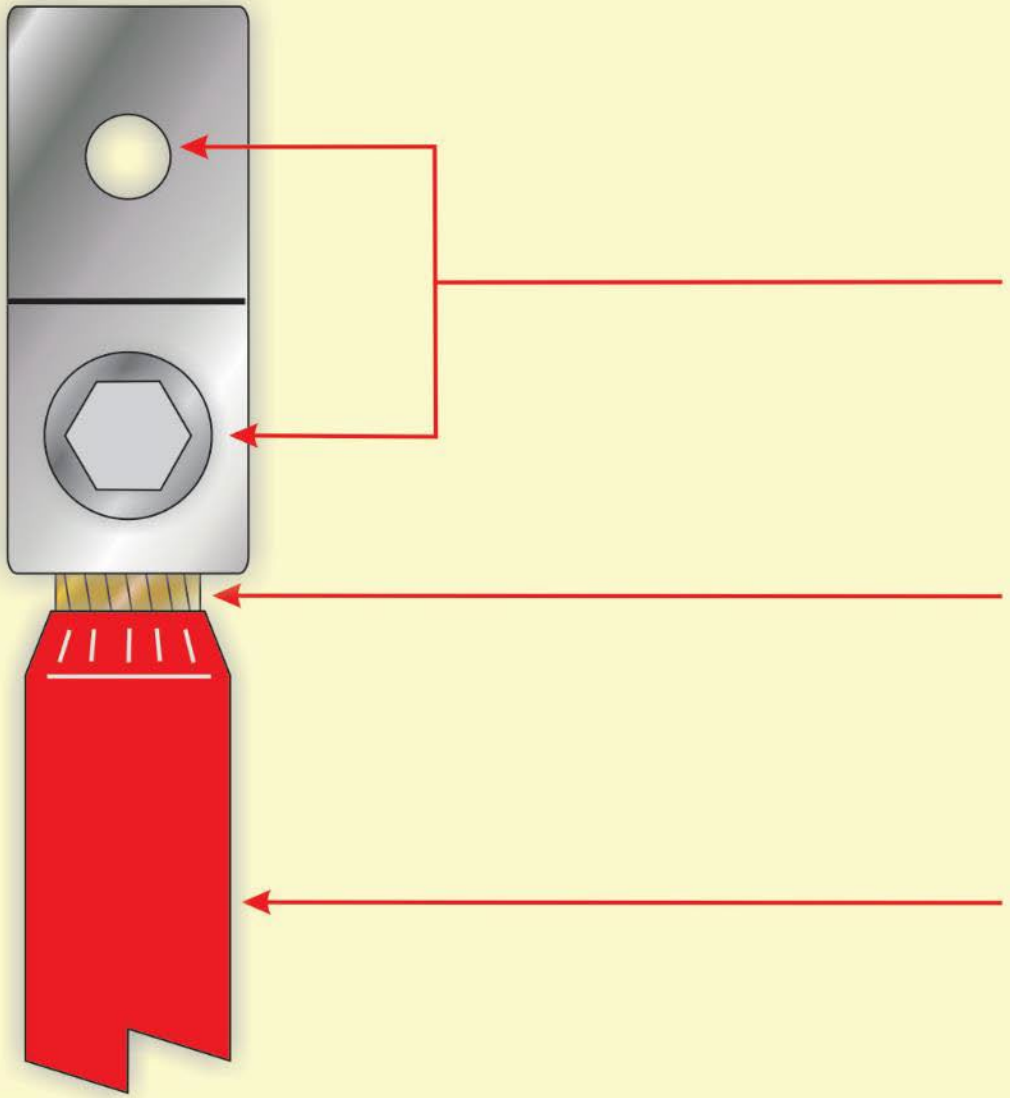
- The Insulated Cable Engineers Association (ICEA) has demonstrated that an insulated copper conductor with a **bolted connection** can safely carry **1 ampere** for every **42.25 circular mils** for **five seconds** without destroying its validity
- This is the I^2t *(amperes x amperes x time)* value for the conductor
- For an insulated copper conductor, the clearing time and short-circuit amperes must be limited to:

1 ampere…for every five seconds…for every 42.25 circular mils

Conductor Withstand Ratings- Bolted Connections *(cont.)*

- Copper conductor with bolted connections may safely carry 1 ampere for every 42.25 circular mil area of conductor for five seconds
- Using this formula, minimum size of equipment grounding conductor *(which may be larger than Table 250.122)* can be calculated

Wire, Insulation and Connection Withstand Ratings



Bolted connection five-second withstand rating
See Column 7, Table 5.4
[Soares textbook]

Copper conductor five-second melting rating
See Column 8, Table 5.4
[Soares textbook]

Conductor insulation five-second withstand rating
See Column 4, Table 5.4
[Soares textbook]

Copyright © IAEI 2020

Short-Circuit Current Withstand Chart

- Generally, where current-limiting overcurrent devices are protecting the circuit, the equipment grounding conductor sizes are determined directly from Table 250.122

- Where available fault currents are high and the overcurrent protective device takes longer than 0.25 cycle to clear the fault, it is suggested that the equipment grounding conductor be sized per the Insulated Cable Engineers Association (ICEA) chart on the next slide, to be on the safe side

Conductor Short-Circuit Withstand Chart

Basic conductor withstand formulas

- One ampere for five seconds for every 42.25 cm (16.63 in.) of *insulated* copper conductor
- One ampere for five seconds for every 29.1 cm (11.45 in.) of *bare* copper conductor

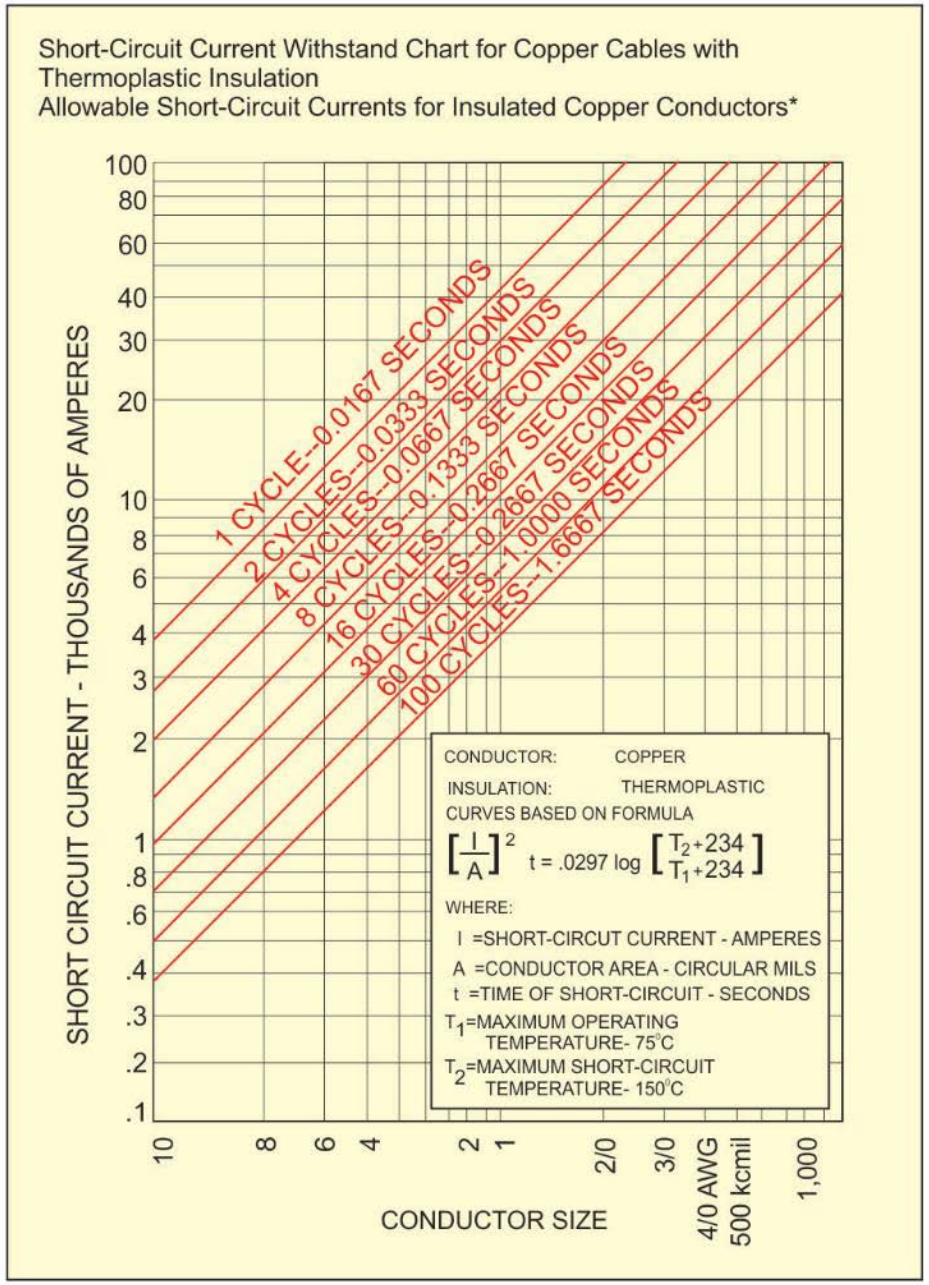


Chart Courtesy of Insulated Cable Engineers Association

Copyright © IAEI 2020

Example:

- 8 AWG conductor has a cross-sectional area of **16,510 circular mils** based on the values in Table 8, Chapter 9 of the *NEC*
- By dividing the circular mil area of the conductor given in Table 8 by the value **42.25**, the 5-second withstand rating for the 8 AWG conductor can be calculated:

$$\frac{16{,}510}{42.25} = 391 \text{ amperes}$$

Examples:

- **Example 1:**
  - How many amperes will the **8 AWG copper conductor** be able to safely carry if the impedance of the circuit along with the operating characteristics of the overcurrent device protecting the circuit results in a **2-cycle (0.0333 seconds)** opening time?
- **Example 2:**
  - How many amperes will the **8 AWG copper conductor** be able to safely carry if the impedance of the circuit along with the operating characteristics of the overcurrent device protecting the circuit results in a **¼ cycle (0.0042)** opening time?
- See next slide

Example 1 - 2 Cycles (0.0333 seconds)

I^2t = 764,405 ampere squared seconds

(591 x 591 x 5 seconds = 764,405)

$$I^2 = \frac{764,405}{t}$$

$$I = \sqrt{\frac{764,405}{0.0333}}$$

I = 4,791 amperes

The 8 AWG copper conductor could carry 4,791 amperes for 2 cycles

Quicker clearing times allow for higher conductor withstand rating

Example 2 - ¼ Cycles (0.0042 seconds)

I^2t = 764,405 ampere squared seconds

(591 x 591 x 5 seconds = 764,405)

$$I^2 = \frac{764,405}{t}$$

$$I = \sqrt{\frac{764,405}{0.0042}}$$

I = 13,491 amperes

The 8 AWG copper conductor could carry 13,491 amperes for a ¼ cycle

Quicker clearing times allow for higher conductor withstand rating

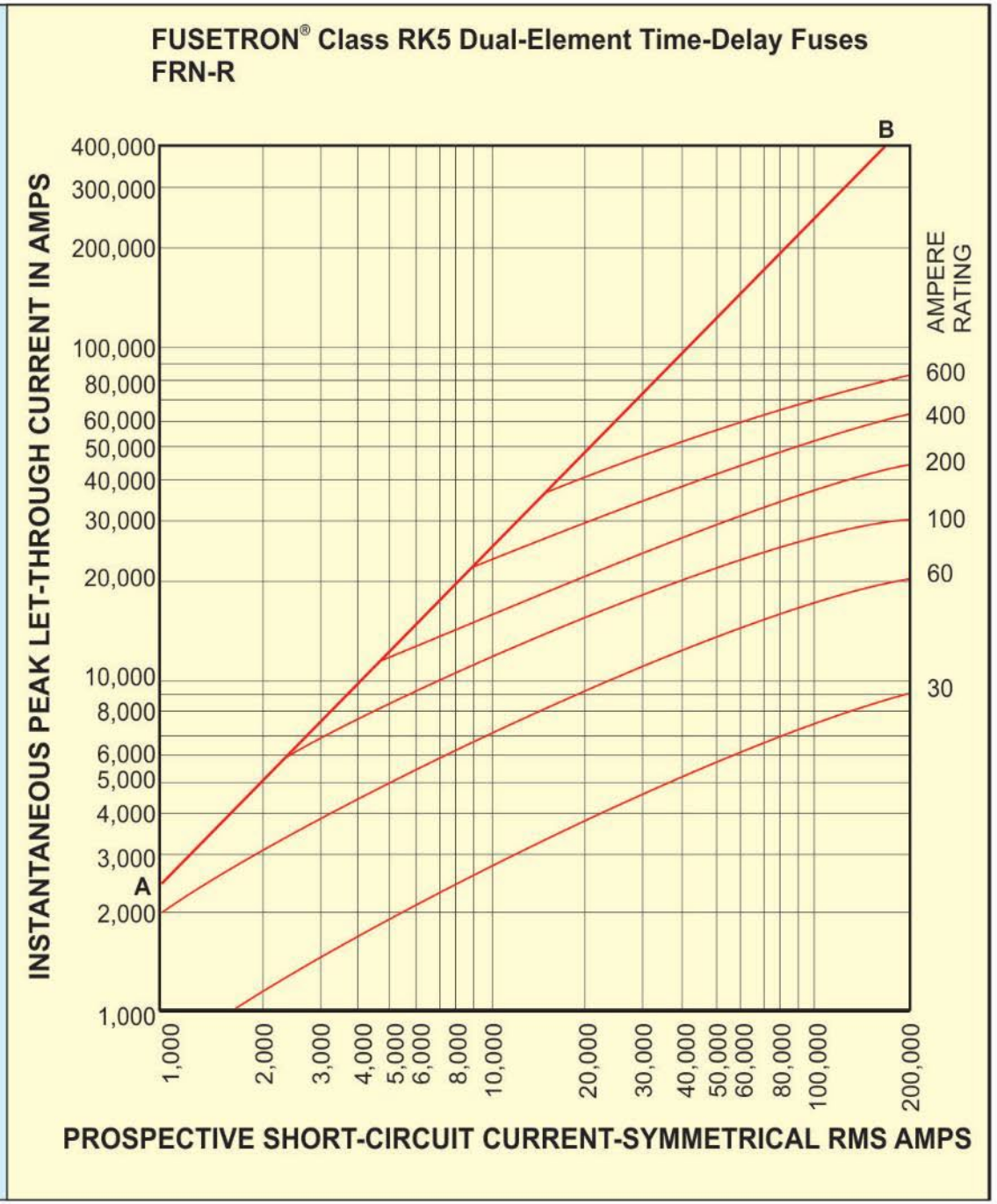
Copyright © IAEI 2020

Conductor Withstand Ratings *(cont.)*

- The follow tables provide information to assist the installer in the proper selection of equipment grounding conductors
- Among other information, it includes:
  - Safe values for 75°C thermoplastic insulated conductors,
  - Safe values for bolted connections,
  - Unsafe (melting) values for the copper conductor itself

Fuse Let-Through Chart

Courtesy of Cooper Bussmann



Copyright © IAEI 2020

Copper 75° C. Thermoplastic Insulated Conductors, Bare Conductors, Bolted Connection Five Second Withstand Rating in Amperes and Melting of Copper Wire

1 Wire Size	2 Area in circular mils	3 Area in square mm	4 ICEA Amperes	5 IEC Amperes	6 IEE Amperes	7 Bolted Connection 250° C. Amperes	8 Melting of Conductor 1,083° C. Amperes
14	4,110	2.080	97	107	107	141	254
12	6,530	3.310	155	170	170	224	403
10	10,380	5.261	246	271	271	357	641
8	16,510	8.367	391	430	430	567	1,020
6	26,240	13.300	621	684	684	902	1,621
4	41,740	21.150	988	1,088	1,088	1,435	2,578
3	52,620	26.670	1,245	1,372	1,372	1,808	3,251
2	66,360	33.620	1,571	1,729	1,729	2,281	4,099
1	83 690	42.410	1,981	2,181	2,181	2,876	5,170
1/0	105 600	53.490	2,499	2,751	2,751	3 629	6,523
2/0	133,100	67.430	3,150	3,468	3,468	4,574	8,222
3/0	167,800	85.010	3,972	4,372	4,372	5,767	10,366

Column 4 - Insulated Cable Engineers Association publication P32-382. One ampere for five seconds for every 42.25 circular mils of conductor area.
Column 5 - International Electrotechnical Commission publication 364-4-43.
Column 6 - Institute of Electrical Engineers publication 434-6.
Column 7 - Electrical Engineers Handbook *(75° C ambient)*. One ampere for five seconds for every 29.1 circular mils of conductor area.
Column 8 - Electrical Engineers Handbook *(75° C ambient)*. One ampere for five seconds for every 16.19 circular mils of conductor area.

Courtesy of the ICEA

Copyright © IAEI 2020

Copper 75° C. Thermoplastic Insulated Conductors, Bare Conductors, Bolted Connection Five Second Withstand Rating in Amperes and Melting of Copper Wire

1 Wire Size	2 Area in circular mils	3 Area in square mm	4 ICEA Amperes	5 IEC Amperes	6 IEE Amperes	7 Bolted Connection 250° C. Amperes	8 Melting of Conductor 1,083° C. Amperes
4/0	211,600	107.200	5,009	5,513	5,513	7,272	13,071
250	250,000	126.700	5,918	6,516	6,516	8,592	15,443
300	300,000	152.000	7,101	7,818	7,818	10,310	18,532
350	350,000	177.300	8,285	9,119	9,119	12,029	21,621
400	400,000	202.700	9,467	10,425	10,425	13,747	24,709
500	500,000	253.300	11,834	13,027	13,027	17,184	30,887
600	600,000	304.000	14,201	15,636	15,636	20,621	37,064
700	700,000	354.700	16,568	18,243	18,243	24,057	43,241
750	750,000	380.000	17,752	19,544	19,544	25,776	46,330
800	800,000	405.400	18,935	20,850	20,850	27,494	49,419
900	900,000	456.000	21,302	23,453	23,453	30,931	55,596
1,000	1,000,000	506.700	23,669	26,060	26,060	34,368	61,773

Column 4 - Insulated Cable Engineers Association publication P32-382. One ampere for five seconds for every 42.25 circular mils of conductor area.
Column 5 - International Electrotechnical Commission publication 364-4-43.
Column 6 - Institute of Electrical Engineers publication 434-6.
Column 7 - Electrical Engineers Handbook *(75° C ambient)*. One ampere for five seconds for every 29.1 circular mils of conductor area.
Column 8 - Electrical Engineers Handbook *(75° C ambient)*. One ampere for five seconds for every 16.19 circular mils of conductor area.

Courtesy of the ICEA

Copyright © IAEI 2020

CHAPTER SIX

GROUND-FAULT PROTECTION

Ground-Faults and Short Circuits

- Considering the total number of faults *(short circuit and ground-faults)* that occur in power systems, **ground-fault by far outnumber short circuits**
- The ratio is approximately **90 percent** of all faults are or start as **ground faults** and the remainder are or start as short circuits
- It should be noted that either one of these can be the result of an overload condition that is not cleared before insulation damage occurs
- With the more common use of elevated voltages, such as 480/277 volts, in power distribution systems ground-faults *(particularly arcing type ground faults)* became even more destructive
- The realization of shock hazards and the means to use ground-fault circuit interrupters (GFCI) was introduced to provide a higher level of protection from this hazard

Article 100 Definitions

- ***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.
  - **Informational Note:** A current in excess of rating may be accommodated by certain equipment and conductors for a given set of conditions. Therefore, the rules for overcurrent protection are specific for particular situations.
- ***Overload:*** Operation of equipment in excess of normal, full-load rating, or of a conductor in excess of rated ampacity that, when it persists for a sufficient length of time, would cause damage or dangerous overheating. A fault, such as a short circuit or ground fault, is not an overload.

Article 100 Definitions *(cont.)*

- ***Ground Fault:*** An unintentional, electrically conductive connection between an ungrounded conductor of an electrical circuit and the normally non-current-carrying conductors, metallic enclosures, metallic raceways, metallic equipment, or earth.
- ***Short Circuit:*** An abnormal connection (including an arc) of relatively low impedance, whether made accidentally or intentionally, between two points of different potential. Note: The term fault or short-circuit fault is used to describe a short circuit. *(IEEE 100-1992, The New IEEE Standard Dictionary of Electrical and Electronic Terms, 5th Edition)*

Article 100 Definitions *(cont.)*

- ***Ground-Fault Circuit Interrupter (GFCI):*** A device intended for the protection of personnel that functions to de-energize a circuit or portion thereof within an established period of time when a current to ground exceeds the values established for a Class A device.
- An Informational Note to this definition includes a specific description of a Class A GFCI device. The information indicates that the Class A device operates when the current to ground has a value in the range of **4 to 6 mA**
- More information is available in UL 943, *The Standard for Ground-Fault Circuit Interrupters*

Article 100 Definitions *(cont.)*

- ***Ground-Fault Protection of Equipment:*** A system intended to provide protection of equipment from damaging line-to-ground fault currents by operating to cause a disconnecting means to open all ungrounded conductors of the faulted circuit. This protection is provided at current levels less than those required to protect conductors from damage through the operation of a supply circuit overcurrent device.

Ground-Fault Protective Devices

- Ground faults happen due to a failure in the insulation system *(either accidental or intentional)* that provides a path for current to pass on or though:
  - Normally non-current-carrying conductors
  - Raceways
  - Enclosures
  - Other parts
- Devices covered in this chapter are specifically designed, or have an element in the design, specifically for protection from ground-fault conditions

Ground-Fault Protective Devices *(cont.)*

- These devices will include:
  - Ground-fault circuit interrupters (GFCI)
  - Equipment ground-fault protective devices (EGFPD)
  - Arc-fault circuit interrupters (AFCI)
  - Ground-fault protection for equipment (GFPE)
- The next slide provides a quick visual of these devices and what they are intended to protect

Table 6.1 Ground-Fault Protection Devices

Protection	GFCI	EGFPD	AFCI	GFPE
Typical trip levels	4-6 (1) (3) milliamps	20-50 milliamps	40-70 (2) milliamps	1 to 1200 amperes
Protect personnel from electric shock	Primary	Minimal	None	None
Protect equipment from arcing fault and or fire	Secondary	Primary	Primary	Primary

(1) *Class A GFCI protection*

(2) *Where ground-fault component is provided in AFCI device*

(3) *Special Purpose GFCI for circuits over 150 volts to ground and with EGC monitoring having 15 to 20 mA trip levels*

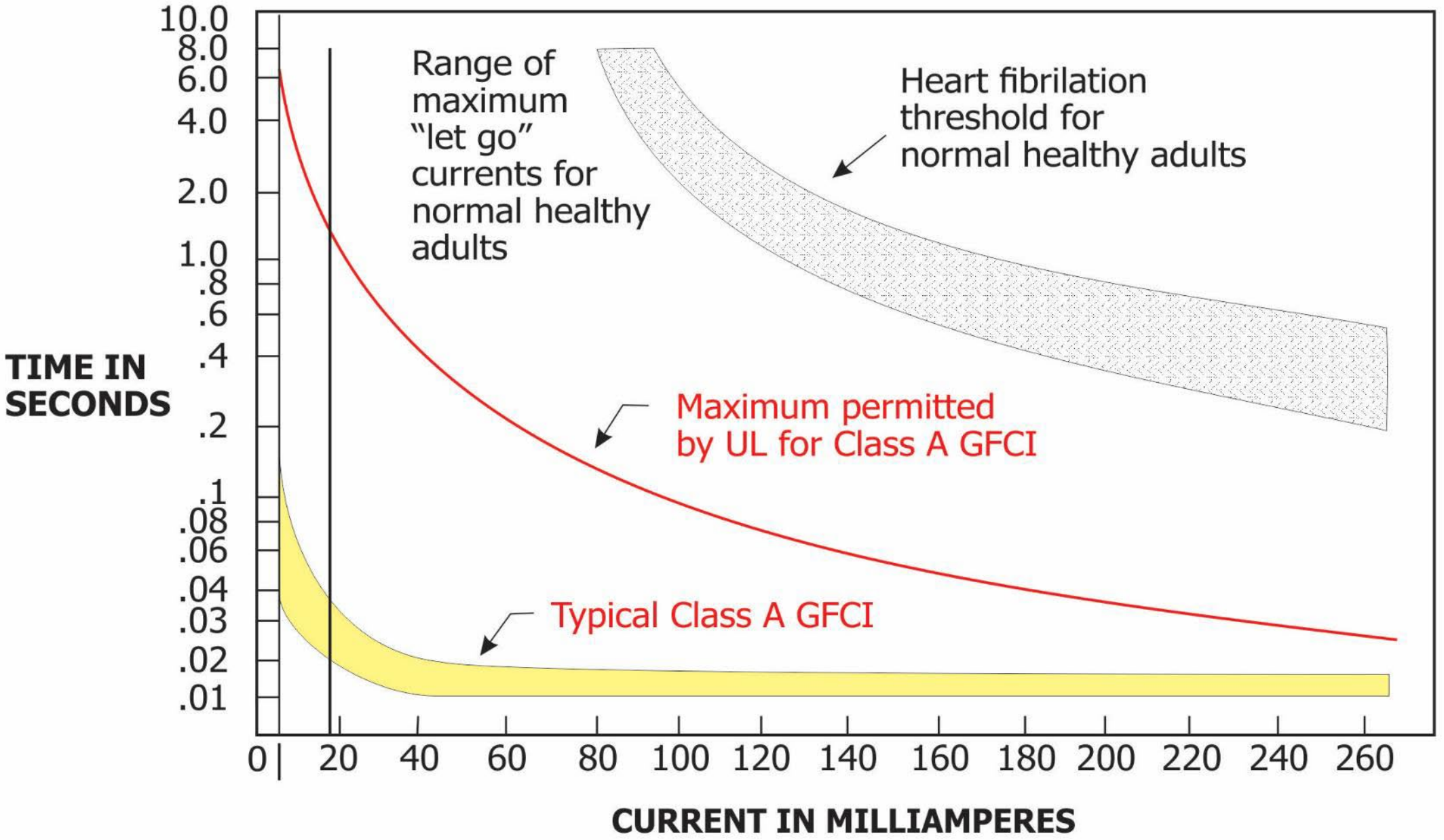
GFCI - Ground-fault circuit-interrupter
EGFPD - Equipment ground-fault protective device
AFCI - Arc-fault current-interrupter
GFPE - Ground-fault protection for equipment

Copyright © IAEI 2020

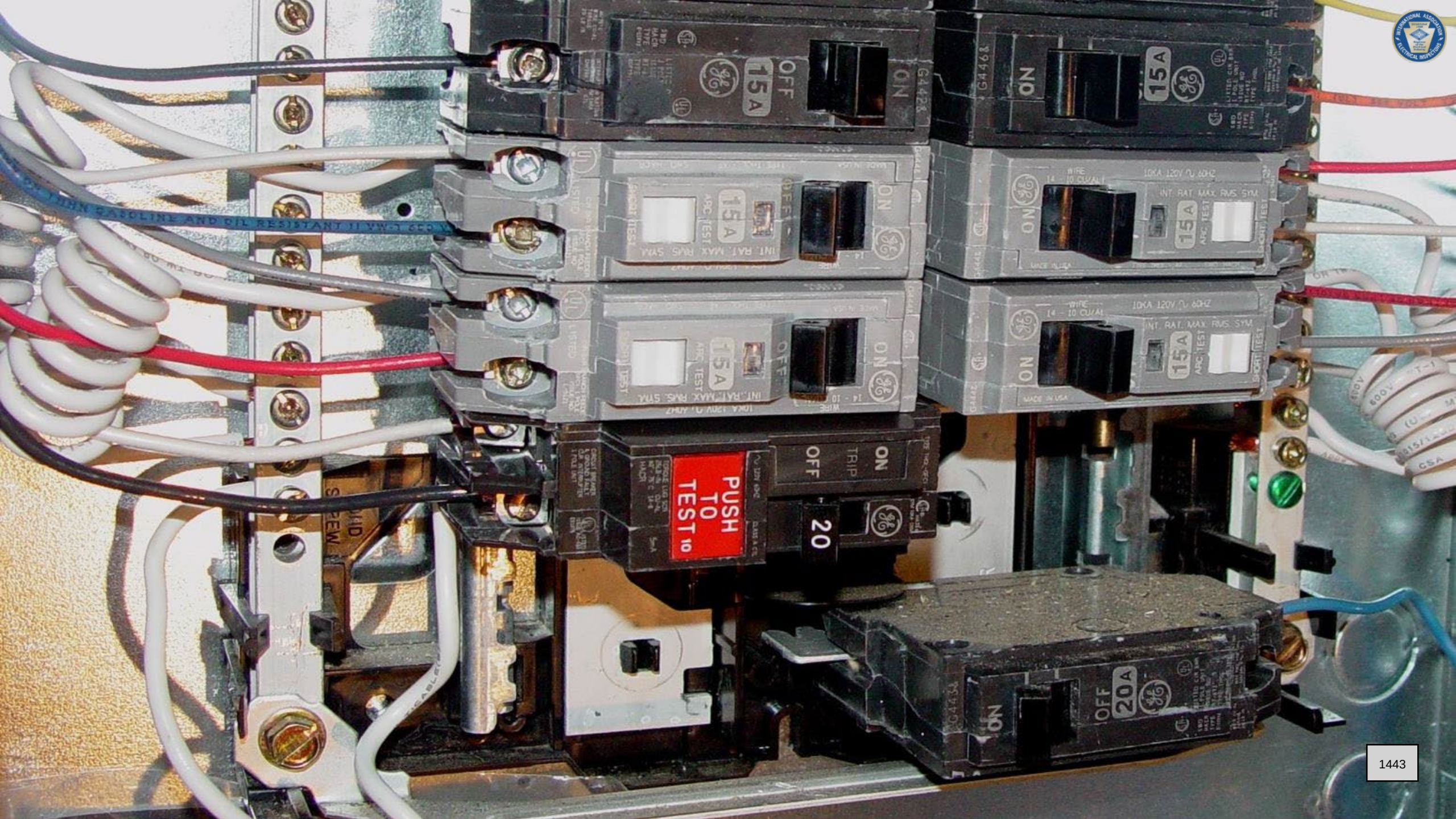
GFCI Tripping Characteristics

- The Underwriters Laboratories (UL) requirement for Class A ground-fault circuit interrupters (GFCIs) is that tripping shall occur when the continuous 60-hertz differential current exceeds **6 mA**
- Tripping shall not occur at less than **4 milliamperes** (5 mA ± 1 mA)
- The next slide shows trip currents for GFCI devices (Class A)

GFCI Tripping Characteristics Graph



Copyright © IAEI 2020


OFF
15 A
ON
15 A
15 A
15 A
PUSH
TO
TEST
OFF
TRIP
ON
20
OFF
20A
ON

GFCI "Let-Go" Thresholds

- ***"Let-go current"*** is defined as the maximum current at which a person is able to release a conductor by commanding those muscles directly stimulated by the shock
- Currents over the let-go levels typically freeze the victim to the circuit
- Primary function of GFCI is to protect persons from hazards relating to shock
- GFCI device is set to provide a level of protection from serious injury to a healthy person where the shock path is through unbroken outer (epidermis) skin
- Class A ground-fault circuit interrupters (GFCIs) are designed so that tripping shall occur when the continuous 60-hertz differential current exceeds **6 mA**, but it shall not occur at less than **4 milliamperes**

Table 6.2 "Let-Go" Thresholds

Percentage of the Population Estimated to be Protected Against Inability to "Let-Go" Thresholds for Several Levels of Shock Current

Level of Shock Currents	6 mA *(rms)*	10 mA *(rms)*	20 mA *(rms)*	30 mA *(rms)*
Men	100%	98.5%	7.5%	0%
Women	99.5%	60%	0%	0%
Children*	92.5%	7.5%	0%	0%

* *Half of the "let-go" threshold for men*

Copyright © IAEI 2020

Implied Safe Voltages

- Several prepared papers have been published on the dangers of electric shock hazards
- C. F. Dalziel's paper, titled "**Electric Shock Hazard**," published in the Institute of Electrical and Electronics Engineers (IEEE) *Spectrum*, Vol. 9, February 1972, summarizes the studies **estimating shock currents** based on effective impedance of the body under various conditions
- According to V. G. Biegelmeier, the onset of fibrillation in a **50-kilogram (110-pound) adult** occurs within the range of **50 mA to 200 mA** when the duration of the shock exceeds **two seconds**
- The following table shows implied safe voltages based on these values

Table 6.3 Implied Safe Voltages

Implied Safe Voltage[4] Based on Several Published Values of Body Resistance and Selected Body Current Safety Criteria as Published by Dalzel

Criterion Ohms	Body Resistance			
	300	500	1500	3000
"Let-go" 4.5 mA for children	1.35 V	2.25 V	6.75 V	13.5 V
"Let-go" 9.0 mA for adult males	2.70 V	4.50 V	13.5 V	27.0 V
Fibrillation at 23 mA 5 sec.pulse of 60-Hz current for 40 lb. child	6.90 V	11.5 V	34.5 V	69.0 V
Fibrillation at 52 mA 5 sec. pulse of 60-Hz current for 110 lb. adult	15.6 V	26.0 V	78.0 V	156.0 V

[4] *According to V. G. Biegelmeier, the onset of fibrillation in a 50-kilogram (110-pound) adult occurs within the range of 50 mA to 200 mA when the duration of the shock exceeds two seconds.*

Copyright © IAEI 2020

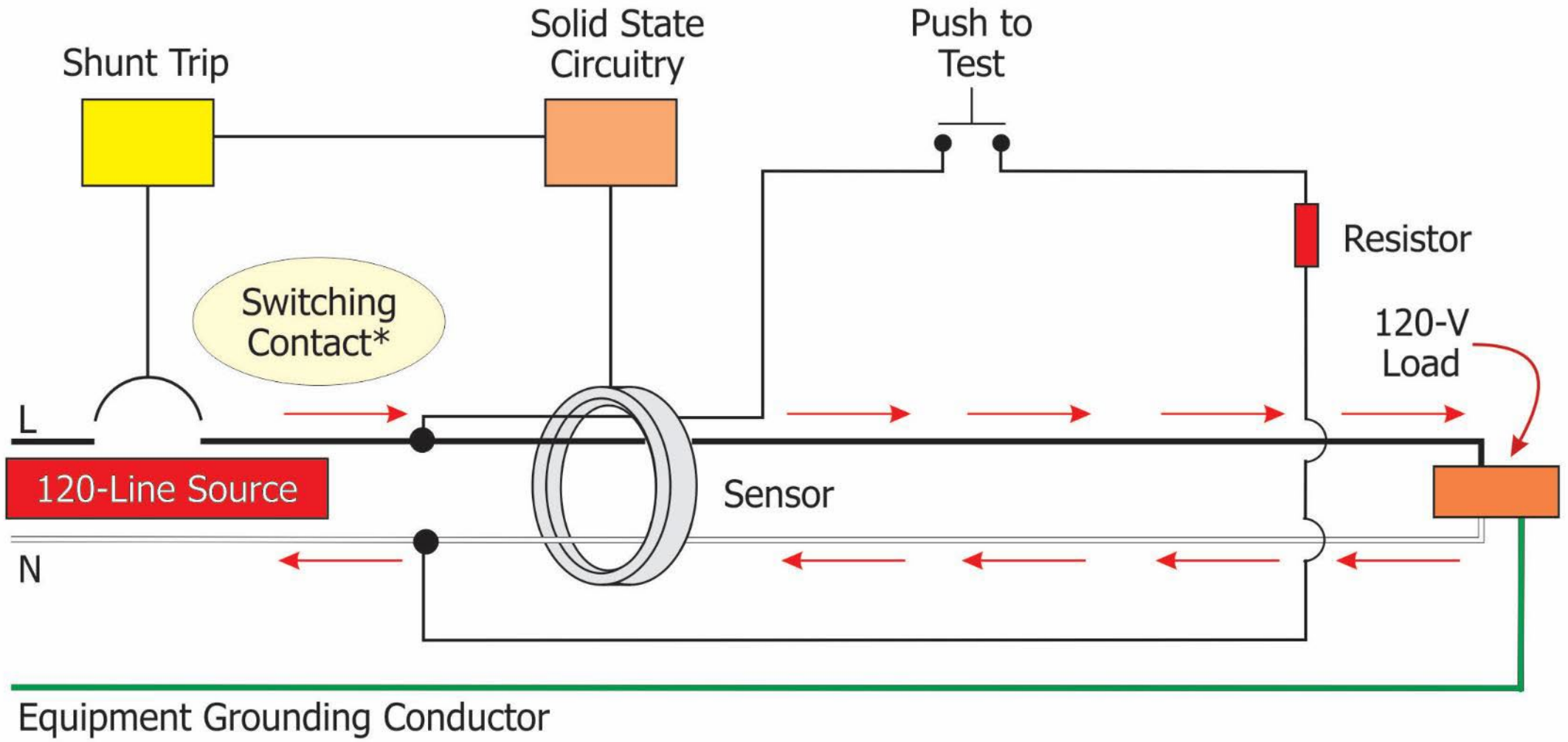
GFCI Principles of Operation

- GFCI sensing system continuously monitors the **current balance** in the ungrounded *(hot)* conductor and the grounded *(neutral)* conductor
- If the current in the grounded conductor becomes less than the current in the ungrounded conductor, a ground fault would exist *(loss of current)*
- When this occurs, a portion of the current returns to the supply source by some path other than the grounded conductor
- With a current imbalance as low as **4-6 mA**, GFCI device will interrupt the circuit

GFCI Principles of Operation *(cont.)*

- Equipment grounding conductor is not needed for a GFCI to function properly
- GFCI provides a significant advancement in safety for both equipment that is grounded by an EGC as well as for equipment that is ungrounded
- GFCI detects an **imbalance of current** in both the supply and return paths, therefore protects equipment supplied by both a 2-wire circuit and a 2-wire circuit with ground circuit
- Next slide shows basic **principles of operation** of a GFCI device

Ground-Fault Circuit-Interrupter *(GFCI)* Principles of Operation



*Receptacle-type GFCI devices switch both the phase conductor and grounded conductor

Copyright © IAEI 2020

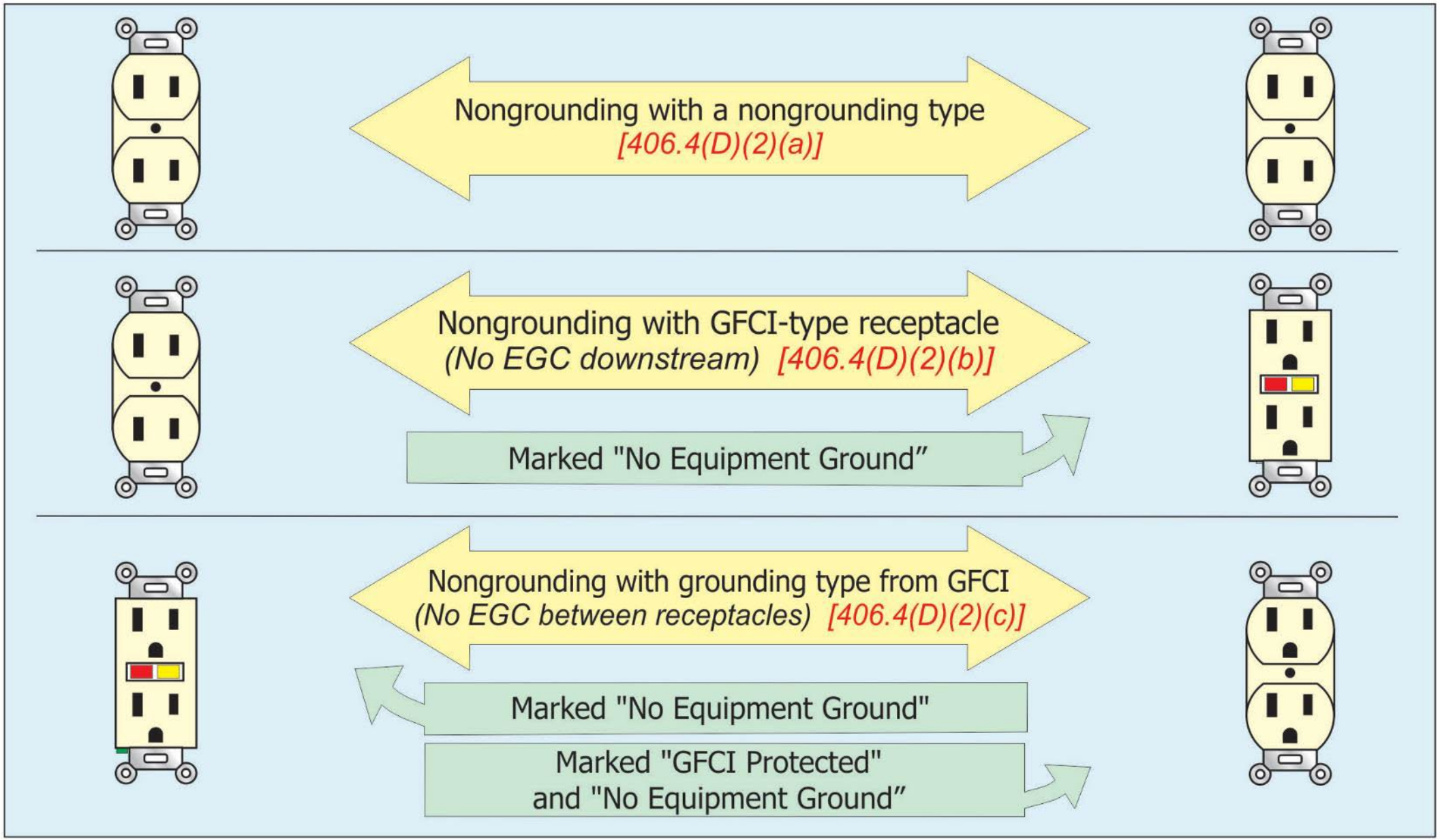
Ground Fault Circuit Interrupters - Special Purpose

- With the changes made in recent editions of the *NEC*, GFCI for personal protection is being required where the voltage to ground is **above 150 volts but less than 300 volts**
- These GFCIs trip when the current to ground has a value in the range of **15 through 20 mA**
- These GFCIs rely upon equipment grounding for let-go protection
- The key factors in the application of the special purpose GFCIs is that an **equipment grounding conductor** is required to help mitigate the voltage that a person coming in contact with the fault equipment will experience and will allow that person to **"let go"**
- Equipment grounding can be achieved by a **monitoring system** within the GFCI protective device or a more robust insulation (double insulation) as provided in the *NEC*

GFCI Required for Replacement Receptacles

- *NEC* **406.4(D)** sets the requirements for replacement receptacles such as where a 2-wire system was installed and non-grounding-type receptacles had been previously installed
- Several options for replacement receptacles *[see 406.4(D)]*
  1. Replace with a **grounding-type receptacle** where an equipment grounding conductor exists in the enclosure or an equipment grounding conductor is installed in accordance with 250.130(C) *[406.4(D)(1)]*
  2. Replace with a **non-grounding-type receptacle** *[406.4(D)(2)(a)]*
  3. Replace with a **GFCI-type receptacle** and mark it with ***"No Equipment Ground"*** *[406.4(D)(2)(b)]*
  4. Replace with a **grounding-type receptacle** where the circuit is protected up stream by a **GFCI device** and marked with both, ***"No Equipment Ground"*** and ***"GFCI Protected"*** *[406.4(D)(2)(c)]*

Replacement of Non-Grounding-Type Receptacles



Copyright © IAEI 2020

Equipment Ground-Fault Protective Device (EGFPD)

- Equipment ground-fault protective devices (EGFPD) are very similar in construction and operation as Class A GFCI devices with the main difference being the trip level
- The ground-fault pick-up level is limited to the range above **6 mA to 50 mA** by the listing of the device and typically has ground-fault trip levels of **20 or 30 mA**
- Primary function is to protect equipment *(not personnel)*
- Select the specific EGFPD for the voltage, full load current and the trip level
- Intended to operate upon a condition of excessive ground-fault leakage current from equipment, rather than minimize damage due to arcing faults in services

Equipment Ground-Fault Protective Device (EGFPD) *(cont.)*

- EGFPDs are intended to be installed only on grounded alternating-current systems in accordance with the *NEC*
- Required by 426.28 *(Fixed Outdoor Electric Deicing and Snow-Melting Equipment)* and 427.22 *(Fixed Electric Heating Equipment for Pipelines and Vessels)*
- These devices also have found wide usage in industrial process equipment

Molded Case Circuit Breaker with Equipment GFP



Type GHBGFEP bolt-on panelboard 30 mA industrial ground-fault circuit protector



Type GHCGFEP cable-in/ cable-out 30 mA industrial ground-fault circuit protector

Courtesy of Eaton Corporation

Copyright © IAEI 2020

3-Phase Molded Case Circuit Breaker with Class A GFCI



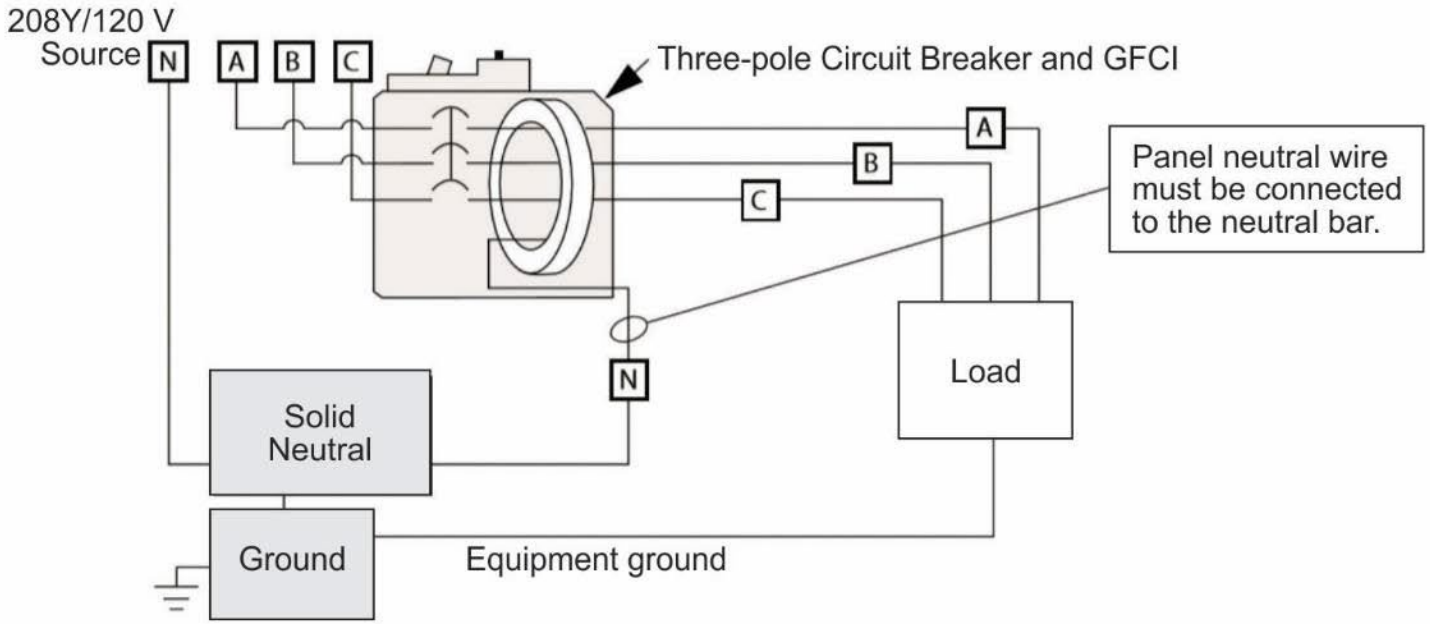


Photo and Diagram Courtesy of Schneider Electric

Three-Pole QO™/QOB Plug-in Circuit Breaker and Ground Fault Circuit Interrupter (GFCI) (4 to 6 mA) 50 A, 3P, 208Y/120 V, 10 kA

Copyright © IAEI 2020


SWITCHBOARD MSA
480Y/277V 3PH-4W 60HZ
4000 AMPERES
QED
POWER STYLE®
SWITCHBOARD
ENCLOSURE TYPE
SQUARE D
SHORT-CIRCUIT CURRENT RATING
DANGER
HAZARD OF ELECTRIC SHOCK, BURN OR EXPLOSION
This equipment must be installed and serviced only by qualified electrical personnel.
Turn off all power supplying this equipment before working on or inside equipment.
Always use a properly rated voltage sensing device to confirm power is off.
Replace all devices, doors, and covers before turning on power to this equipment.
Failure to follow these instructions will result in death or serious injury.
SERVICE DISCONNECT
This section contains the:
NEUTRAL DISCONNECT LINK
MAIN BONDING JUMPER
GROUNDING ELECTRODE CONDUCTOR TERMINAL
MASTERPACT
Push to Open
Push to close
SQUARE D
DANGER
HAZARD OF ELECTRIC SHOCK, BURN OR EXPLOSION
This disconnect(s) does not turn off control power and instrument circuits.
Turn off Control / Instrument Circuit Disconnect(s) before working on or inside this equipment.
Failure to follow these instructions will result in death or serious injury.
Ground fault control components are located behind this cover.
CAUTION
1458

Arc-Fault Circuit Interrupters (AFCI)

- Section 210.12 of the *NEC* sets the requirements for where AFCI is required to protect branch circuits in dwelling units
- AFCI technology is based on monitoring the voltage waveform and identifying spikes or other distortions that are signatures of an electrical arc occurring
- The term "**combination**" type for AFCI is **not for a combination of AFCI and GFCI** protection
- "Combination" provides **parallel** arcing protection *(hot to neutral, hot to EGC)* as well as the **series** arcing fault where a single current-carrying conductor *(hot or neutral)* has a poor connection or a break causing an arc to form to bridge that poor connection

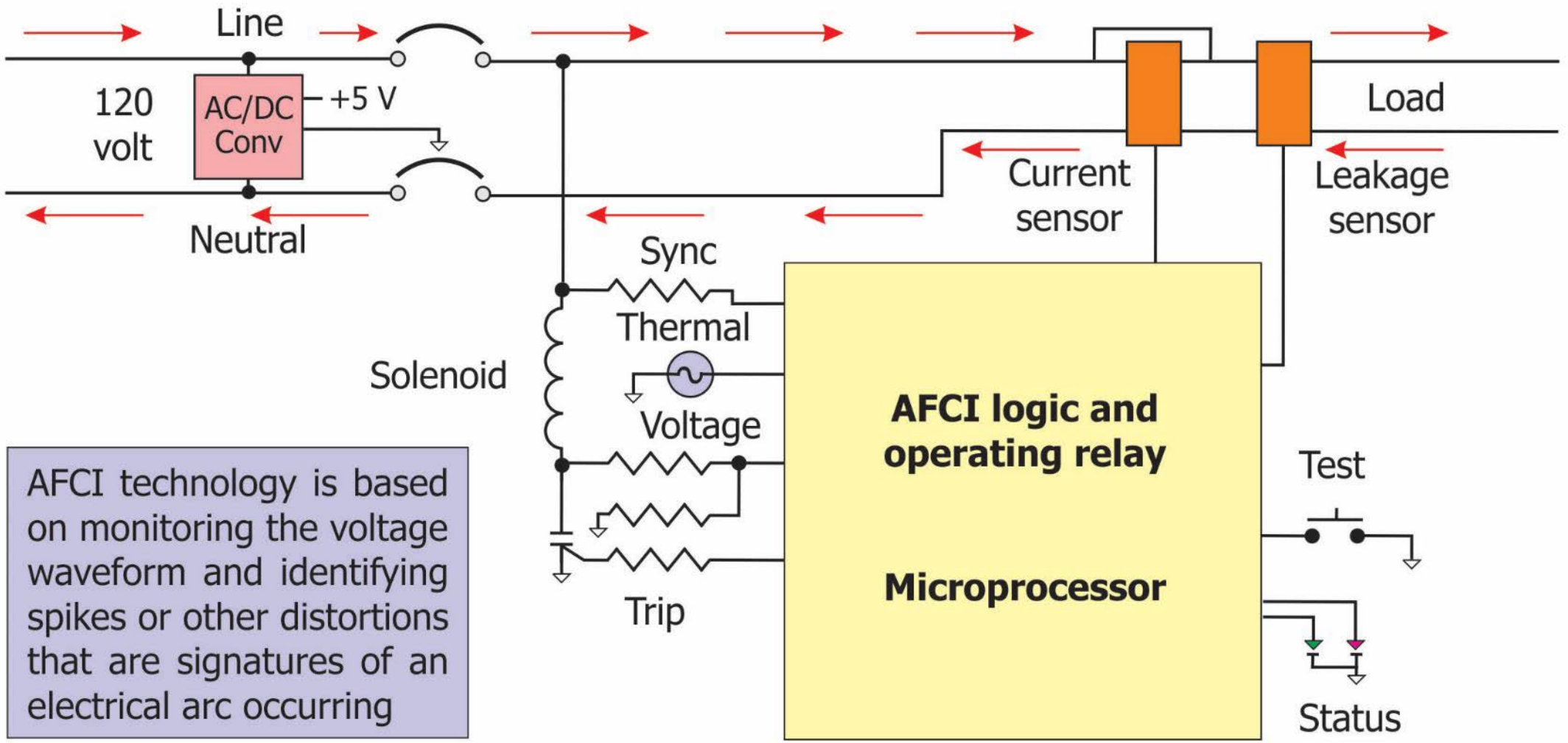
Arc-Fault Circuit Interrupters *(cont.)*

- GFCI protection and AFCI protection can be installed on the same branch circuits *(or same device)*
- There is **no incompatibility issues** between these devices due to the different technologies employed
- AFCI protection is now required to be installed in dwelling unit:

kitchens	family rooms	dining rooms
living rooms	parlors	libraries
dens	bedrooms	sunrooms
recreation rooms	closets	hallways
laundry areas	similar rooms or areas	

- Some of these areas also call for GFCI protection

Arc-Fault Circuit-Interrupter *(AFCI)* Principles of Operation



AFCI technology is based on monitoring the voltage waveform and identifying spikes or other distortions that are signatures of an electrical arc occurring

Copyright © IAEI 2020

Arc-Fault Circuit Interrupters *(cont.)*

- AFCI protection can be delivered in a variety of methods *(see next slide)*
- AFCI protection can be delivered in a "**Dual-Function**" device that provides both **Arc-Fault and Ground-Fault protection** in a single, easy-to-install device
- Combination *(**parallel** and **series** arcing protection)* AFCI protection can also be delivered in an **outlet branch circuit (OBC)** receptacle outlet device or an **overcurrent protection device (OCPD)** circuit breaker type

210.12(A) Arc-Fault Circuit-Interrupter Protection



Courtesy of Pass & Seymour/Legrand

Listed Outlet Branch-Circuit Type Dual Function AFCI-GFCI Device



Courtesy of Schneider Electric

Listed Dual Function AFCI-GFCI Circuit Breaker Device



Courtesy of Pass & Seymour/Legrand

Listed Outlet Branch-Circuit Type AFCI Device



Courtesy of Eaton Corporation

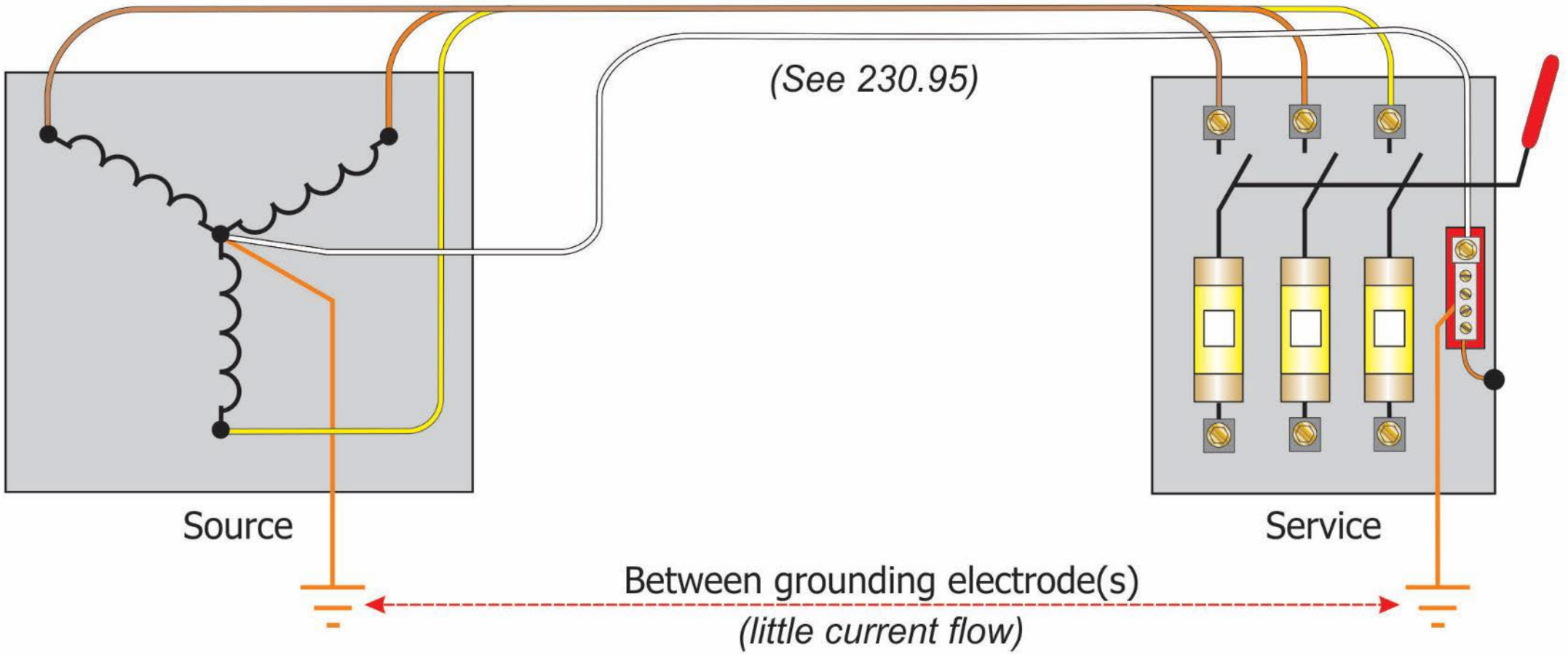
Listed Combination Type AFCI Circuit Breaker Device

Copyright © IAEI 2020

Ground-Fault Protection Required

- GFPE required by 230.95 for:
  - Solidly grounded systems more than 150 volts to ground, and not more than 600 volts phase-to-phase, for each service disconnect rated 1,000 amperes or more
  - There is a **mandatory exception** to this rule:
    - ***Exception No. 1:*** *GFPE shall not be required for a service disconnect for continuous industrial process where nonorderly shutdown would introduce additional or increased hazards.*
- *Note: 695.6(G) prohibits GFPE for fire pumps*

Ground-Fault Protection *(GFP)* for Equipment



Ground-fault protection for equipment required for the following:

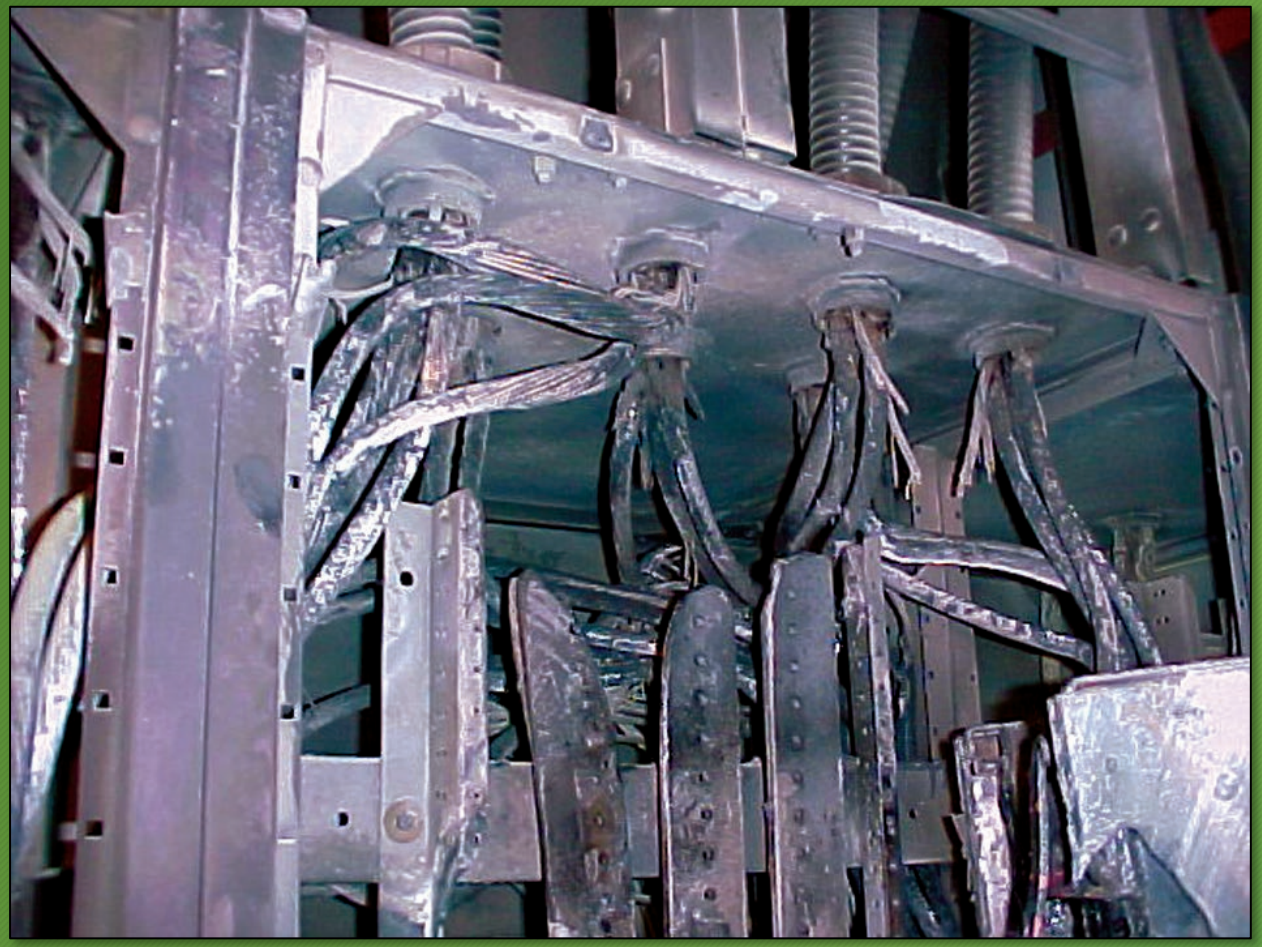
- Solidly grounded wye system over 150 volts to ground
- Not greater than 1000 volts from phase-to-phase
- Each service disconnect rated 1000 amperes or more

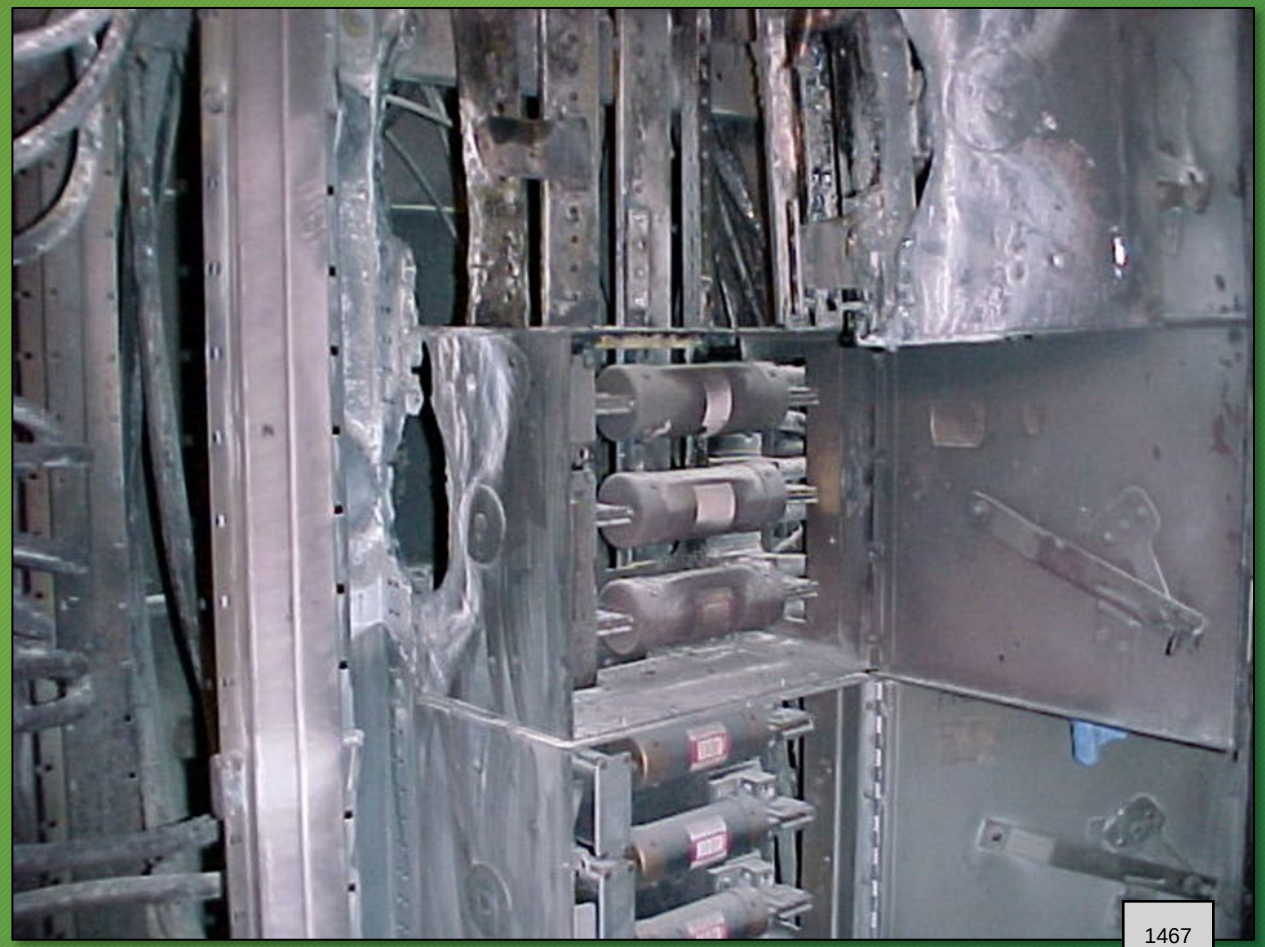
Copyright © IAEI 2020

Reason for Ground-Fault Protection of Equipment

- Provides protection against line-to-ground faults at levels below the normal overcurrent protection device ratings or settings
- The following photos *(next slide)* shows the destructive effects of line-to-ground faults in equipment
- Equipment was extensively damaged by a ground-fault event that at some point also became a phase-to-phase short circuit
- Equipment was supplied by a utility source delivering considerably high levels of short-circuit current *(approximately 42,000 amperes)*

Reason for Ground-Fault Protection of Equipment





Reason for Ground-Fault Protection of Equipment *(cont.)*

- This **2500-ampere 480Y/277-volt, 3-phase**, 4-wire switchboard had a remote main service fused disconnect switch rated **3000 amperes** with **2500 amperes current-limiting fuses**, **200,000 amperes interrupting rating**, installed
- Main fused switch had ground-fault protection installed, but due to a previous nuisance trip, the control power to the ground-fault protection system was **turned off**
- ground-fault event happened in the distribution switchboard when facility electricians were replacing a fuse that had opened for what appeared to be no apparent reason
- Ground fault quickly escalated into an arcing short-circuit fault and the combination of these two faults destroyed the equipment

Ground-Fault Protection Required *(cont.)*

- Similar requirements for **feeders** exist in Sections 215.10 and 240.13
- GFPE required where ground-fault protection is not provided on the main overcurrent device ahead of the feeder in the same system
- 210.13 requires GFPE where such protection is not provided ahead of the **branch circuit**
- GFPE protection is required for nominal 480Y/277 or 600Y/347-volt, three-phase, 4-wire wye connected systems where the circuit breaker or fused switch rating is 1000 amperes or more

Ground-Fault Protection System Types

- There are basically two types of equipment ground-fault protection systems in use
- One of them has two configurations, although these systems may have different names in the industry
- The most common types are known as **zero-sequence system** and an alternate configuration is called the **residual system**, which may have more than one form
- The other main type is the **neutral ground strap-type**, which is sometimes referred to as ground-strap, or ground-return type

Ground-Fault Protection System Types *(cont.)*

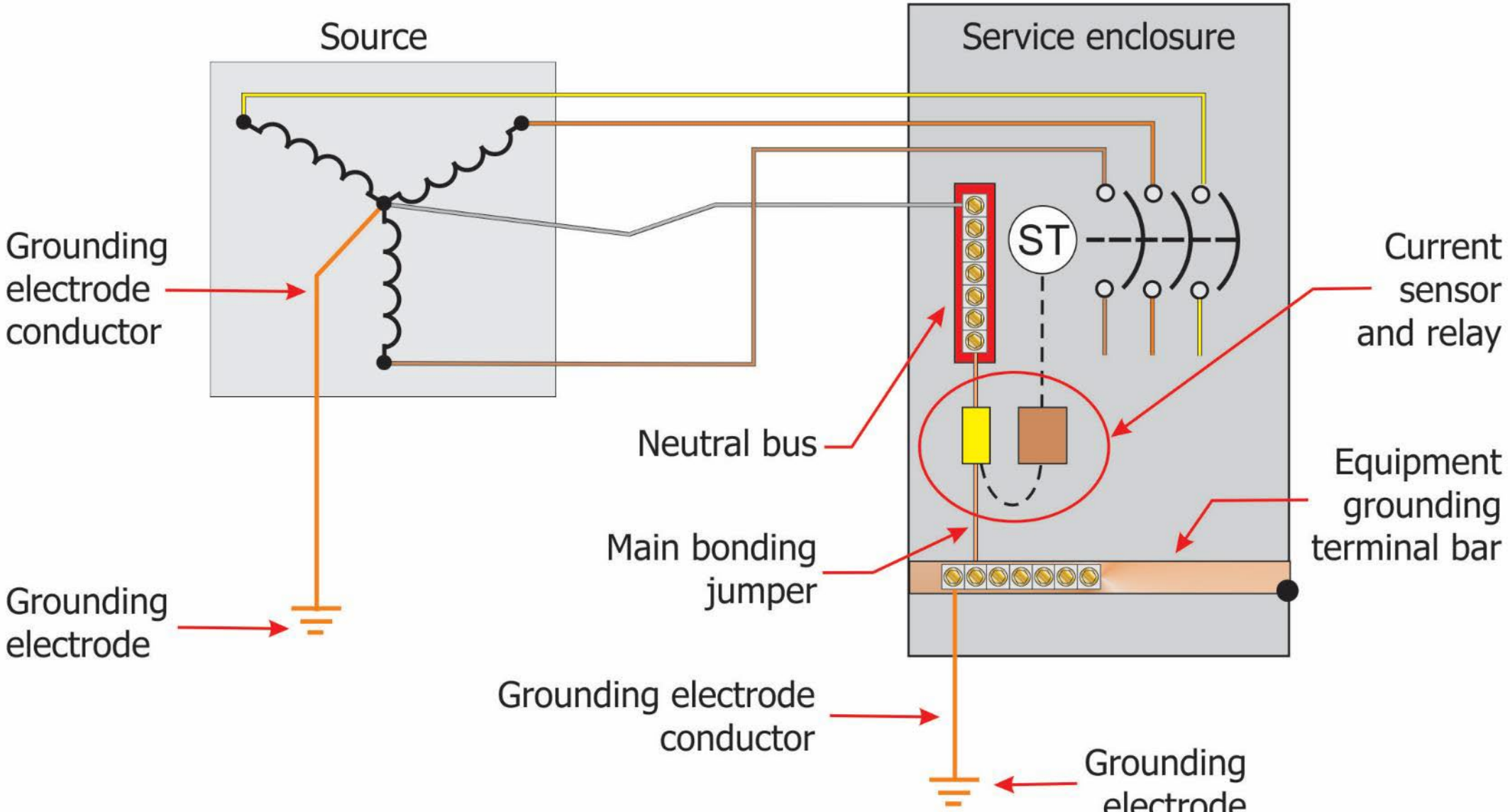
- All ground-fault protection systems are designed to protect equipment downstream of the ground-fault sensor from **destructive arcing burn downs**
- Note that these two types of equipment GFP will not protect equipment or the system on the **line side** of the sensor from line-to-ground faults
    - Fault current will not pass through the ground-fault sensing equipment

Ground-Fault Protection System Types *(cont.)*

- **Neutral Ground Strap-Type System:**
  - Consists of current sensor, control power source, ground-fault relay, and a circuit breaker or fused disconnect switch equipped with a shunt-trip
  - Unique design feature of this type system is that **main bonding jumper** *(or for a separately derived system the **system bonding jumper**)* passes through the **current sensor**
  - One advantage: least expensive
  - Big disadvantage: limited to application only at the main service or separately derived system supply source
  - Cannot be used for downstream protection of feeders since main bonding jumper *(service)* or system bonding jumper *(separately derived system)* are the only sensing path provided

Ground-Fault Protection for Equipment *(GFPE)*

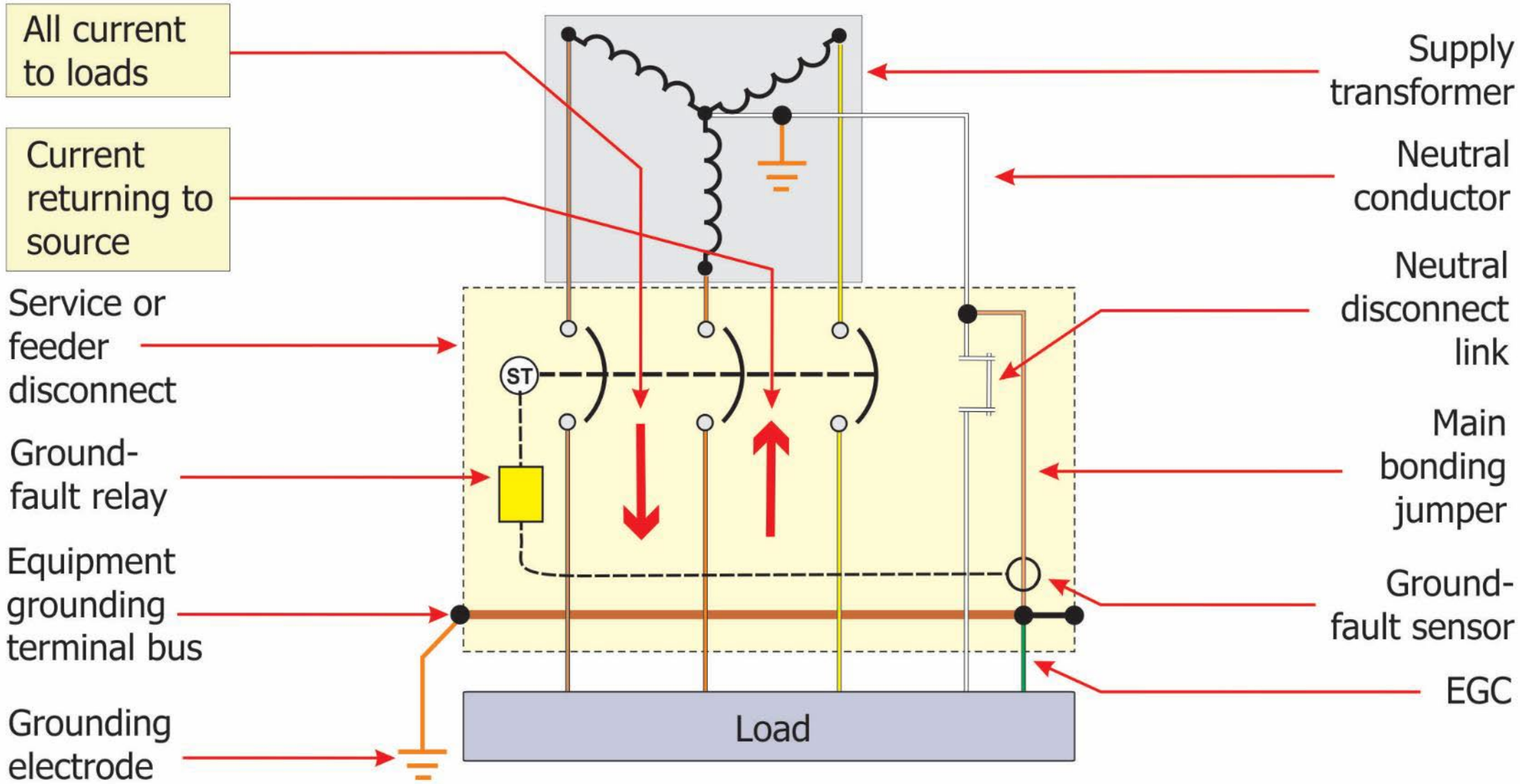
(Neutral Ground Strap Type)



Copyright © IAEI 2020

Neutral Ground Strap - Normal Operation

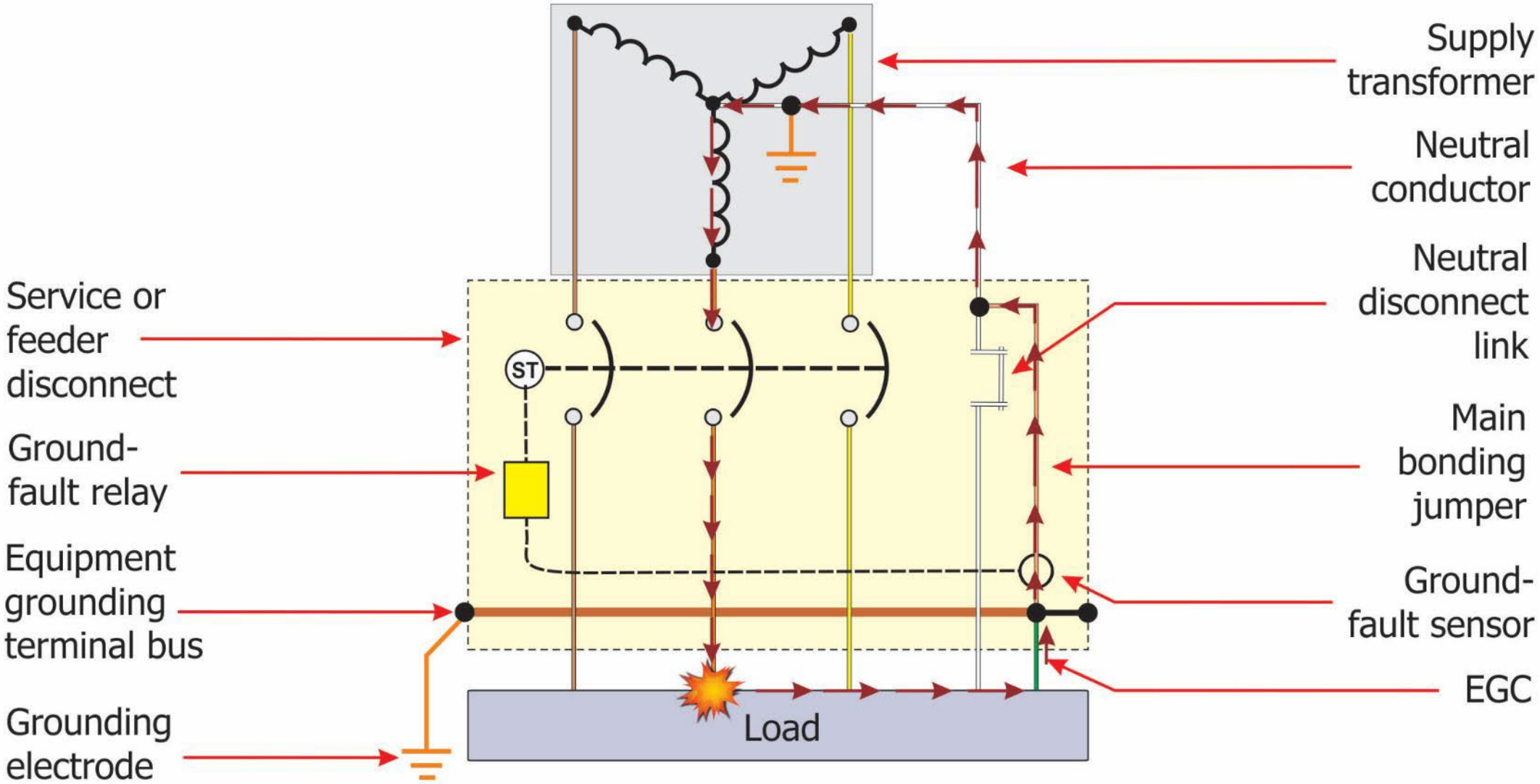
Ground-fault protection *(neutral ground strap type)*



Copyright © IAEI 2020

Neutral Ground Strap - Ground-Fault Condition

Ground-fault protection *(neutral ground strap type)*



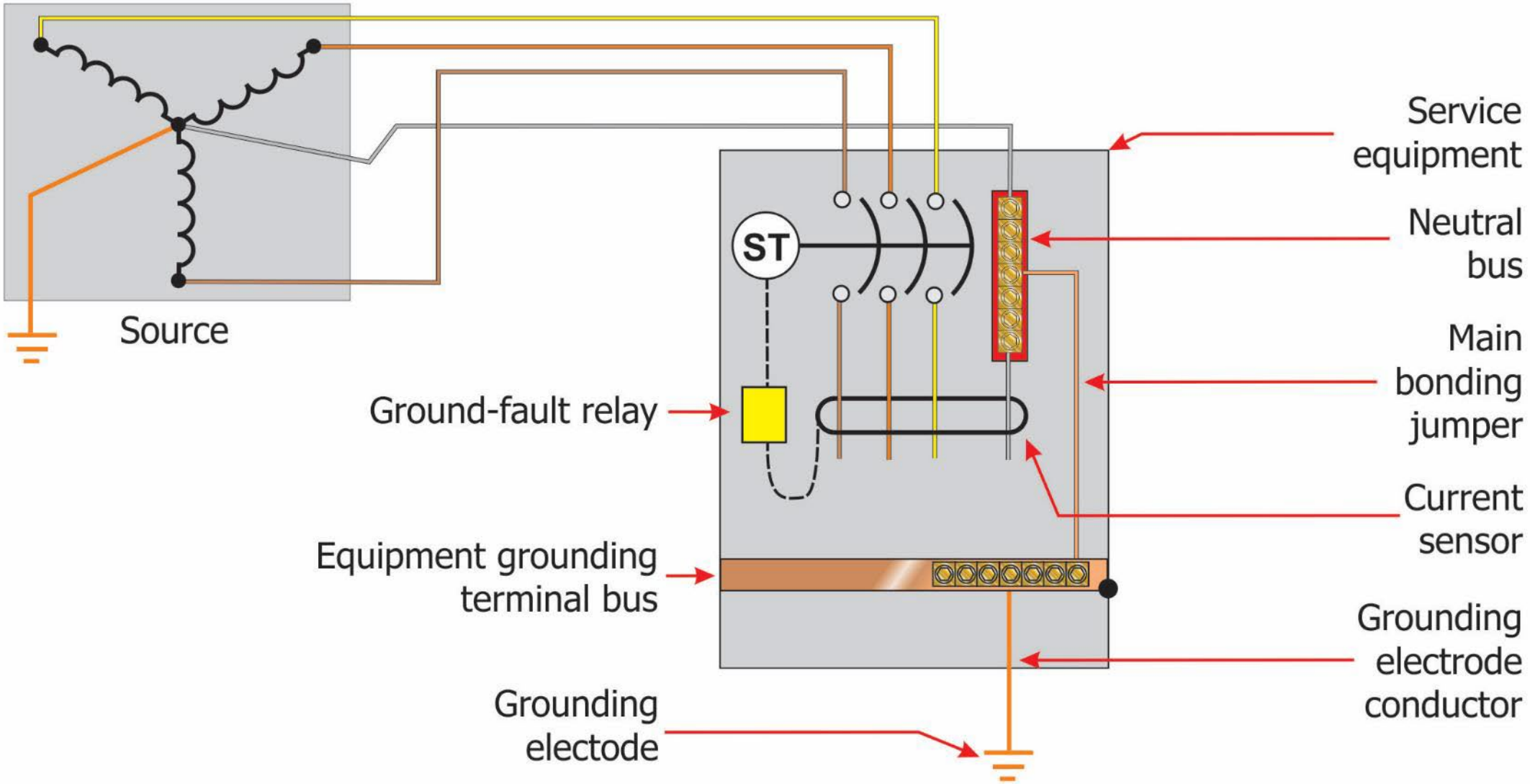
Copyright © IAEI 2020

Ground-Fault Protection System Types *(cont.)*

- **Zero-Sequence Ground-Fault Sensing-Type System:**
  - Most popular and common type of ground-fault protection system
  - Consists of one current sensor placed around all the current-carrying conductors of the circuit *[including the grounded (neutral) conductor]*, a control power source, a ground-fault relay, and a shunt-trip circuit breaker or shunt-trip fused disconnect switch
  - Optionally, there may be one sensor around all the phase conductors and a second sensor for the grounded (neutral) conductor
  - Sensor must be placed around the neutral downstream from the main bonding jumper connection point

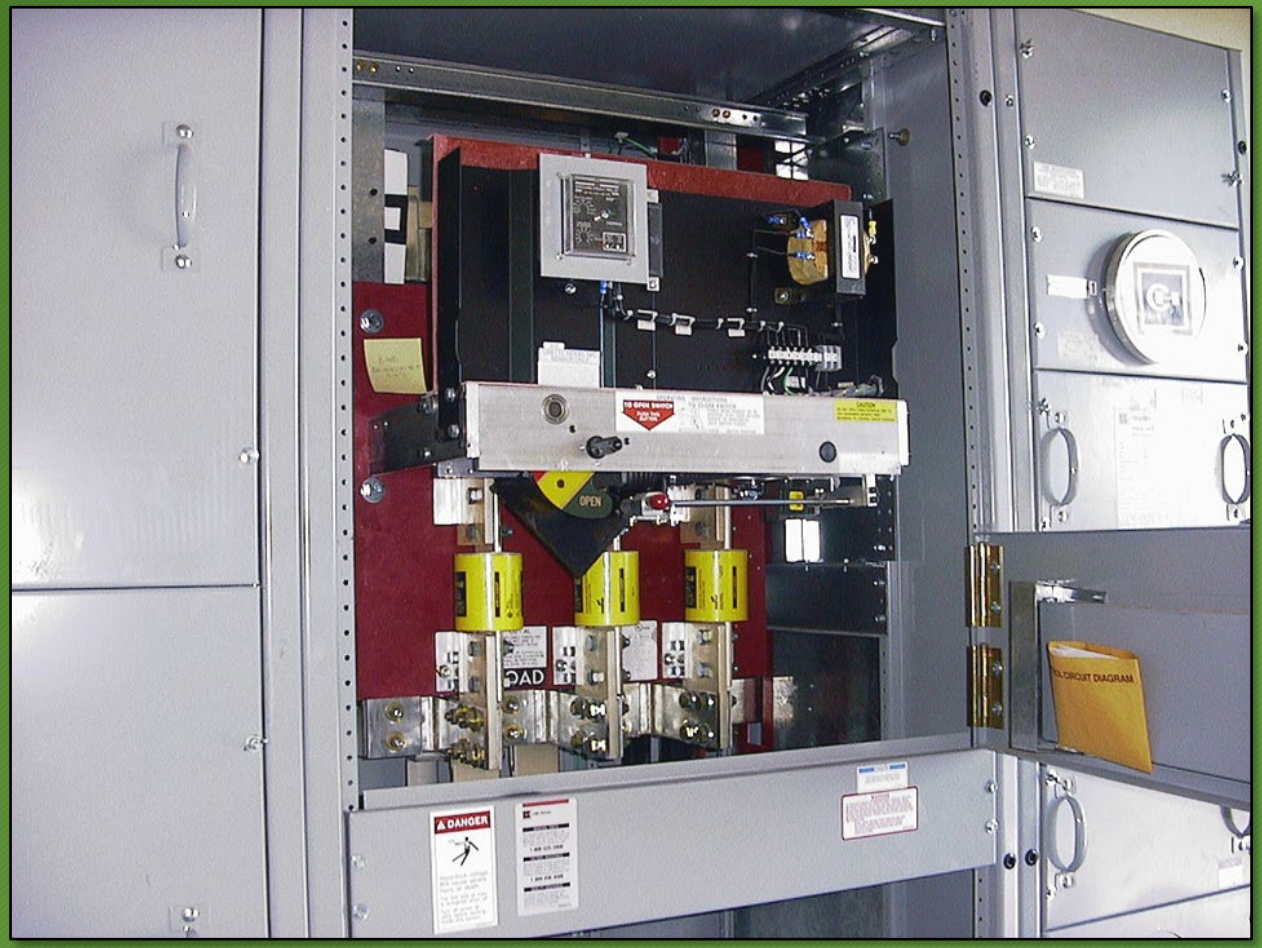
Ground-Fault Protection for Equipment *(GFPE)*

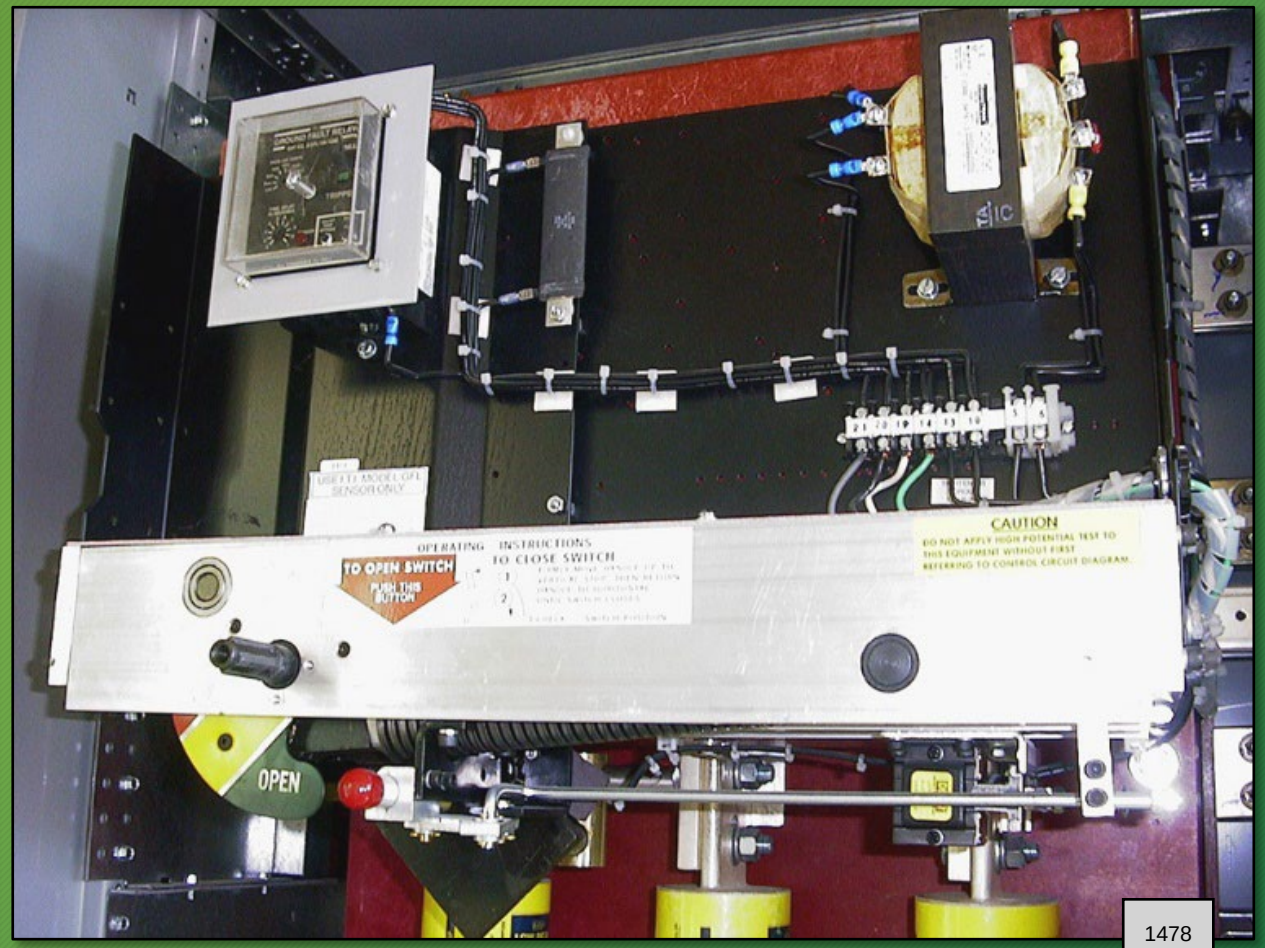
Ground-fault protection *(zero sequence type)*



Copyright © IAEI 2020

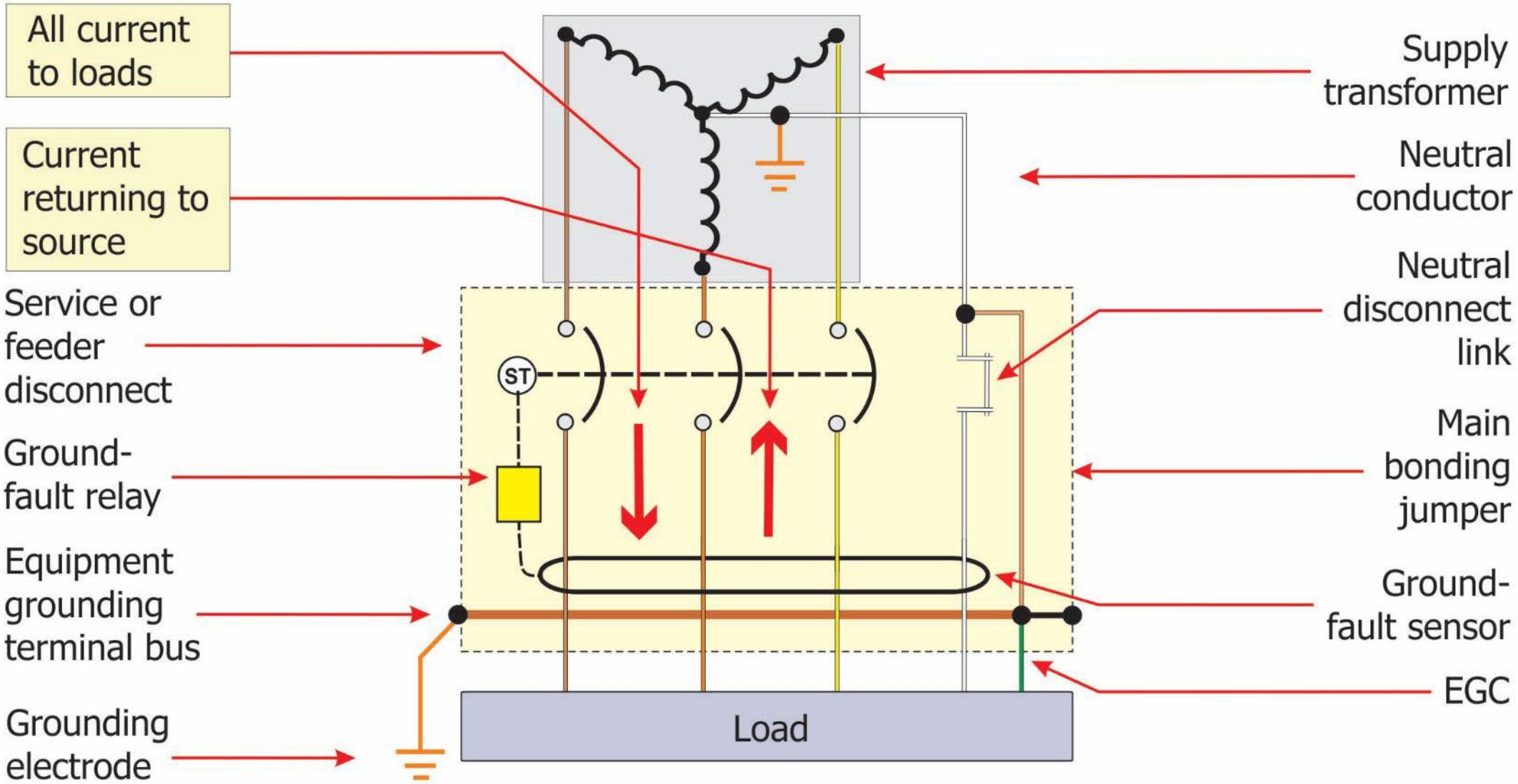
Ground-Fault Protection of Equipment (Bolted Pressure Switch with GFPE)





Zero Sequence System - Normal Operation

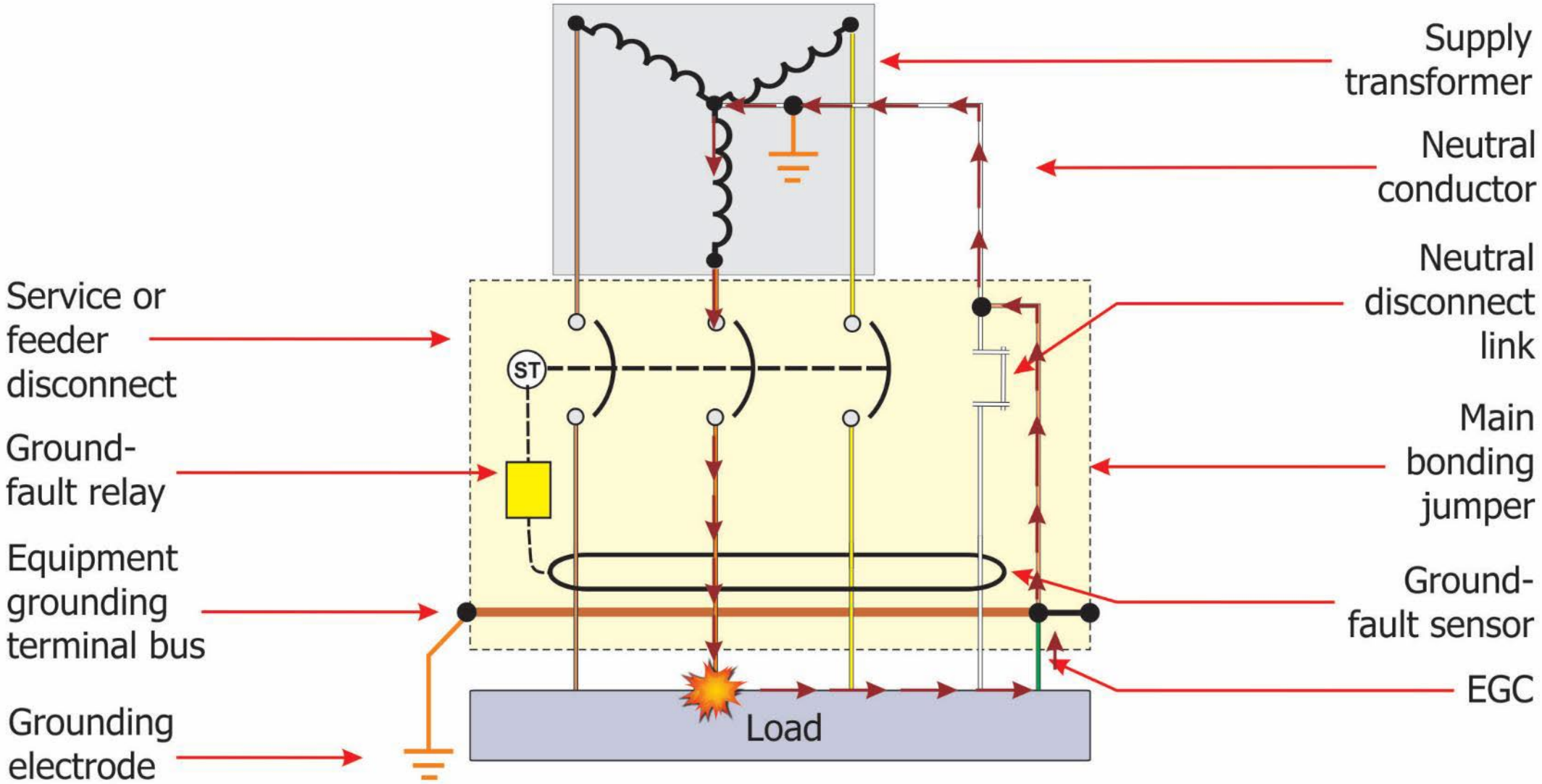
Ground-fault protection *(zero sequence type)*



Copyright © IAEI 2020

Zero Sequence System - Ground-Fault Condition

Ground-fault protection *(zero sequence type)*



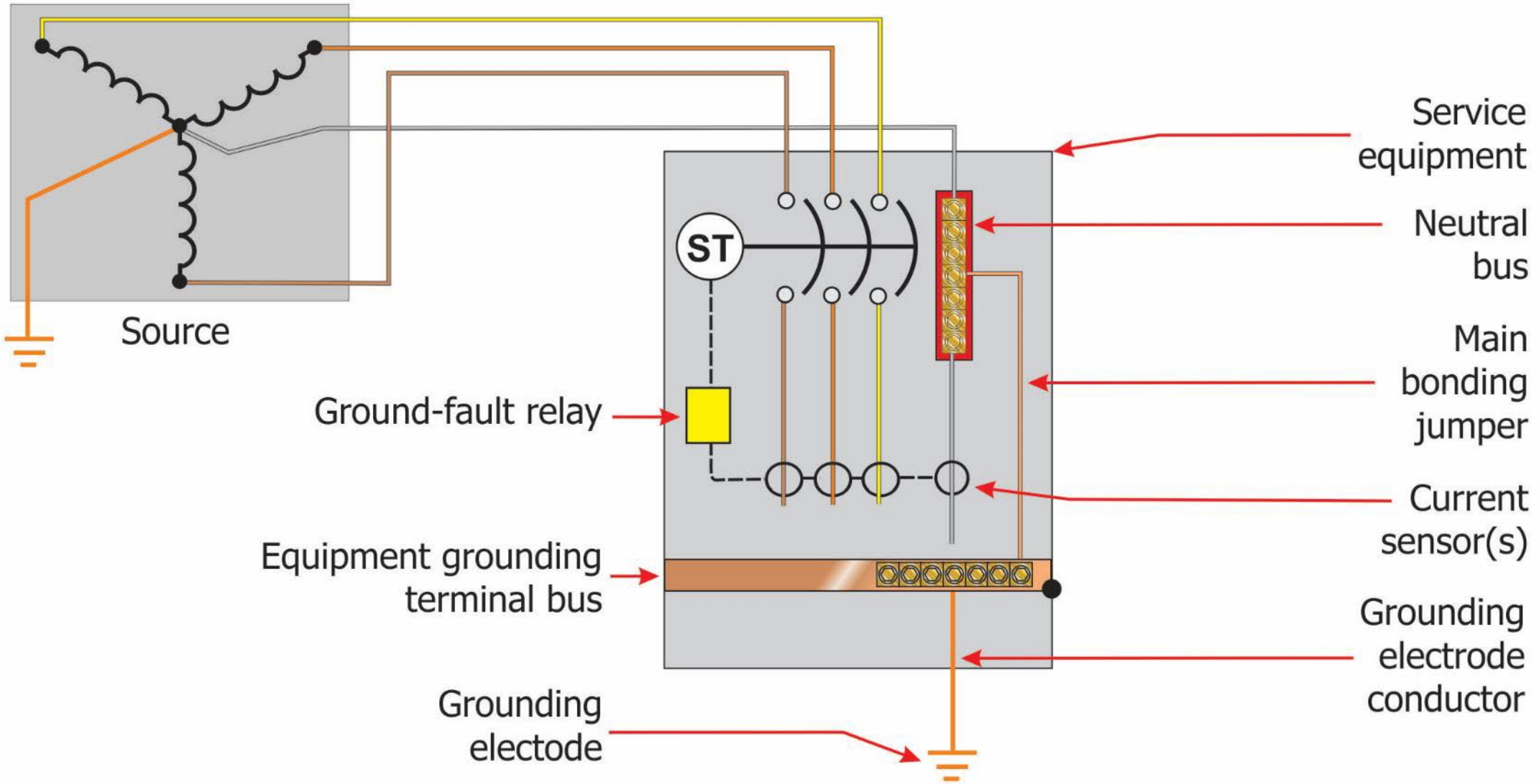
Copyright © IAEI 2020

Ground-Fault Protection System Types *(cont.)*

- **Residual-Type Ground-Fault System:**
  - Basic difference between the zero-sequence and residual-type systems is the number of current sensors
  - Current sensors can be external or more commonly now the phase sensors are built into the circuit breakers with integral ground-fault protection
  - Integral ground-fault system will have an external ground-fault current sensor through which the neutral passes
  - In some cases, neutral sensor may be field-installed
  - Often, these same internal current sensors are used by the circuit breaker as a part of its internal overcurrent protection operating system

Residual GFPE with Neutral Current Sensor

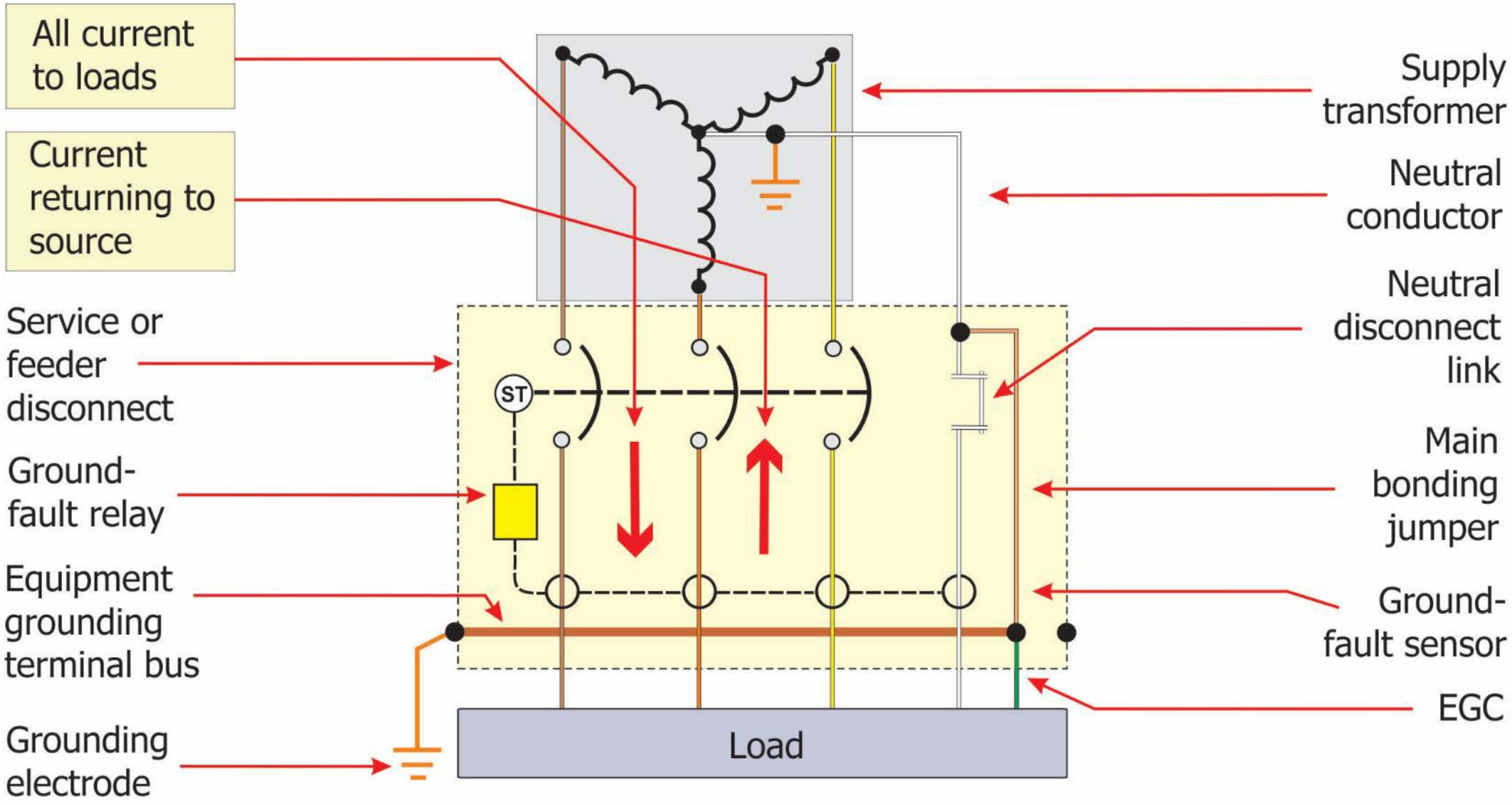
Ground-fault protection equipment
(Residual system type with neutral current sensor)



Copyright © IAEI 2020

Residual System - Normal Operation

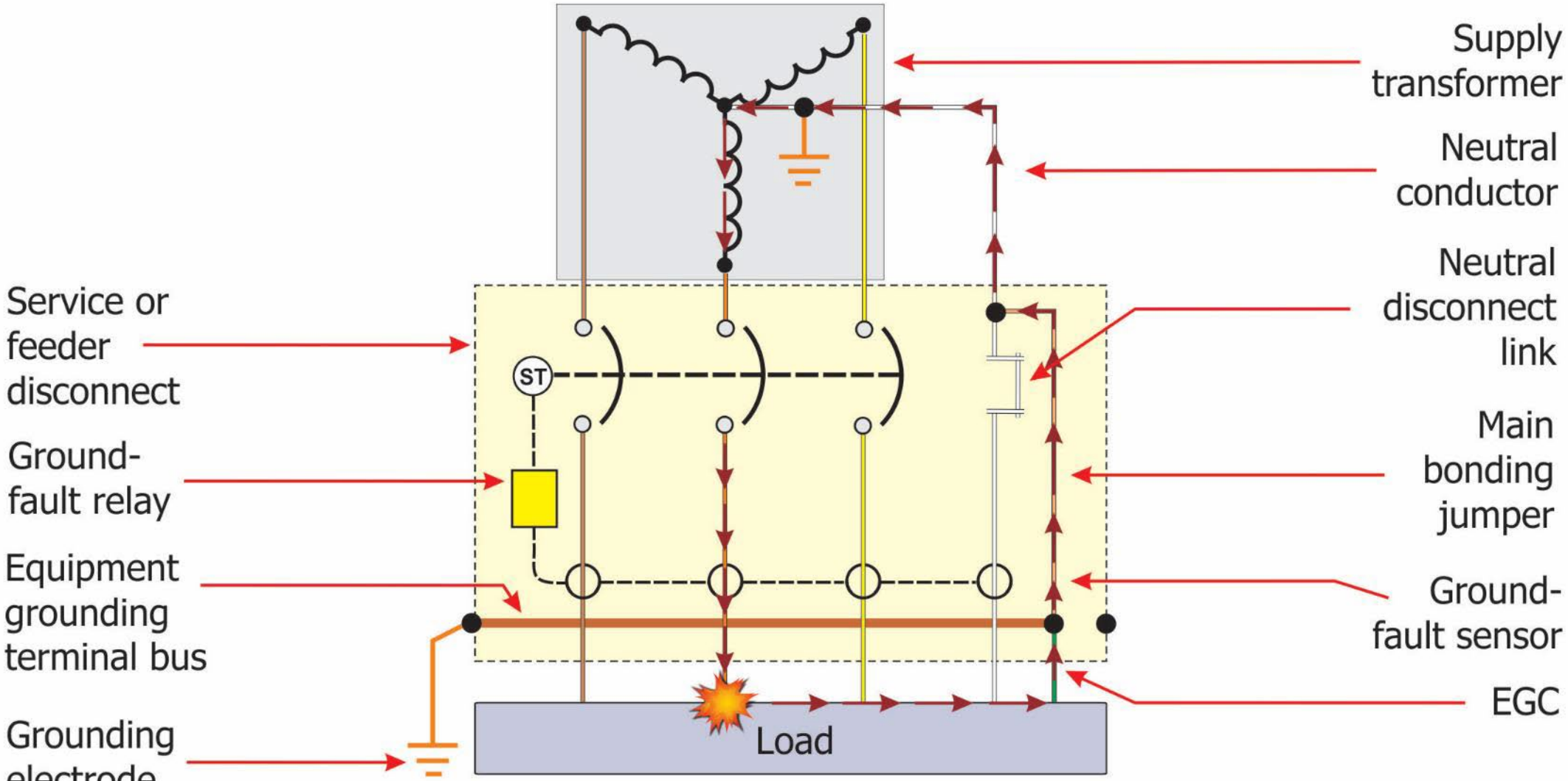
Ground-fault protection *(residual type)*



Copyright © IAEI 2020

Residual System - Ground-Fault Condition

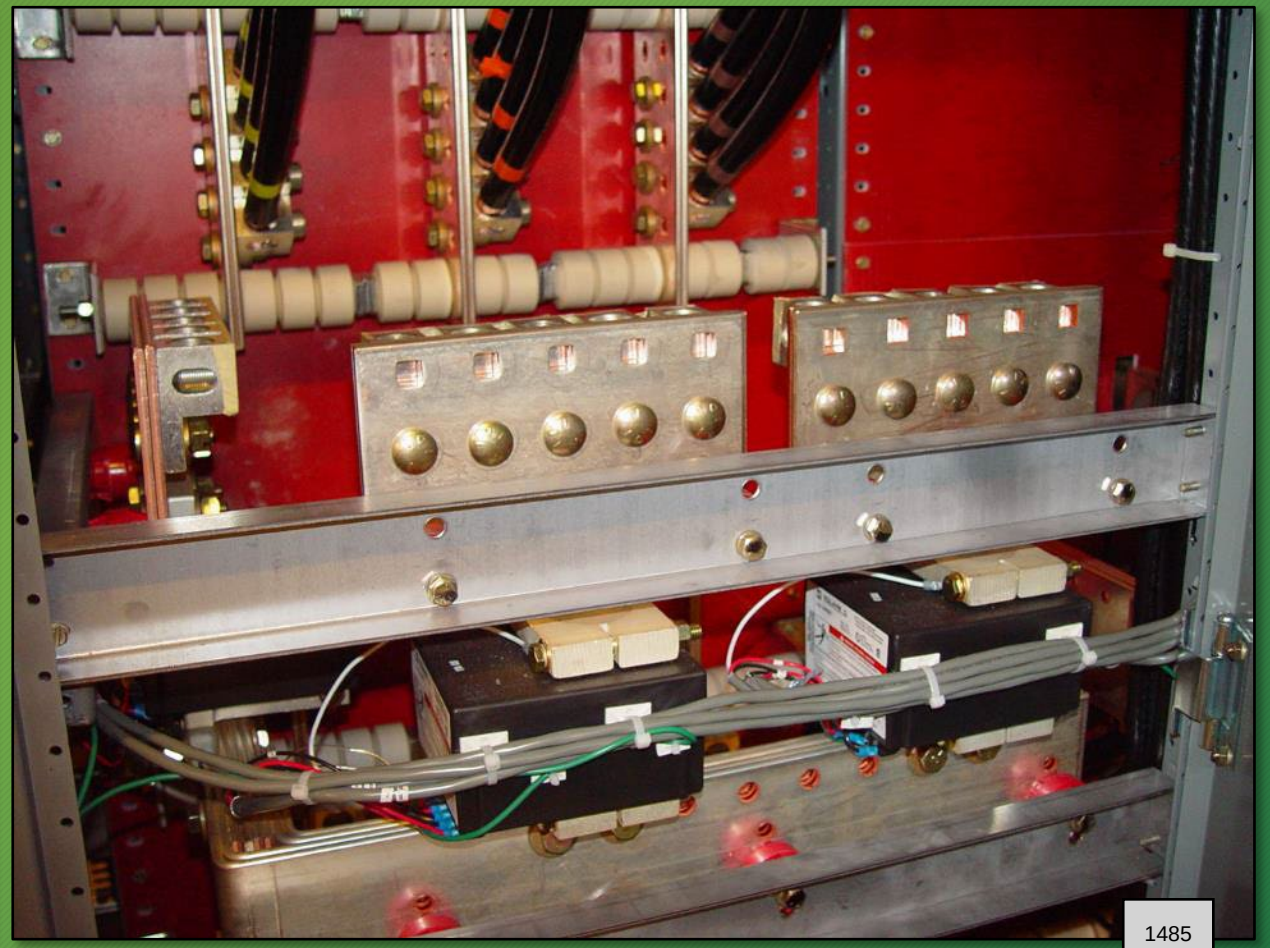
Ground-fault protection *(residual type)*



Copyright © IAEI 2020

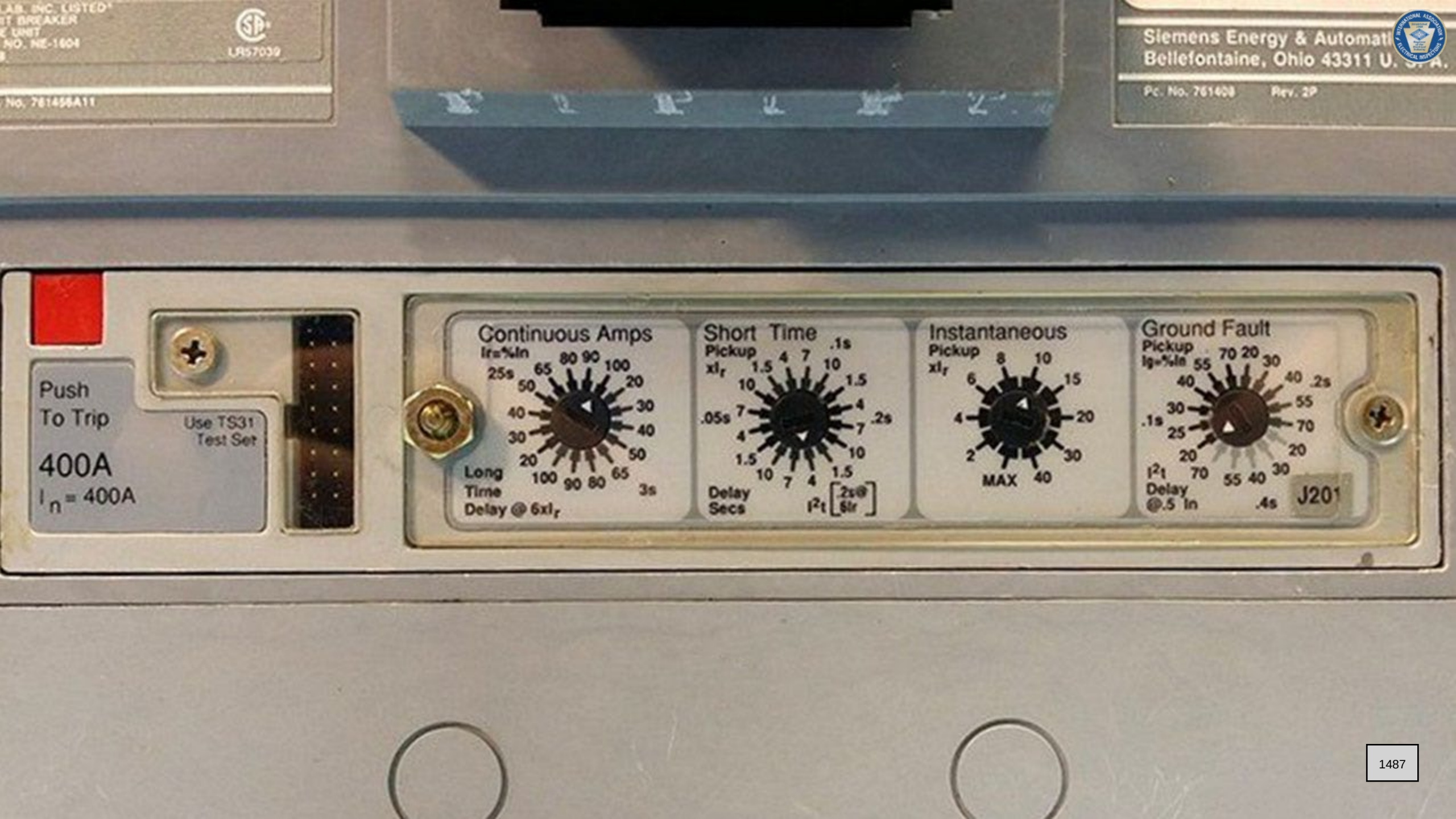
Ground-Fault Protection of Equipment (Residual Current System)






SBA 2000
Amps Max.
2000
Volts Max.
600 AC
Type
SBA2020
Poles
3
Current Interrupting Rating
RMS Symmetrical
Amps
Volts
Frequency
85,000
240 AC
50/60 Hz
65,000
480 AC
50/60 Hz
50,000
600 AC
50/60 Hz
Listed
Circuit Breaker Frame
3 Pole Unit
LR57039
Trip Units
Cat No.
SB20TLI
SB20TLSI
SB20TLSG
SB20TMLI
SB20TLS
SB20TLIG
SB20TLSIG
SB20TP01
SB20TP01G
SB20TP02
SB20TP02G
Rating Plugs
Cat. No.
Amp Rating
Cat. No.
Amp Rating
20SB1000
1000 A
20SB1600
1600 A
20SB1200
1200 A
20SB2000
2000 A
Connectors
Pressure Wire Connector
Cat. No.
Wire Range
Torque
TA4R600SB
250-600 kcmil CU/AL
375 in-lb
Bus Connector
Cat. No.
SB20TCON
Suitable for continuous operation at 100% of rating - fixed construction with bus connectors, or drawout construction in a minimum enclosure size of 21" high x 15.5" wide x 16" deep. Ventilation is not required.
BREAKER IS EQUIPPED WITH A NEUTRAL SENSING TRANSFORMER
Motor Fuse
Fuse Not Installed
Part No. 12289813
Siemens Energy & Automation, Inc.
Spring Charged
Spring Discharged
Contacts Closed
Contacts Open
Push To Close
Push To Open
2000
DANGER
SIEMENS
SIEMENS
SYSTEM CHECK
Long Time Delay
Short Time Pickup
Short Time Delay
Instantaneous Pickup
Ground Fault Pickup
Test

1486


Siemens Energy & Automati
Bellefontaine, Ohio 43311 U. S. A.
Pc. No. 761408 Rev. 2P
No. 761456A11
LR57039
Push
To Trip
Use TS31
Test Set
400A
In = 400A
Continuous Amps
Ir=%In
Long
Time
Delay @ 6xIr
3s
Short Time
Pickup
xIr
.1s
.05s
.2s
Delay
Secs
I2t
Instantaneous
Pickup
xIr
MAX
Ground Fault
Pickup
Ig=%In
.1s
.2s
I2t
Delay
@.5 In
.4s
J201

Testing of GFPE Systems

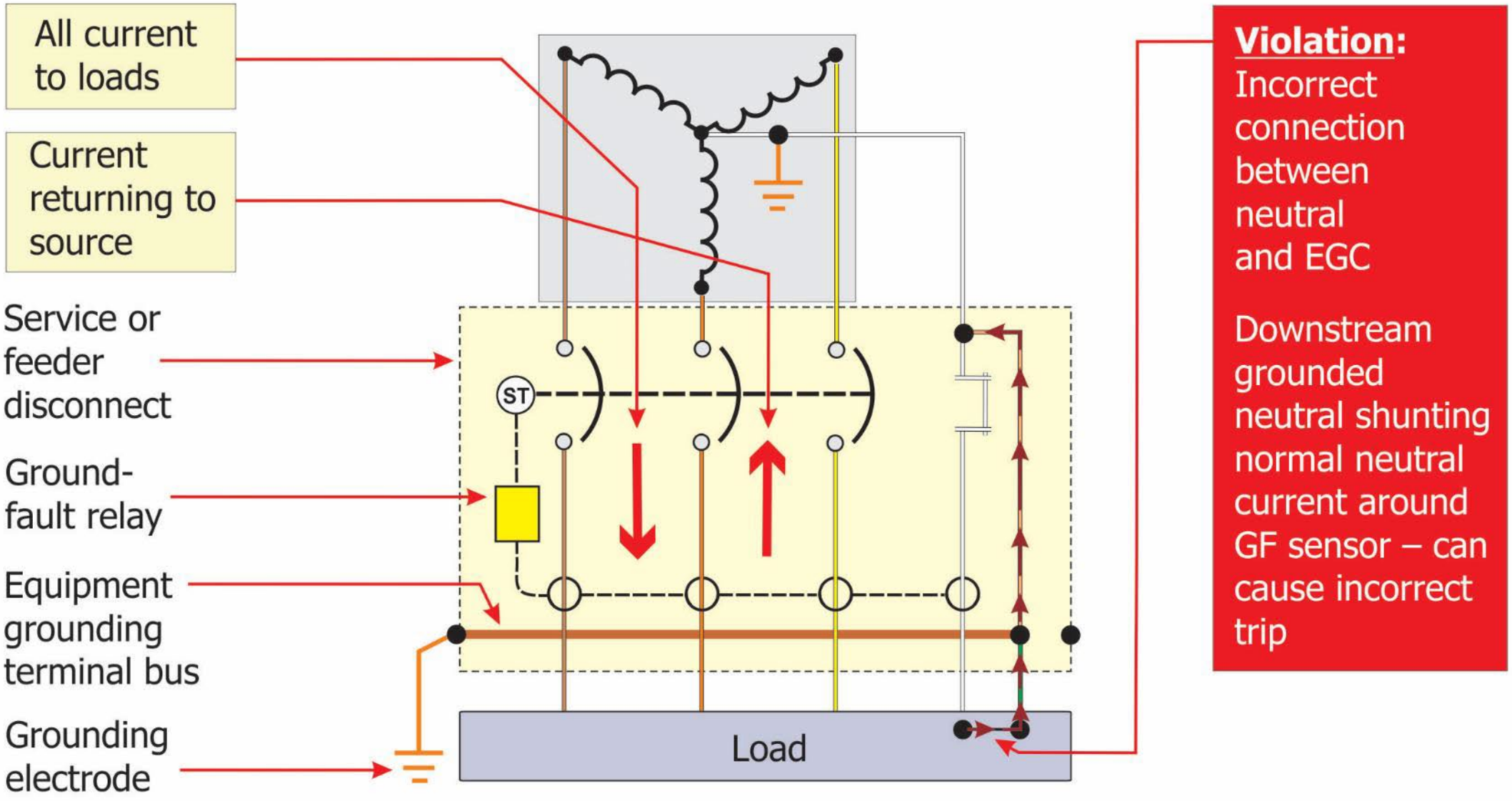
- Section 230.95(C) requires that service ground-fault protection systems be **performance-tested** when first installed on site to ensure that they will operate properly
- Experience has shown that the majority of these systems do not operate properly *(or at all)* when first installed
- This is most often due to improper field wiring of the system

Testing of GFPE Systems *(cont.)*

- The **three most common problems** encountered with these systems are:
  - Undersized main or system bonding jumpers
  - Incorrect location of the sensor on the neutral bus in relation to the main bonding jumper and/or grounding electrode conductor termination points
  - Connecting downstream panelboard, generator or branch-circuit neutral conductors to ground *(equipment grounding conductors, enclosures or earth)*

Residual System - Normal Operation

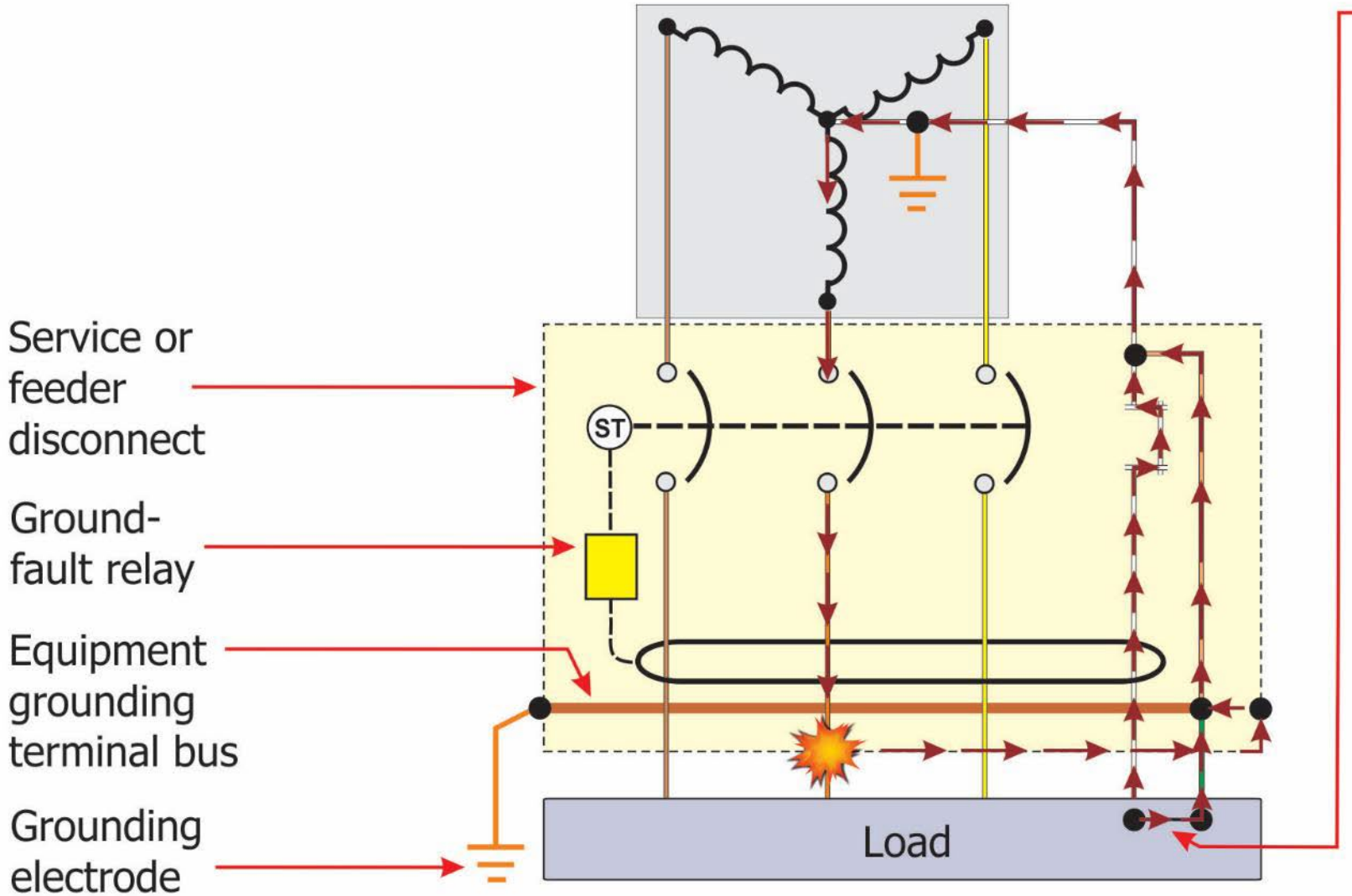
Ground-fault protection *(residual type)*



Copyright © IAEI 2020

Zero Sequence System - Ground-Fault Operation

Ground-fault protection *(zero sequence type)*



Violation:
Incorrect connection between neutral and EGC

Downstream grounded neutral shunt ground-fault current onto neutral desensitizing GF system

Copyright © IAEI 2020

Testing of GFPE Systems *(cont.)*

- Test must be performed in full compliance with the **manufacturer's written instructions** *[see 230.95(C)]*
- Instructions must be furnished with the equipment and are part of the listing requirements
- GFPE testing requirements apply to services, feeders, and branch circuits when first installed
- A vital part of the test is to remove the **neutral disconnect link** in the distribution equipment and test the neutral system of conductors with a continuity tester or megohm meter to be certain that it is **clear from any grounding connections downstream** from main bonding jumper at the service

Testing of GFPE Systems *(cont.)*

- A written record of this test shall be made and shall be available to the authority having jurisdiction (AHJ)
- System safety requires that the GFPE equipment be properly **installed**, **tested** and be **maintained** in an operable condition
- Many jurisdictions now require this test to be completed before they will authorize the equipment to be energized
- Test procedure may also require **two** testing evolutions considering construction schedules:
  - **1st test** would be *(before system energized)* when the equipment is first installed
  - **2nd test** would be *(after system energized)* on the neutral to ensure there are no downstream ground connections to the neutral

SOARES Grounding and Bonding

Based on the 2020 NEC®

End of Part I - Grounding and Bonding Fundamentals

International Association Of Electrical Inspectors

Presented by the International Association of Electrical Inspectors

Ohio Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor
Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: Department of Industrial Compliance

Organization: STATE OF OHIO

Address: 6606 Tussing

E-mail: michael.thompson@com.ohio.gov Telephone: 614-728-5293

Website: com.ohio.gov

Conference Sponsor (if applicable)_____ Conference Email:_____

Check here if Course Renewal:_____Prior course number _____ (*i.e. BBS2018-429*)

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: NEC 2020 Soares Grounding and Bonding Fundamentals Presented by The IAEI Association

Course instructor: Michael Thompson

Course description: We will study and go through the IAEI 3part Power point presentation on grounding and bonding course study to help with the inspection and plan review processes Part 3

Instructional hours per session: 6 hrs Number of Sessions: 1 each

Course Date(s) and Location: Department of Commerce in Reynoldsburg

Special Content:

Code Administration: X
Existing Buildings: X
Electrical Instruction: X
Plumbing Instruction:_____

Conference Course: _____
Conference Name: _____
Conference location:_____

Course to be offered online? X **On Demand**_____ **Webinar**_____

Course Website: Might use Microsoft TEAMS on course if travel becomes a issue

Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation*):
Microsoft Teams attendance

Course applicable for the following certifications

Residential Certifications Only: _____ Commercial Certifications: X

Administrative Course, All Certifications: X

Application materials included:

X Course Outline or Course Learning Objectives
X Presentation Materials/Slides (not required for roundtable courses)
_____ Assessment Materials (for online courses)
X Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

2020 NEC Soares Grounding Part 3

7:30 – 8:00- Greetings.

8:00 am 8:10 am – To go over purpose of this class and go over the power point. The class will follow along with the PDF book of Soares Grounding.

Chapter 16 GROUNDING AND BONDING FOR SPECIAL LOCATIONS

Chapter 17 GROUNDING AND BONDING FOR SPECIAL CONDITIONS

Chapter 18 GROUNDING AND BONDING FOR ALTERNATE ENERGY SYSTEMS

Chapter 19 GROUNDING AND BONDING FOR ELECTRONIC EQUIPMENT

Chapter 20 LOW-VOLTAGE AND INTERSYSTEM GROUNDING AND BONDING

Chapter 21 GROUNDING OF SYSTEMS OR CIRCUITS OF OVER 1000 VOLTS

Chapter 22 FUNDAMENTALS OF LIGHTNING PROTECTION

8:10 -9:20 - Chapter 16 GROUNDING AND BONDING FOR SPECIAL LOCATIONS

9:20 – 9:30 break

9:30- 10:30 – Chapter 17 GROUNDING AND BONDING FOR SPECIAL CONDITIONS

10:30 – 12-00 – Chapter 18 GROUNDING AND BONDING FOR ALTERNATE ENERGY SYSTEMS

12:00- 1:00 Lunch

1:00 pm– 2:00 pm - Chapter 19 GROUNDING AND BONDING FOR ELECTRONIC EQUIPMENT

2:00 -2:30 – Chapter 20 LOW-VOLTAGE AND INTERSYSTEM GROUNDING AND BONDING

2:30 -2:45 Break

2:30 -3:30 - Chapter 21 GROUNDING OF SYSTEMS OR CIRCUITS OF OVER 1000 VOLTS, Chapter 22 FUNDAMENTALS OF LIGHTNING PROTECTION

SOARES Grounding and Bonding

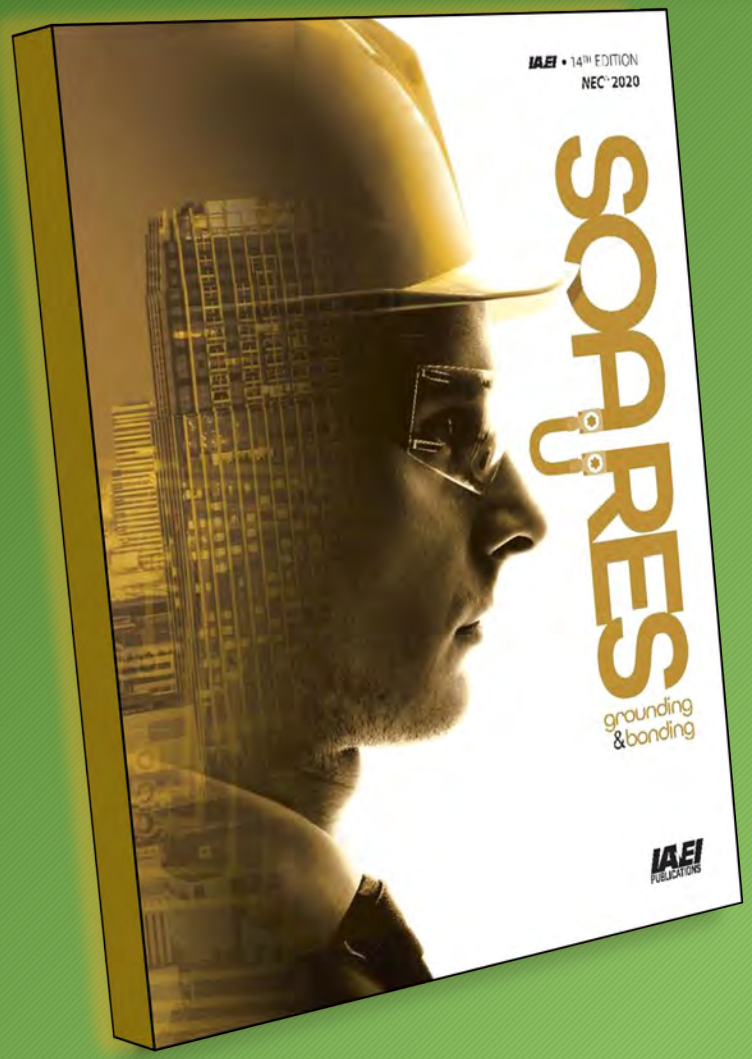
Based on the 2020 NEC®

Part III of III – Grounding and Bonding Specific Applications

International Association Of Electrical Inspectors

Presented by the International Association of Electrical Inspectors

Soares Grounding and Bonding



- IAEI's *Soares Grounding and Bonding*
- 14th Edition
- Based on the requirements of the ***2020 National Electrical Code***
- Dedicated to the memory of Eustace Soares

Soares Chapter Index Links – Part III

Chapter 16	Grounding and Bonding for Special Locations
Chapter 17	Grounding and Bonding for Special Conditions
Chapter 18	Grounding and Bonding for Alternate Energy Systems
Chapter 19	Grounding and Bonding for Electronic Equipment
Chapter 20	Low-Voltage / Intersystem Grounding and Bonding
Chapter 21	Grounding of Systems/Circuits of Over 1000 Volts
Chapter 22	Fundamentals of Lightning Protection

Click on any chapter to link directly to that chapter

CHAPTER SIXTEEN

GROUNDING AND BONDING FOR SPECIAL LOCATIONS

Grounding and Bonding for Special Locations

- Grounding and bonding requirements for **special locations** is found in *NEC* Chapter 5
- This chapter also provides general information about grounding and bonding for **static electricity protection** that is beyond the scope of the *NEC*
- ***Static electricity*** is directly related to similar safety concerns for both hazardous *(classified)* locations and, to some degree, health care facilities
- Some general requirements from **NFPA 77 *Recommended Practice on Static Electricity*** are provided as well

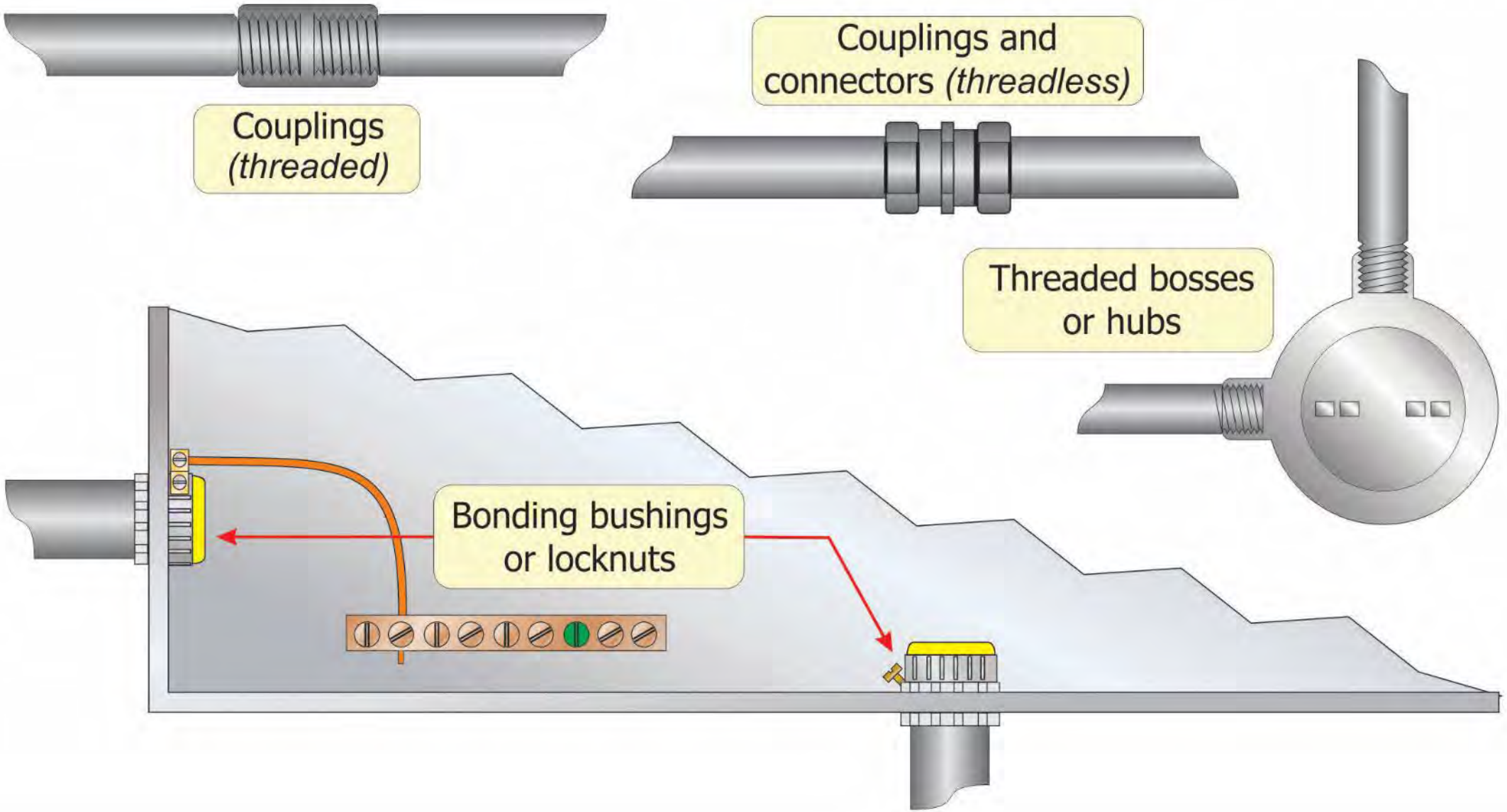
Hazardous (Classified) Locations Grounding and Bonding

- Grounding and bonding is essential for electrical safety in nonhazardous locations and even more essential in hazardous *(classified)* locations
- In hazardous *(classified)* locations it is vital to have effective grounding and bonding to **prevent ignition resulting in a fire or an explosion**
- If there is an arcing fault to a metal enclosure located in a hazardous *(classified)* location, the external surface temperature of the metal enclosure *(at the point of the arcing fault)* can rise to temperatures that could cause ignition of the **flammable vapors** or accumulations of **combustible dust**
- The *Code* has some special requirements for grounding and bonding in hazardous *(classified)* locations

Hazardous (Classified) Locations Grounding and Bonding *(cont.)*

- The basic requirement for grounding and bonding in hazardous *(classified)* locations is found in **250.100** with the additional installation requirements found in:
  - 501.30(A) - Class I locations
  - 502.30(A) - Class II locations
  - 503.30(A) - Class III locations
- These sections call for bonding to be required from hazardous *(classified)* location to service equipment or source of separately derived system including all intervening raceways, fittings, boxes, enclosures, and so forth
- *See exception for separate buildings or structures*

Bonding Methods Suitable for Hazardous *(Classified)* Locations

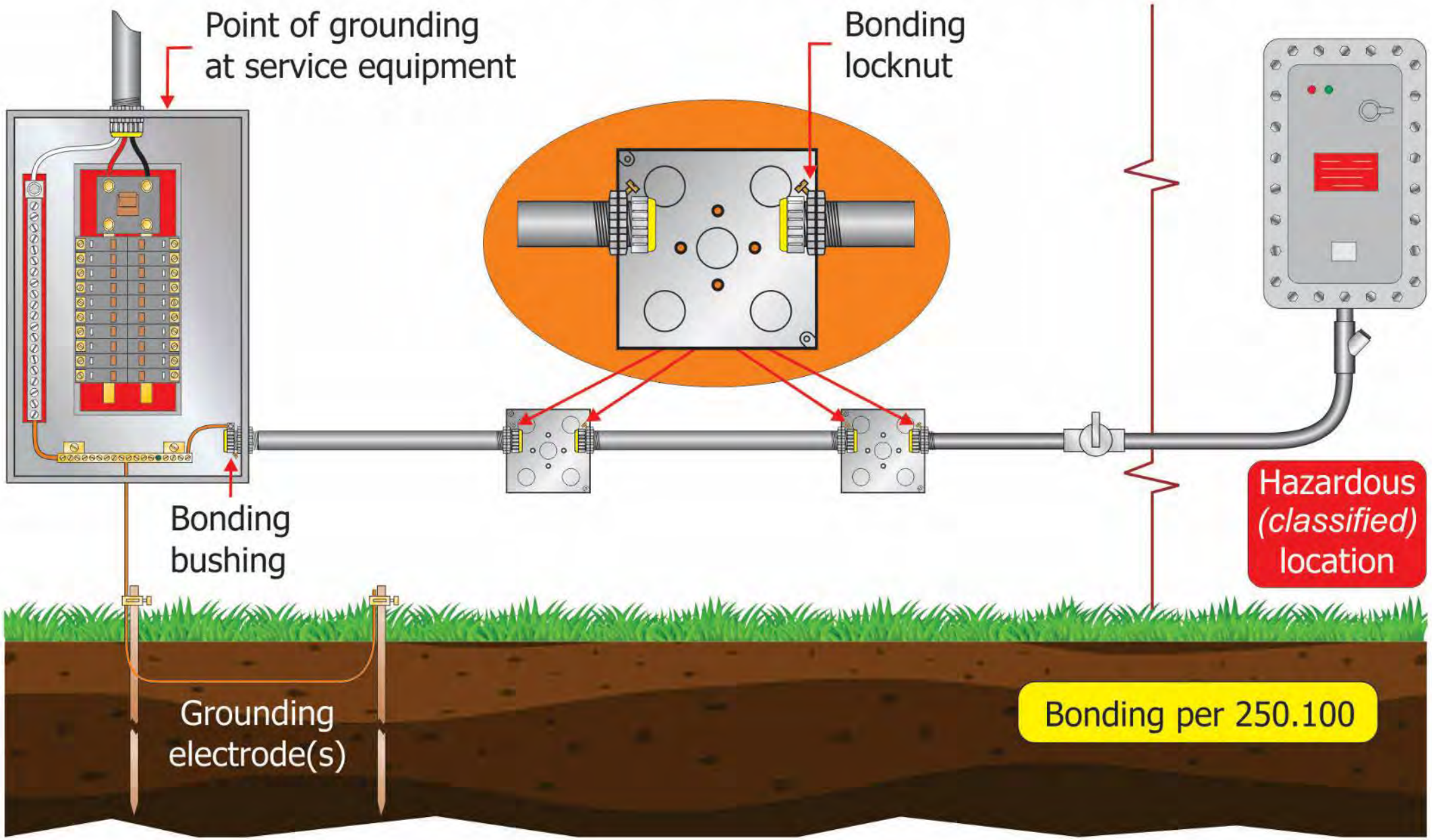


Copyright © IAEI 2020

Bonding to the Point of Grounding

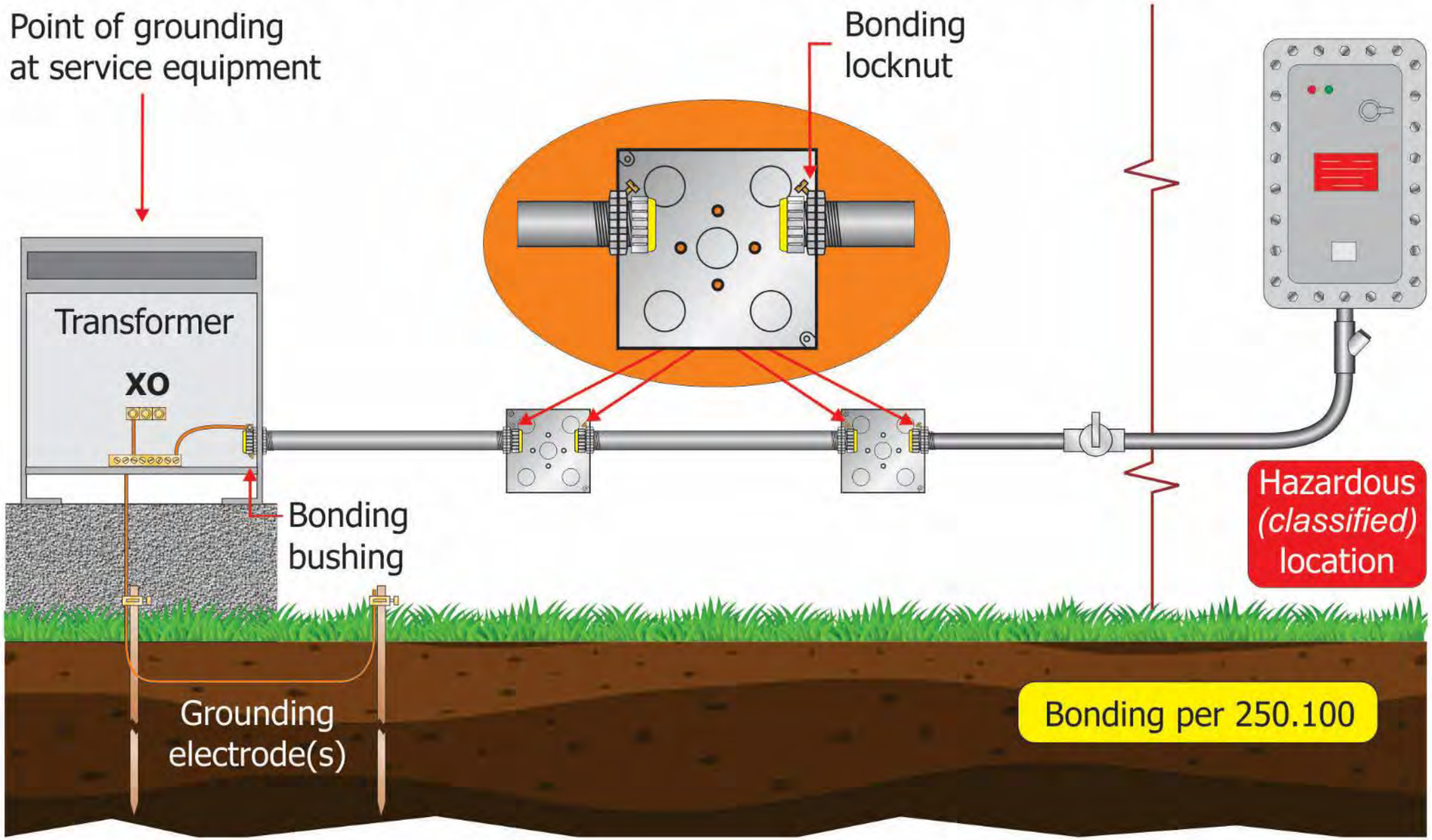
- The bonding means specified in **501.30(A)**, **502.30(A)**, **503.30(A)** are required to be installed all the way from the hazardous *(classified)* location to the service equipment or point of grounding of a separately derived system that is the source of the circuit
- Such means of bonding shall apply to all intervening **raceways, fittings, boxes, enclosures**, and so forth between (Class I, Class II, or Class III) locations and the point of grounding for service equipment or point of grounding of a separately derived system

Bonding to the Point of Grounding at Service



Copyright © IAEI 2020

Bonding to the Point of Grounding at Service



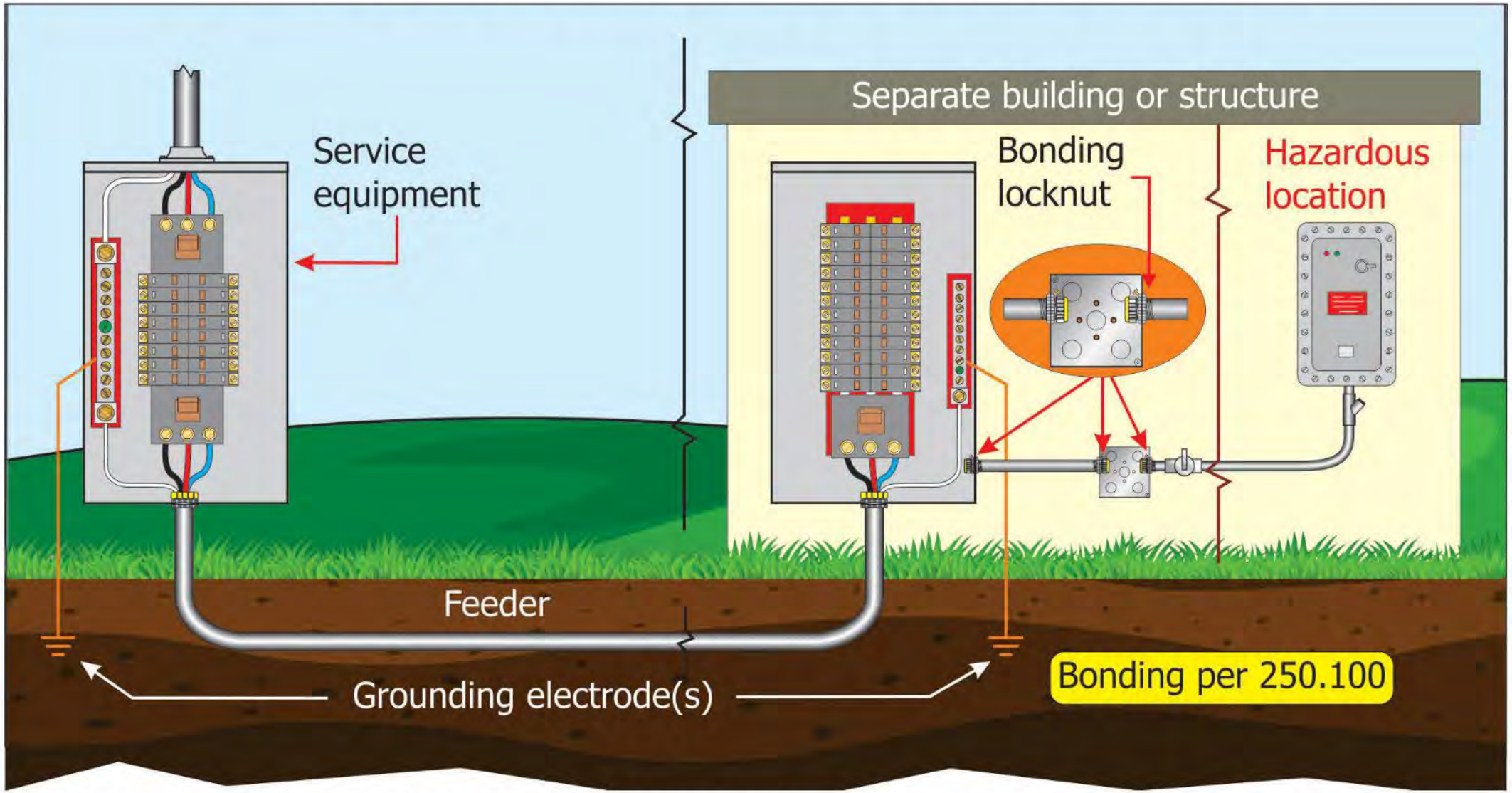
Copyright © IAEI 2020


S
N

Bonding to the Point of Grounding *(cont.)*

- For buildings or structures supplied by feeder(s) or branch circuit(s), the **exceptions** to 501.30(A), 502,30(A), and 503.30(A) clarify that:
  - *"the specific bonding means shall only be required to the **nearest point where the grounded circuit conductor and the grounding electrode are connected together** on the line side of the building or structure disconnecting means as specified in 250.32(B), provided the branch-circuit overcurrent protection is located on the load side of the disconnecting means"*

Bonding Not Required Past Building Disconnect



Bonding in accordance with 250.100 not required past the disconnect for a separate building or structure as provided in the exception to 501.30(A), 502.30(A), and 503.30(A)

Copyright © IAEI 2020

Static Protection Through Grounding and Bonding

- In hazardous *(classified)* locations, electrical wiring *(including the grounding and bonding circuits)* are extremely **important for safety**
- Because **sources of ignition** are a primary concern in explosive atmospheres, it is often necessary to also provide a more enhanced protection system of handling **static electricity** in hazardous *(classified)* locations
- Using grounding and bonding for protection from the effects of **static electricity** are typically **beyond the scope of the *NEC***

Static Protection Through Grounding and Bonding *(cont.)*

- *IAEI's Soares Grounding and Bonding* discusses the following topics concerning protection methods for **static electricity** *(see Chapter 16 of Soares textbook)*
- General information
- Humidity control
- Static as an ignition source
- Differences of potential
- Static discharge
- Basic methods of protection
- Static grounding and bonding protection
- Lightning protection information

Static Protection Through Grounding and Bonding *(cont.)*

- Reference standards for additional information include:
  - **NFPA 77-2019** *Recommended Practice on Static Electricity*
  - **NFPA 780-2017** *Standard for the Installation of Lightning Protection Systems*
  - **API RP 2003-2015** *Protection Against Ignitions Arising Out of Static Lightning and Stray Currents [published by the American Petroleum Institute (API)]*

Static Protection: General Information

- Protection against **static electricity** is a requirement in a number of industries and establishments
- Grounding of equipment is not necessarily a full solution to these specific problems
- Each static problem requires its own study and solution
- Two examples of areas of concern related to static electricity are **hazardous *(classified)* locations** and installations of **sensitive electronic equipment** such as computers and data processing equipment

Static Protection: Humidity as a Solution

- Humidity can help reduce the static problem
- Higher levels of humidity have proven to be effective in reducing static charges from building and possibly discharging
- Humidity increases surface conductivity of material, but will only discharge if there is a conductive path for dissipation
- Humidity of **65% or higher** increases the absorption characteristics of most materials to ensure surface conductivity that is sufficient to prevent the accumulation of static charges
- Humidity of **less than 30%** allows these same materials to become good insulators which causes accumulation of charges to increase
- *Note: Humidification is not necessarily the solution to all static electricity problems encountered*

Static Electricity as an Ignition Source

- In hazardous *(classified)* locations, the concerns of protection from static electricity center around removing the ignition source from the fire triangle
- Each problem requires its own study and solution
- The degree of protection needs to be specific to each particular problem
- There are no mandatory *NEC* requirements to provide such protection
- The hazards do exist and must be considered for safety

Static Electricity as an Ignition Source *(cont.)*

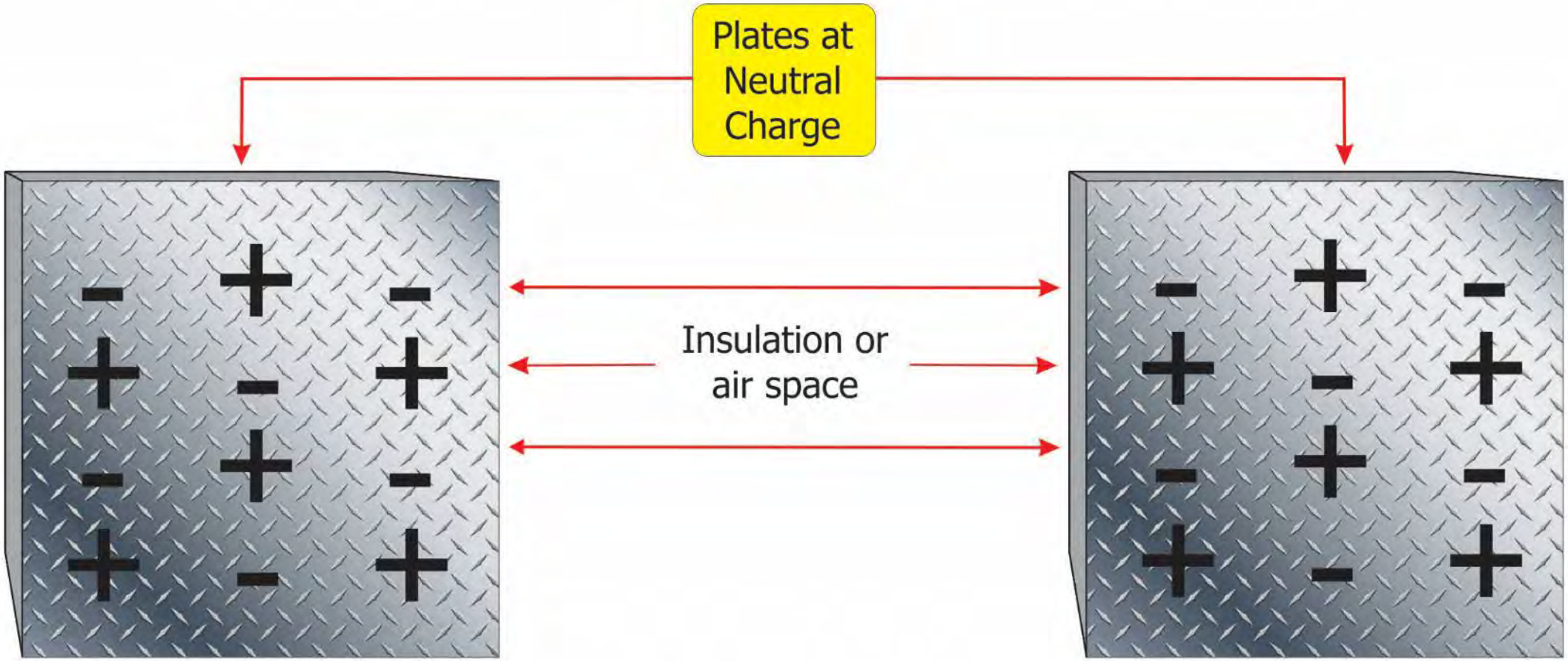
- For a static electricity discharge to be a **source of ignition**, the following (4) conditions **must exist simultaneously**:

    1. An effective means of separating the charge must be present
    2. A means of accumulating the separated charges and maintaining a difference of electrical potential must be available
    3. A discharge of the static electricity of adequate energy must occur
    4. The discharge must occur in an ignitable mixture *[NFPA 77-2019, 5.5.1]*

Static Electricity Fundamentals

- All matter is made up of various arrangements of atoms
- Atoms are made up of positively charged nuclear components that give them mass and are surrounded by negatively charged electrons
- Basically, positive and negative charges are present in atoms
- Atoms are considered to be electrically neutral in their normal state
- Atoms can become charged when there is an **excess or deficiency of electrons** relative to the neutral state

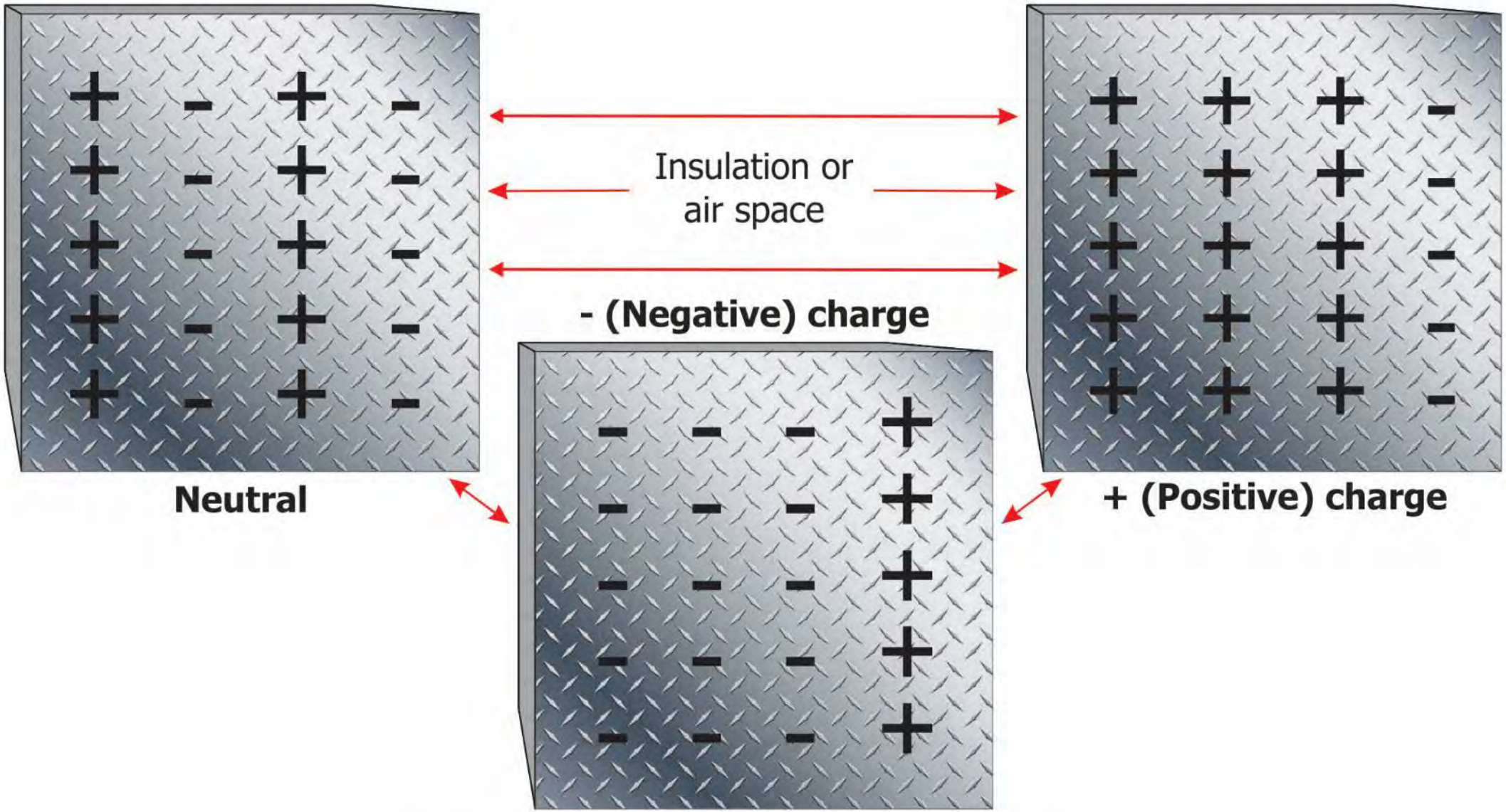
Equal Potential Between Conductive Parts



Conductive parts at the same potential

Copyright © IAEI 2020

Difference of Potential Between Conductive Parts



Conductive parts at the different potential

Copyright © IAEI 2020

Beyond the *NEC*

- The *NEC* provides (3) references through Informational Note No. 2 at 500.4(B) to the **recommended practice on protection from static electricity**
- Referenced document is titled ***Recommended Practice on Static Electricity***, NFPA 77-2019
- Lightning protection systems are also important considerations and provide reasonable planned protection for those natural events in weather that produces lightning
- Industry standard for lightning protection systems titled ***Standard for the Installation of Lightning Protection Systems*** NFPA 780-2017

Beyond the *NEC (cont.)*

- The American Petroleum Institute (API) also has produced a document that addresses protection techniques used to tackle these concerns:
- ***Protection Against Ignitions Arising Out of Static Lightning and Stray Currents***, API RP 2003-2015
- *See NEC 500.4 Informational Note No. 2*

Beyond the *NEC (cont.)*

- Definitions:
  - ***Static electric discharge***. "A release of static electricity in the form of a spark, corona discharge, brush discharge, bulking brush discharge, or propagating brush discharge that might be capable of causing ignition of a flammable atmosphere under appropriate circumstances." *[NFPA 77 3.3.39]*
  - ***Static electricity***. "The branch of electrical science dealing with the effects of the accumulation of electric charge." *[NFPA 77 3.3.40]*

Definitions of Grounding and Bonding

- The next two slides compare the definitions of these terms between **NFPA 70** *(National Electrical Code)* and **NFPA 77** *(Recommended Practice on Static Electricity)*
- The terms to be compared are as follows:
  - Grounded (Grounding)
  - Bonded (Bonding)

Definitions of Grounding and Bonding *(cont.)*

- ***Grounded (Grounding):*** Connected (connecting) to ground or to a conductive body that extends the ground connection. *[NFPA 70, Article 100]*
- ***Grounding:*** The process of bonding one or more conductive objects to the ground, so that all objects are at zero (0) electrical potential; also referred to as *earthing. [NFPA 77 – 3.3.22]*
- *Note: The term "earthing" is not a defined term in the NFPA 70 or NFPA 77*

Definitions of Grounding and Bonding *(cont.)*

- ***Bonded (Bonding):*** Connected to establish electrical continuity and conductivity. *[NFPA 70, Article 100]*
- ***Bonding:*** For the purpose of controlling static electric hazards, the process of connecting two or more conductive objects together by means of a conductor so that they are at the same electrical potential, but not necessarily at the same potential as the earth. *[NFPA 77 – 3.3.2]*
- *Note: The following slides show the two functions of grounding and bonding separately and how the two concepts working together provide a level of static electricity protection*

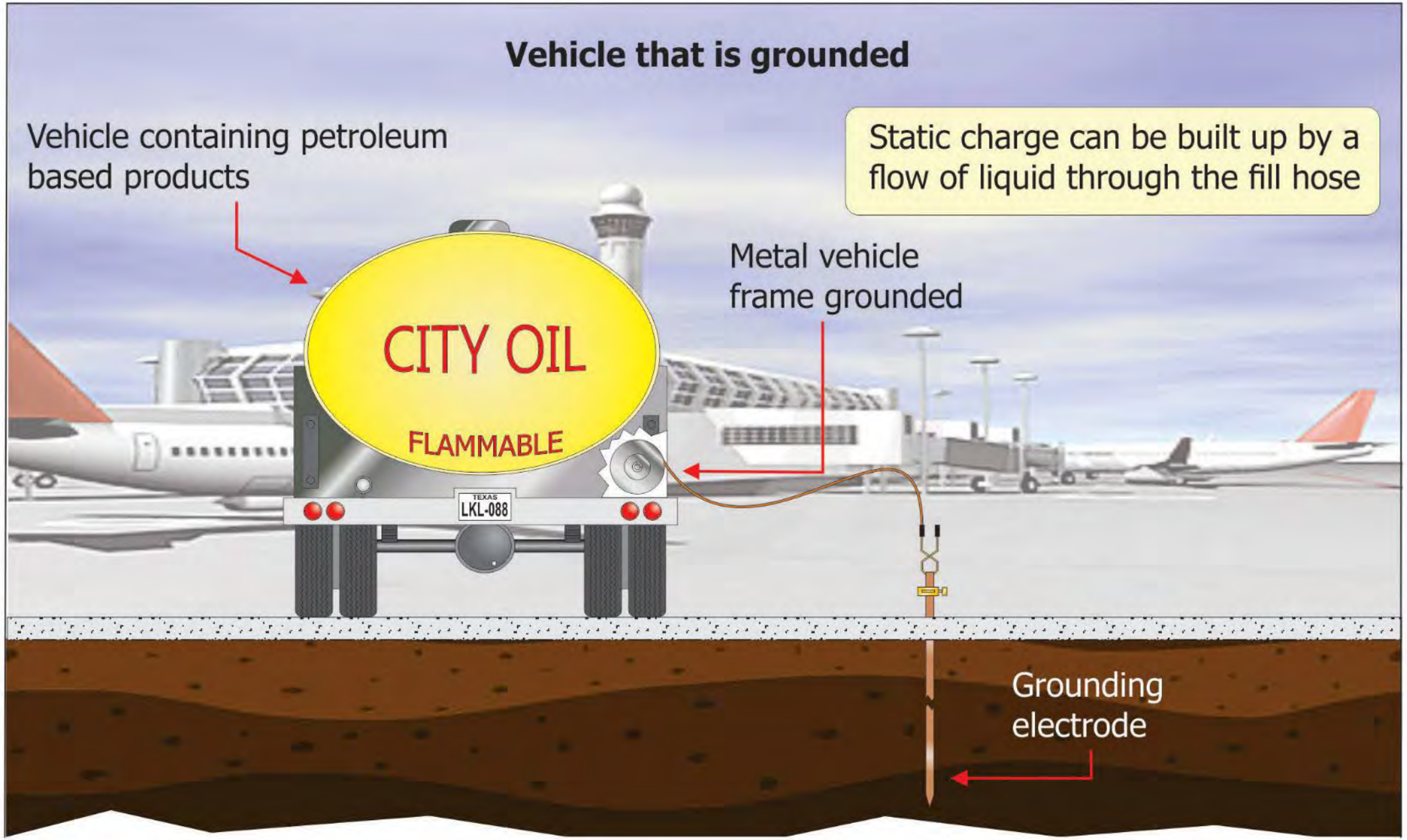
Grounding and Bonding

- When the term ***grounding*** is used, it should be thought of as including a **connection or path to the earth** to put electrically conductive materials at the same potential as the earth
- When the term ***bonding*** is used, it should be thought of as **connecting electrically conductive materials together** to mitigate or ultimately eliminate differences of potential between them and to form one conductive mass
- Note that bonding generally includes a path to the earth, but the earth is not referred to in the previous definitions

Grounding and Bonding *(cont.)*

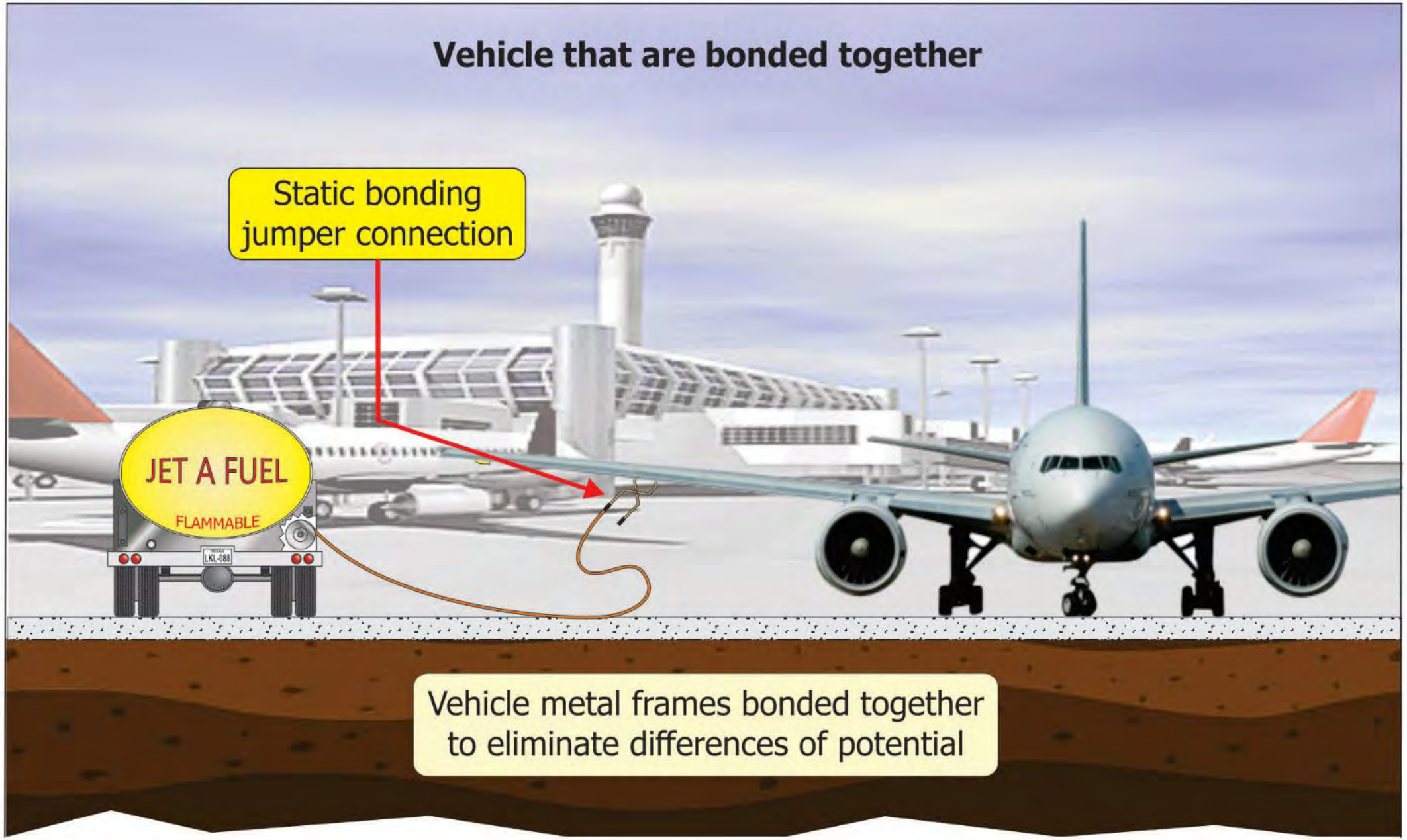
- The following illustrations graphically demonstrate the differences between the two concepts
- The following illustrations also show the two working together to provide desired protection
- ***Bonding*** conductive parts together minimizes the potential differences between them, even when the resulting system is not grounded
- ***Grounding*** (earthing), on the other hand, equalizes the potential differences between the objects and the earth
- Relationship between bonding and grounding is shown in the following slides

Grounded *(Grounding)*



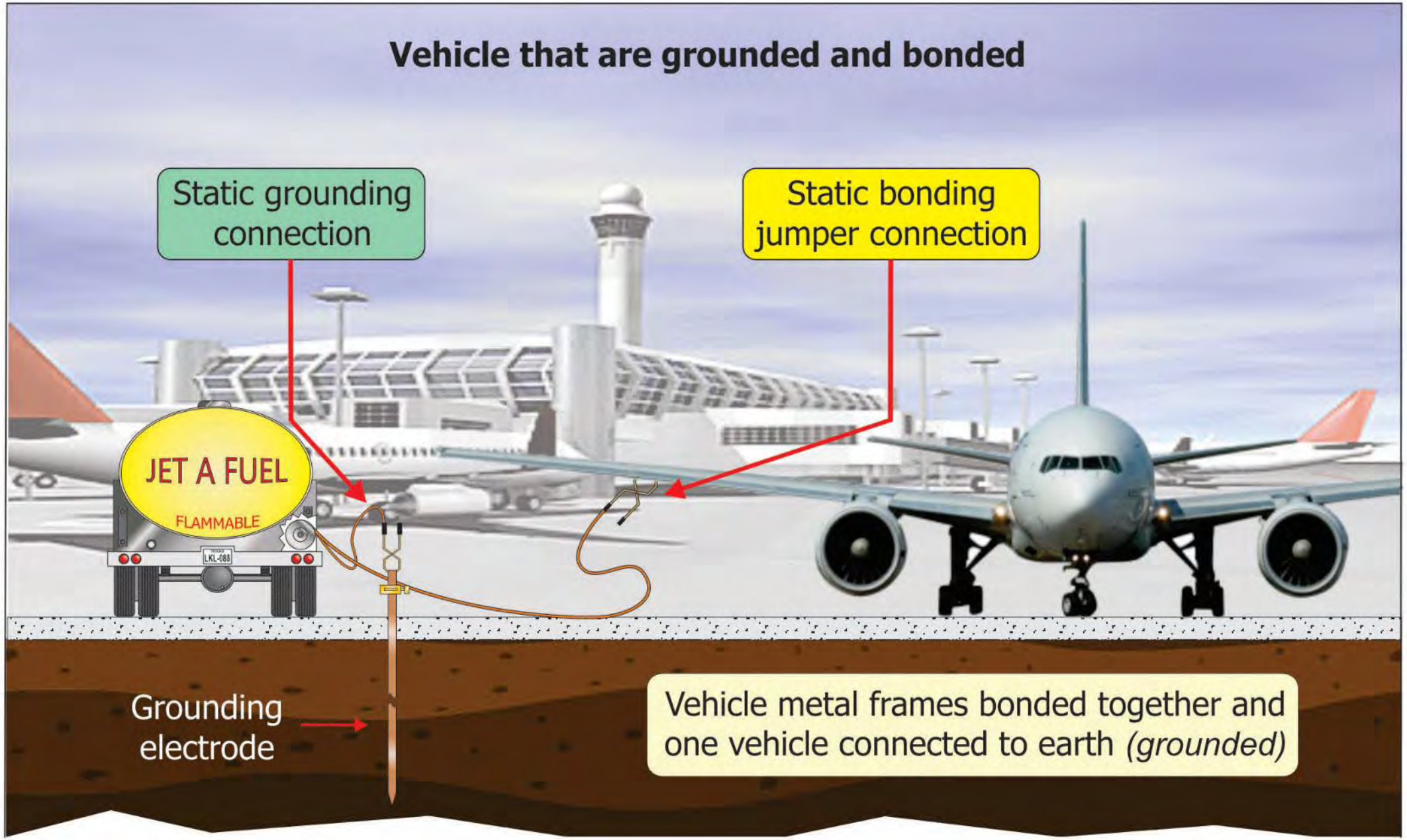
Copyright © IAEI 2020

Bonded *(Bonding)*



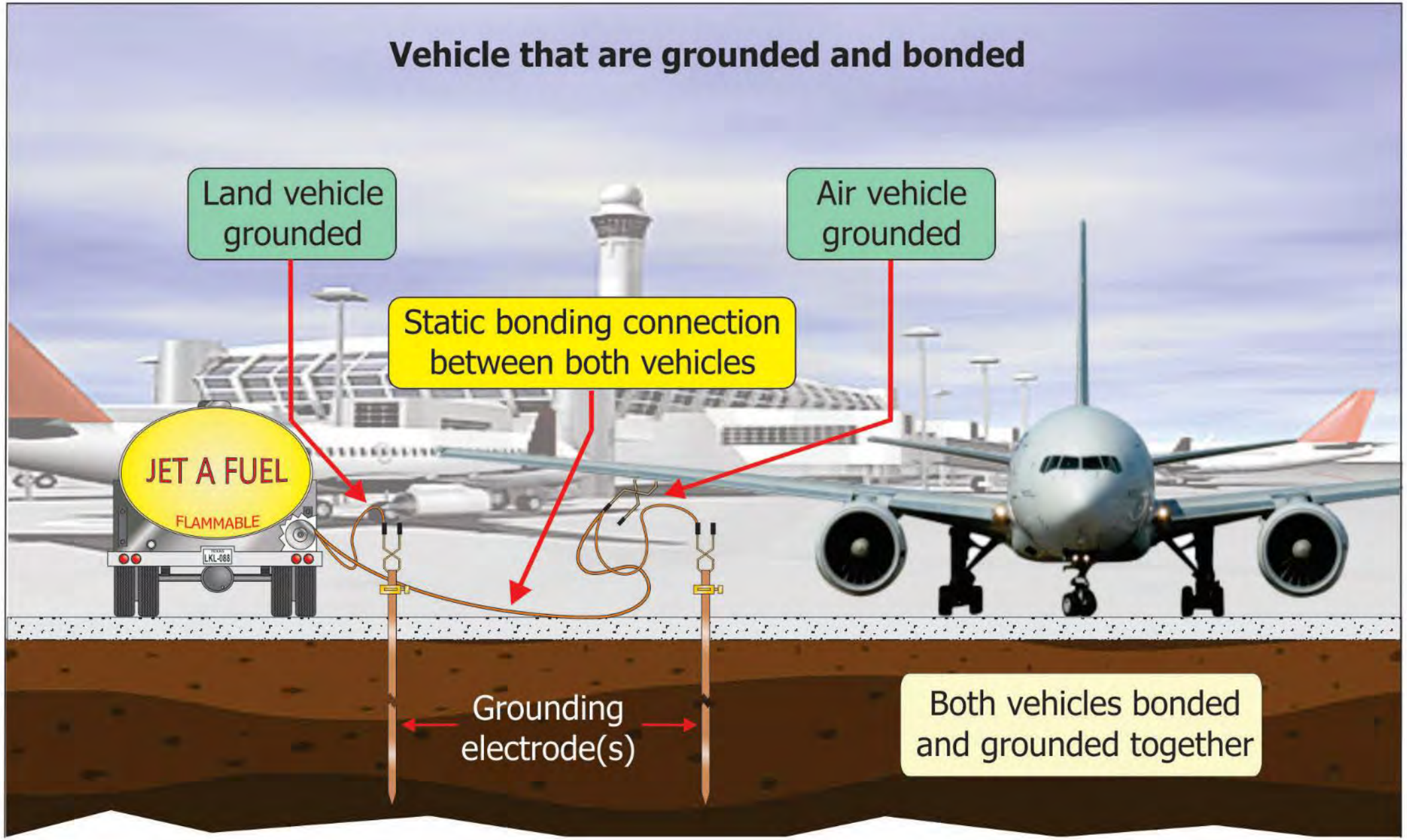
Copyright © IAEI 2020

Grounded and Bonded



Copyright © IAEI 2020

Grounded and Bonded



Copyright © IAEI 2020

Beyond the *NEC (cont.)*

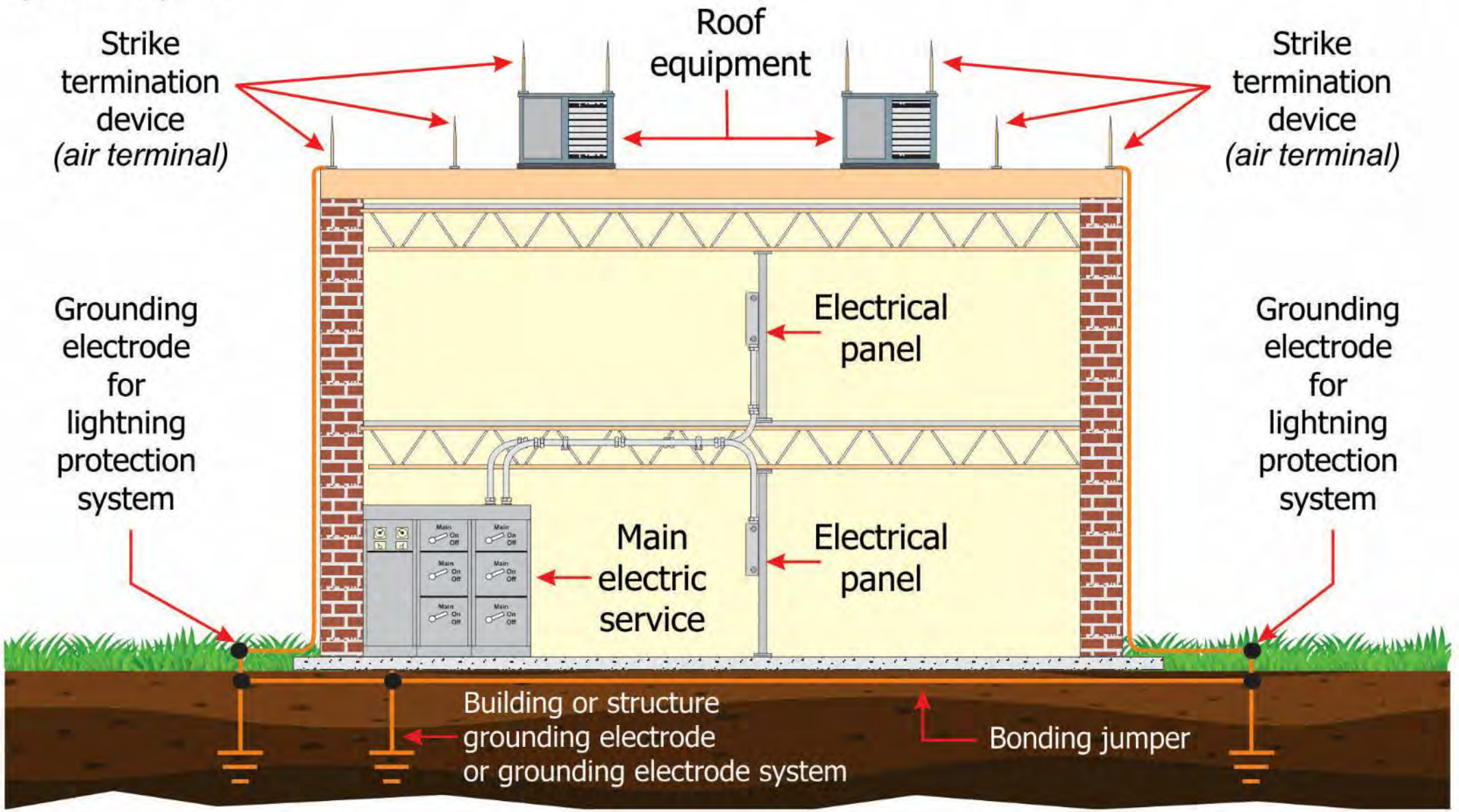
- The *NEC* provides references in the hazardous *(classified)* location articles to the document containing information about protection against static electricity
- **NFPA – 77 2017** is titled ***Recommended Practice on Static Electricity***
  - *Note: This is a recommended practice*
- The American Petroleum Institute (API) also has produced a document that addresses these concerns, which is titled ***Protection Against Ignitions Arising Out of Static Lightning and Stray Currents, API RP 2003-2015***
- *See NEC 500.4 Informational Note No. 2*

Lightning Protection

- The requirements for lightning protection systems are provided in **NFPA 780** ***Standard for the Installation of Lightning Protection Systems***
- These requirements are beyond the scope of the *NEC*
- The *NEC* requires grounding electrode systems covered by the *NEC* to be bonded to the grounding terminal system for lightning protection covered by NFPA 780
- Lightning discharges usually consist of **very large currents** of extremely **short duration**
- Protection is accomplished by deliberately providing a path of low resistance to earth, compared to other paths
- *See 250.106*

250.106 Bonding of Grounding Systems Together

Bonding of building grounding electrode system to strike termination device of lightning protection system required



Copyright © IAEI 2020


Strike Termination Device
STOP

Grounding and Bonding in Health Care Facilities

- Must comply with at least two safety standards:
  - NFPA 70 *National Electrical Code*
  - NFPA 99-2018 *Standard for Health Care Facilities*
- These two standards provide minimum requirements for both the **initial installation** and for **maintenance and testing** of electrical systems in health care facilities
- Specific grounding and bonding requirements for patient care spaces as defined in Article 517
- Requirements contained in the *NEC* and NFPA 99 primarily built around providing **"redundant" grounding paths** *(two paths for grounding)*

Grounding in Patient Care Spaces

- Reasons for the extra or specialized requirements ***(redundant grounding paths)*** are given in the informational note following 517.11
- In a health care facility, it is difficult to prevent the occurrence of a **conductive or capacitive path** to or from the patient's body to some grounded object
- Conductive or capacitive path can be established accidentally or through instrumentation directly connected to the patient
- Other electrically conductive surfaces that can make an additional contact with the patient *(or instruments that can be connected to the patient)* then become possible sources of currents that can traverse the patient's body

Grounding in Patient Care Spaces *(cont.)*

- All branch circuits serving patient care spaces shall be provided with an effective ground-fault current path by installation in a **metal raceway system**, or cable having **metallic armor** or sheath assembly
- The metal raceway system, or metallic cable armor, or sheath assembly shall itself qualify as an equipment grounding conductor in accordance with 250.118 *[See 517.13(A)]*
- In addition to the metallic raceway, 517.13(B) requires an **insulated copper equipment grounding conductor** to be installed with the branch circuit conductors

“Redundant” Grounding in Patient Care Spaces

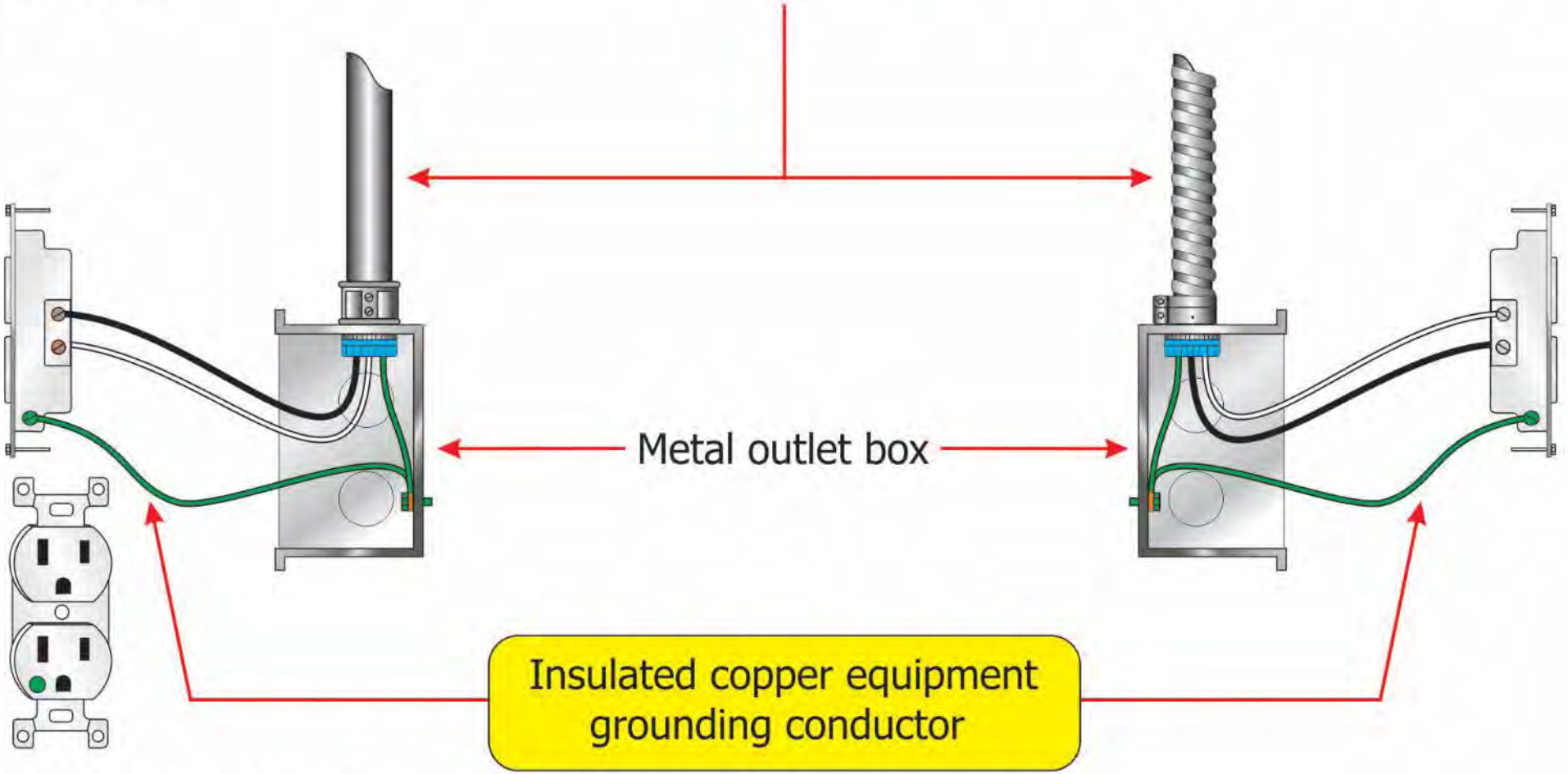
- Both the qualified metal raceway or cable armor and the additional wire type EGC are commonly called **“redundant” grounding** required in patient care spaces of health care facilities
- The term **“redundant”** is commonly used but is not the language used in the *NEC* which **can cause some confusion**
- The term **“redundant”** implies that one of the two items is not really needed *(and that is false)*
- Both the metal raceway and wire type equipment grounding conductors are considered **equal** and **both are required**

“Redundant” Grounding in Patient Care Spaces *(cont.)*

- Basic concept is to require **two equipment grounding paths** to be installed for electrical equipment in patient care spaces to assure that at **least one positive return path** for fault current is always present if either one or the other should fail
- Requires the installation of **two suitable equipment grounding return paths** to ensure that at **least one path** provides the required effective equipment grounding path

Equipment Grounding in Patient Care Locations

Raceway, cable armor, or sheath assembly **must qualify** as an equipment grounding return path as per 250.118



517.13(A) Wiring Methods *(metal raceways or metallic armor)*

517.13(B) Insulated Equipment Grounding Conductors and Insulated Equipment Bonding Jumpers

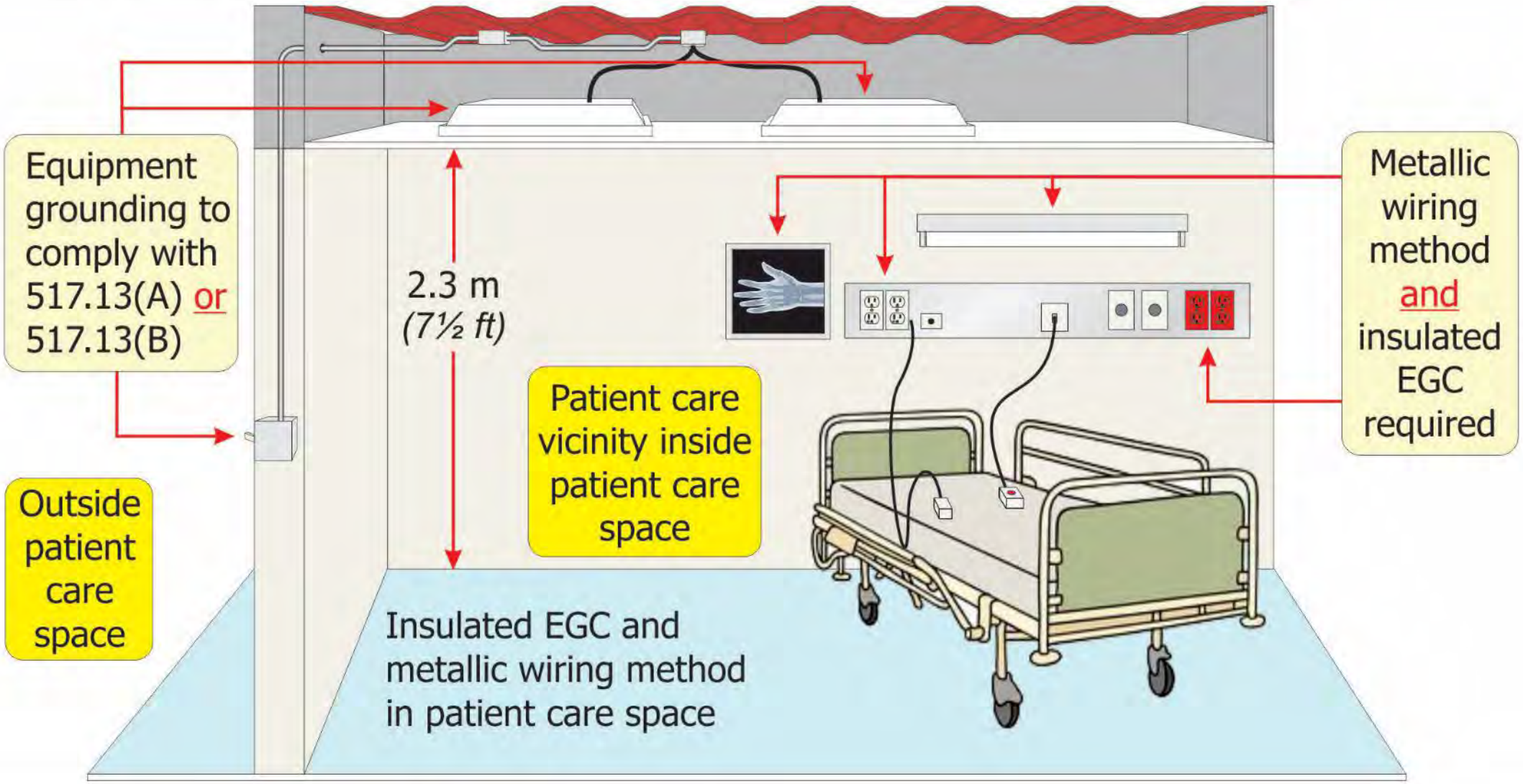
Copyright © IAEI 2020

Luminaires in Patient Care Spaces

- All non-current-carrying conductive surfaces of fixed electrical equipment *(including luminaires)* likely to become energized and operating at over 100 volts are required to be directly connected to an insulated copper EGC that is clearly identified along its entire length by green insulation and installed with the branch circuit conductors in the metallic wiring methods that also qualifies as an EGC *[see 517.13(B)(1)]*
- Exception No. 2 to this rule provides that luminaires in the patient care space *(but outside the patient care vicinity)* do have to be grounded by the wiring method EGC used to supply the luminaires, but **not with both** the metal raceway and the insulated equipment grounding conductor

517.13(B)(1) Ex. No. 2 Grounding of Switches and Luminaires

Luminaires more than 2.3 m *(7½ ft)* above floor and switches located outside the patient care vicinity do not require an insulated EGC in addition to metal raceway or cable armor



Copyright © IAEI 2020

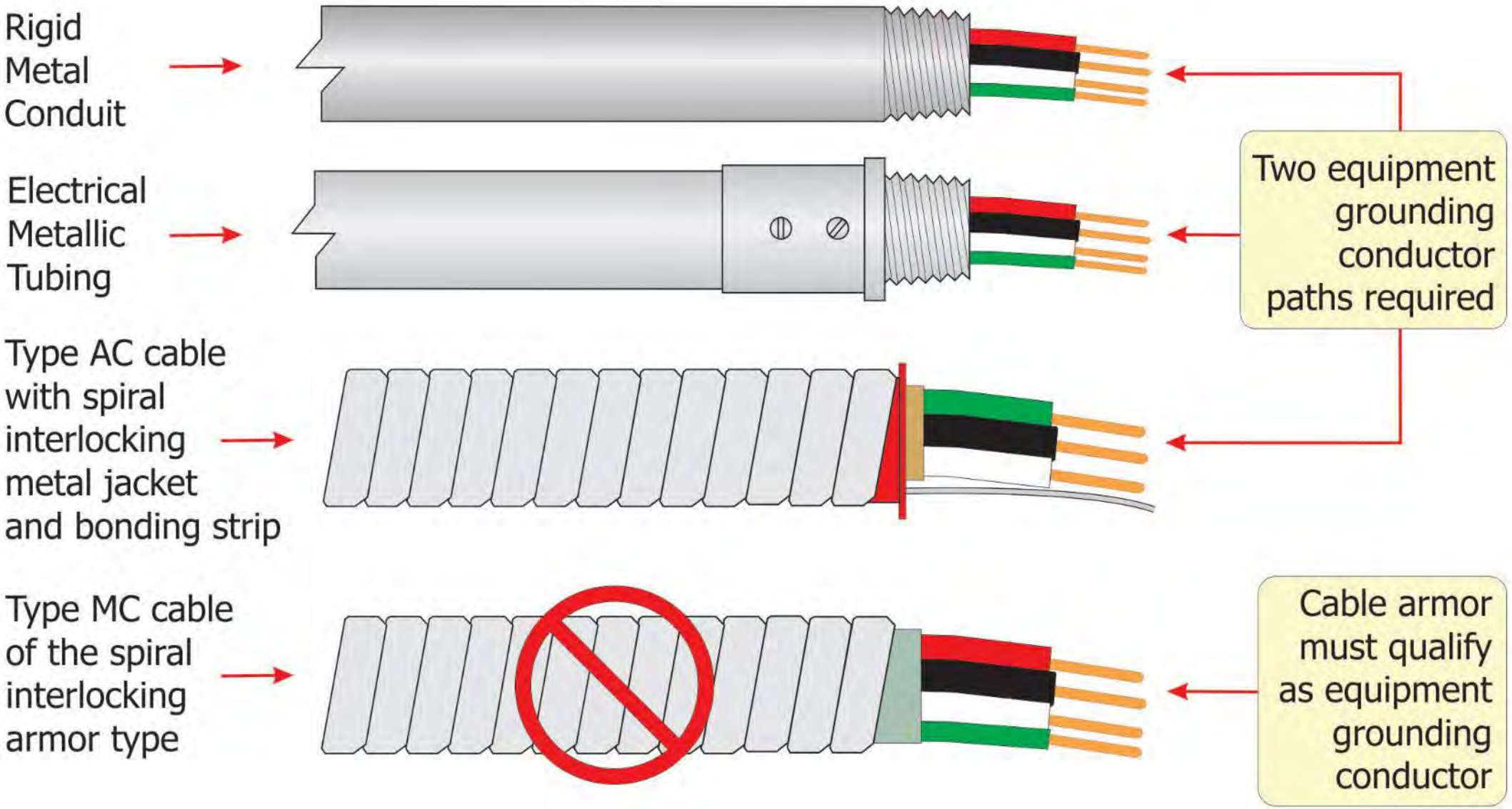

STOP!
CALL

Patient Care Space Wiring Methods *(Metallic)*

- Rigid metal conduit
- Intermediate metal conduit
- Electrical metallic tubing
- Listed flexible metal conduit *[max 1.8 m (6 ft) in ground-fault return path, max 20-amp OCPD, listed fittings]*
- Armor of listed Type AC cable where the outer jacket is identified as an equipment grounding conductor
- Type MC cable that provides two grounding paths as required by 517.13(A) and (B)

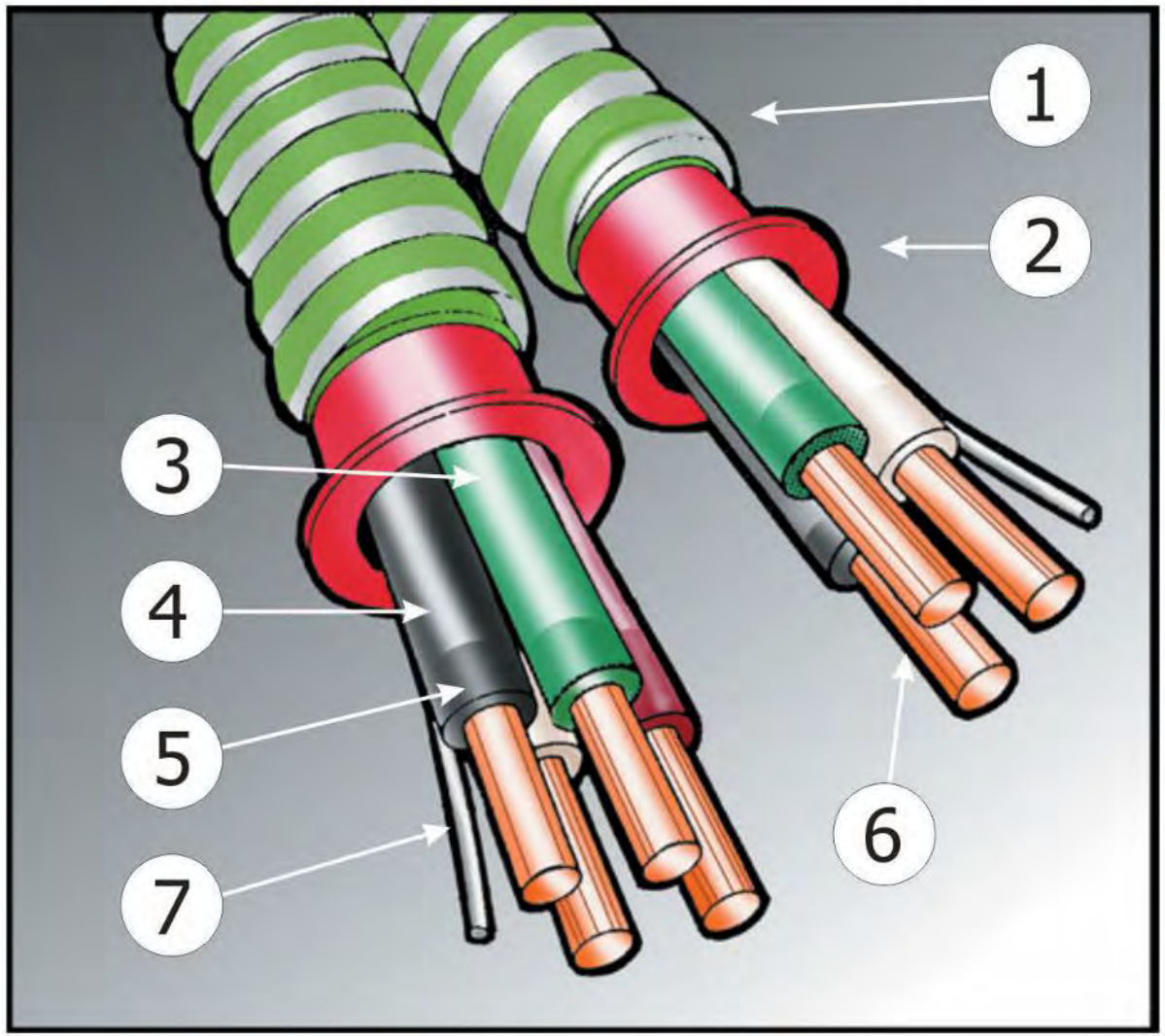
517.13 Two Equipment Grounding Paths Required

Some wiring methods permitted for patient care spaces



Copyright © IAEI 2020

Type AC Cable for Health Care Facilities



1. Galvanized steel armor
2. Insulated bushing
3. Green insulated equipment grounding conductor
4. Nylon
5. Thermoplastic insulation 90°C rated
6. Copper conductors
7. Bonding wire

Copyright © IAEI 2020

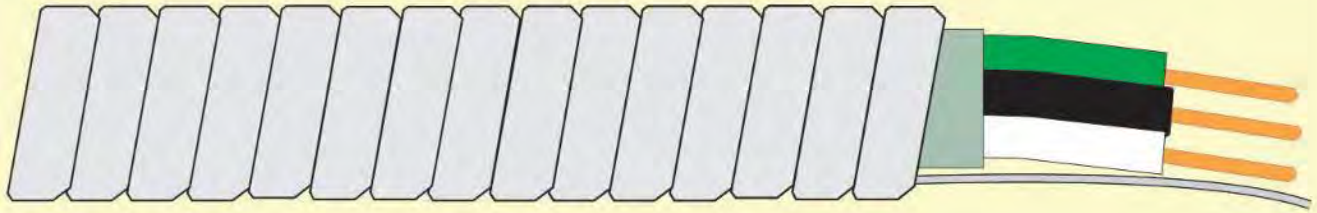
Patient Care Area
Wiring Methods *(Metallic) (cont.)*

- Listed Type MI cable and Type MC cable where the outer jacket is identified as an equipment grounding conductor
- Listed liquidtight flexible metal conduit:
  - Not more than 1.8 m (6 ft) in ground-fault return path
  - Maximum 20-amp OCPD for metric designators 12 through 16 (trade sizes ⅜ and ½)
  - Maximum 60-amp OCPD for metric designators 21 through 35 (trade sizes ¾ through 1¼)
  - Terminated in listed fittings

Types of MC Cable in Patient Care Areas

Two equipment grounding conductor paths required

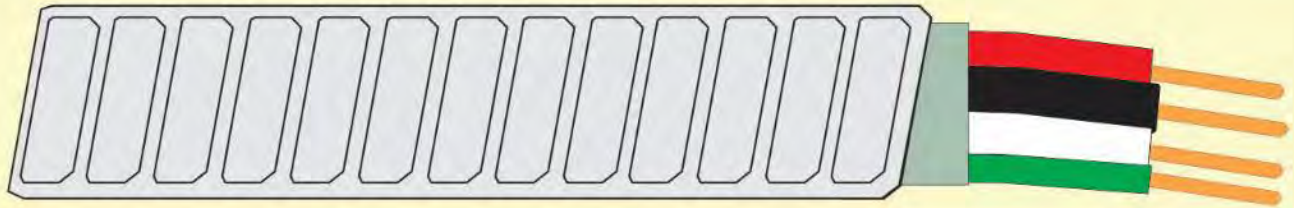
Interlocking metal tape-type with armor bonding conductor



Smooth tube

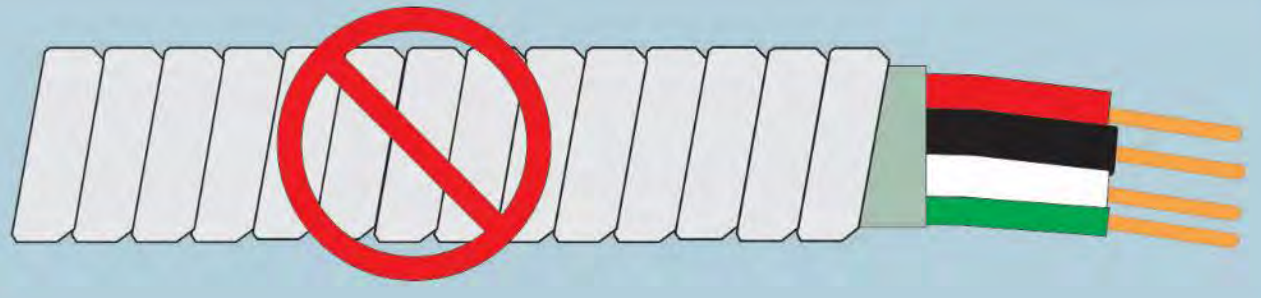


Corrugated tube



Interlocking metal armor type

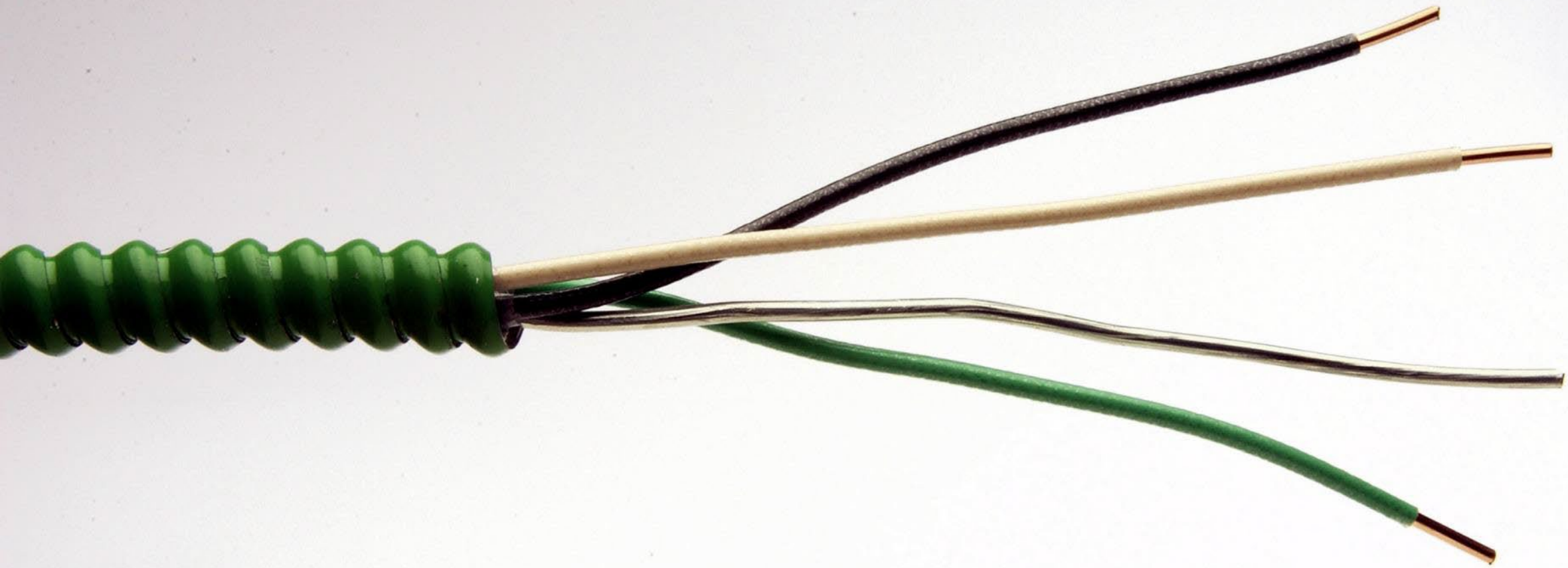
Cable armor must qualify as equipment grounding conductor



Copyright © IAEI 2020

Type MC Cable Armor as Grounding Path

- There is one type of MC cable that has an interlocking metal tape construction, and the armor is recognized as an EGC
- This and other MC cables are listed and evaluated to **UL Standard 1569**
- Fittings suitable for the use are required
- Installing in accordance with the manufacturer's installation instructions is required *[NEC 110.3(B)]*
- This type of MC cable *(providing two grounding paths)* is suitable for use where two grounding paths are required by the *NEC* for installations such as branch circuits in patient care areas or isolated grounding circuits often used for sensitive electronic equipment



1553

Type MC HCF MC AP® Cable *Courtesy of Southwire Company*

Patient Care Area
Wiring Methods *(Metallic) (cont.)*





Testing of Grounding System in Patient Care Spaces

- NFPA 99, *The Standard for Health Care Facilities*, requires the **integrity of the equipment grounding path** provided by the wiring method in patient care spaces to be tested:
  - Before acceptance of the initial installation and…
  - After any alterations or replacement of the electrical system is made
- Both voltage and impedance measurements must be made of exposed conductive surfaces and include the grounding contacts of receptacles in the patient-care vicinity
- *See NFPA 99: 6.3.3.1.1.1 and 6.3.3.1.1.4*

Testing of Grounding System in Patient Care Spaces *(cont.)*

- NFPA 99, *The Standard for Health Care Facilities*, requires the **integrity of the equipment grounding path** provided by the wiring method in patient care spaces be tested: *(cont.)*
- Excluded from the testing requirements are **small, wall-mounted conductive surfaces not likely to become energized**, such as surface-mounted towel and soap dispensers, mirrors and the like *[NFPA 99: 6.3.3.1.1.2]*
- Also exempt are **large, metal conductive surfaces not likely to become energized**, such as window frames, door frames, and drains *[NFPA 99: 6.3.3.1.1.3]*
- Testing should include all the grounding system, including both metallic raceway and equipment grounding conductor, as an integral system

Testing of Grounding System in Patient Care Spaces *(cont.)*

- The voltage and impedance measurements must be measured against a **reference point**
- The reference point is permitted to be one of the following as provided in NFPA 99, 6.3.3.1.1.2:

  (1) A reference grounding point

  (2) Grounding point, in or near the room under test, that is electrically remote from receptacles (e.g.an all-metal cold-water pipe)

  (3) Grounding contact of a receptacle that is powered from a different branch circuit from the receptacle under test

Testing of Grounding System in Patient Care Spaces *(cont.)*

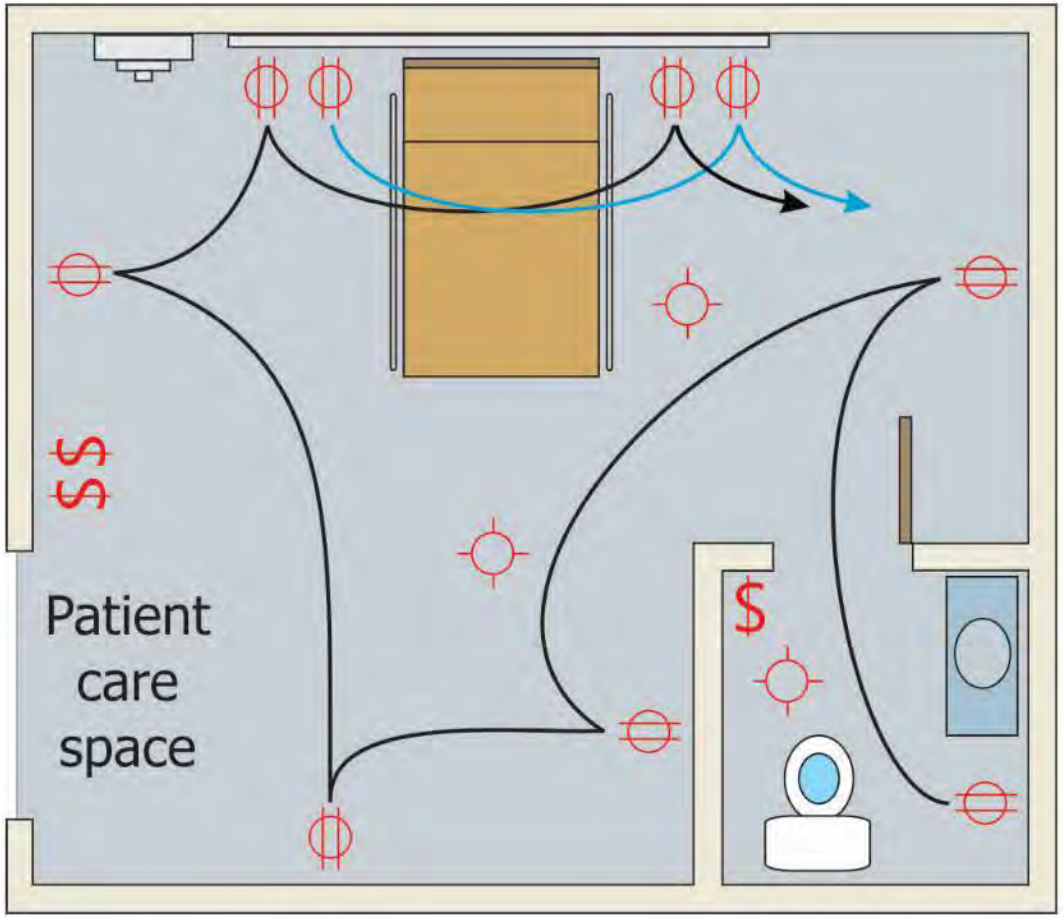
- The criteria for new construction that must be met are as *follows [NFPA 99: 6.3.3.1.6]*:

  (1) The voltage limit is 20 mV

  (2) The impedance limit shall be 0.2 ohm for systems containing isolated ground receptacles and 0.1 ohm for all others

Testing Grounding System in Patient Care Space *(NFPA 99)*

Voltage and impedance measurements from one of the following as the reference point:



Testing of grounding system in patient care spaces:

1. Reference grounding point
   [NFPA 99: 6.3.3.1.2(1)]
2. Remote grounding point in room
   [NFPA 99: 6.3.3.1.2(2)]
3. Grounding contact on receptacle from different branch circuit
   [NFPA 99: 6.3.3.1.2(3)]

Criteria to be met for new construction:
[NFPA 99: 6.3.3.1.6]

1. Voltage max. 20 mV
2. Impedance *(general)* max. 0.1 ohm
3. Isolated ground receptacle circuits max 0.2 ohm

Copyright © IAEI 2020

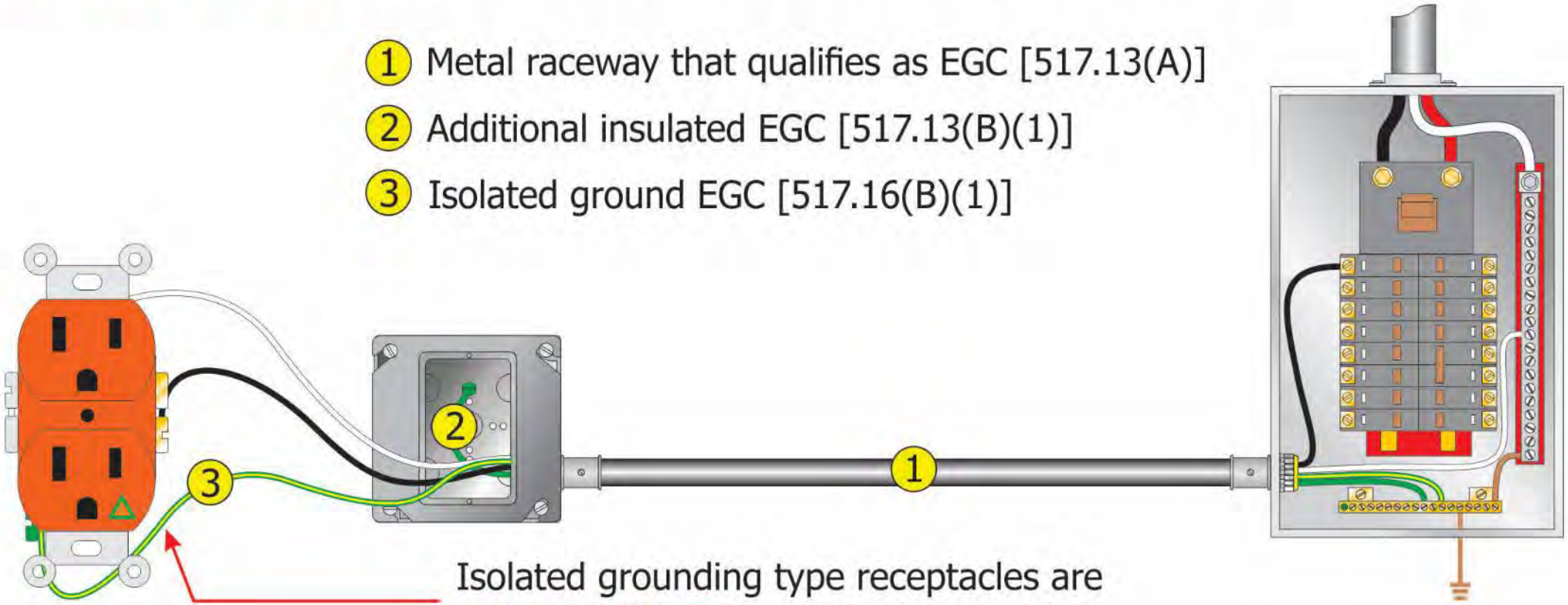
Use of Isolated Ground Receptacles

- The 2014 *NEC* prohibited the use of isolated ground receptacles in all patient care vicinities
- 2017 *NEC* added provisions for where and when isolated ground receptacles can be used outside the patient care vicinity but within the patient care space
- Equipment grounding path consists of the **metal raceway** [517.13(A)] plus the **additional wire type EGC** [517.13(B)] and a **third equipment grounding path of a wire type EGC** [250.146(D)] for the IG receptacle
- EGC required by 517.13(B) to be colored **green** *(no yellow stripes)*
- Isolated EGC must be colored **green with yellow stripes**

517.16 Use of Isolated Ground Receptacles

The installation of isolated ground receptacles located inside a patient care space but outside of a patient care vicinity is permitted but cannot defeat the purpose of 517.13

1. Metal raceway that qualifies as EGC [517.13(A)]
2. Additional insulated EGC [517.13(B)(1)]
3. Isolated ground EGC [517.16(B)(1)]



Isolated grounding type receptacles are **not permitted** in a patient care vicinity

The prohibition of isolated ground receptacle inside a patient care vicinity are addressed in 517.16(A) and isolated ground receptacles installed outside a patient care vicinity are addressed in 517.16(B)

Copyright © IAEI 2020

Bonding of Panelboards in Patient Care Spaces

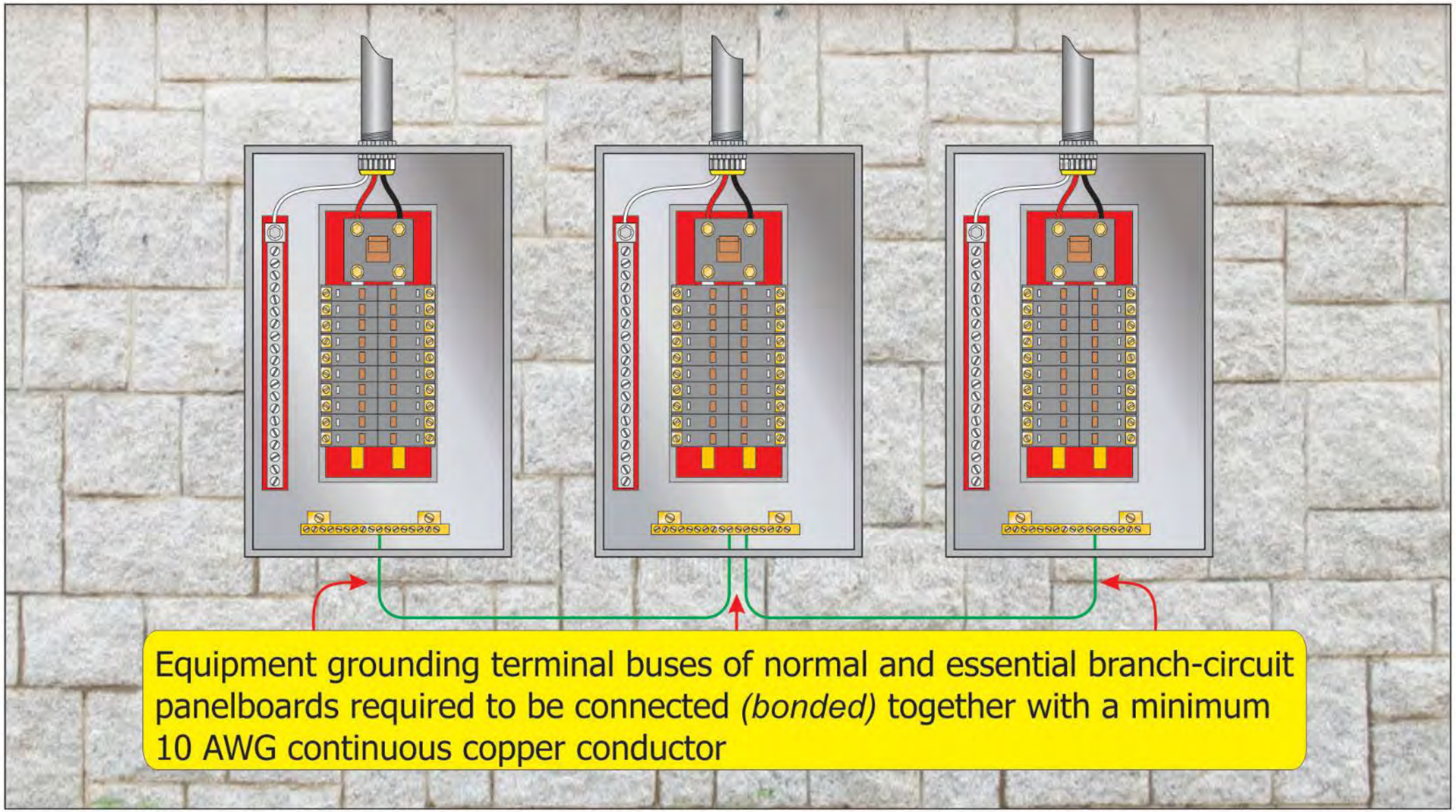
- Equipment grounding terminal buses of the normal and essential branch-circuit panelboards serving the same individual patient vicinity are required to be **connected together** with an insulated continuous copper conductor not smaller than 10 AWG
- Where two or more panelboards serving the same individual patient care vicinity are served from separate transfer switches on the essential electrical system, the equipment grounding terminal buses of those panelboards shall be **connected together** with an insulated continuous copper conductor not smaller than 10 AWG
- This conductor must be **continuous from panelboard to panelboard** but permitted to be broken in order to terminate on the equipment terminal bus in each panelboard

Bonding of Panelboards in Patient Care Spaces *(cont.)*

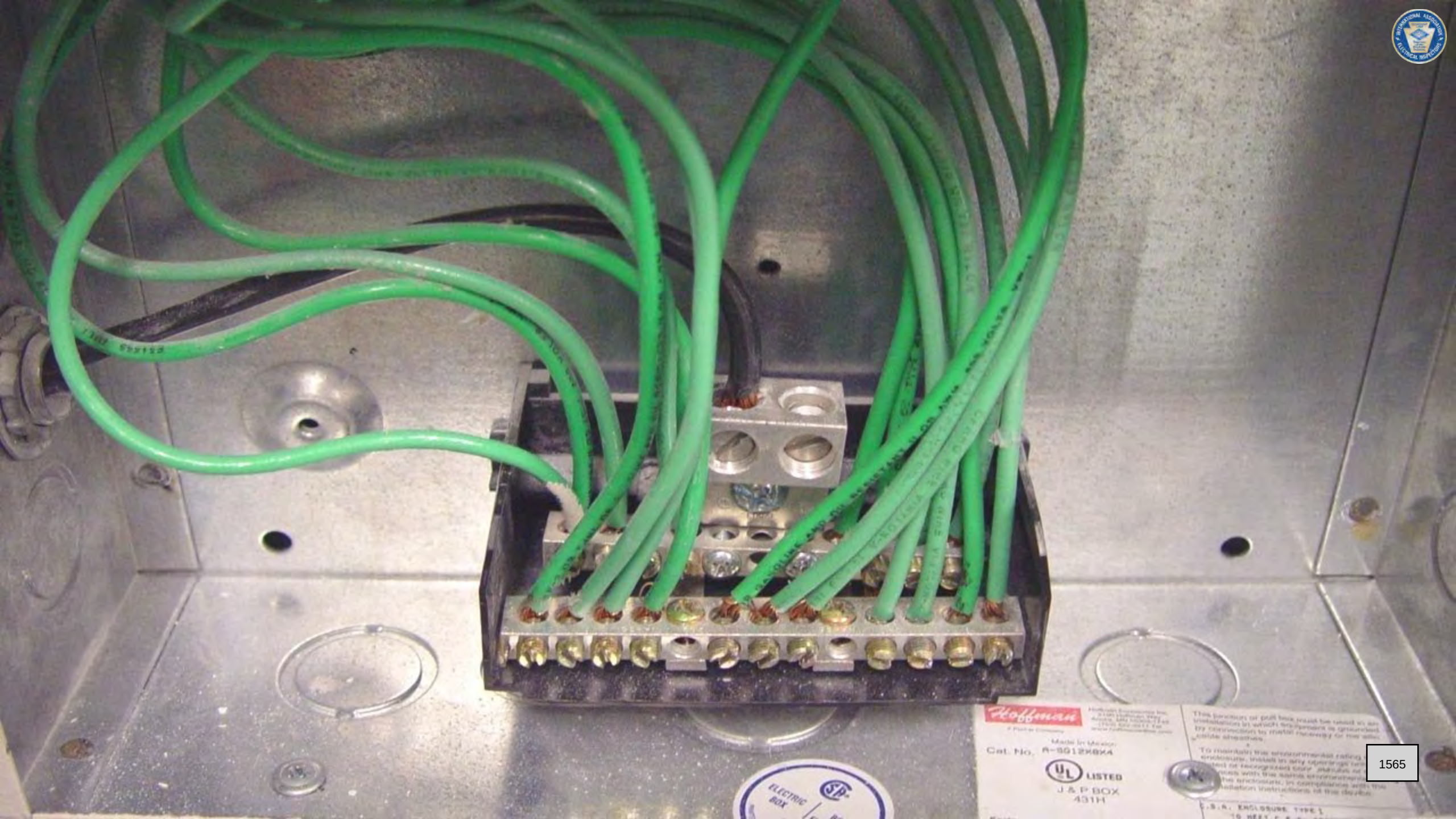
- This bonding is provided to **equalize the potential** of electrical equipment in the patient vicinity that might be supplied from two different panelboards
- This is especially important should a line-to-ground fault occur in one piece of equipment while another piece of equipment in the same patient vicinity is in a stable condition
- The 10 AWG bonding conductor helps keep the electrical equipment in the patient care vicinity at the **same potential** thus reducing the shock hazard
- See 517.14
- *Note: The 10 AWG copper is the minimum size (increase in size for long runs is a design issue)*

517.14 Bonding Health Care Panelboards Together

Two or more panelboards serving the same patient care vicinity

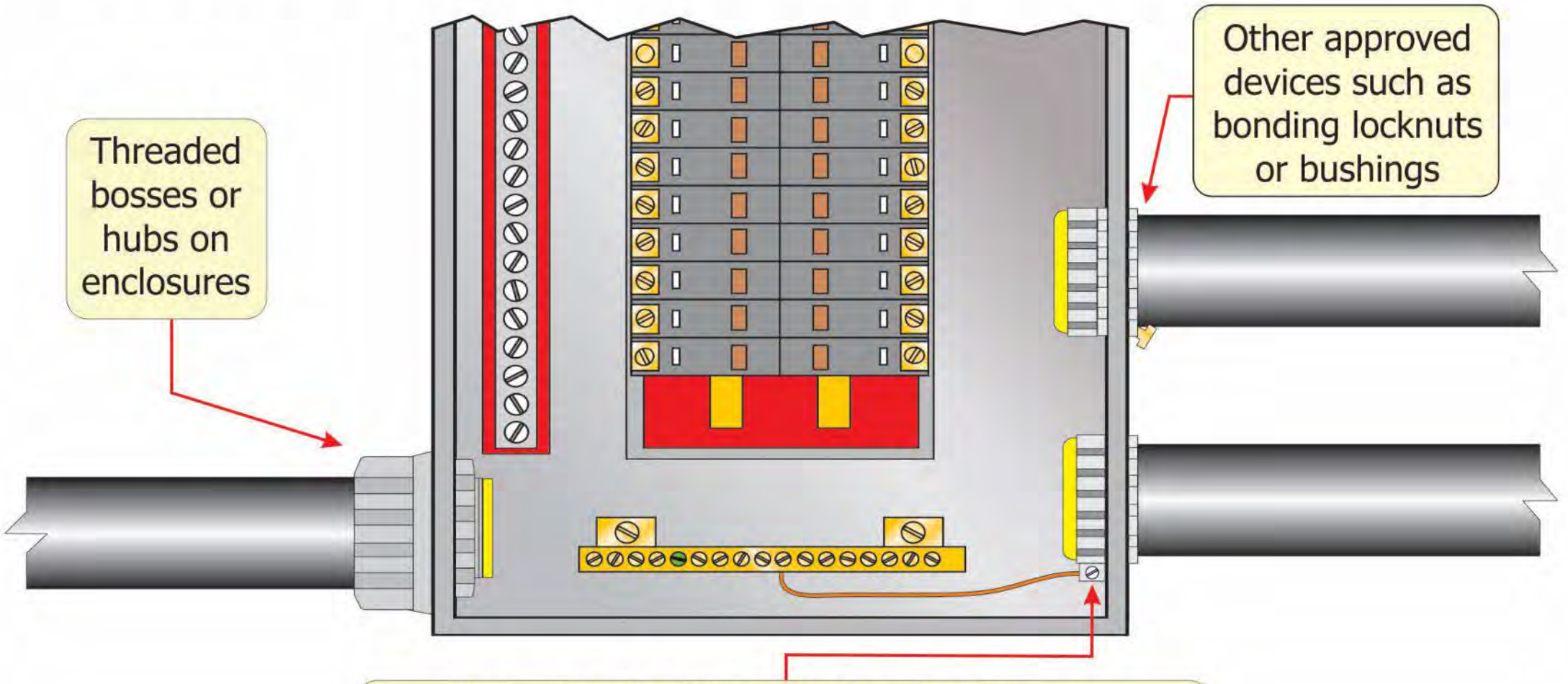


Copyright © IAEI 2020


Hoffman
Cat. No. A-SQ12X8X4
UL LISTED
J & P BOX
431H
1565

517.19(E) Bonding Requirements for Feeders

Where the feeder is in a metallic raceway, bonding enclosures and equipment such as panelboards, switchboards, and switchgear shall be ensured by one of the following methods:



Copyright © IAEI 2020

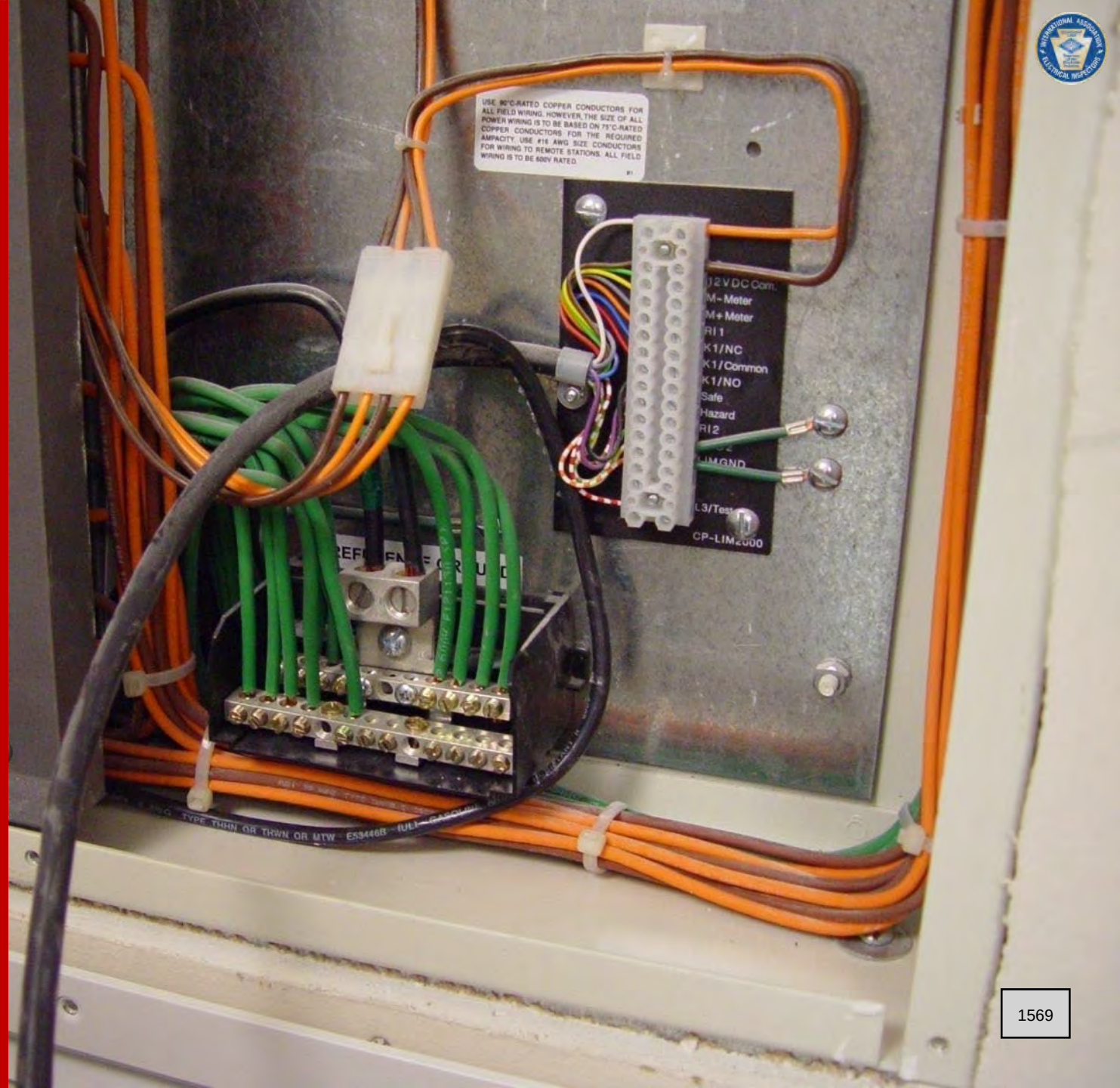
Isolated Power Systems Permitted as Protection Technique

- Isolated power systems are ungrounded systems by definition *(see 517.2)*
- Permitted to be used for **Category 1 *(critical care)* spaces**, and, if used, the isolated power system equipment shall be **listed as isolated power equipment**
- Must be designed and installed in accordance with 517.160
- Exception permits the **audible and visual indicators** of the line isolation monitor to be located at the **nursing station** for the area being served
- *See 517.19(F)*

Isolated Power Systems Permitted as Protection Technique *(cont.)*

- An isolated power system usually consists of a transformer that has an ungrounded secondary
- Conductive metal protective shield is placed between the primary and secondary windings *(shield is grounded)*
- Line isolation monitor with visual and audible alarms is provided to warn of excessive **line-to-ground leakage** as well as to indicate that a **line-to-ground fault on the secondary** has occurred
- Primary purpose is to allow equipment to function with first line-to-ground fault without opening an overcurrent device
- Faulty equipment can be repaired or replaced at the earliest opportunity but will remain in service until a second line-to-ground fault occurs ***(line-to-line fault)***


MAIN BREAKER
LIM Fuses
2AG 1A

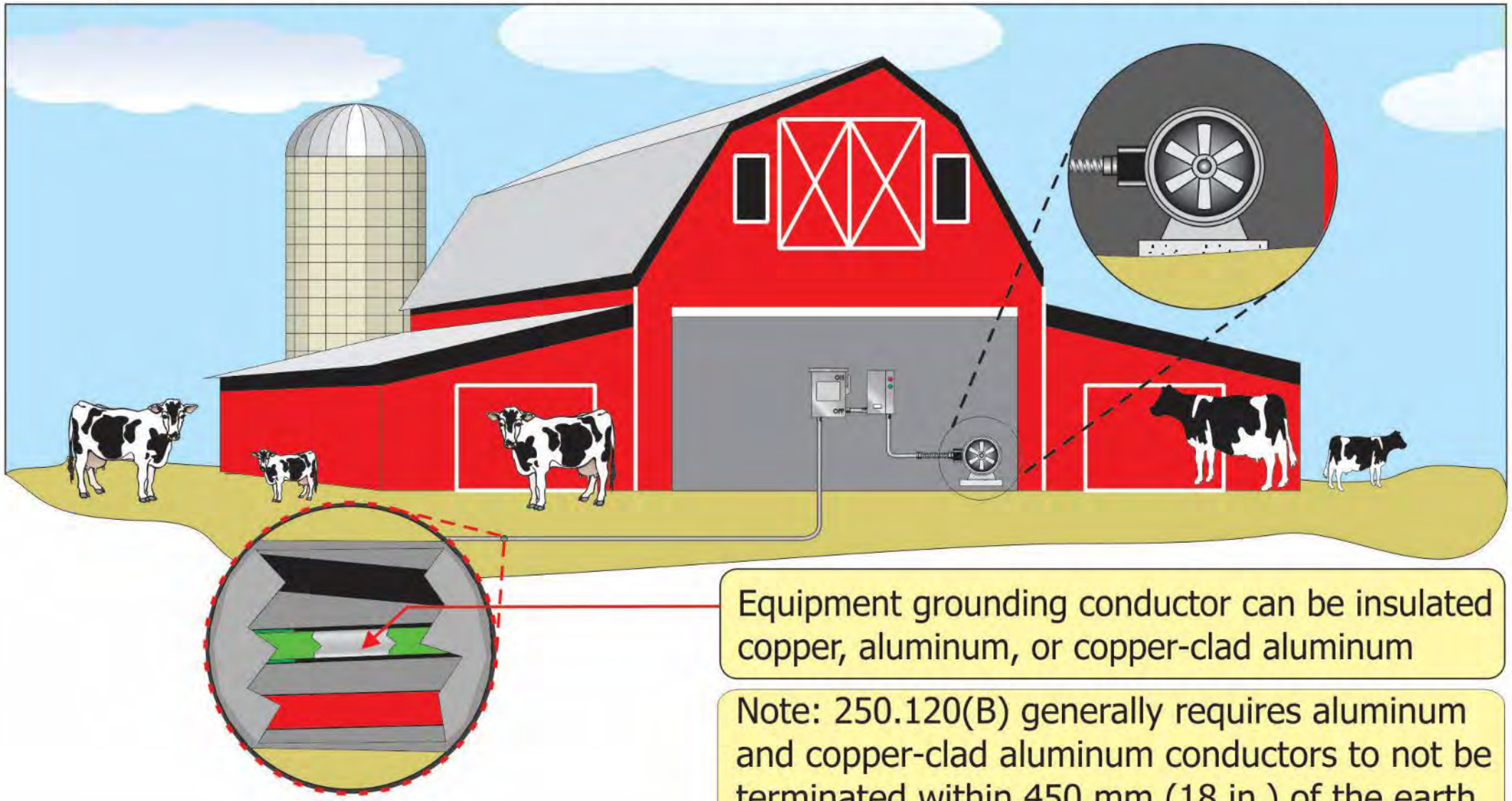

USE 90°C-RATED COPPER CONDUCTORS FOR ALL FIELD WIRING. HOWEVER, THE SIZE OF ALL POWER WIRING IS TO BE BASED ON 75°C-RATED COPPER CONDUCTORS FOR THE REQUIRED AMPACITY. USE #16 AWG SIZE CONDUCTORS FOR WIRING TO REMOTE STATIONS. ALL FIELD WIRING IS TO BE 600V RATED.
12VDC Com.
M- Meter
M+ Meter
RI 1
K1/NC
K1/Common
K1/NO
Safe
Hazard
RI2
CP-LIM2000
TYPE THHN OR THWN OR MTW E53446B

Bonding & Grounding at Agricultural Buildings

- Specific requirements regarding grounding and bonding
- Two major concerns:
  - **Integrity of the equipment grounding and bonding path(s)** due to corrosive conditions that can exist in these buildings *(especially where livestock are present)*
  - **Neutral-to-earth stray voltages**, if excessive, can cause negative behavior responses and can lead to loss of production and health problems in livestock
- Separate EGC *(not part of a listed cable assembly)* run underground to these locations must be **insulated** *(copper, aluminum, of copper-clad aluminum)*
- *See 547.5(F), 547.9 and Article 547*

Insulated Equipment Grounding Conductor *(Agricultural Buildings)*

Where a seperate equipment grounding conductor *(not part of a listed cable assembly)* is installed underground for agricultural building installations, EGC must be insulated *[see 547.5(F)]*



Equipment grounding conductor can be insulated copper, aluminum, or copper-clad aluminum

Note: 250.120(B) generally requires aluminum and copper-clad aluminum conductors to not be terminated within 450 mm (18 in.) of the earth

Copyright © IAEI 2020

Bonding & Grounding at Agricultural Buildings *(cont.)*

- Isolation of the grounded conductor *(usually the neutral)* at an additional building or structure served by a feeder or branch circuit on the same premises as the electrical service is required by 250.32(B)
- In the case of agricultural buildings, the conditions of 547.9(B) must be satisfied as well
- The two general methods for grounding and bonding are described on the next slide
- *See 250.32(B) and 547.9(B)*

547.9(B)(3) Grounding and Bonding *(Agricultural Buildings)*



Where the service disconnecting means and overcurrent protection is located at the agricultural building, grounding and bonding shall comply with 250.32 and...

1. The equipment grounding conductor *(EGC)* is to be the same size as the largest supply conductor if of the same material, or adjusted in size in accordance with the sizing columns of Table 250.122 if of different materials
2. The EGC is to be connected to the grounded circuit conductor and the site-isolating device enclosure at the distribution point

Copyright © IAEI 2020

Stray (Tingle) Voltage

- Livestock behavioral responses *(including production and health problems)* can be caused by **stray voltage** *(also referred to as tingle-voltages)*
- These voltages can appear between various portions of grounded or ungrounded metallic systems *(such as electrical equipment or piping systems)* and the earth or floor such that livestock can come between **two different potentials**
- Not uncommon to find voltage differences between adjacent concrete slabs or between a concrete slab and the adjacent earth
- For dairy cows, a voltage difference as low as **1 volt** can be detected and will have negative effects above **2 volts**

Equipotential Planes and Bonding of Equipotential Planes

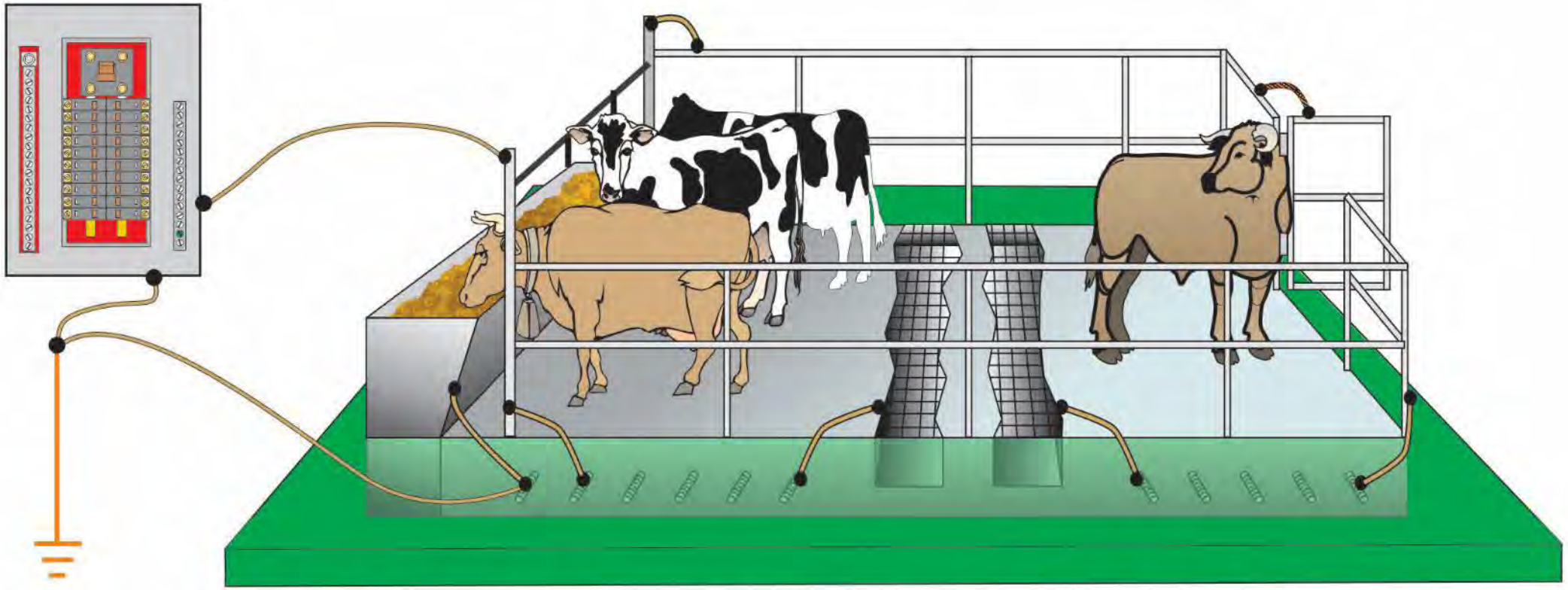
- Definition:
  - ***Equipotential Plane (as applied to agricultural buildings):*** "An area where wire mesh or other conductive elements are embedded in or placed under concrete, bonded to all metal structures and fixed nonelectrical equipment that may become energized, and connected to the electrical grounding system to minimize voltage differences within the plane and between the planes, the grounded equipment, and the earth."
- *See 547.2*

Equipotential Planes and Bonding of Equipotential Planes *(cont.)*

- **Indoor locations** requires equipotential plane(s) to be installed in confinement areas with concrete floors where metallic equipment may become energized and is accessible to livestock *[see 547.10(A)(1)]*
- **Outdoor confinement areas** *(such as feedlots)* shall have equipotential planes per 547.10(A)(2)
- Best method of controlling the effects of **stray voltages** on livestock
- Equipotential bonding does not correct or remove the faults that are causing the problem but keeps everything in the livestock area at the **same voltage potential**
- Prevents the livestock from being aware of and being affected by the stray voltage

547.10(B) Equipotential Planes - Bonding *(Agricultural Buildings)*

Equipotential planes must be installed in confinement areas with concrete floors *(indoors)* and areas with concrete slabs *(outdoors)* where metallic equipment is located that may become energized and accessible to livestock



The bonding conductor for the equipotential bonding plane at agricultural buildings is required to be a solid copper, insulated, covered or bare conductor, not smaller than 8 AWG

Copyright © IAEI 2020

Equipotential Bonding in Animal Confinement Areas



Equipotential bonding plane is required in animal confinement areas with concrete floors or slabs in ***indoor*** and ***outdoor*** locations

Copyright © IAEI 2020


899
506

CHAPTER SEVENTEEN

GROUNDING AND BONDING FOR SPECIAL CONDITIONS

Grounding and Bonding for Special Conditions

- Section 90.3 sets out the organization of the *NEC*
- The requirements in Chapters 1 to 4 **apply generally** except where **modified or expanded** in Chapter 5 *(Special Occupancies)*, Chapter 6 *(Special Conditions)*, or Chapter 7 *(Special Systems)*
- Section 90.3 also includes applicable requirements between Chapters 5, 6 and 7 *(rules in Chapter 7 can modify rules in Chapter 6, etc.)*
- This chapter will provide information and discussion on those modifications and expansions to the basic requirements relative to grounding and bonding where **special conditions** exist

Electric Signs and Outline Lighting Systems

- Requirements for grounding and bonding of **electric signs and outline lighting systems** are found at 600.7 and 600.32
- Article 600 supplements or amends rules in Article 250 *(for grounding and bonding)*
- For the newer technology **LED signs**, Article 725 *(remote-control, signaling, and power-limited circuits)* can be applied where needed
- Signs and metal equipment of outline lighting systems required to be grounded and bonded with several specific additional requirements
- Sign circuits and neon installations are not exempt from basic grounding requirements and they must be grounded

Electric Signs and Outline Lighting Systems *(cont.)*

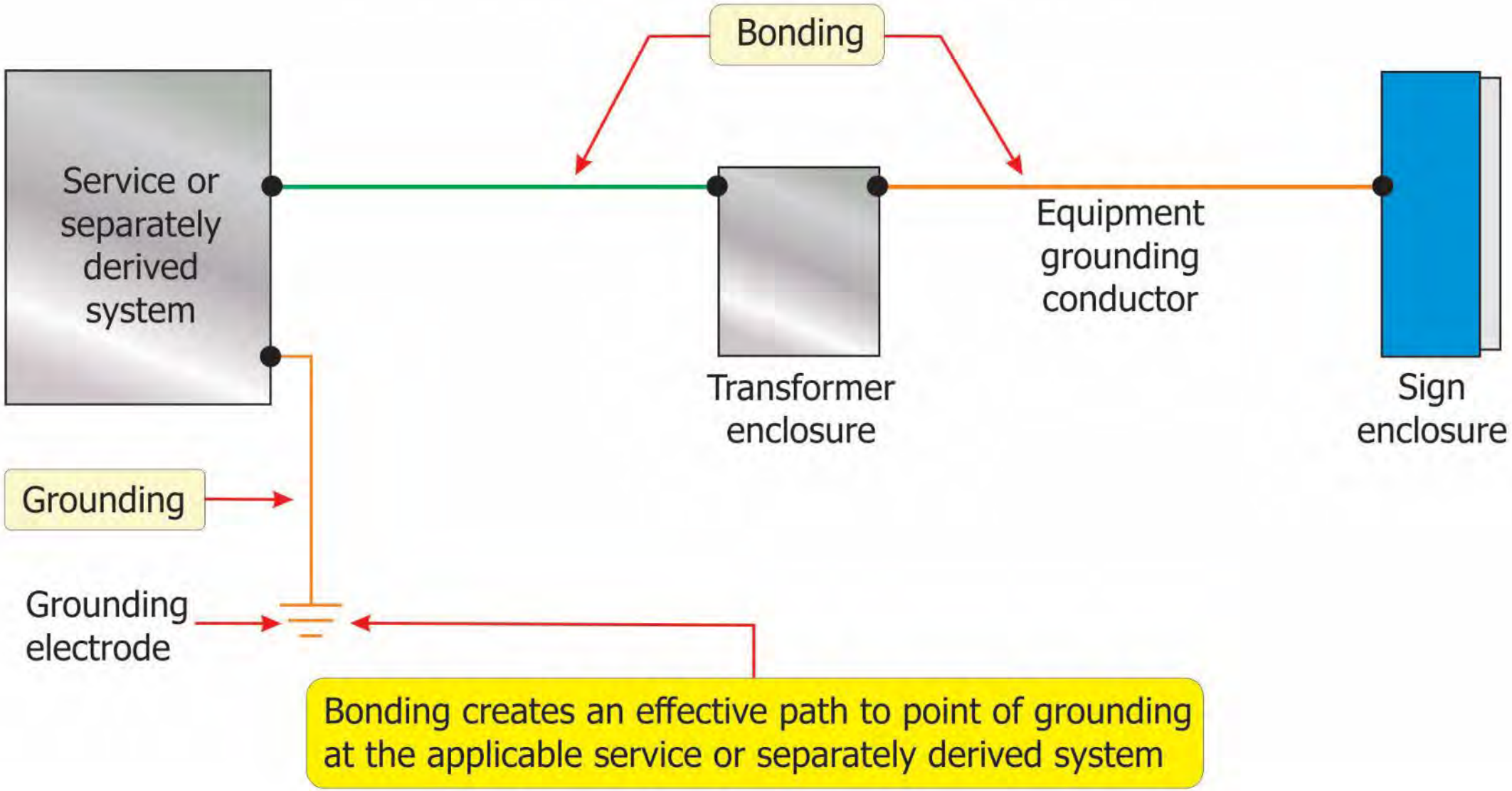
- Metal parts of buildings or structures are **not permitted** to be used as secondary return conductors or equipment grounding conductors *[250.121 and 600.7(B)(3)]*
- Spacing is required for secondary circuits installed in nonmetallic conduits from grounded or bonded metal parts and from the nonmetallic conduit where separate bonding conductors are installed *[600.7(B)(6) and 600.32(A)(4)]*
- Many signs now employ light-emitting diode (LED) technology, moving away from the high voltage systems associated with neon signs
- An exception to 600.7(B)(1) eliminates bonding conductor for remote metal parts of section signs or outline lighting systems when supplied by a remote Class 2 power supply *(such as for LED signs)*


McCallum
MARKET & DELI

Grounding and Bonding Basics for Signs

- Equipment grounding conductors (EGC) and proper bonding are essential elements for safety in electrical signs and neon installations
- The branch circuit supplying the equipment provides the required EGC for accomplishing the grounding *(the connection to earth or ground)*
- The acceptable EGCs are specified in 250.118 and the method of connection to the sign or metal enclosure is provided in 250.120(A) and 250.8
- The EGC must be connected to the equipment using methods consistent with 250.8

Grounding and Bonding Basics - Signs



Copyright © IAEI 2020

SMOOVE
Series
UL2
SGF

Article 600 – Electric Signs and Outline Lighting





Article 600 – Electric Signs and Outline Lighting






Hard Eight
Pit B·B·Q
ENTRANCE

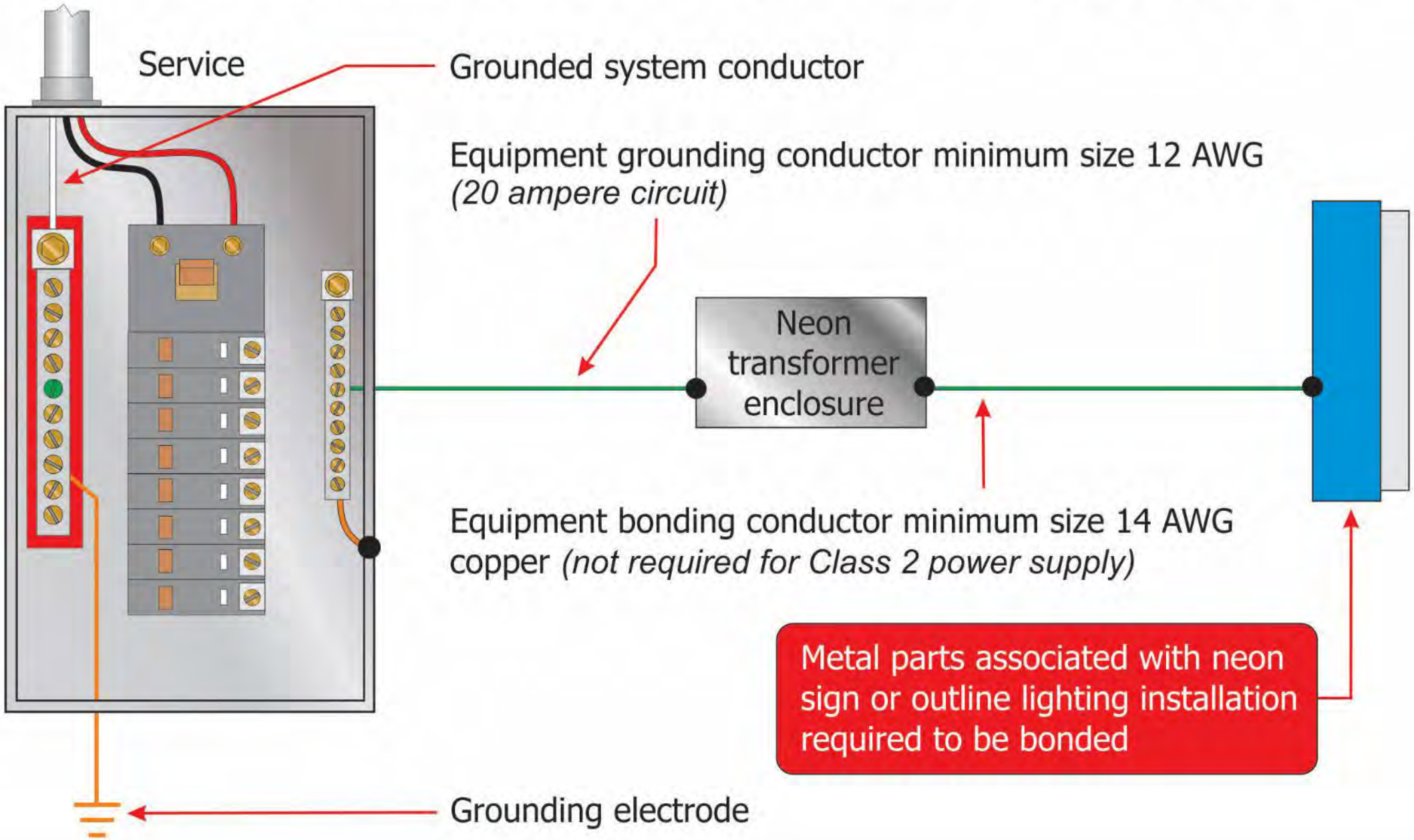

babe's
CHICKEN


FRESH OYSTERS
CRAB CAKES
SCALLOPS
SHRIMP COCKTAIL
CLAM CHOWDER
FRESH FISH

Equipment Grounding and Bonding for Signs

- The equipment grounding conductor (EGC) and proper bonding are essential elements for safety in electrical signs and neon installations
- The branch circuit supplying the equipment provides the required equipment grounding conductor for accomplishing the grounding *(connection to earth)*
- Minimum size wire-type EGC with the branch circuit must not be less than the sizes in **Table 250.122** based on the branch-circuit breaker or fuse rating
- EGC connects the equipment to ground and works to maintain it at or near earth's voltage potential
- *See 600.7*

600.7 Equipment Grounding and Bonding for Signs



Copyright © IAEI 2020

Bonding Requirements

- High voltage secondary circuits *(using gas tube sign and ignition cable type)*, such as GTO *(gas tube and oil)* cables in a wiring method that extends from the transformer to the discharge tubing for neon installations produce various levels of **capacitance**
- Capacitance is inherent to these secondary circuits and is unavoidable
- Capacitance coupling in the neon or cold cathode secondary circuit can actually raise the potential *(voltage)* on ungrounded metal equipment and metal parts if not bonded together and connected to ground

Flexible Metal Conduit as a Bonding Means

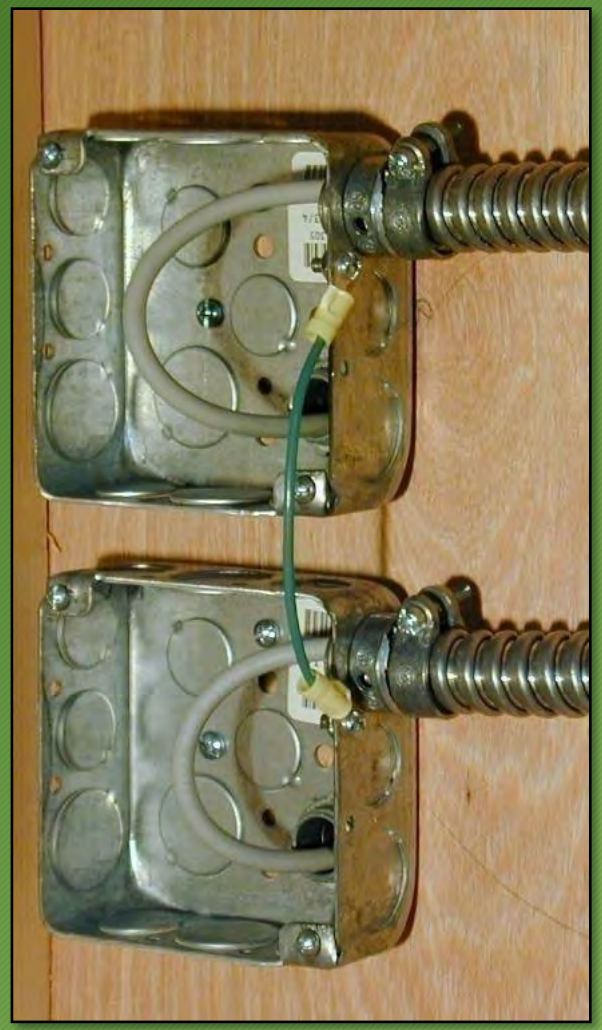
- The *Code* allows for listed **flexible metal conduit** or listed **liquidtight flexible metal conduit** to be used as a bonding means in total accumulative lengths not exceeding **30 m (100 ft)** on the secondary side of the sign transformer or power supply
- Flexible metal conduits are suitable as a bonding means since the current on the secondary side of a neon transformer is in the milliampere range
- Bonding provided through the conduit or bonding conductor here is not to clear an overcurrent device on the primary (supply side) of the neon transformer or power supply
- *See 600.7(B)(4)*

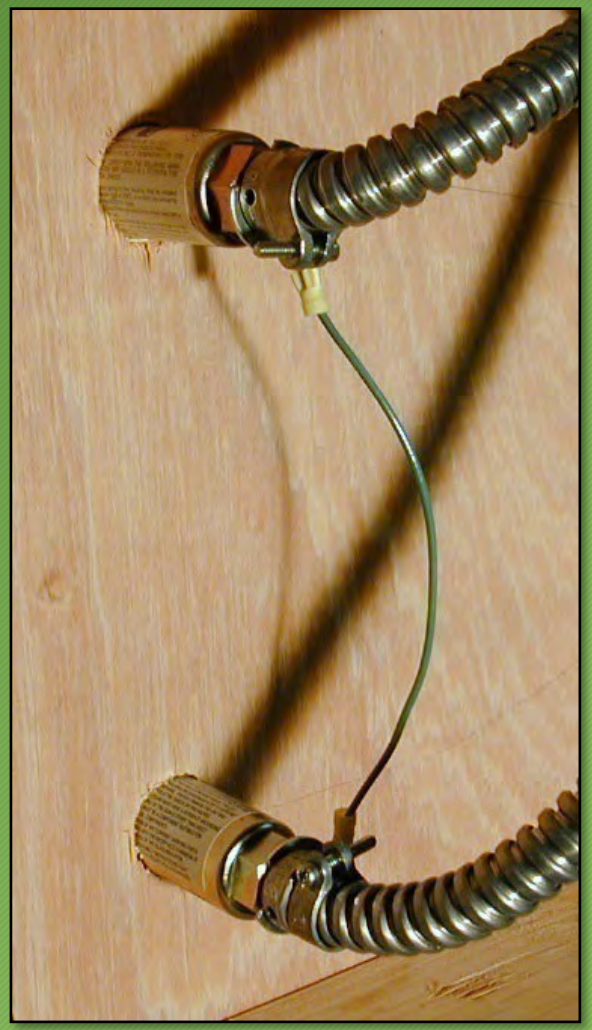
Flexible Metal Conduit as a Bonding Means *(cont.)*

- Length limitation on secondary GTO conductors:
  - **6 m (20 ft)** installed in metallic wiring methods
  - **16 m (50 ft)** installed in nonmetallic wiring methods
- Length limitation required to minimize the capacitance effect in the secondary that impacts both the secondary conductors *(GTO cable)* and the transformer
- See 600.32(J)(1) and (2)



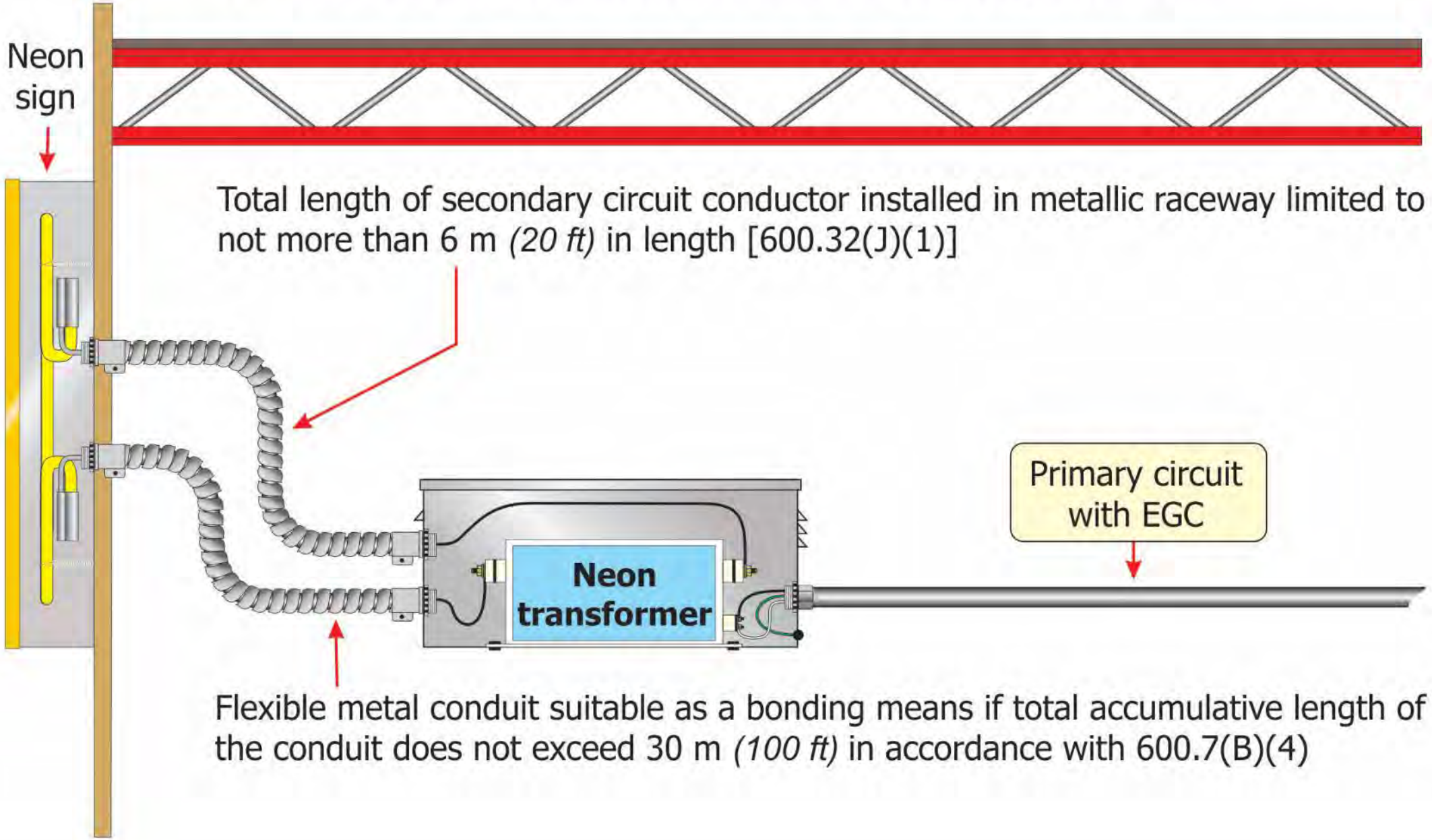
Bonding Conductor for Bonding Metal Parts





- These photos show a 14 AWG bonding conductor being used for bonding metal parts associated with a field-installed neon skeleton tubing installation

Flexible Metal Conduit as a Bonding Means



Copyright © IAEI 2020

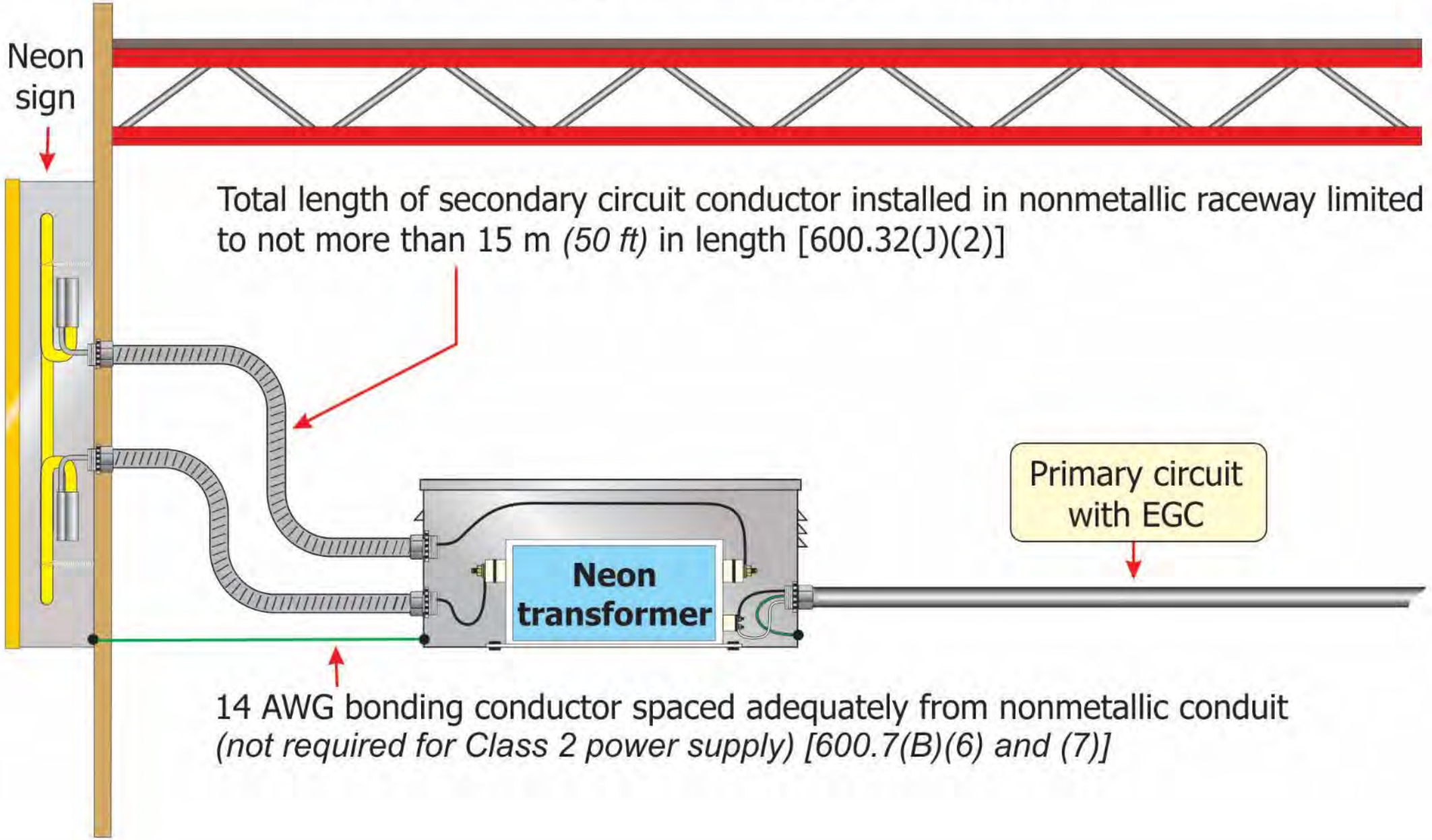
Bonding Requirements *(cont.)*

- Where listed **nonmetallic conduit** is used for installing the secondary high voltage GTO conductors from the transformer or power supply to the neon tubing and where there are associated metal parts that require bonding, a **bonding conductor** is required to be installed
- Bonding conductor shall be:
  - Installed separate and remote from the nonmetallic conduit
  - Copper
  - Not smaller than 14 AWG
- Spacing requirement established to reduce stresses that might be imposed on the GTO conductor due to magnetic flux lines no longer symmetrical around the conductor

Bonding Requirements *(cont.)*

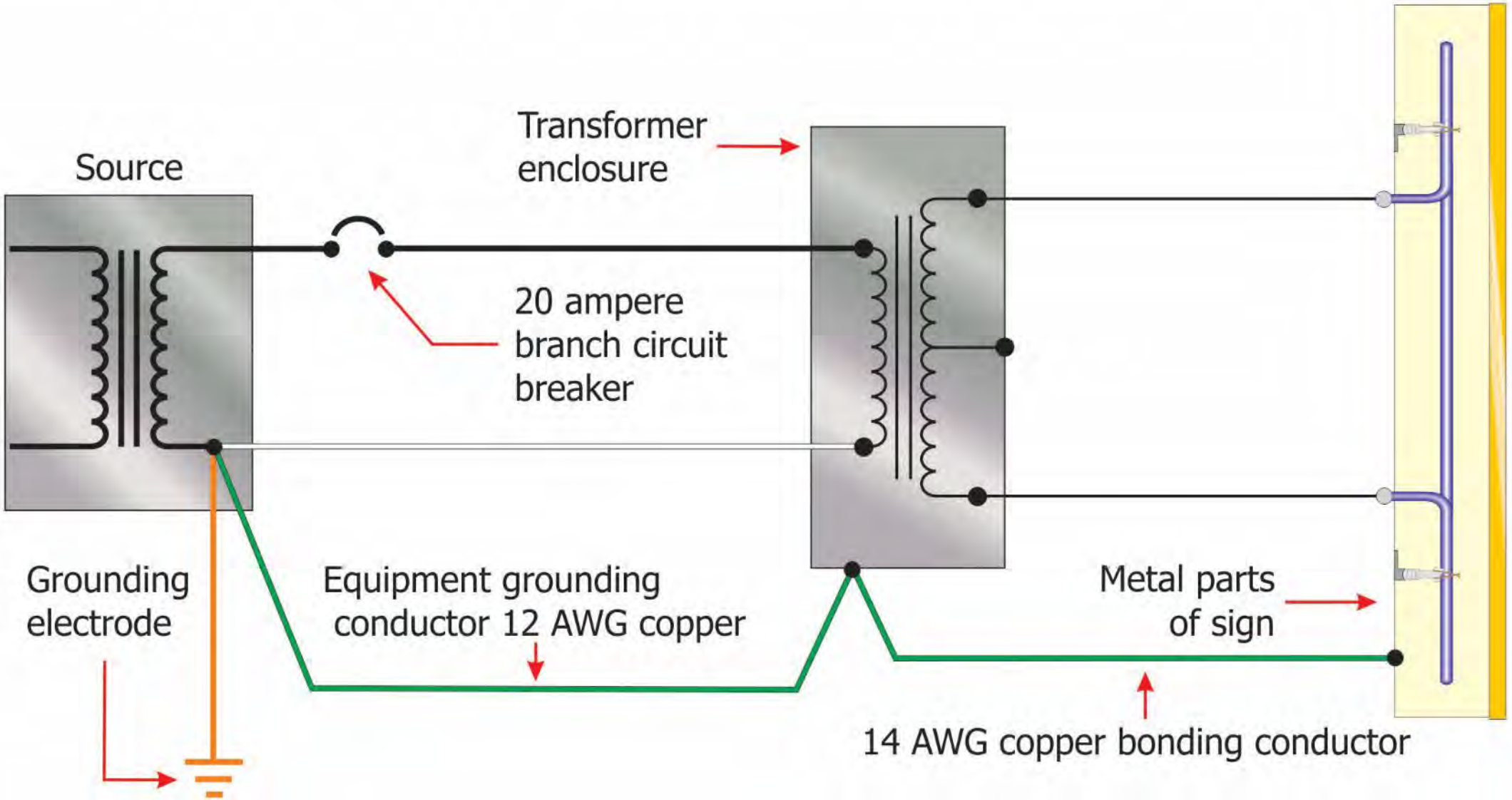
- Where listed **nonmetallic conduit** is used to enclose secondary conductor from transformer or power supply, the **bonding conductor** shall be **installed separate and remote** from the nonmetallic conduit and be spaced at least:
  - **38 mm (1½ in.)** from conduit ***(100 Hz or less)***
  - **45 mm (1¾ in)** from conduit ***(over 100 Hz)***
- Exception to 600.7(B)(1) eliminates this bonding conductor for remote metal parts of section signs or outline lighting systems when supplied by a remote **Class 2 power supply** *(such as an LED sign)*
- *See 600.7(B)(6) and 600.32(A)(4)*

14 AWG Copper Bonding Conductor



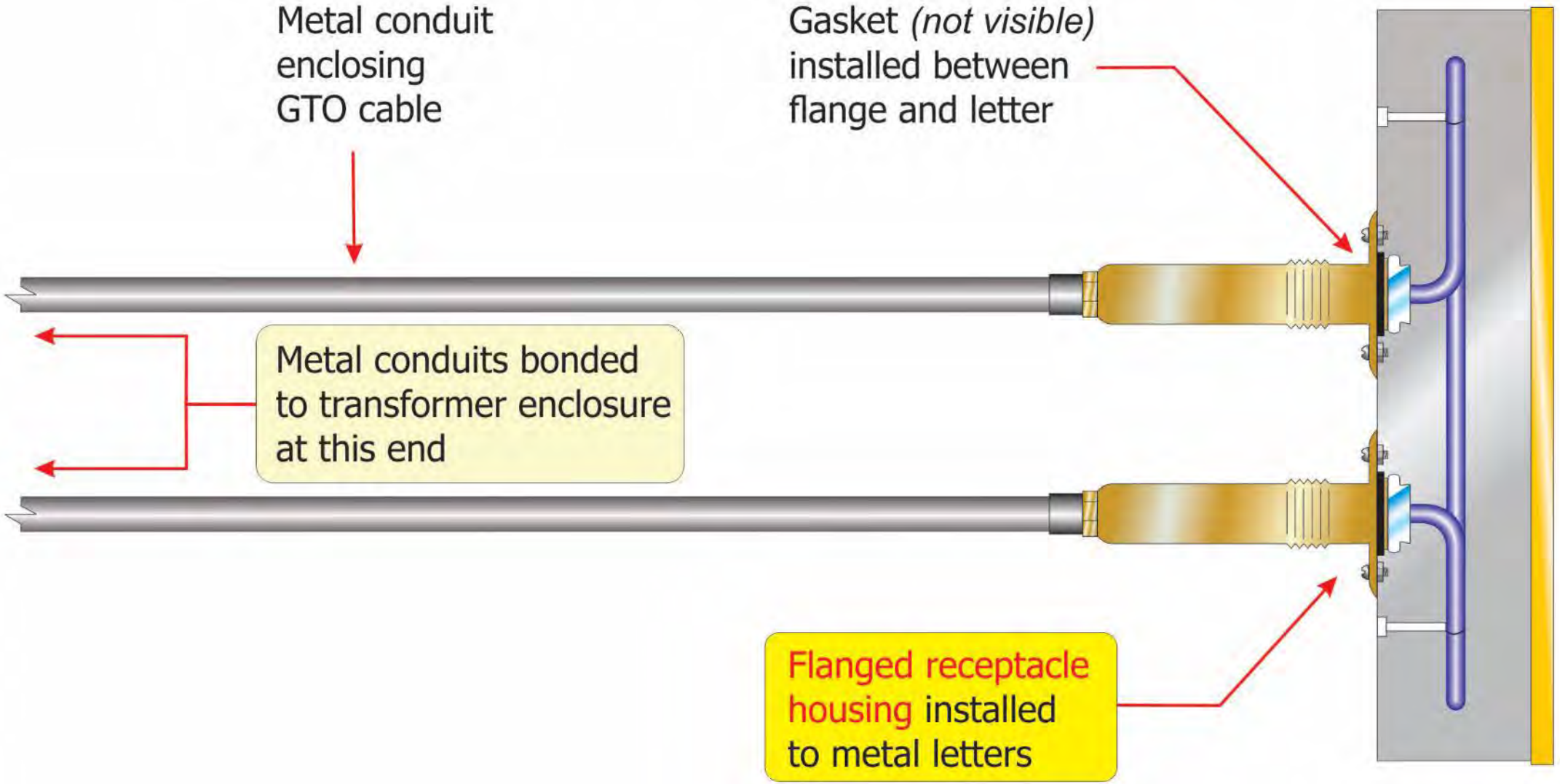
Copyright © IAEI 2020

600.7(A) and (B) Grounding and Bonding Path



Copyright © IAEI 2020

Bonding and Through Electrode Receptacles

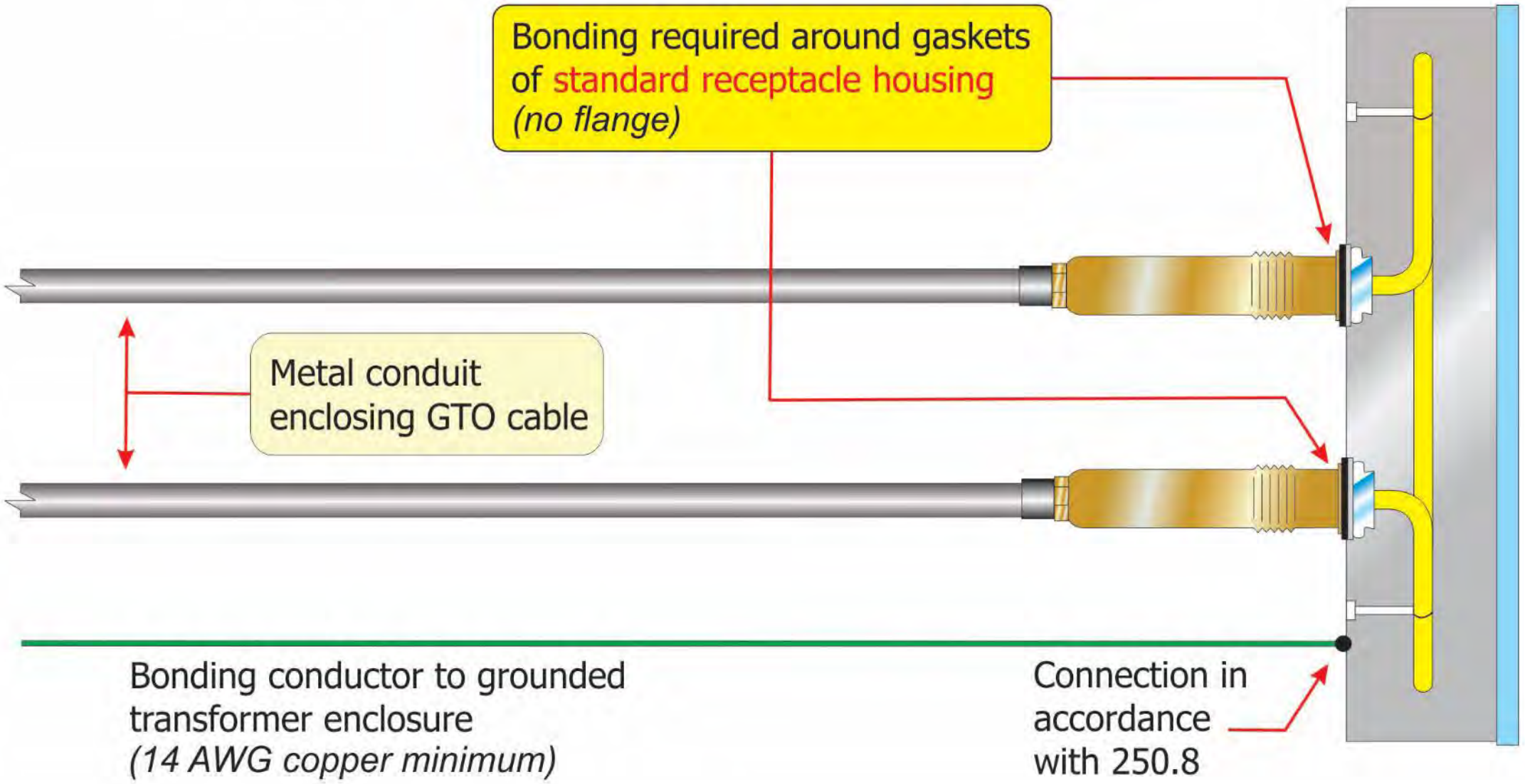


Copyright © IAEI 2020

Bonding With Electrode Receptacles

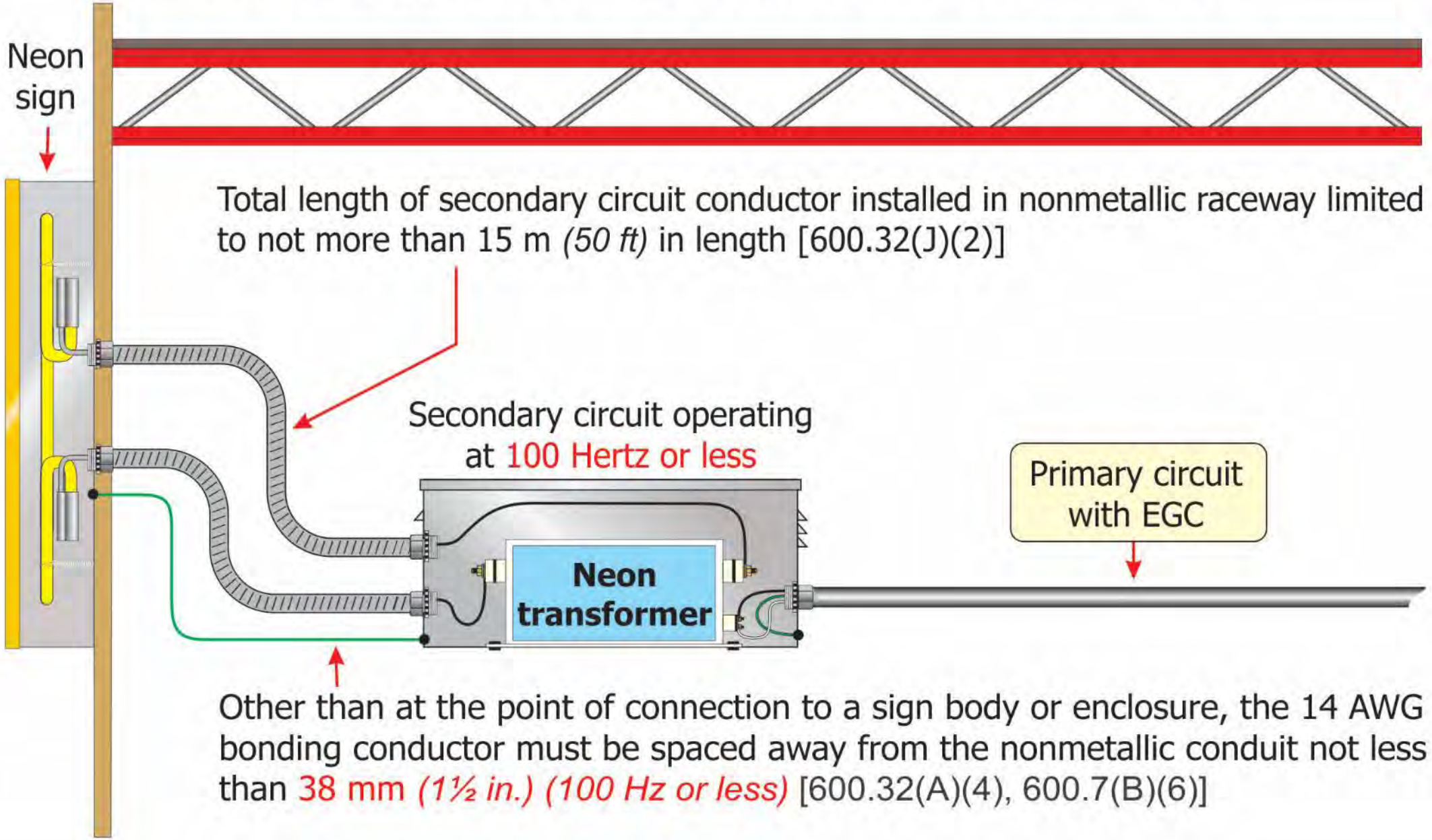
- When metallic wiring methods are used for secondary circuits and the type of electrode connection to the neon tubing is through an **electrode receptacle**, particular attention to bonding must be applied
- Electrode receptacles *(often referred to in the industry as PK housings)* provide **rubber gaskets** that must be installed, particularly in wet locations
- The installation instructions of listed parts must be followed *[NEC 110.3(B)]*
- Bonding of metallic parts must be assured around any gaskets that cause isolation between the channel letter of a sign and the metallic conduit connect to the electrode receptacle
- Important to be thorough in the inspection of secondary circuits of neon signs and outline lighting systems as this gasket isolation happens all too often in the field

Bonding Around Electrode Receptacle Gaskets



Copyright © IAEI 2020

600.32(A)(4) Spacing For Nonmetallic Conduit

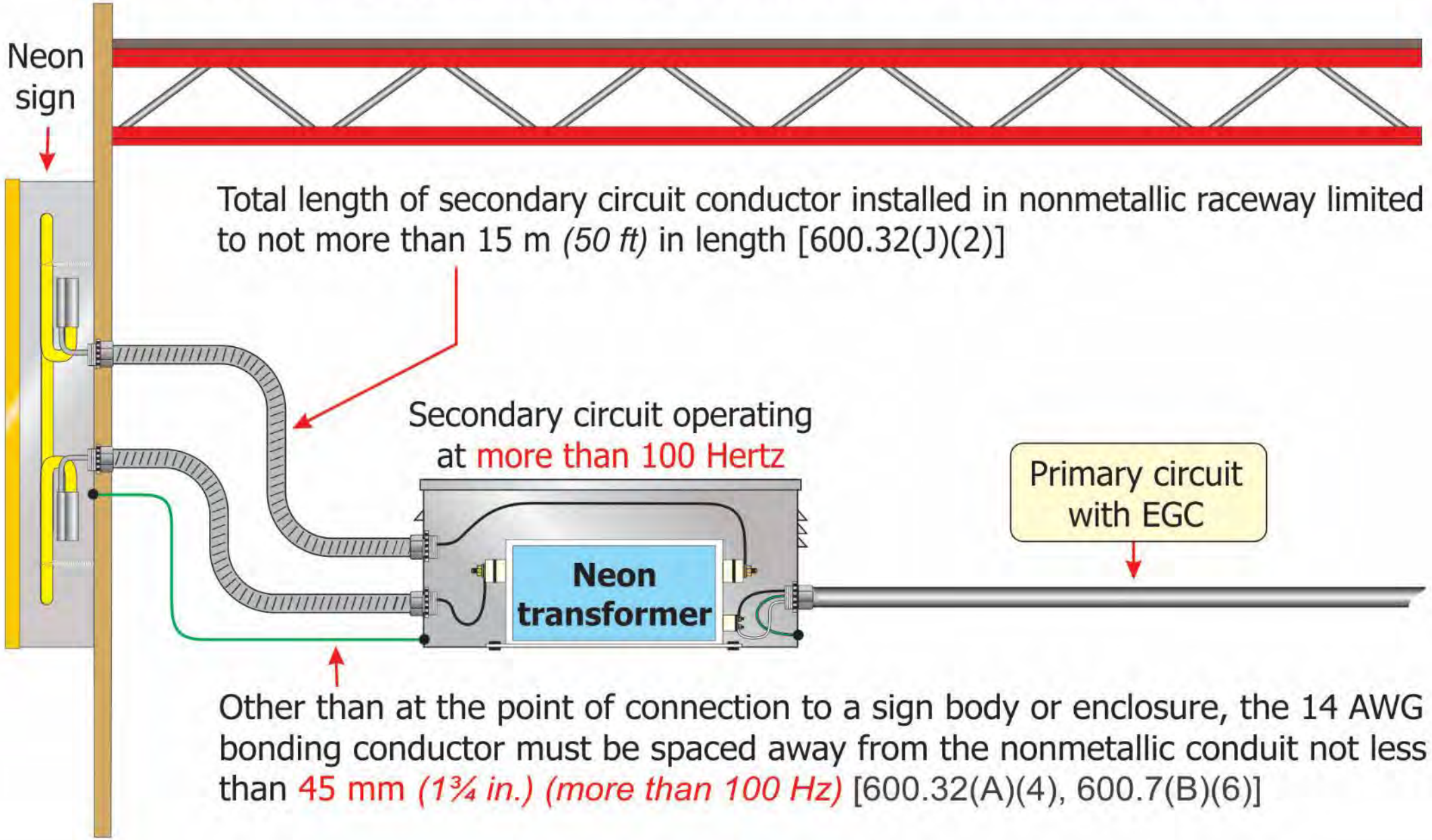


Copyright © IAEI 2020

Spacing for Neon Secondary Circuit Conductors Nonmetallic Conduit

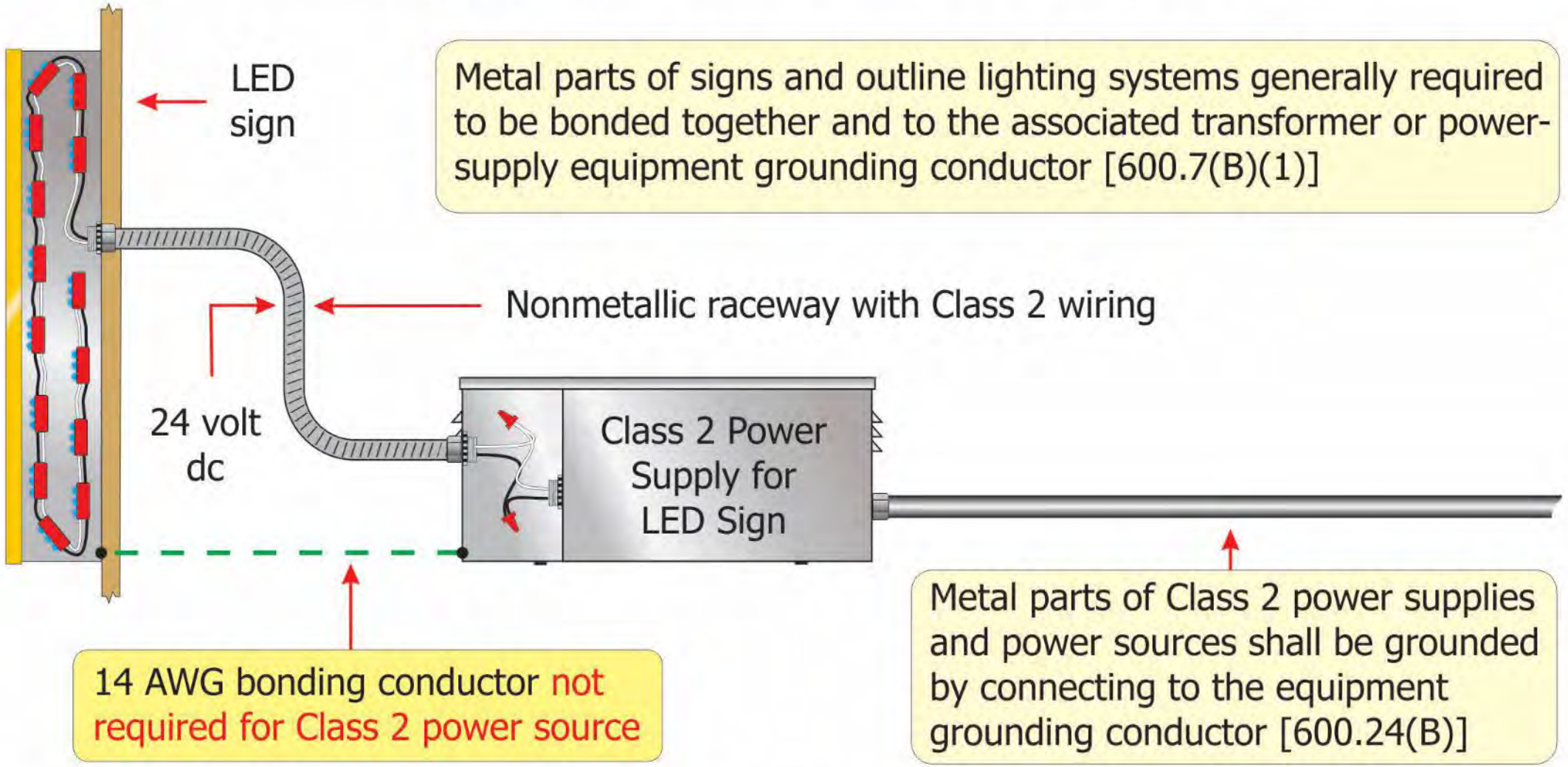
- Where listed **nonmetallic conduit** is used for the neon secondary circuit conductors and a bonding conductor is installed for bonding metal components associated with the sign or neon installation, separation must be maintained
  - For secondary circuits operating at **100 Hz or less**, a minimum 38 mm **(1½ in.)** spacing is required
  - For secondary circuits operating at **over 100 Hz**, a minimum 45 mm **(1¾ in.)** spacing is required
- *See NEC 600.7(B)(6) and 600.32(A)(4)*

600.32(A)(4) Spacing For Nonmetallic Conduit



Copyright © IAEI 2020

600.7(B)(1), Ex. Bonding of Metal Sign Parts



Exception eliminates the requirements for bonding of remote sections of a sign supplied by a Class 2 power source

Copyright © IAEI 2020

Neon Electrode Receptacles



Standard Type

Flanged Type

Courtesy of Westrim Products

Copyright © IAEI 2020

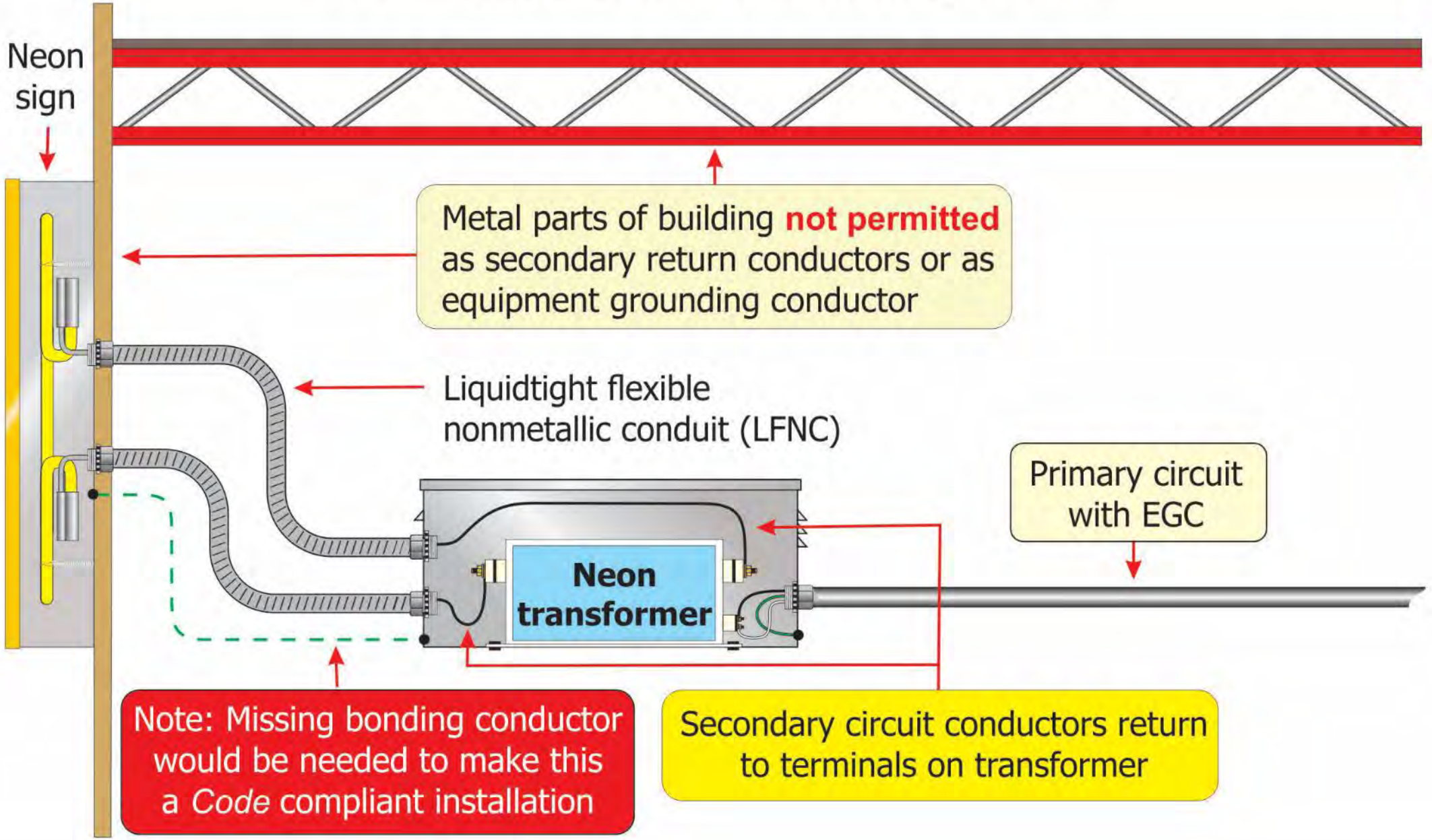
Metal Building Parts

- Metal parts of a building are **not permitted** as a secondary return conductor or an equipment grounding conductor (EGC)

- Metal parts of a building shall not be used as a means for bonding metal parts and equipment of signs or outline lighting systems together or to the transformer or power-supply equipment grounding conductor of the supply circuit

- See *NEC* 600.7(A)(5), 600.7(B)(3), and 600.32(A)(5)

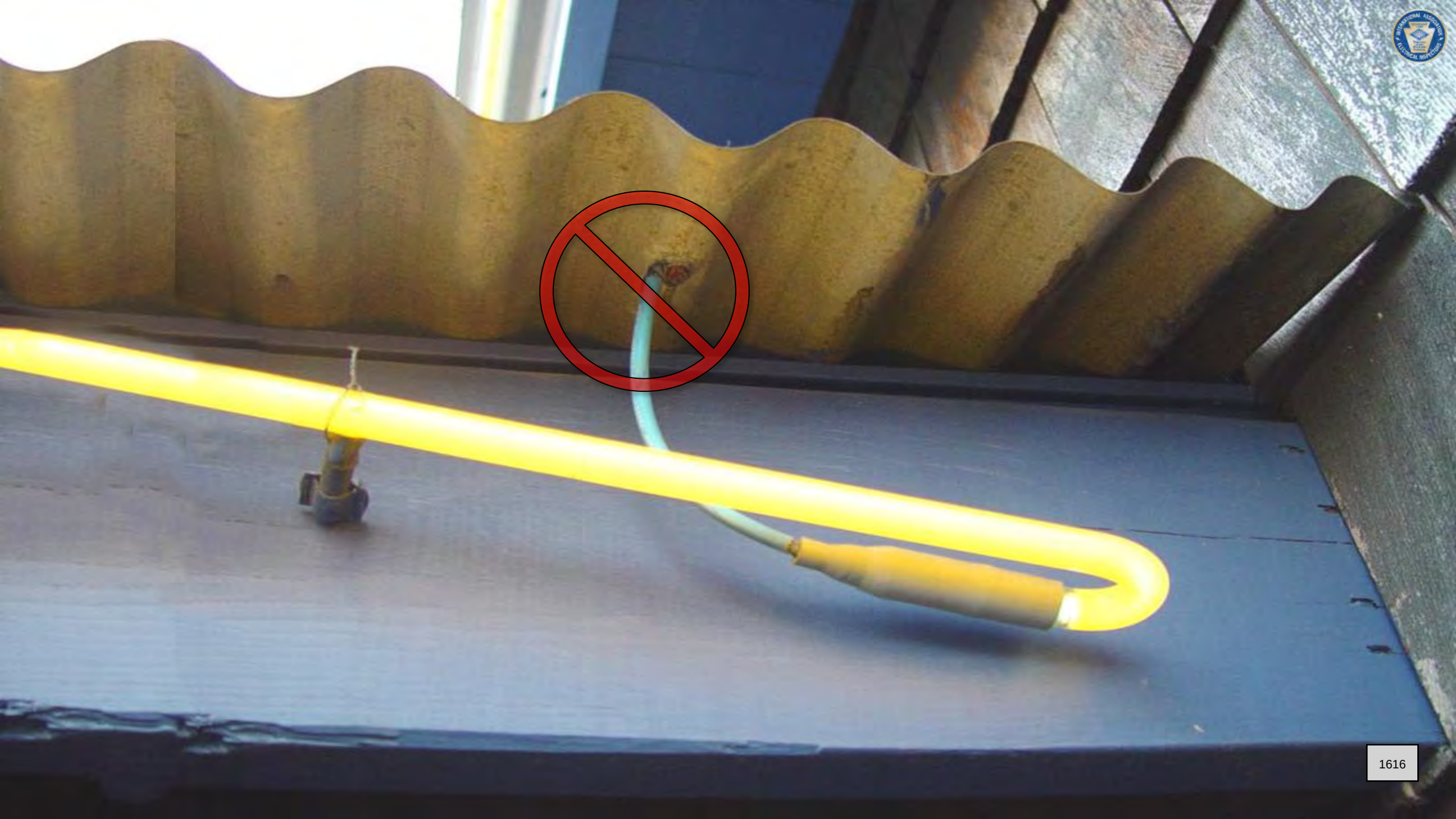
600.7(B)(3) Metal Building Parts



Copyright © IAEI 2020



1615



1616

Swimming Pools and Similar Installations

- Article 680 consists of Part I through Part VIII
- Part I *(General Requirement)* applies to all equipment and installations covered in Article 680 *[excluding Parts VII and VIII (unless specifically referenced)]*
- There are specific and **unique grounding and bonding requirements** for pools and similar installations
- **Equipotential bonding grid requirements** for permanently installed pools can be found at 680.26
- Grounding requirements for specific items *(such as panelboards)* are found at 680.6
- Spas and hot tub grounding and bonding requirements to comply with 680.42 *(outdoor)* and 680.43 *(indoor)*



Bonding and Equipment Grounding of Swimming Pools and Similar Installations

- Electrical equipment shall be:
  - Bonded in accordance with Part V of Article 250
  - Meet equipment grounding requirements of Parts VI and VII of Article 250
  - Connected by Chapter 3 wiring method *(except as modified by Article 680)*
- *See 680.6*

Bonding and Equipment Grounding of Swimming Pools and Similar Installations *(cont.)*

- The following equipment shall be bonded and grounded:
  - Through-wall lighting assemblies and underwater luminaries *(Some listed low-voltage lighting products not required to be grounded)*
  - All electrical equipment *[within 1.5 m (5 ft.) of water]*
  - Recirculating system electrical equipment
  - Junction boxes
  - Transformer and power supply enclosures
  - GFCIs
  - Panelboards *(not part of service equipment)*
- *See 680.6*

Bonding and Equipment Grounding Terminations to be Identified

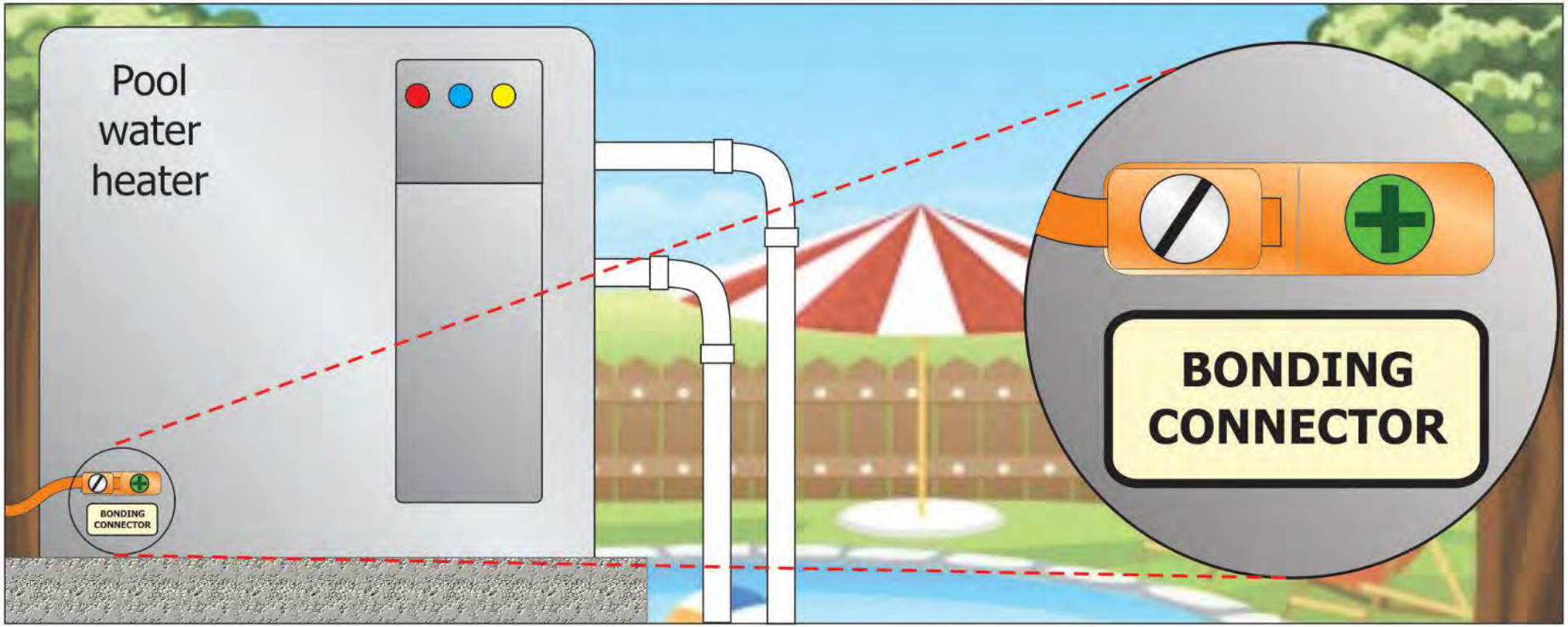
- Several changes in Article 680 over the last two *Code* cycles added to recognize the **corrosive environment** surrounding pool equipment
- Corrosive environment could be from chlorination of fresh water pools or pools filled with salt water
- All bonding and equipment grounding terminations required to be identified for use in **wet** and **corrosive environments**
- **Field-installed terminals** in a damp, wet, or corrosive environment must be:
  - Composed of copper, copper alloy, or stainless steel and…
  - Listed for direct burial use
- See 680.7

680.7 Bonding and Equipment Grounding Terminals

Terminals used for bonding and equipment grounding shall be identified for use in wet and corrosive environments

Field-installed terminals in a damp, wet, or corrosive environment shall be composed of copper, copper alloy, or stainless steel

Grounding and bonding terminals shall be listed for direct burial use



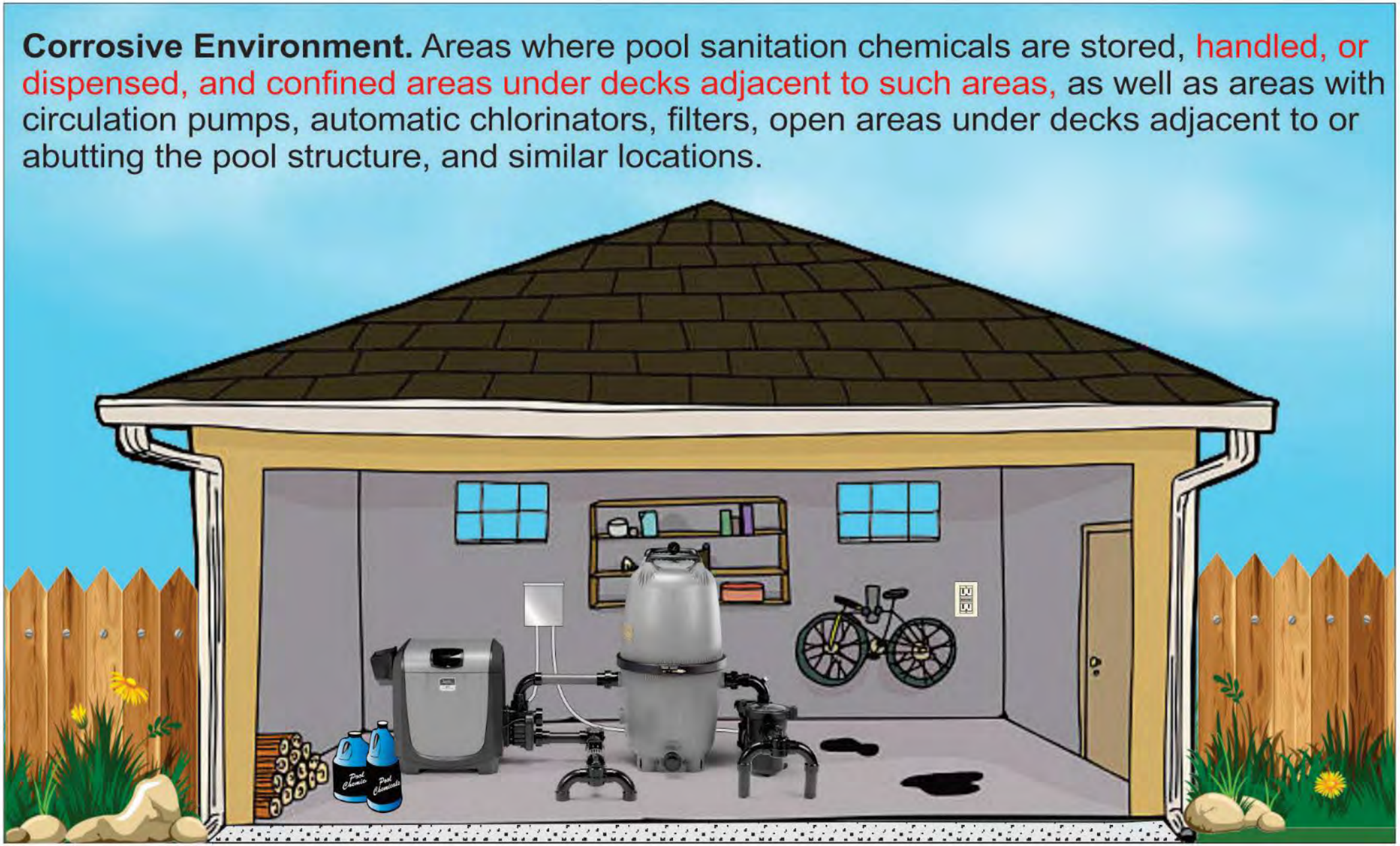
Copyright © IAEI 2020

Definition: Corrosive Environment

- ***Corrosive Environment.*** Areas where pool sanitation chemicals are **stored, handled, or dispensed**, and **confined areas** under decks adjacent to such areas, as well as areas with circulation pumps, automatic chlorinators, filters, **open areas under decks** adjacent to or abutting the pool structure, and similar locations.
- ***Informational Note:*** Sanitation chemicals and pool water are considered to pose a risk of corrosion (gradually damage or destroy materials) due to the presence of oxidizers (e.g., calcium hypochlorite, sodium hypochlorite, bromine, chlolinated isocyanurates) and chlorinating agents that release chlorine when dissolved in water.
- *See 680.2*

680.2 and 680.14 Corrosive Environments

Corrosive Environment. Areas where pool sanitation chemicals are stored, handled, or dispensed, and confined areas under decks adjacent to such areas, as well as areas with circulation pumps, automatic chlorinators, filters, open areas under decks adjacent to or abutting the pool structure, and similar locations.



Copyright © IAEI 2020

Wiring Methods in Corrosive Environments

- Wiring methods in corrosive environments shall be **listed and identified** for use in such areas
- Wiring methods considered to be resistant to the corrosive environment include:
  - Rigid metal conduit (RMC)
  - Intermediate metal conduit (IMC)
  - Rigid polyvinyl chloride conduit (PVC)
  - Reinforced thermosetting resin conduit (RTRC)
  - Type MC cable listed for location *[see 680.21(A)(1)]*
- *See 680.14*

Grounding of Pool Pump Motors for Permanently Installed Pools

- Wiring methods installed in a **corrosive environment** for pool-associated motors for permanently installed pools must contain an **insulated copper** equipment grounding conductor sized in accordance with Table 250.122
  - This EGC cannot be smaller than **12 AWG**
- Wiring method of branch circuits to permanently installed pool-associated motors installed in **noncorrosive environments** must comply with the general requirements in **Chapter 3** of the *NEC*
- *See 680.21(A)(1)*



1627

Pool-Associated Panelboard Grounding

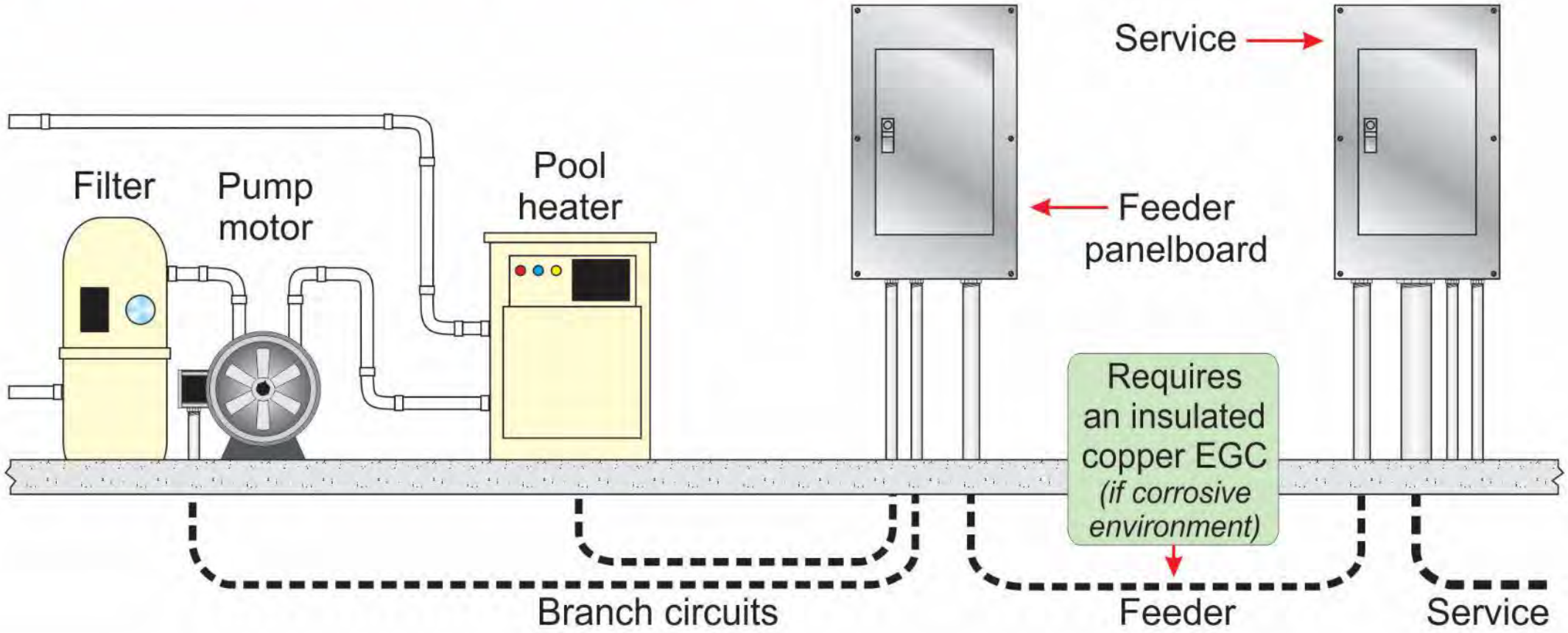
- Where feeders are installed in corrosive environments *[see 680.2]*, the wiring method of that portion of the feeder shall be as follows:
  - **Corrosive environment**
    - Comply with 680.14 wiring methods or liquidtight flexible nonmetallic conduit
    - Contain an **insulated copper** equipment grounding conductor sized in accordance with Table 250.122 *(not smaller than **12 AWG**)*
  - **Noncorrosive environments**
    - Comply with the general requirements in Chapter 3
- *See 680.25(A)*

680.25 Feeder to Swimming Pool Panelboard

Feeder to swimming pool panelboard requires restricted wiring methods only in areas where harsh conditions *(physical damage, environmental conditions, corrosive conditions, etc.)* are present

In corrosive environments, feeder requires an insulated, copper equipment grounding conductor *(not smaller than 12 AWG)* where installed in such a location

In noncorrosive environments, Chapter 3 wiring methods permitted



Copyright © IAEI 2020

Swimming Pool Panelboards at Other Buildings

- Grounding at the disconnecting means for remote buildings is covered in 250.32
- For any **new construction**, 250.32(B) requires an **equipment grounding conductor** of one of the types identified in 250.118 to be installed with the feeder conductors
- Where an equipment grounding conductor is installed with the feeder in accordance with 250.32(B), it must be an **insulated copper** EGC in accordance with 680.25(A) *(if installed in a corrosive environment)*

Swimming Pool Panelboards at Other Buildings *(cont.)*

- For **existing installations only**, the limited exception to 250.32(B) permits the **feeder grounded conductor** to be used for grounding where:
  - An EGC is not run with supply to building or structure
  - No continuous metallic paths between buildings/structures
  - Ground-fault protection of equipment has not been installed on the common ac service
- Grounded conductor run with the supply to the building or structure must be connected to the building or structure disconnecting means and to the grounding electrode(s)
- Grounded conductor to be used for grounding or bonding of equipment, structures, or frames required to be grounded or bonded

Equipotential Bonding of Permanently Installed Pools

- Equipotential bonding is required for pools to **reduce voltage gradients** in the pool area
- Swimming pools, spas and hot tubs present special shock hazards to people due to mixing **water** enriched with chemicals, **people** and **electricity** together
- Bonding together of conductive portions of the pool and metal parts of electrical equipment associated with the pool help achieve this **equipotential bonding**

Equipotential Bonding of Permanently Installed Pools *(cont.)*

- The goal is to provide a means of **equalizing the potential** of all equipment and parts so there will be no current when a person provides a path between conductive parts
- Regular **inspection and maintenance** are required to ensure the installation maintains it integrity, especially where exposed to corrosive environments *(see 680.4)*
- See 680.26(B)

Equipotential Bonding of Permanently Installed Pools *(cont.)*

- The following shall be bonded together:

1. **Conductive pool shells:** structural reinforcing steel
2. **Perimeter surfaces:** unpaved surfaces as well as poured concrete and other types of paving
3. **Metallic components:** metallic parts of the pool structure
4. **Underwater lighting:** metal forming shells and mounting brackets

Equipotential Bonding of Permanently Installed Pools *(cont.)*

- The following shall be bonded together: *(cont.)*

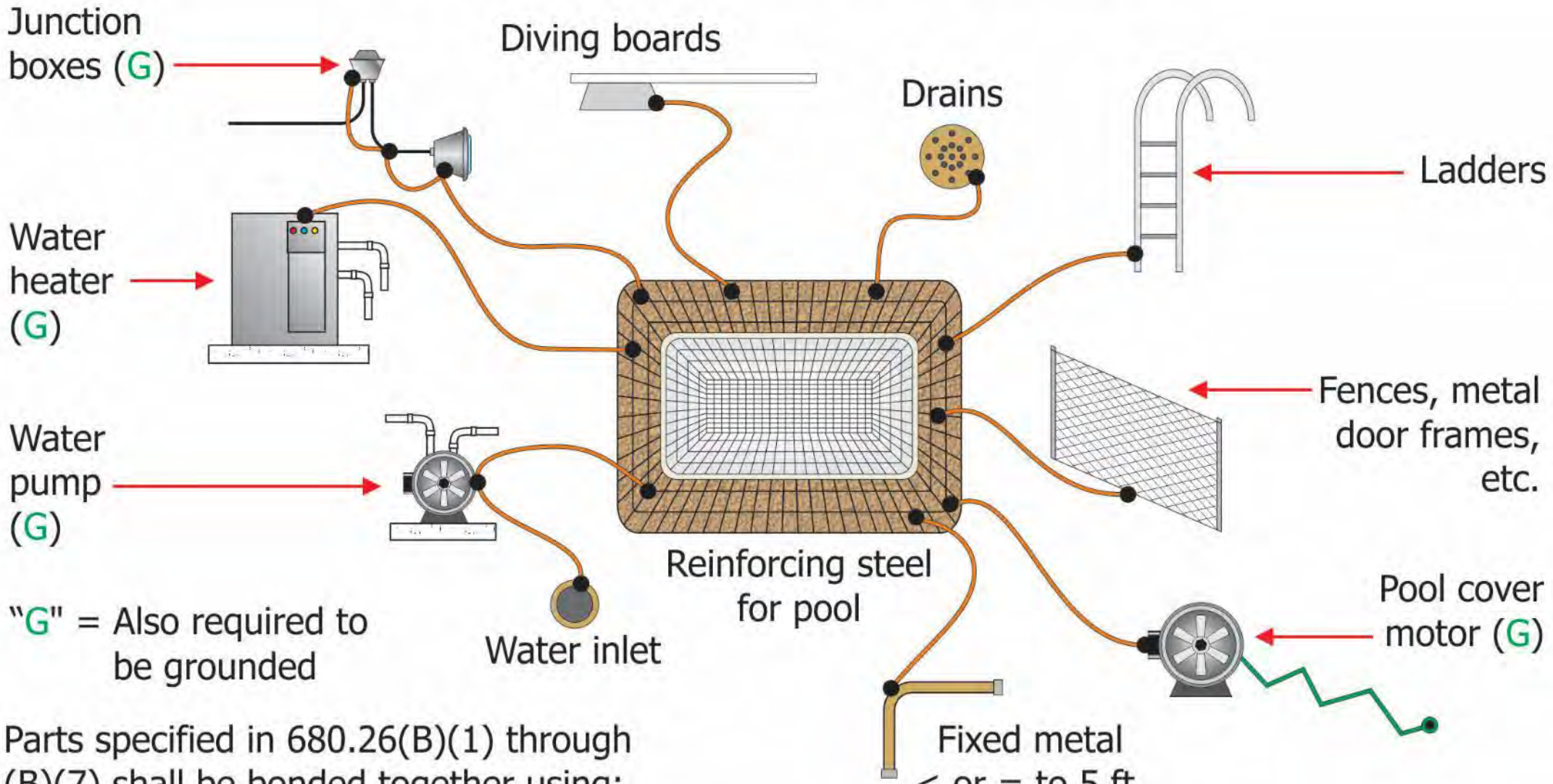
5. **Metal fittings:** Metal fittings within or attached to the pool structure *(excluding small isolated parts)*

6. **Electrical equipment:** Circulating system, pump motors, metal parts of equipment associated with pool covers, including electric motors

7. **Fixed metal parts:** Metal-sheathed cables and raceways, metal piping, and all fixed metal parts

8. **Pool water:** [680.26(C)]

680.26(B) Equipotential Bonding



Parts specified in 680.26(B)(1) through (B)(7) shall be bonded together using:

- Solid copper conductors, insulated covered, or bare, not smaller than 8 AWG
- Rigid metal conduit of brass or other identified corrosion-resistant metal

Copyright © IAEI 2020


1637

Equipotential Bonding of Permanently Installed Pools *(cont.)*

- Parts specified in 680.26(B)(1) through (B)(7) to be bonded together to form an **equipotential bonding grid**
- Required to be connected together with a solid copper conductor(s), insulated, covered, or bare, not smaller than 8 AWG copper
- Rigid metal conduit of brass or other identified corrosion-resistant metal can also be used for this bonding purpose
- Connections to bonded parts to be made per 250.8
- Bonding conductor(s) **not required** to be extended or attached to remote panelboards, service equipment, or electrodes

Equipotential Bonding of Permanently Installed Pools *(cont.)*

- The equipotential bonding grid permitted to consist of any of the following for the **Conductive Pool Shell *(belly steel)***:
  - Unencapsulated **structural reinforcing steel** where bonded together by the usual tie wires or equivalent
  - **Copper conductor grid** *(where structural reinforcing steel is encapsulated or no structural reinforcing steel exists)*
    - Min. 8 AWG bare solid copper conductors
    - Conform to the contour of the pool
    - 300 mm (12 in.) by 300 mm (12 in.) grid pattern or network
    - Secured within or under pool no more than 150 mm (6 in.) from pool shell

Equipotential Bonding of Permanently Installed Pools *(cont.)*

- The equipotential bonding grid permitted to consist of any of the following for the **Perimeter Surfaces *(deck)***:
  - Unencapsulated **structural reinforcing steel** where bonded together by the usual tie wires or equivalent
  - Alternate means of **copper conductor(s)** *(where structural reinforcing steel is encapsulated or no structural reinforcing steel exists)*
    - Min. 8 AWG bare solid copper conductor(s)
    - Conform to the contour of the perimeter surface
    - Only listed splices devices or exothermic welding permitted
    - 450 mm to 600 mm (18 in. to 24 in.) from the inside walls of the pool
    - Within or under the perimeter surface 100 mm to 150 mm (4 in. to 6 in.)

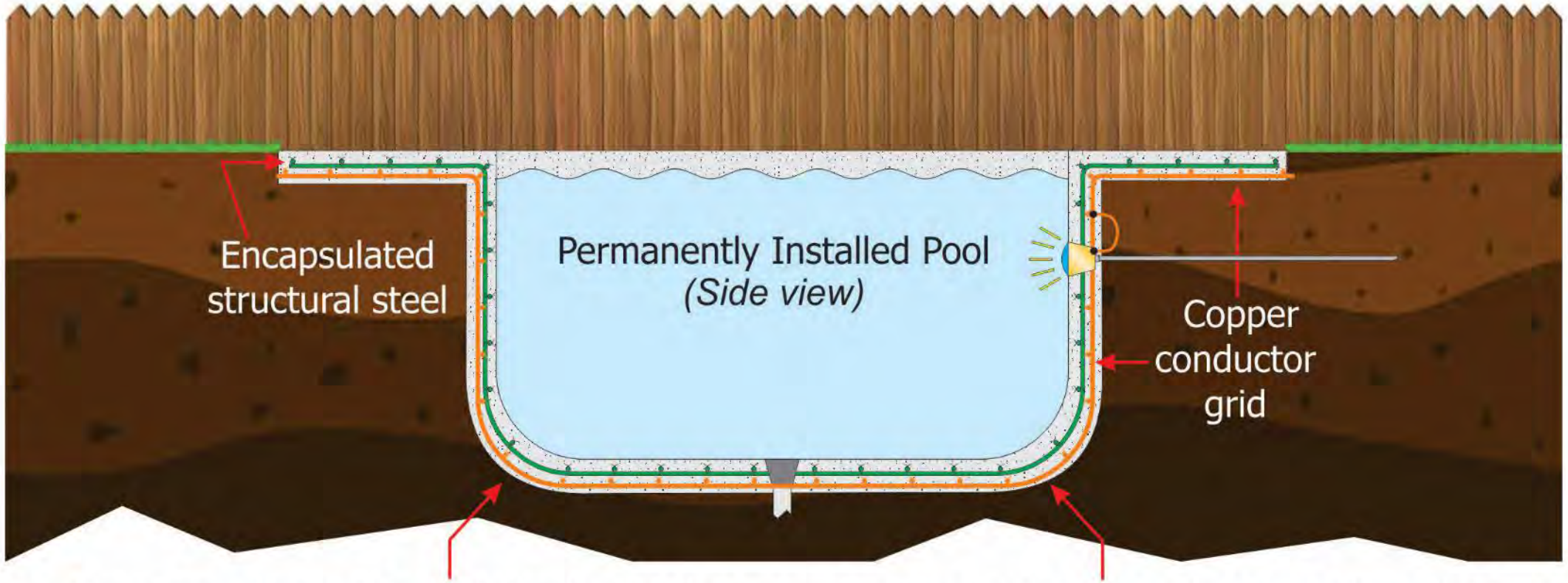
Equipotential Bonding of Permanently Installed Pools *(cont.)*

- The equipotential bonding grid permitted to consist of any of the following for the **Perimeter Surfaces *(deck)***:
  - Alternate means of **copper grid** *(where structural reinforcing steel is encapsulated or no structural reinforcing steel exists)*
    - Constructed of 8 AWG solid bare copper conductor(s) arranged in a 300 mm (12 in.) by 300 mm (12 in.) grid pattern or network
    - Follow the contour of the perimeter surface extending 1 m (3 ft) horizontally beyond the inside walls of the pool
    - Only listed splicing devices or exothermic welding permitted
    - Secured within or under the deck or unpaved surfaces between 100 mm to 150 mm (4 in. to 6 in .) below the subgrade

Equipotential Bonding of Permanently Installed Pools *(cont.)*

- **Perimeter surface** considered to extend for **1 m (3 ft) horizontally** beyond the inside walls of the pool and shall include unpaved surfaces and other types of paving
- Perimeter surfaces separated from the pool by a **permanent wall or building** 1.5 m (5 ft) in height or more require equipotential bonding only on the **pool side** of the permanent wall or building
- Bonding to the perimeter surface to be attached to the pool reinforcing steel or copper conductor grid at a minimum of **four (4) points uniformly spaced** around the perimeter of the pool

680.26(B)(1)(b) Copper Conductor Grid



For the conductive pool shell *(belly steel)* where structural reinforcing steel is not available, a copper conductor grid to be installed meeting the following requirements:

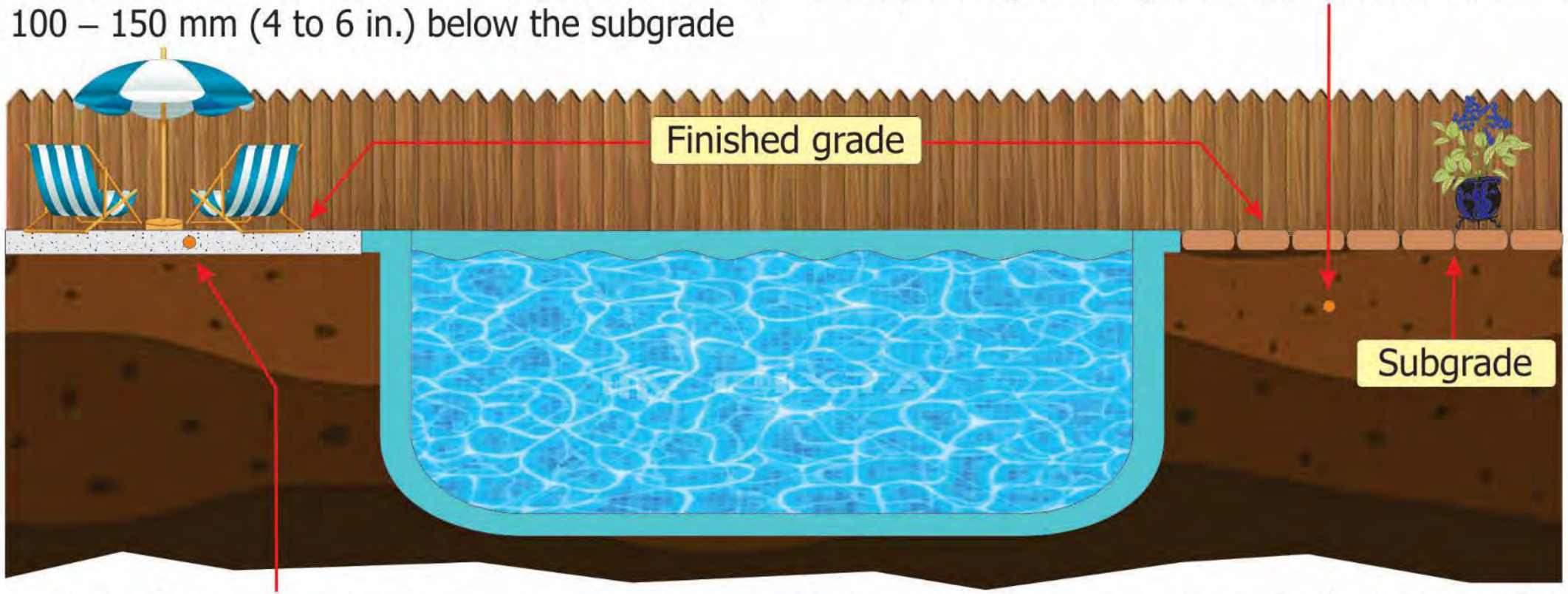
(1) Minumum 8 AWG bare solid copper conductors bonded at all points of crossing per 250.8 *(or other approved means)* (2) Conform to the contour of the pool (3) Arranged in a 300 mm (12 in.) by 300 mm (12 in.) network uniformly spaced in a perpendicular grid pattern with a tolerance of 100 mm (4 in.) (4) Secured within or under the pool not more than 150 mm (6 in.) from the outer contour of the pool shell

Copyright © IAEI 2020

680.26(B)(2)(b) Perimeter Surfaces (Copper Ring)

Where structural reinforcing steel is not available or encapsulated, at least one 8 AWG solid copper conductor is permitted to be secured within or under the perimeter surface and installed 450 – 600 mm (18 to 24 in.) measured horizontally from the inside walls of the pool

Where installed beneath the final grade material, the copper ring bonding conductor shall be buried 100 – 150 mm (4 to 6 in.) below the subgrade



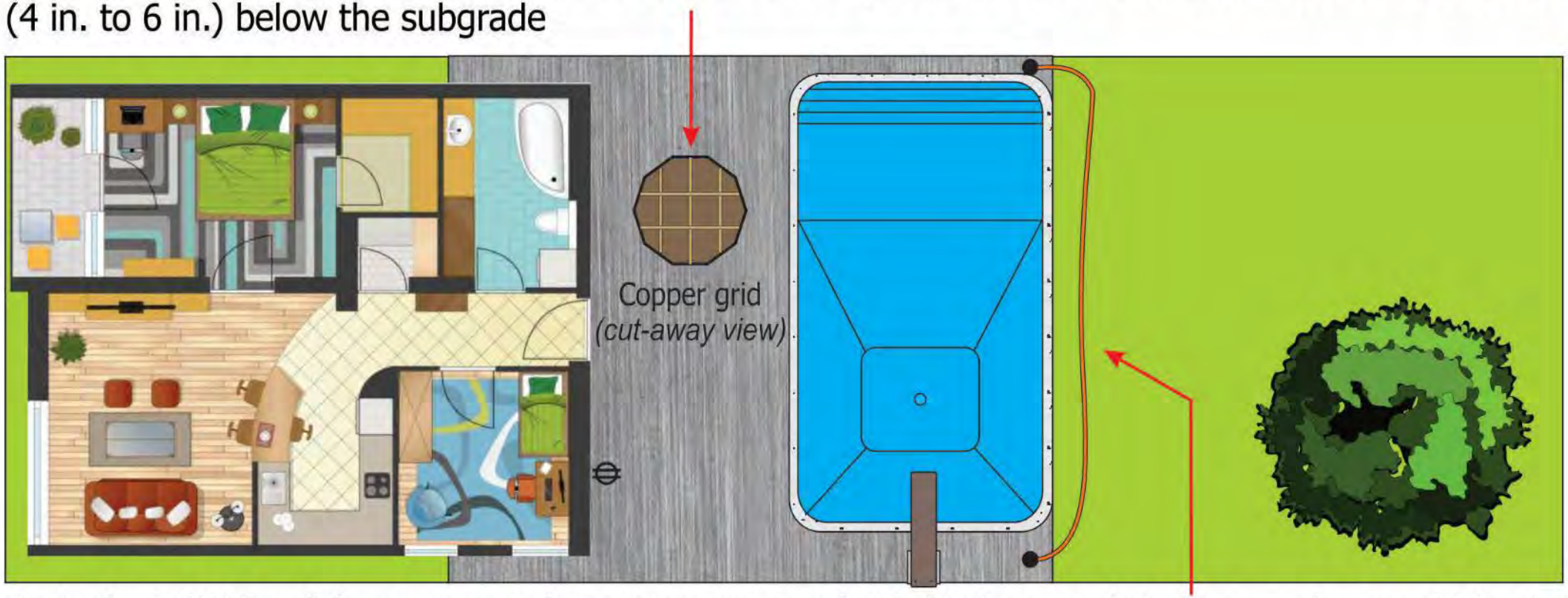
In lieu of structural reinforcing steel *(rebar or wire mesh)* in the concrete, a single 8 AWG solid copper conductor is permitted as one of the two alternate means for bonding provisions for the perimeter surface *(copper grid system also permitted)*

Copyright © IAEI 2020

680.26(B)(2)(c) Copper Grid for Perimeter Surfaces

Where structural reinforcing steel is not available or encapsulated, an 8 AWG copper grid system is permitted to be utilized arranged in a 300 mm (12-in.) by 300 mm (12-in.) network of conductors in a uniformly spaced perpendicular grid pattern with a tolerance of 100 mm (4 in.)

Required to be secured within or under the deck or unpaved surfaces between 100 mm to 150 mm (4 in. to 6 in.) below the subgrade



A single 8 AWG solid copper conductor or structural reinforcing steel *(rebar or wire mesh)* in the concrete is also permitted as the bonding grid for the perimeter surface

Copyright © IAEI 2020

Electrical Equipment (Motors)

- Metal parts of electrical equipment associated with the **pool water circulating system** *(including pump motors and metal parts of equipment associated with pool covers)* shall be bonded to the equipotential bonding grid
- Regardless of its location to the water's edge
- Double-insulated pool pump motors are not permitted to be bonded to the equipotential bonding grid
- *See 680.26(B)(6)*

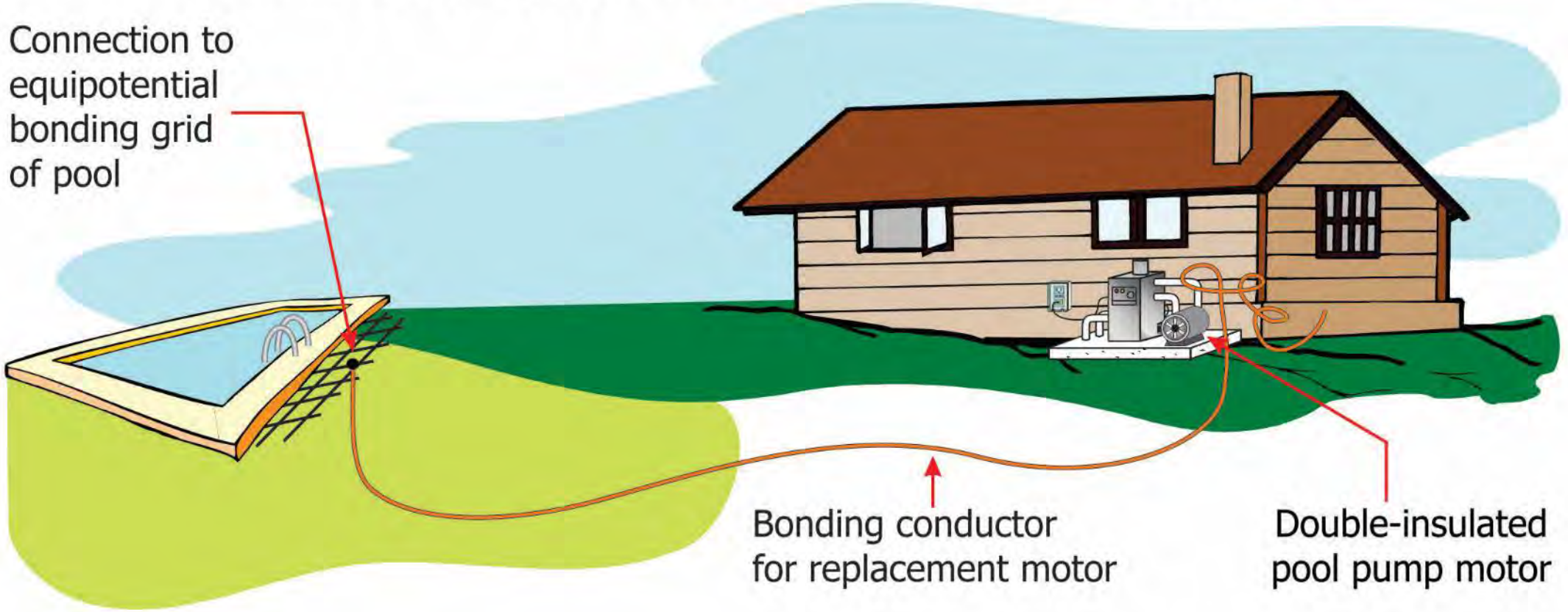


Pool pump motor and heater showing bonding termination lugs

Double-Insulated Pool Pump Motors

- Double-insulated water pump motors are **not permitted** to be bonded to the 8 AWG copper conductor
- An 8 AWG copper bonding conductor is to be **extended to the water pump location** as a provision for a possible pump motor replacement that is not of the double insulated type
- If there is no connection between the swimming pool bonding grid and the equipment grounding conductor for the premises, the bonding conductor is required to be connected to the equipment grounding conductor of the motor circuit
- *See 680.26(B)(6)(a)*

680.26(B)(6)(a) Double-Insulated Pump Motor



Listed double-insulated equipment shall not be bonded *(see 680.26(B)(6) Exception)*

Where a double-insulated pool pump motor is installed, a bonding means is required to be provided for a non-double-insulated replacement motor

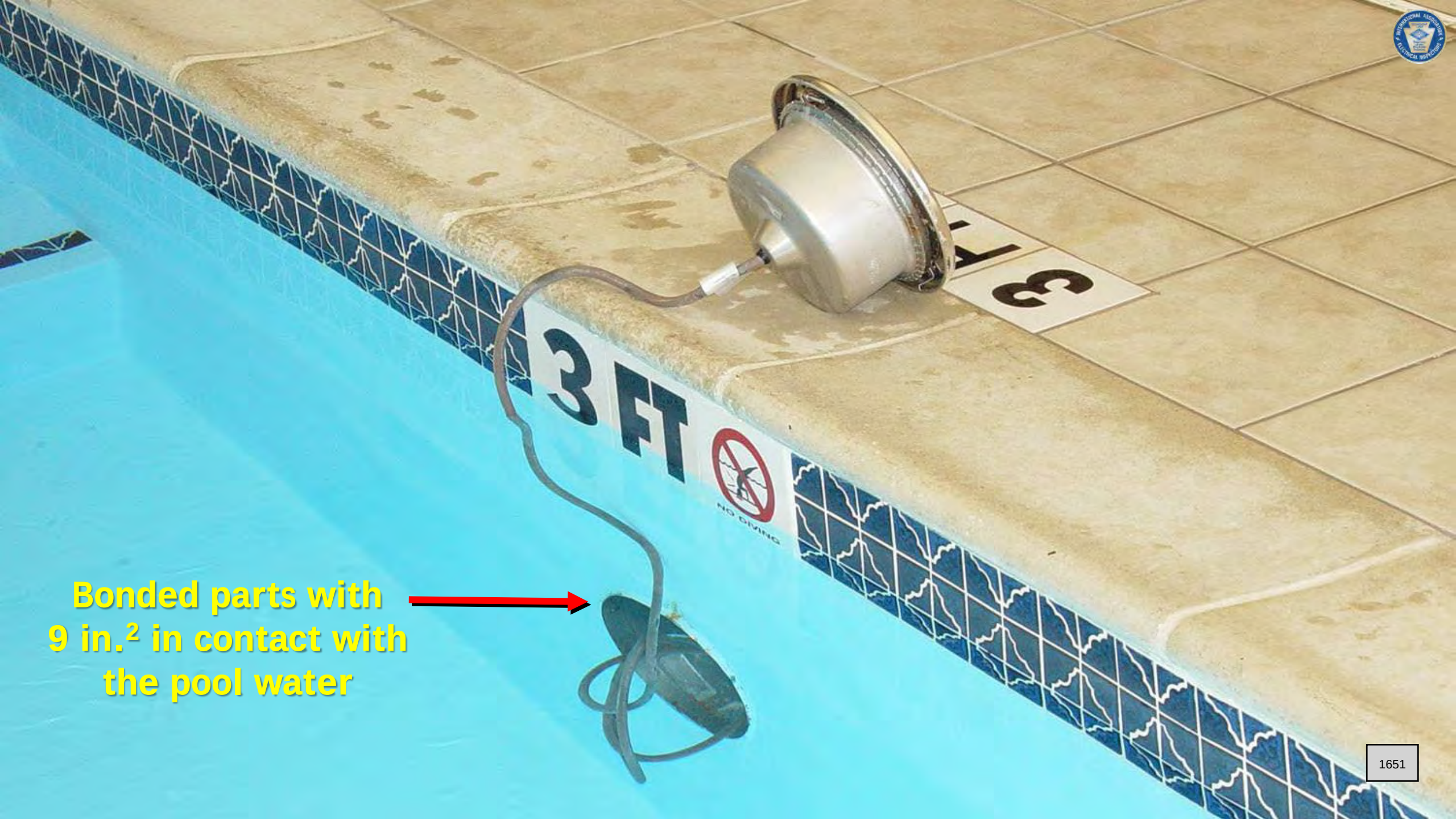
Bonding means shall be a solid 8 AWG copper conductor run from the equipotential bonding means of the pool to the motor vicinity

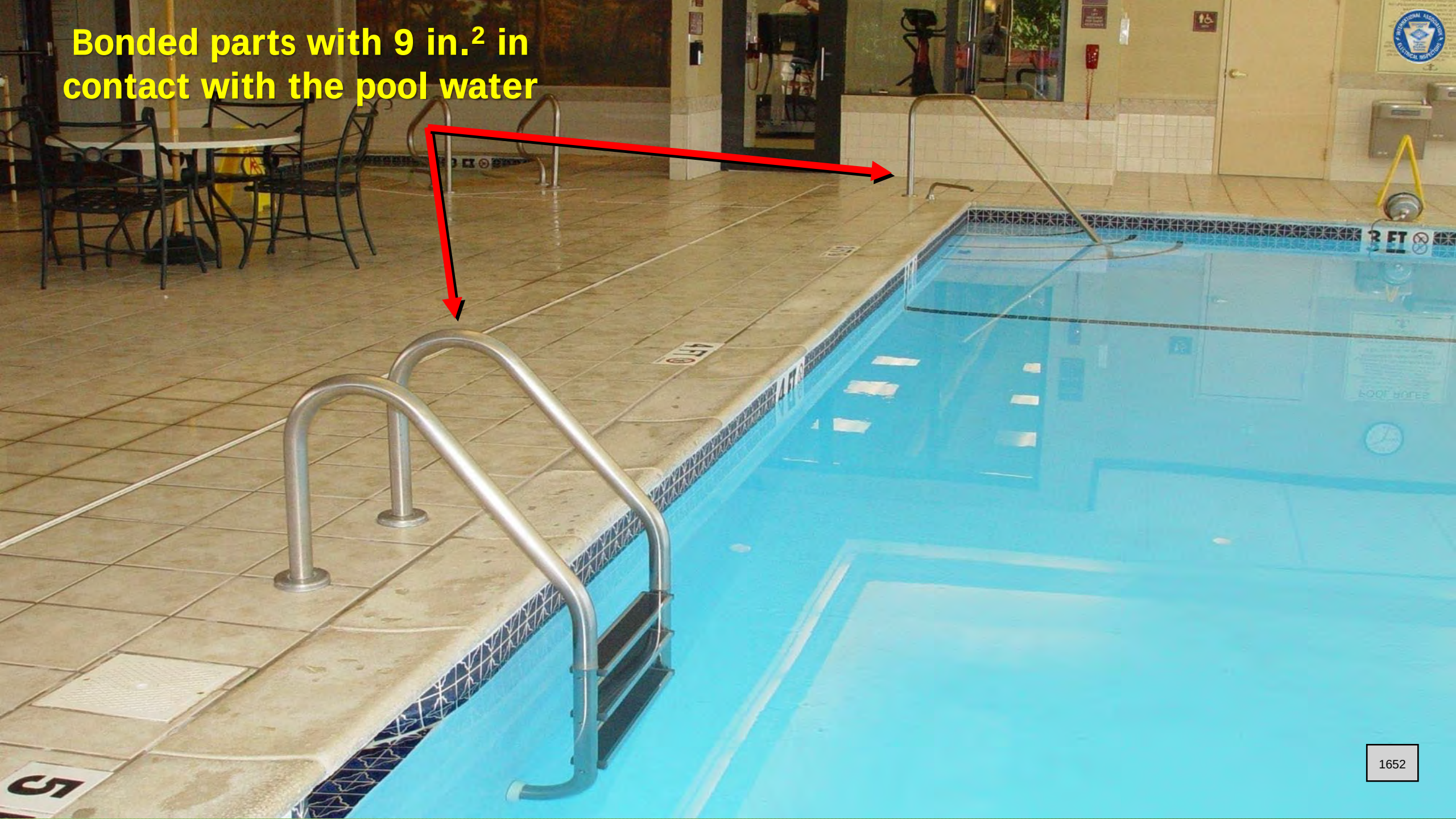
Connect to EGC of motor circuit if no prior connection

Copyright © IAEI 2020

Bonding of Pool Water

- **Pool water** is required to be bonded to the equipotential bonding grid
- Bonding can be accomplished by **conductive bonded parts** that are in contact with the pool water *(wet-niche luminaire metal forming shell, metal handrails or ladders, etc.)*
- Minimum conductive surface area of **5800 mm^2 (9 in.^{2})** in contact with pool water required
- Where a nonconductive pool shell *(prefab fiberglass)* is installed and no conductive parts are in contact with the pool water, provisions must be made to bond pool water as well


3 FT
NO DIVING
Bonded parts with
9 in.² in contact with
the pool water
1651

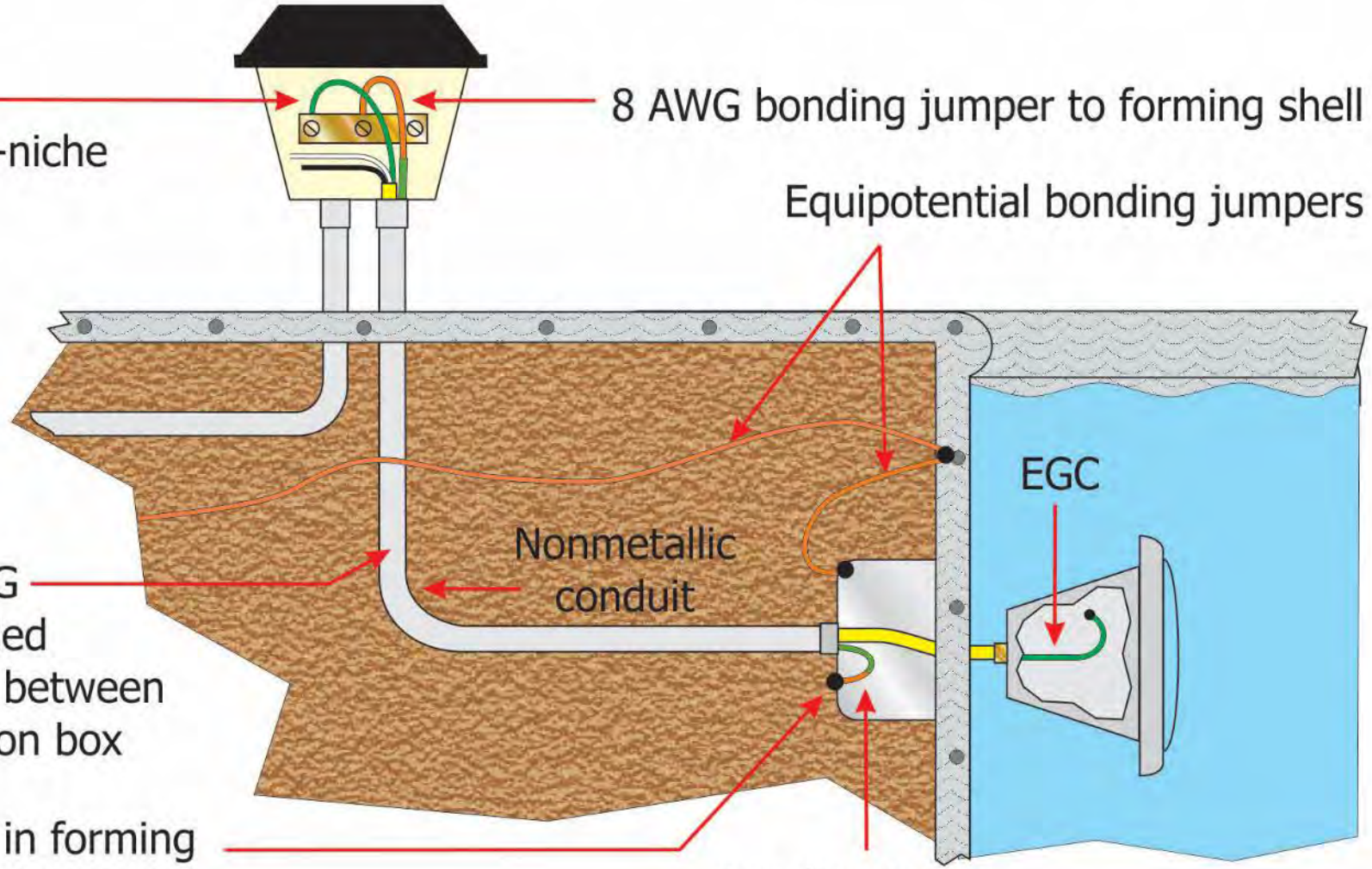

Bonded parts with 9 in.² in contact with the pool water
1652


Conductive surface bonding product with
9 in.² in contact with the pool water
Product made by Perma-Cast Co.
PVC 1
NSF-PW
D2466
1653

Bonding of Wet-Niche Luminaires

- The **metal forming shells** of underwater wet-niche luminaires must be bonded to the equipotential bonding grid *[see 680.26(B)(4)]*
- Where a metallic raceway method is used from the junction box to the forming shell, the bonding of the two enclosures is accomplished through the metal conduit *[see 680.23(B)(2)(a)]*
- Where rigid PVC or liquidtight flexible nonmetallic conduit is used, an **8 AWG insulated solid or stranded copper bonding jumper** must be installed along with the pool flexible cord assembly so that it can be terminated on a suitable lug in the forming shell, junction box, transformer enclosure, or ground-fault circuit-interrupter enclosure *[see 680.23(B)(2)(b)]*

680.23(B)(2) Wiring Methods to Wet-Niche Luminaires



Copyright © IAEI 2020

Listed Junction Boxes and Enclosures

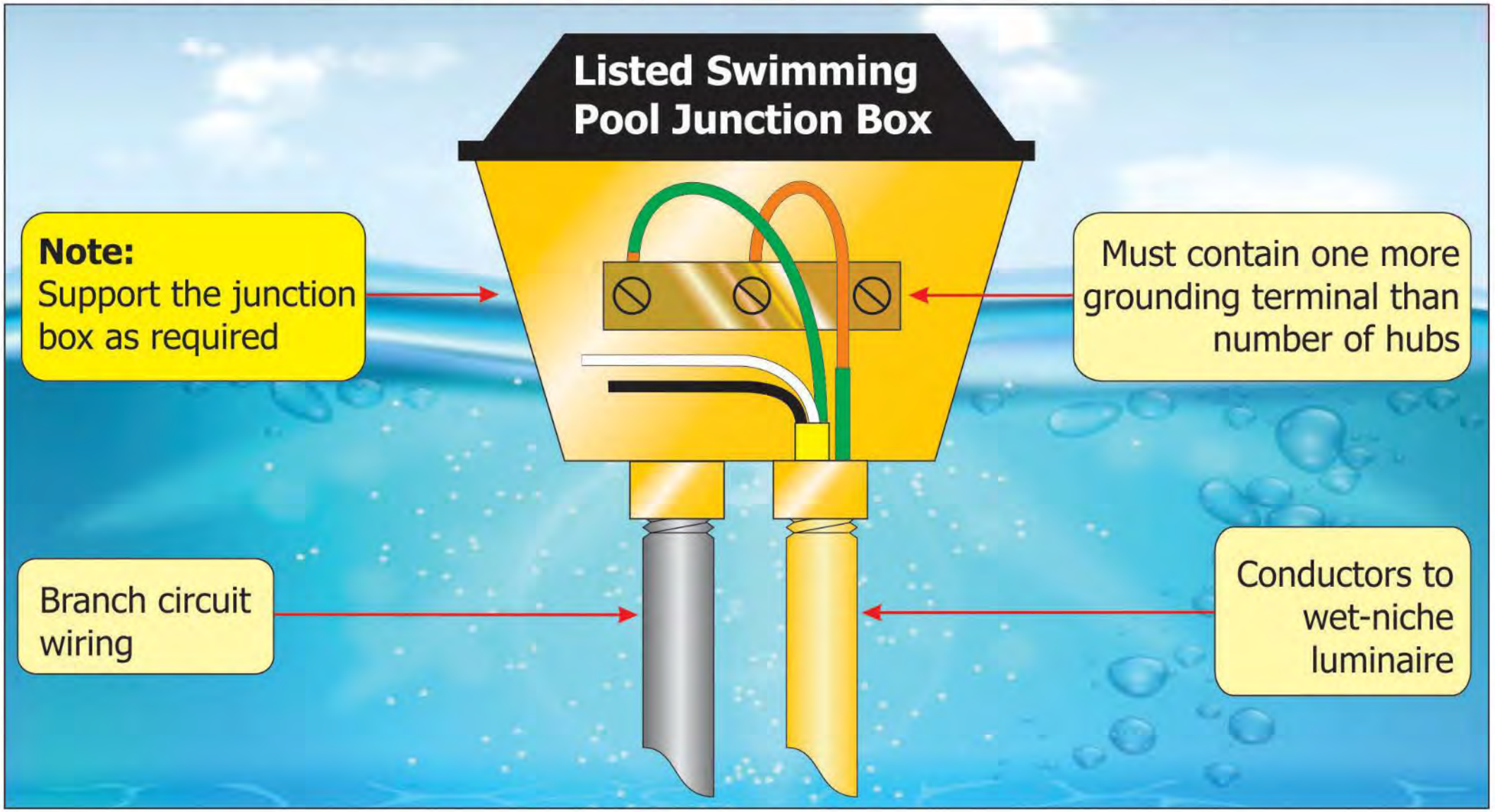
- Special requirements apply to the construction of **junction boxes** connected to a conduit that extends directly to a forming shell or mounting bracket for a no-niche luminaire *[see 680.24(A)]*
- Listed swimming pool junction boxes must have at least one more grounding terminal than the number of conduit entries *[see 680.24(D)]*
  - For example, where there are two conduit entries, the grounding terminal bar is required to have not less than three terminals

Listed Junction Boxes and Enclosures *(cont.)*

- The junction box must be **listed as a swimming pool junction box** and comply with the following conditions:
  - Be equipped with threaded entries or hubs or a nonmetallic hub
  - Be comprised of copper, brass, suitable plastic, or other approved corrosion-resistant material
  - Be provided with **electrical continuity** between every connected metal conduit and the grounding terminals by means of copper, brass, or other approved corrosion-resistant metal that is integral with the box

680.24(A) and (D) Junction Boxes for Wet-Niche Luminaire(s)

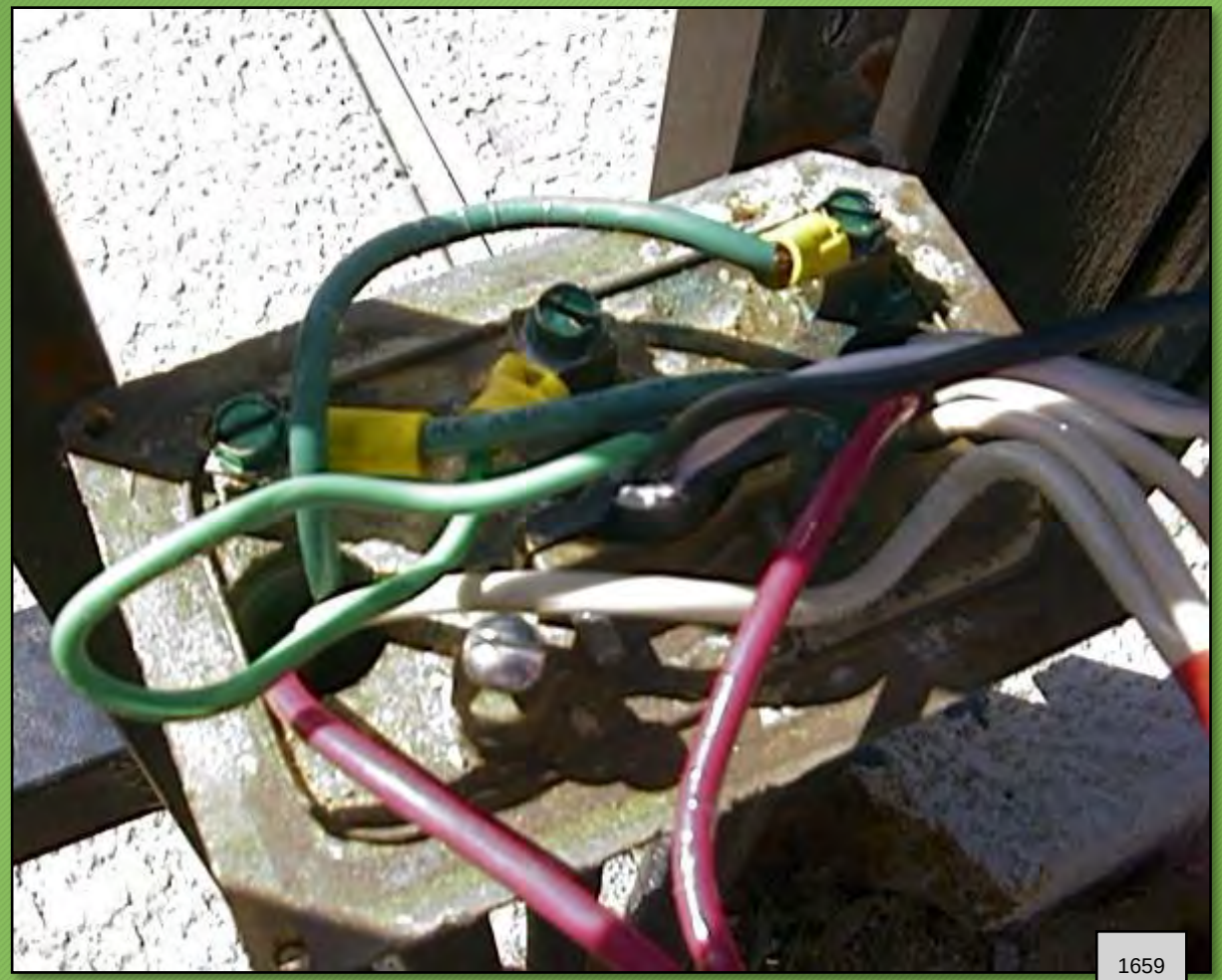
Junction boxes connected to a conduit that extends directly to a forming shell for wet-niche luminaires required to be listed, labeled, and identified as a swimming pool junction box



Copyright © IAEI 2020

Listed Swimming Pool Junction Boxes






Listed Swimming Pool Junction Boxes
1660

GFCI Requirements for Hydromassage Bathtubs

- Hydromassage bathtubs and their associated electrical components must be provided with **Class A ground-fault circuit interrupter (GFCI)** protection
- All 125-volt, single-phase receptacles *(not exceeding 30 amperes)* and located within 1.83 m (6 ft) measured horizontally of the inside walls of a hydromassage tub must be provided with Class A GFCI protection as well
- *See 680.71*
- *Note: A Class A GFCI trips when the current to ground is **6 mA or higher** and does not trip when the current to ground is **less than 4 mA***

Bonding Requirements for Hydromassage Bathtubs

- Section 680.74(A) requires the following parts associated with a hydromassage bathtub to be bonded together:
  - All **metal fittings** within or attached to the tub structure that are in contact with the circulating water
  - Metal parts of **electrical equipment** associated with the tub water circulating system *(pumps and blower motors)*
  - **Metal-sheathed cables** and **metal raceways** and **metal piping** that are within 1.5 m (5 ft) of the inside walls of the tub *(not separated from the tub by a permanent barrier)*

Bonding Requirements for Hydromassage Bathtubs *(cont.)*

- Section 680.74(A) requires the following parts associated with a hydromassage bathtub to be bonded together: *(cont.)*
  - All exposed **metal surfaces** that are within 1.5 m (5 ft) of the inside walls of the tub *(not separated from the tub area by a permanent barrier)*
  - Non-current-carrying metal parts of **electrical devices and controls** that are not associated with the hydromassage tubs and that are located within 1.5 m (5 ft) from such units

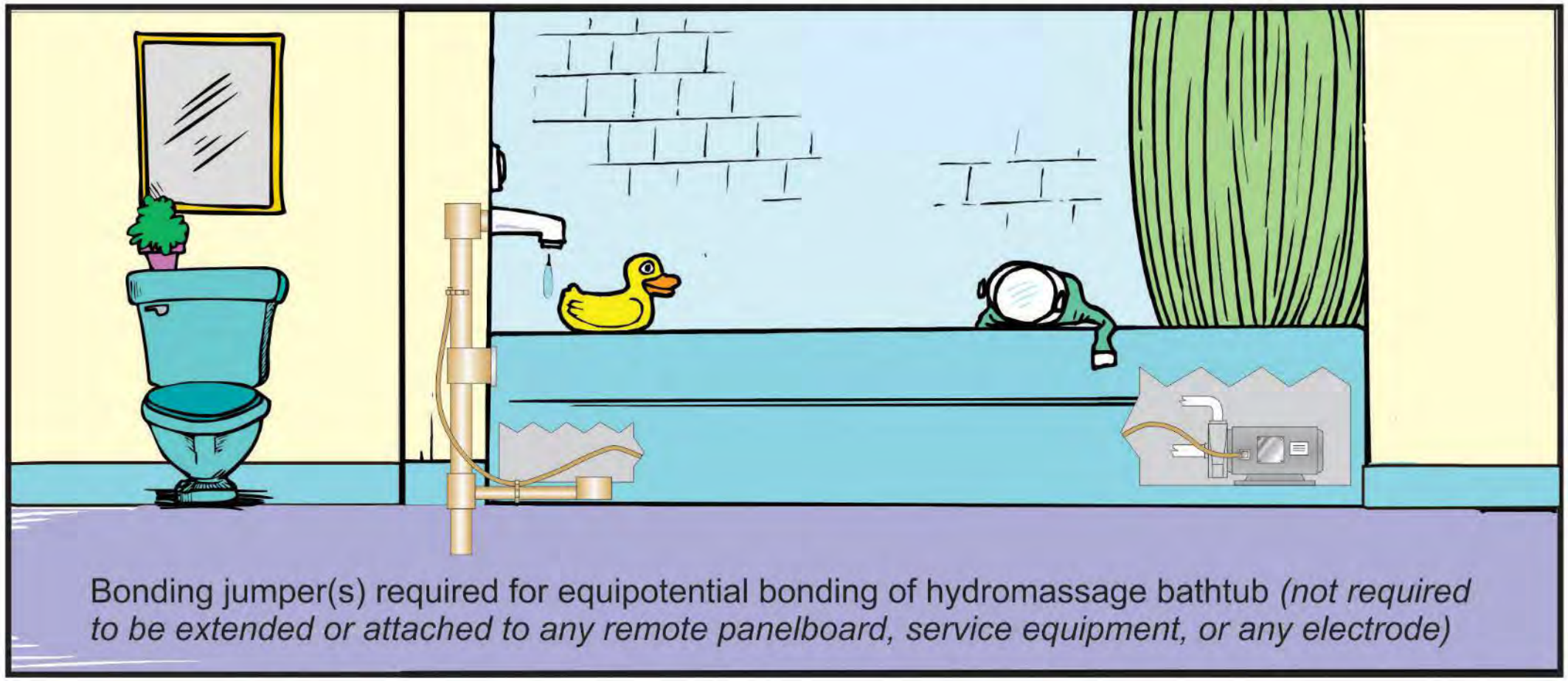
Bonding Requirements for Hydromassage Bathtubs *(cont.)*

- Section 680.74(A) requires the following parts associated with a hydromassage bathtub to be bonded together:
  - Exceptions to hydromassage bathtub bonding:
    - **Small conductive surfaces** not likely to become energized *(air and water jets, supply valve assemblies, and drain fittings not connected to metallic piping, and towel bars, mirror frames, and similar nonelectrical equipment not connected to metal framing)*
    - **Double-insulated motors** and blowers

Bonding Requirements for Hydromassage Bathtubs *(cont.)*

- All metal parts required to be bonded must be bonded together using a **solid copper bonding jumper**, insulated, covered, or bare, not smaller than **8 AWG**
- Bonding jumper(s) required for **equipotential bonding** of the hydromassage bathtub and **not required to be extended or attached to any remote panelboard**, service equipment, or any grounding electrode(s)
- Bonding jumper long enough to terminate on a **replacement nondouble-insulated pump or blower motor** to be provided and must be terminated to the EGC of the branch circuit of the motor when a double-insulated circulating pump or blower motor is used

680.74(A) Bonding Requirements

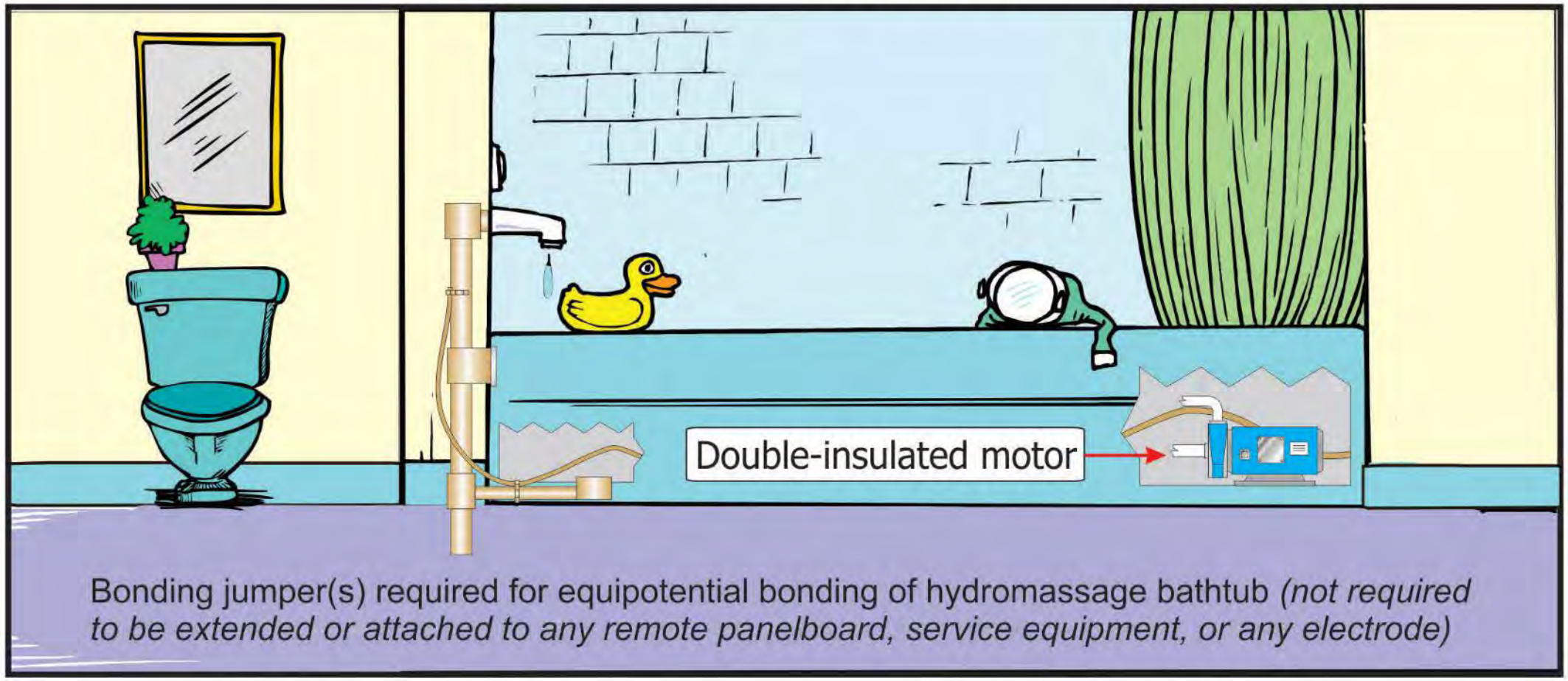


Bonding jumper(s) required for equipotential bonding of hydromassage bathtub *(not required to be extended or attached to any remote panelboard, service equipment, or any electrode)*

Items required to be bonded: (1) All metal fittings within or attached to tub in contact with circulating water, (2) any metal parts of electrical equipment associated with the circulating system, (3) all metal-sheathed cables, metal raceways, metal piping, (4) all exposed metal surfaces *(not separated from tub by a permanent barrier)*, (5) non-current-carrying metal parts of electrical devices and controls *(not associated with tub)* located within 1.5 m (5 ft) from such units

Copyright © IAEI 2020

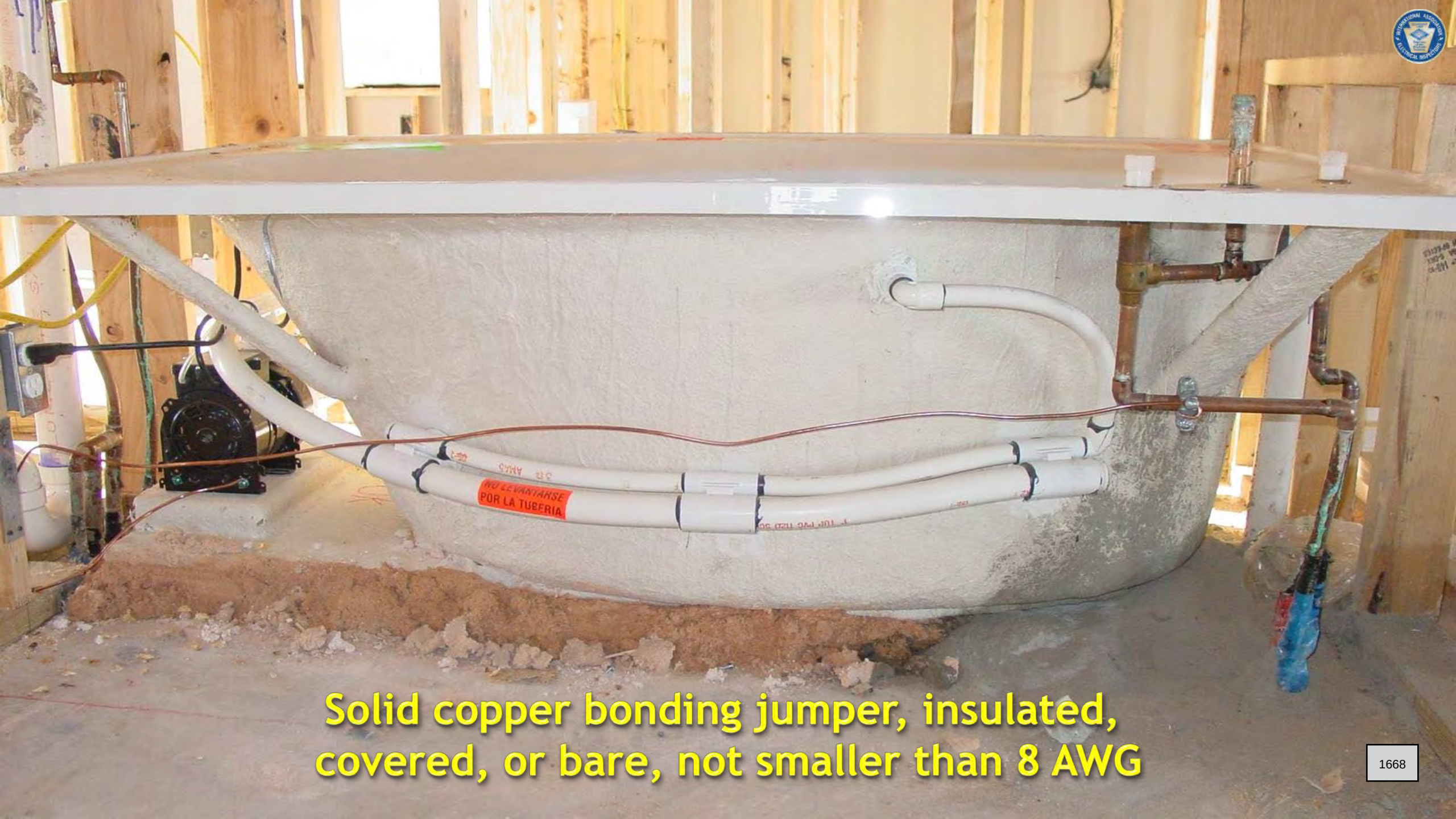
680.74(B) Bonding Conductors



Bonding jumper not required to be connected to double-insulated pump motor

8 AWG or larger solid copper bonding jumper is required to be long enough to terminate on a replacement non-double-insulated circulating pump or blower motor *(terminated to EGC of branch circuit of double-insulated motor)*

Copyright © IAEI 2020



Solid copper bonding jumper, insulated, covered, or bare, not smaller than 8 AWG

Electrically Powered Pool Lifts

- Pool lifts connected to premises wiring and operated above the low-voltage contact limit required shall be provided with **GFCI protection** for personnel
- Pool lifts are to be **bonded** in accordance with 680.26(B)(5) and (B)(7)
  - All **metal fittings** within or attached to the pool structure shall be bonded *(exception for small isolated parts)*
  - All **fixed metal parts** within 1.5 m (5 ft) horizontally shall be bonded *(metal-sheathed cables and raceways, metal piping, metal awnings, metal fences, and metal door and window frames, etc.)*


3 FT 0.9 M
3 FT 0.9 M
NO DIVING

CHAPTER EIGHTEEN

GROUNDING AND BONDING FOR ALTERNATE ENERGY SYSTEMS

Alternate Energy and Distributed Generations Systems

- As new energy generation construction costs, regulatory requirement, and energy demand have all grown, alternatives are being sought and implemented
- Multiple alternate energy options currently exist
- These alternate energy or distributed generation systems can include engine generators, hydroelectric generation, photovoltaic, wind, fuel cell, battery/converter energy storage systems and new technologies still under development
- There are many common requirements when considering the grounding and bonding of these systems whether **stand alone** or connected in **parallel with the utility power grid**, or are a **bimodal system**

Alternate Energy and Distributed Generations Systems *(cont.)*

- These systems can be installed to provide power "off grid," meaning they are **stand alone** and may include some means for energy storage (batteries)
- Examples of **stand along systems** include:
  - PV powered homes with no connection to any utility
  - PV powered signs such as flashing light traffic warning, directional, or alerting signs
  - PV powered energy efficient LED school zones warning signs


SCHOOL
SPEED
LIMIT
20
CELL PHONE
USE
PROHIBITED

Alternate Energy and Distributed Generations Systems *(cont.)*

- There are multiple options growing in popularity and/or dictated by government regulations or incentives
- These alternate energy systems include:
  - Photovoltaic systems (PV) [Article 690]
  - Fuel cells [Article 692]
  - Wind generation [Article 694]
  - Energy storage systems [Article 706]
  - Co-generation using natural gas or process steam, solar-thermal, and small hydro *(no specific NEC article…yet)*


FuelCell Energy
DFC300

Article 100 Definitions:

- ***Interactive System.*** "An electric power production system that is operating in parallel with and capable of delivering energy to an electric primary source supply system."
- ***Interactive Inverter.*** "An inverter intended for use in parallel with power source(s) such as an electric utility to supply common loads and capable of delivering power to the utility."
- ***Separately Derived System.*** **"**An electrical source, other than a service, having no direct connection(s) to circuit conductors of any other electrical source other than those established by grounding and bonding connections."

Article 100 Definitions: *(cont.)*

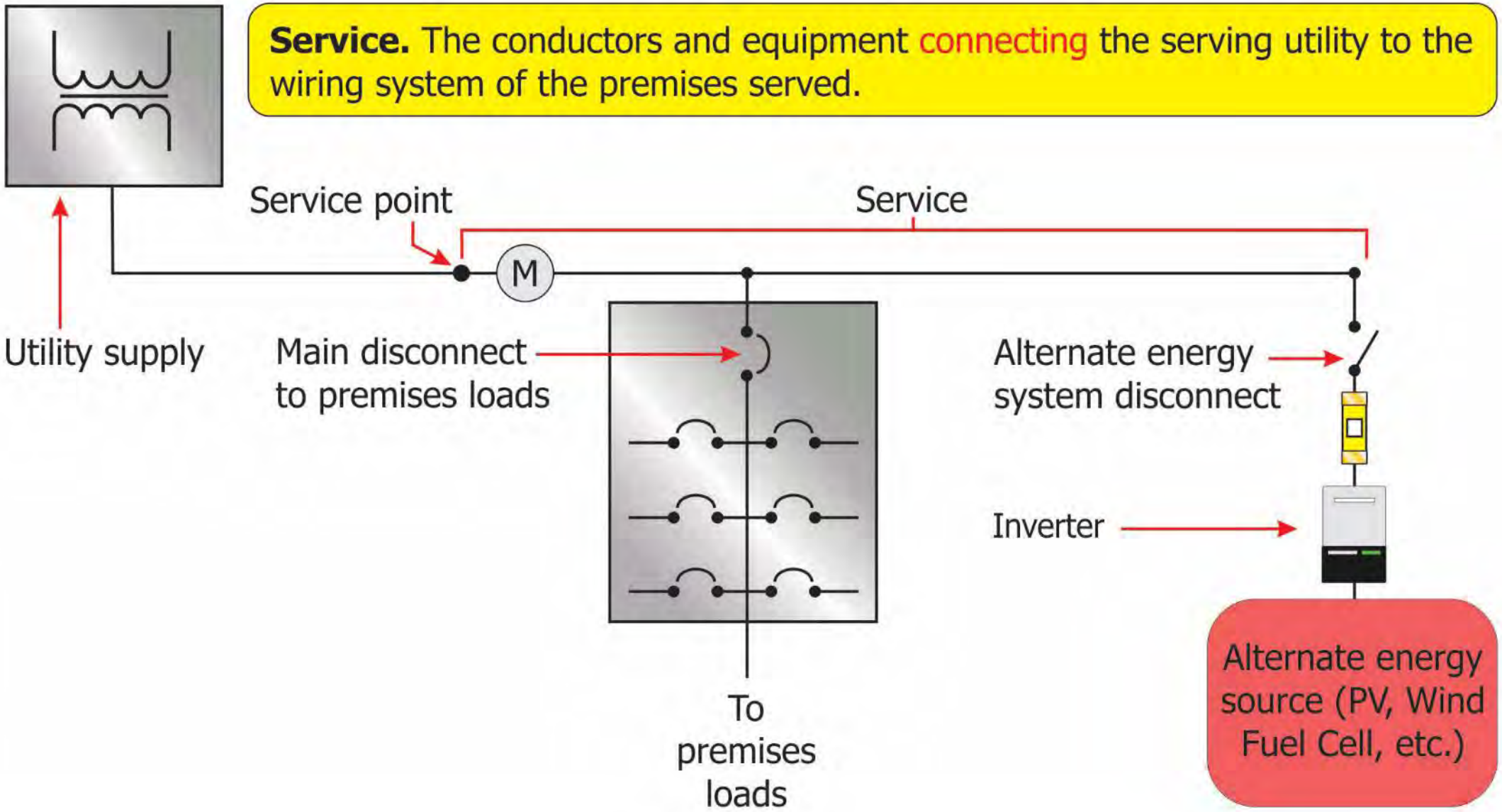
- ***Service.*** "The conductors and equipment connecting the serving utility to the wiring system of the premises served."
- ***Stand-Alone System.*** "A system that is capable of supplying power independent of an electric power production and distribution network."

Separately Derived System or Not?

- One of the first items to determine is if the alternate energy system is a **separately derived system**?
- Since these systems are typically **privately owned**, they are not considered as services *(as defined in Article 100…not power that is generated and supplied by the utility)*
- Significant change to the definition of **"service"** occurred in the 2020 *NEC*
- *P*revious definition was based on utilization equipment being powered from the utility *(which was true for most installations until recent history and the expansion of distributed generation)*
- New **"service"** definition recognizes distributed generation
- Utilization equipment on the premises may be supplied in whole or part by the utility or alternate energy system may export power back to the utility

Article 100: Definitions - Service

Service. The conductors and equipment connecting the serving utility to the wiring system of the premises served.



Copyright © IAEI 2020

Separately Derived System or Not? *(cont.)*

- The definition for **"service"** now includes the conductors and equipment that connect the premises wiring to the utility at the service point without regard to direction of power flow
- This is an important change as many installers were claiming that interconnection to the utility was not a **"service"** since the alternate energy system never used power from the utility *(but sent power toward the utility)*
- There are concerns regarding proper installation with grounding and bonding and the ac disconnect interface back to the utility grid
- Privately-owned systems *(even those built just as power production plants)* are **not wholly owned and controlled by the utility**; therefore, they do fall under the requirements of the *NEC*

Separately Derived System or Not? *(cont.)*

- Definition of ***"service"*** is very important as the requirements for installations services in Article 230 and related requirements in Chapters 1 to 3 **do not apply to these installations**
- **Stand alone "off grid" systems** are very likely **separately derived systems**
- Grounding and bonding requirements in 250.20, 250.26, 250.30 and other sections would apply
- Depending on the type of system *(PV, fuel cell, wind, or energy storage systems)* some of these grounding and bonding requirements are **supplemented or modified** in Articles 690, 692, 694, 705, and 706 respectfully

Separately Derived System or Not? *(cont.)*

- Using the definition of ***"separately derived system,"*** the **grid interactive inverter feeder output** that is connected directly to the ungrounded (phase) conductors *[and sometimes a grounded (neutral) conductor]* by the definition is **not a separately derived system**

- Grounding and bonding requirements applicable for this part of the installation are provided in **Articles 250 and 705**

Stand Alone Systems

- As defined, a **stand-alone system** is one where one or more alternate energy sources are installed to supply power to premises wiring or specific equipment *(no connection to the utility grid)*
- Treated as **separately derived systems** and follow the requirements from *NEC* 250.30(A)
- If the system is **required to be grounded** *[in accordance with 250.20(B)]* or **chosen to be grounded** *(250.21)*, then the steps and requirements for completing the grounding and bonding follow **250.30(A)** for grounded systems
- If the choice is to have an **ungrounded system** *[permitted by 250.20(B) or 250.21]*, requirements of **205.30(B)** applicable

Stand Alone Systems *(cont.)*

- It may appear to be **one system**, but many alternate energy sources *(such as typical photovoltaic systems)* may in fact be **two or more separate systems** *(dc system produced then changed into ac system with the inverter)*
- When there is more than one energy source connected in parallel *(such as multiple PV inverter outputs to an AC combiner panel)* the overall ac output installation is to be considered as a **single separately derived system** for grounding and bonding purposes *(see 250.30)*

Stand Alone Systems *(cont.)*

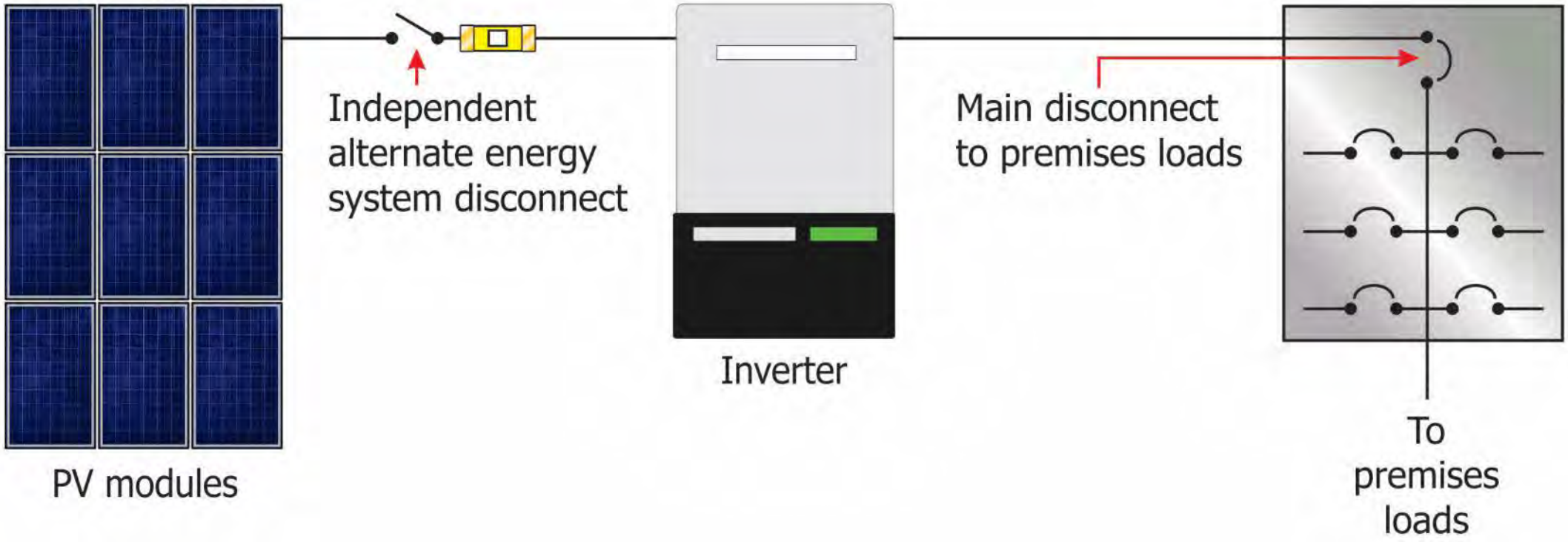
- Also common for the stand-alone systems to include a means of **energy storage** to provide for power to the loads being served when source unable to produce power
- For any of these installations this means that a grounding electrode or **grounding electrode system** meeting Part III of Article 250 is required to be used or installed
- Where the building or structure already has a **grounding electrode system for the service**, this same grounding electrode system **must be used** for the alternate energy system *(see 250.58)*

Stand Alone Systems *(cont.)*

- **Grounding electrode conductor** required to go to equipment as the source or optionally the main disconnect and would be connected to a neutral conductor *(if one is provided)*
- Otherwise, the GEC is connected to the equipment grounding terminal or bus at the source or the first disconnect
- **Equipment grounding** follows 250.120 and 250.122 as well as any additional modifications or requirements found in the respective articles for the particular alternate energy system

Article 100: Definitions - Stand-Alone System

Stand-Alone System. A system that is capable of supplying power independent of an electric power production and distribution network.



Copyright © IAEI 2020


CAMPSITES
GROS VENTRE
JENNY LAKE
SIGNAL MTN
COLTER BAY
LIZARD CREEK
FLAGG RANCH

Grid Connected Systems

- **Grid connected alternate energy systems** will have an appearance very much like a stand-alone system *(energy source, an inverter or converter, disconnects and similar equipment)*
- Difference is the ac output power is connected in some manner in parallel with the utility power supply
- Aspects of the alternate energy source *(such as the dc side of the PV system)* have the same requirements for being treated as a separately derived system as does the stand-alone system
- Main difference is on the ac side where there is **interconnection with the utility**

Grid Connected Systems *(cont.)*

- From a grounding and bonding standpoint for the derived system, a **grounding electrode conductor** is required to be installed to the inverter or alternate source neutral conductor at the main AC disconnect *(if there is one)* or to the equipment enclosure *(if there is no neutral)*
- When being interconnected to the grid, the determination of being a "grounded" system or an "ungrounded system" is from the utility side and almost always it will be a **grounded system**
- The inverter output and the presence of *(or lack of)* a neutral conductor does not change the type of system

Grid Connected Systems *(cont.)*

- Grounding electrode used is generally the same electrode present and used for the building electrical service supply
- The first grounding and bonding reference for an **interconnected alternate energy system** is found in 250.25 *(Grounding Systems Permitted to Be Connected on the Supply Side of the Disconnect) (new for the 2020 NEC)*
- 250.25 is not just for alternate energy systems *(applies to any system or equipment connected to the line side of the service disconnect as permitted in 230.82)*
- While the ac disconnect from the alternate energy system that interconnects with the utility is not called a “service” the grounding and bonding requirements are applied **as if it was a service disconnect**

Grid Connected Systems *(cont.)*

- Secondary general article for this system interconnection is **Article 705 *(Interconnected Electric Power Production Sources)***
- Article 705 applies for any alternate energy source *(not just photovoltaic, wind, fuel cells etc.)*
- Section 705.6 deals with equipment approvals and states that, "All equipment shall be **approved for the intended use**. Interactive equipment **intended to operate in parallel** with the electric power production sources including, but not limited to, interactive inverters, engine generators, energy storage equipment, and wind turbines **shall be listed for interactive function** or be evaluated for interactive function and have a field label applied, or both."

Grid Connected Systems *(cont.)*

- Main sections in Article 705 that affects grounding and bonding for grid interconnection are **705.11** and **705.12**
- Section **705.11** *(new for the 2020 NEC)* addresses requirements for interconnection on the **line side** of the service
- Section **705.12** sets the requirement for the connection of the alternate energy system to the **load side** of the service disconnect
- The term **"line side connections"** means connection **ahead of the service disconnect** to the service entrance conductors but on the **load side of the utility** metering equipment and service point
- For these supply side connections, 705.11 establishes several requirements

Grid Connected Systems *(cont.)*

- Section **705.12** had previously covered both line side and load side connections
- 2020 *NEC* saw extensive revision to this section to address **load side connections only**
- Since this is for the **load side**, the grounding and bonding requirements are already addressed for the installation in 250.24, 250.30, and 250.32
- The grounding and bonding of the alternate energy system is then focused on the equipment, enclosures, raceways and where it is a grounded system, alternate energy system itself

Grid Connected Systems *(cont.)*

- Where the connection is made on the **load side**, the concern is that the common bus **can become overloaded** and not have overcurrent protection
- Limits as detailed in **705.12(B)(1) to (B)(6)** for the alternate source connection are in place to prevent such action on the load side
- Where connection is made to the **line side** of main overcurrent device, main breaker provides the protection to the main bus since all the power to the loads must pass through it
- Only limits to the size of the alternate source is the ampacity of the service entrance conductors where the interconnection is made

Grid Connected Systems *(cont.)*

- While the *Code* is very clear that the ac disconnect from alternate source to the premises service is **not a "service,"** from a grounding and bonding standpoint, this installation needs to be **treated as if it was another service disconnect**
- Conductor from the line side connection to the ac disconnect are very much like service-entrance conductors
- While power will flow from the alternate energy system to the utility system under normal conditions, under ground-fault conditions, the fault current is supplied by both the utility and the alternate source system
- There may be **multiple alternate energy systems** that work together and come to a single point, but these should be viewed as a **single separately derived system** for grounding and bonding purposes

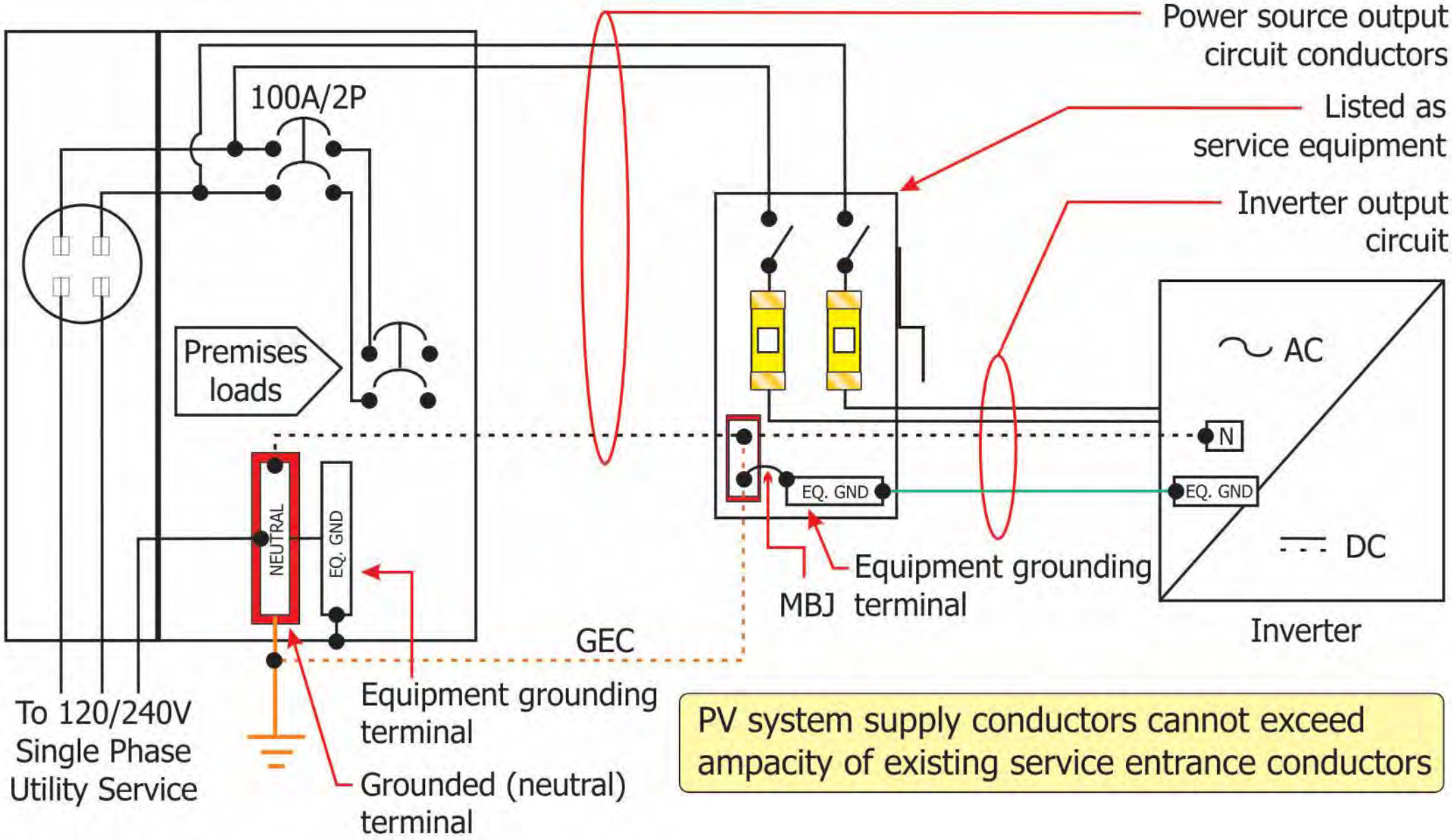
Grid Connected Systems *(cont.)*

- The following points need to be considered for **interconnection on the line side** of the service disconnect:
  - Must be a **low impedance ground fault return path** *[accomplished by installing a neutral conductor sized at least to Table 250.102(C)(1) to the alternate energy ac disconnect]*
  - Disconnect and overcurrent protection for the alternate energy system required to be within **3 m (10 ft)** of the connection to the line side of the service for dwelling units and **5 m (16.5 ft)** for other than dwelling units *(unless suitable cable limiters are installed) [see 705.11(C)]*
  - If these conductors are installed in a **metal raceway**, grounding and bonding is required to be in accordance with 250.92(B) for **service raceways**

Grid Connected Systems *(cont.)*

- The following points need to be considered for **interconnection on the line side** of the service disconnect: *(cont.)*
  - Where the neutral conductor and/or metal raceway exist, a separate supply side bonding jumper should not be installed *(parallel path for any normal neutral current may be provided)*
  - The ac disconnect should have the grounding electrode conductor installed to it and the neutral bus within the ac disconnect must be bonded to the enclosure
  - AC disconnect to be rated as "Suitable for Use as Service Equipment" *(SUSE rated)* to facilitate the grounding and bonding required by 250.25

Grid Interconnected Alternate Energy System



Copyright © IAEI 2020

Transformers

- For many medium to larger alternate energy systems *(particularly photovoltaic)* inverter outputs of 480 or 277/480 volts, 3-phase, has become more common
- Large scale PV systems (Article 691) often have inverter outputs at 347 volts or 480 volts with transformers stepping the voltage up to a medium voltage such as 12.47 KV or 35 KV
- The higher voltage allows greater power to be provided at a lower current and thereby saving on conductor and conduit size as well as minimizing losses from conductor impedance
- When one of these systems operating at 480 or 277/480 volts is to be grid connected but the service is 280/120 volts, a **transformer** is required to change the voltage

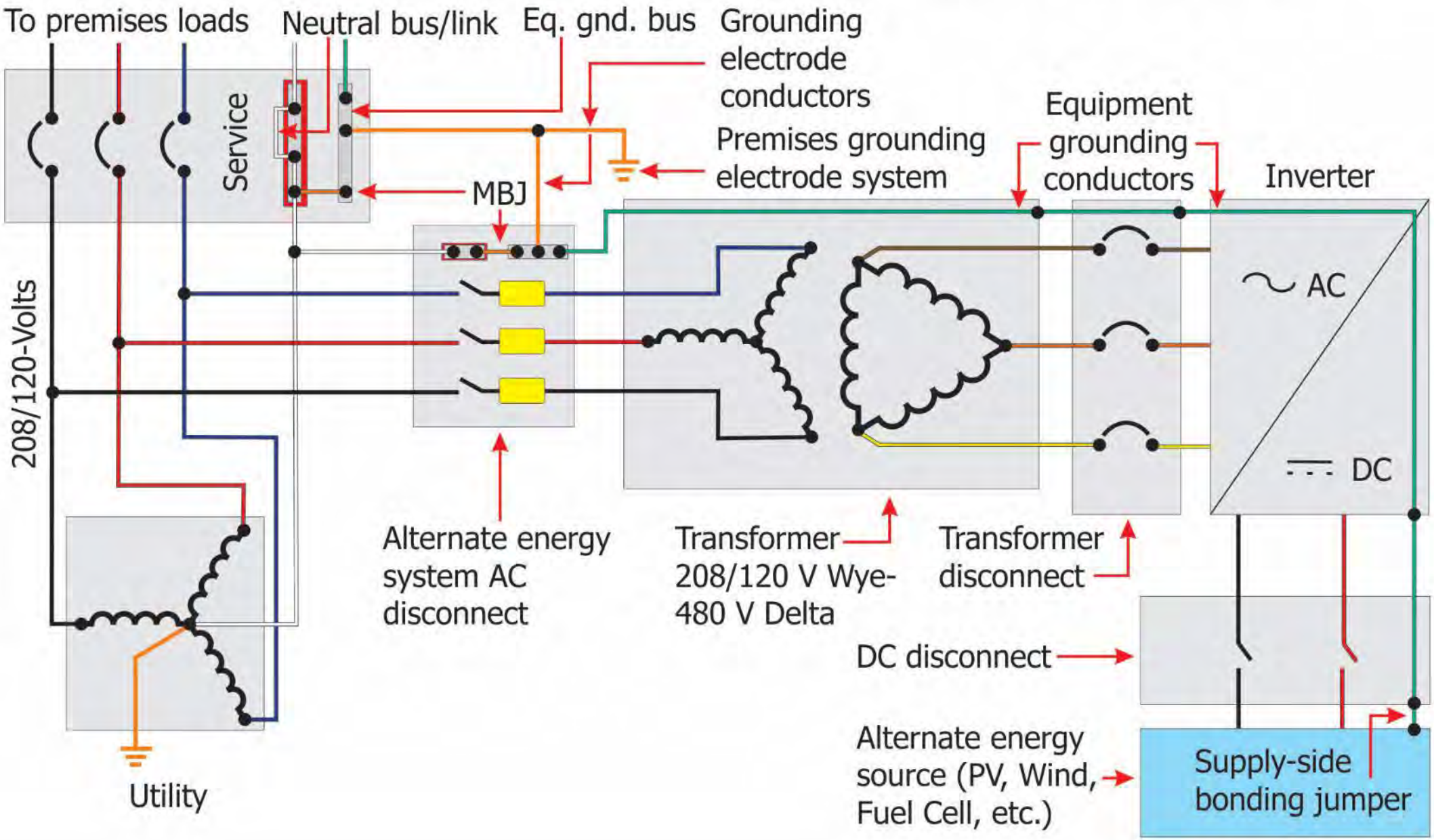
Transformers *(cont.)*

- This design will now create another **separately derived system** for the portion of the installation between the **inverter ac output** and the **transformer input**
- The grounding and bonding of the additional separately derived system will need to be addressed and may present, what some may consider, unusual installations
- For a 480-volt 3-phase, 3-wire alternate energy system the transformer can be a typical 480-volt delta to 208/120-volt wye configuration
- Normally when this configuration is encountered, the grounding and bonding on the 208/120-volt side follows 250.30

Transformers *(cont.)*

- This 208/120-volt output is being solidly connected to the grid via the grounded service
- Therefore, the 208/120-volt transformer output is **not a separately derived system** *(no grounding or bonding of the XO terminal is allowed)*
- Grounding and bonding of this part of the system is accomplished at the service
- The installation from the service to the transformer would include the 3 phases of ungrounded conductors, an option for a neutral conductor, and an equipment grounding conductor
- The neutral is optional since in normal operation there should not be any unbalanced loads and therefore no neutral current to return to the transformer

480-Volt, 3-Phase, 3-Wire Alternate Energy System



Copyright © IAEI 2020

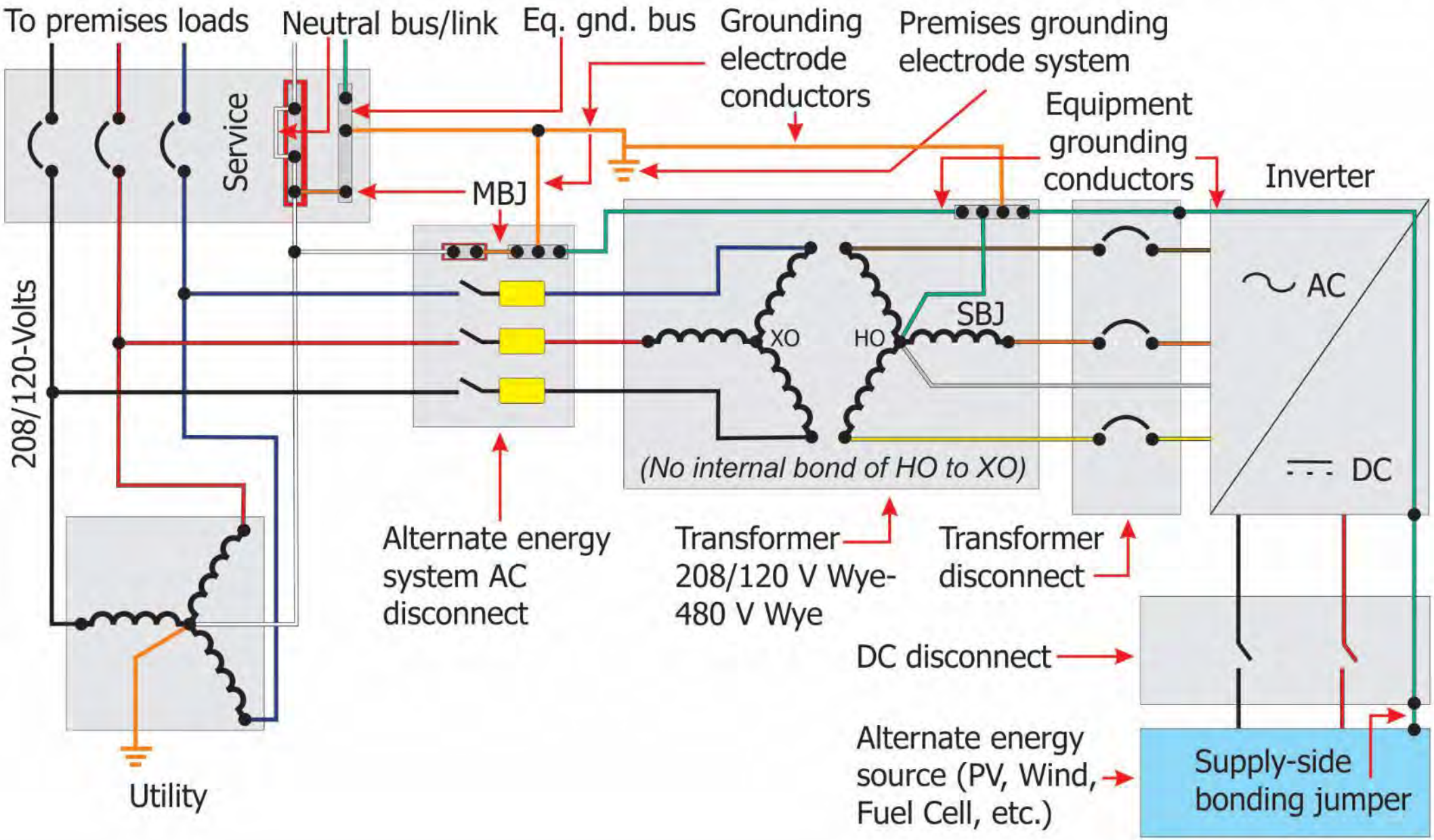
Transformers *(cont.)*

- Another system design that has been recently seen is a **277/480 wye to a 208/120-volt wye transformer** to accomplish the voltage change
- This transformer configuration may have an internal bond between the HO and XO star points or…
- May have separate internal terminals or buses for the 277-volt neutral and the 120-volt neutral
- Recommended that **no bond be installed between the HO and XO terminals** to facilitate grounding and bonding of each system and for controlling ground fault current paths

Transformers *(cont.)*

- For the installation between the inverter and the transformer, **treated as a separately derived system** with connection for the three ungrounded phase conductors, a neutral, and either an equipment grounding conductor or supply side bonding jumper *(depending on where the inverter output overcurrent protection is installed)*
- Grounding and bonding of this system could be completed at the inverter *or* at the transformer *(one location only)*
- Size of the **system bonding jumper** for the 480/277-volt side would be from **250.102(C)(1)** based on the size of the largest phase conductors between the inverter and transformer
- Installation from the service to this transformer should include the 3 ungrounded phase conductors and the equipment grounding conductor only

277/480-Volt, 3-Phase to 208/120-Volt, 3-Phase Transformer



Copyright © IAEI 2020

Grounding of Photovoltaic (PV) Systems

- Article 690 has undergone extensive changes in the last few *Code* cycles *(including the 2020 cycle)*
- PV systems have evolved and developed to become more economical and have gained much more widespread use in many varied installation applications
- As Article 690 evolves, so does the grounding and bonding requirements
- In addition to the requirements found in Article 250, additional or modified grounding and bonding requirements for PV systems are found in Part V of Article 690

Grounding of Photovoltaic (PV) Systems *(cont.)*

- A definition of **"functionally grounded"** is found at 690.2, which is unique to Article 690
- This term was introduced in the 2017 *NEC* and was modified along with the informational note in the 2020 *NEC* revision cycle
- ***Grounded, Functionally.*** "A system that has an electrical ground reference for operational purposes that is not solidly grounded."
- ***Informational Note:*** A functionally grounded system is often connected to ground through an electronic means internal to an inverter or charge controller that provides ground-fault protection. Examples of operational purposes for functionally grounded systems include ground-fault detection and performance-related issues for some power sources.

Grounding of Photovoltaic (PV) Systems *(cont.)*

- One key to applications in Part V of Article 690 is fully understanding a **solidly grounded system**, and a **functionally grounded system**
- Functionally grounded system applies to the dc side from the solar cells and modules up to the dc input to the inverter
- The new ac system from the inverter grounding and bonding follows the normal ac requirements from Articles 250 and 705

Grounding of Photovoltaic (PV) Systems *(cont.)*

- Two other items of note are in **690.31**
  - **First Item**: The **identification of the dc source conductor** meeting requirements found in 200.6 ***(white, gray or three white stripes)*** applies when the system is truly solidly grounded *[see 690.31(B)(1)]*
  - For other than solidly grounded systems *(such as functionally grounded systems)* complying with 690.41(A)(5), the **identification of the "functionally grounded conductor"** shall be permitted by **other means**
  - This includes markings with the words **"POSITIVE"**, "POS" or the "+" symbol for the positive side and the words **"NEGATIVE"**, NEG" or the "-" symbol on the negative side conductors with **colors other than white, gray or green**

Grounding of Photovoltaic (PV) Systems *(cont.)*

- Two other items of note are in **690.31** *(cont.)*
  - **Second Item:** Dealing with multiconductor cables *[see 690.31(C)(3)]*
  - Commonly used to take the power from a group of PV modules in a part of the array to a combiner box *(typically are installed in cable tray or a wireway)*
  - Previous *Code* required each multiconductor cable to include a full-sized EGC within each cable assembly *(even when installed in the wireway or cable tray that qualified as an EGC)*

Grounding of Photovoltaic (PV) Systems *(cont.)*

- Two other items of note are in **690.31** *(cont.)*
  - The current *NEC* now requires that the multiconductor cable be **part of a listed PV assembly** *or* where not part of a listed assembly, multiconductor jacketed cables *(including DG cable)* required be installed in accordance with the **product listing**
  - If listed and identified for the application, the internal equipment grounding conductor would not be provided since the application in cable tray or wireway would be suitable

Grounding of Photovoltaic (PV) Systems *(cont.)*

- As stated earlier, **Part V of Article 690** provides the grounding and bonding requirements for PV systems
- The first section in Part V is **690.41**, with requirements for **"System" Grounding"**
- One or more of the following system grounding configurations must be employed:
  1. 2-wire PV arrays with one functional grounded conductor
  2. Bipolar PV arrays according to 690.7(C) with a functional ground reference *(center tap)*
  3. PV arrays not isolated from the grounded inverter output circuit

Grounding of Photovoltaic (PV) Systems *(cont.)*

- One or more of the following system grounding configurations must be employed: *(cont.)*
  4. Ungrounded PV arrays
  5. Solidly grounded PV arrays *[690.41(B) Exception]*
  6. PV systems that use other methods that accomplish equivalent system protection in accordance with 250.4(A) with equipment listed and identified for the use
- 690.41(A)(6) allows **alternatives for system grounding** as long as the performance requirements of 250.4(A) for grounded systems are met

Grounding of Photovoltaic (PV) Systems *(cont.)*

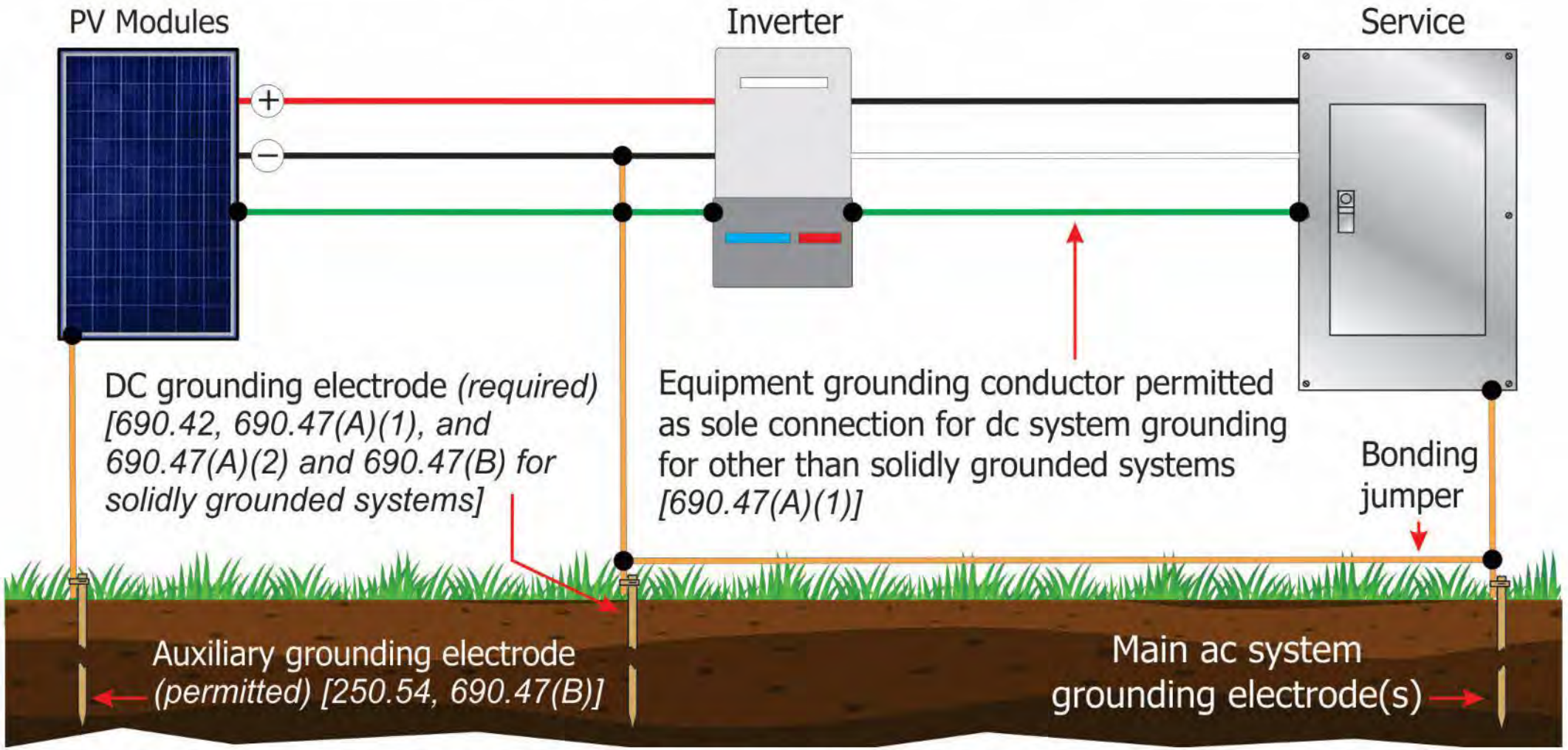
- The requirements **for PV system ground fault protection** is found at **690.41(B)** *(for dc circuit systems that exceed **30 volts** or **8 amperes**)*
- PV source circuits with **not more than two modules** in parallel and **not on or in a building** excluded from required ground fault protection
- 690.42 starts where ground-fault protection is provided and where the system has ground-fault protection as required or permitted in 690.41(B), then the required system grounded conductor to ground connection is to be made through the ground-fault protective device
- If this connection is inherent within the ground-fault protective device, then it shall not be duplicated with another connection elsewhere in the system

Grounding of Photovoltaic (PV) Systems *(cont.)*

- Otherwise for solidly grounded PV system this section permits the dc system grounding to be completed at any single convenient location in the system
- Most common location for this dc system grounding is at the inverter
- All equipment frames and enclosures, modules, combiner boxes, junction boxes, metallic raceways, disconnect enclosures and the inverters are to be connected together by equipment grounding conductor(s) *(see 690.43)*
- There is an equipment grounding system for the **dc side** and another equipment grounding system for the **ac output** to the load or grid interconnection point
- These equipment grounding systems are **connected at the inverter** and are connected to ground either at the inverter or at the service

System Grounding and Bonding *(PV Systems)*

[See Article 690, Part V (690.41 - 690.47)]



The dc system grounding connection to be made at any single location on the PV output circuits

The most common location for this dc system grounding is typically at the inverter

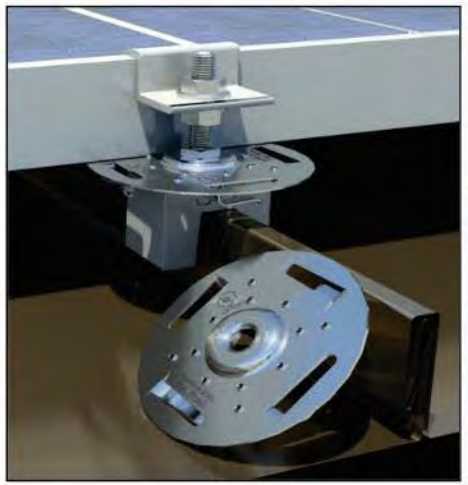
Copyright © IAEI 2020

Grounding of Photovoltaic (PV) Systems *(cont.)*

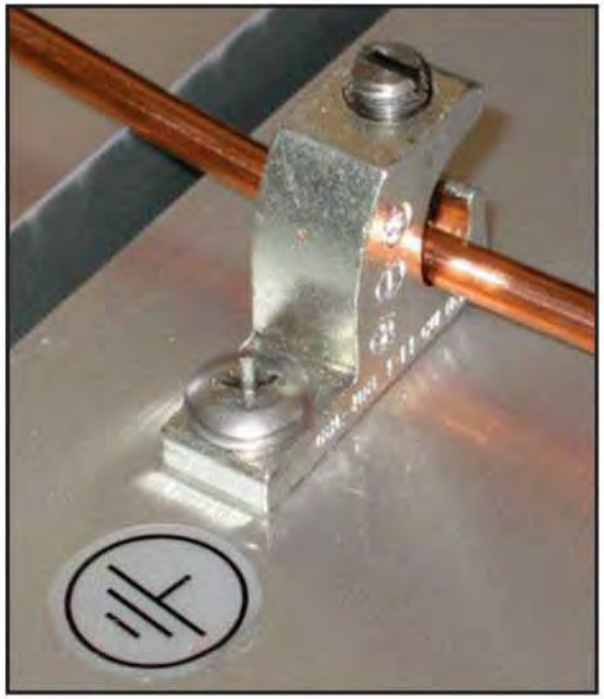
- All equipment frames and enclosures, modules, combiner boxes, junction boxes, metallic raceways, disconnect enclosures and the inverters are to be connected together by equipment grounding conductor(s) *(see 690.43)*
- 690.43 refer to 250.134, and 250.136 for equipment fastened in place and equipment secured to grounded metal supports
- Sections 690.43(A), (B), and (C) gives specific requirements for using the **module support framework** *(racking systems)* and **specially listed devices** to achieve bonding of the various parts
- These bonded parts become part of the equipment grounding path and are all connected to the equipment grounding conductor

690.43 Equipment Grounding *and Bonding (PV Systems)*









690.43(A), (B), and (C) have specific allowances for using the framework of PV systems and specially listed devices to achieve bonding of the various parts and these bonded parts becoming part of the equipment grounding path





Copyright © IAEI 2020

Grounding Electrode System for PV Array Grounding

- A building or structure supporting a PV array must utilize a grounding electrode system installed in accordance with Part III of Article 250 *(250.50 through 250.70 – Grounding Electrode System and Grounding Electrode Conductors)*
- PV array EGCs are required to be connected to the grounding electrode system of the building or structure supporting the PV array in accordance with Part VII of Article 250 *(250.130 through 250.148 – Methods of Equipment Grounding)*
- This connection must be in addition to any other EGC requirements in 690.43(C) *(With Circuit Conductors)*
- The PV array EGCs shall be sized in accordance with 690.45
- *See 690.47(A)*

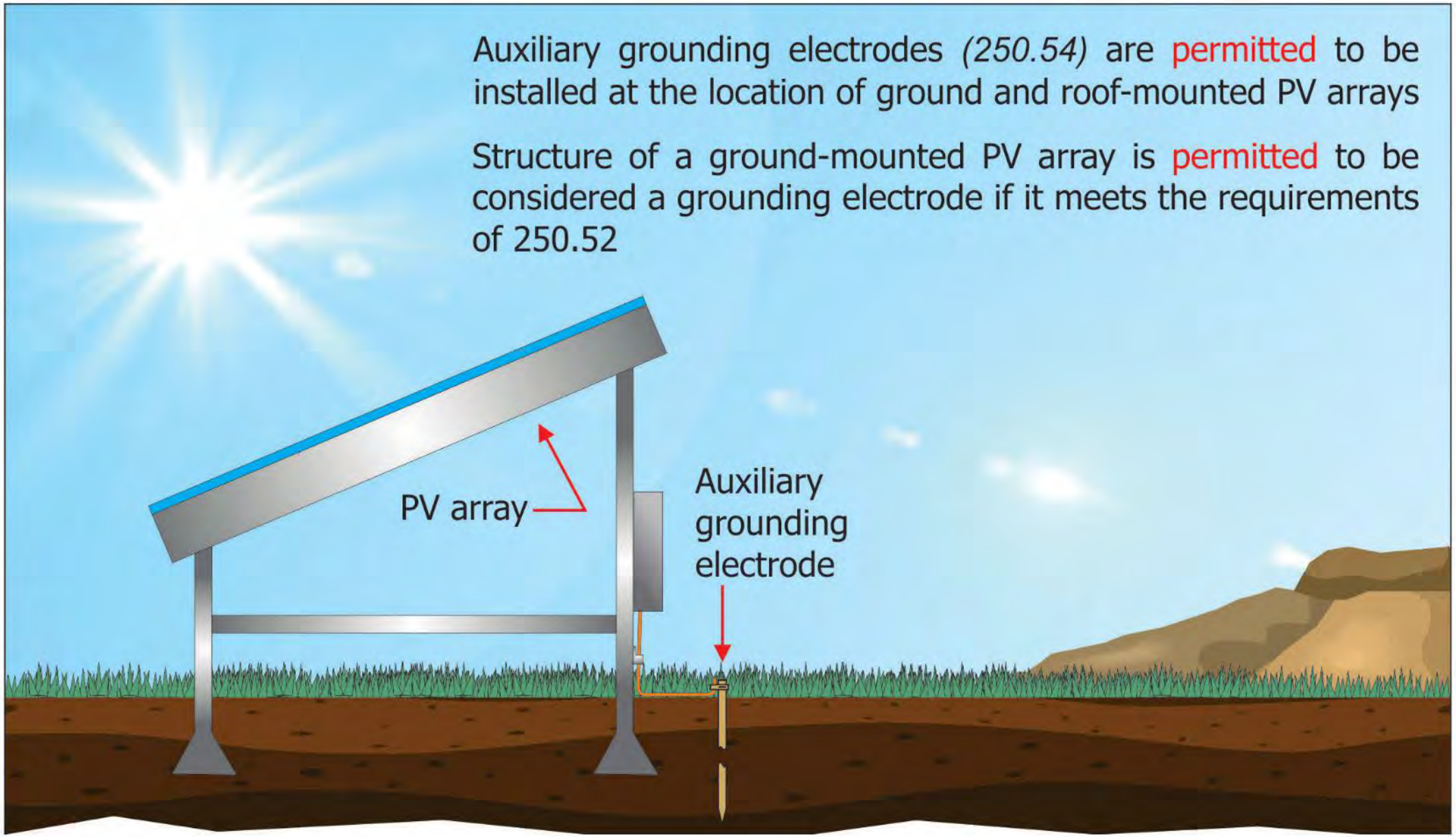
Grounding Electrode System for PV Array Grounding *(cont.)*

- For specific PV system grounding configurations permitted in 690.41(A), one of the following conditions shall apply:
  - For PV systems that are **not solidly grounded**, the EGC for the output of the PV system *(connected to associated distribution equipment)* permitted to be the only connection to ground for the system
  - For **solidly grounded PV systems** *[permitted in 690.41(A)(5)]*, the grounded conductor must be connected to a grounding electrode system by means of a grounding electrode conductor sized in accordance with 250.166

Additional Auxiliary Electrode(s) Permitted for PV Array Grounding

- Additional *(Auxiliary)* grounding electrodes are **permitted** to be installed in accordance with 250.52 and 250.54
- Grounding electrodes **permitted** to be connected directly to the PV module frame(s) or support structure
- Grounding electrode conductor(s) to be sized according to 250.66
- Support structure for a ground-mounted PV array **permitted** to be considered a grounding electrode *(meeting the requirements of 250.52)*
- PV arrays mounted to buildings **permitted** to use the metal structural frame of the building *[if the requirements of 250.68(C)(2) are met]*

690.47(B) Additional (Auxiliary) Electrodes for Array Grounding



Copyright © IAEI 2020

Fuel Cell Systems

- Grounding and bonding requirements for **fuel cell systems** are found in Part V of Article 692
- Where the fuel cell is a separately derived system ***(stand-alone system)***, **ac systems** are to follow the requirements found in 250.20 and 250.30 *[692.41(A)]*
- **dc system** grounding is to follow the requirements of 250.160 *[692.41(B)]*
- Where there are **ac and dc grounding requirements**, 692.41(C) provides that the dc grounding system shall be bonded to the ac grounding system

Fuel Cell Systems *(cont.)*

- A **separate equipment grounding conductor** must be installed to fuel cell systems *[692.44]*
- EGC to be sized in accordance with Table 250.122 *[692.45]*
- When an auxiliary electrode is installed *(perhaps required by manufacturer's installation instructions)*, it must be connected to the equipment grounding conductor specified in 250.118
- *See Part V of Article 692*


PureCell®
Power Your Independence.®
DOOSAN
Doosan
Fuel Cell America, Inc.
Productive
Secure
Clean
Did you
know?
Fuel cells
operate without
annually.

Wind Electric Systems

- Wind electric generating system grounding and bonding are found in Part V of Article 694 *[specifically 694.40]*
- Two areas *(items)* required to be grounded and bonded to the premises grounding and bonding system
  - Equipment grounding and bonding
  - Tower grounding and bonding
- Exposed non-current-carrying metal parts of towers, turbine nacelles, other equipment, and conductor enclosures are required to be grounded and bonded to the premises grounding and bonding system
- Without any modifications this grounding and bonding would need to be in accordance with Article 250 Parts IV, V, and VI

Wind Electric Systems *(cont.)*

- Parts that are not likely to become energized *(such as the blades)* are not required to be connected to an equipment grounding conductor
- A wind turbine tower is required to be connected to a grounding electrode system *[694.40(B)(1)]*
- Where installed in close proximity to galvanized foundation or tower anchor components, galvanized grounding electrodes must be used
- Article 694 provides specific requirements for bonding of parts together and to the grounding electrode system, connections to the tower, and connections to guy wires *(were used)*
- *See 694.40(A) and (B)*




1731

CHAPTER NINETEEN

GROUNDING AND BONDING FOR ELECTRONIC EQUIPMENT

Requirements for IT Equipment Rooms

- The scope of Article 645 covers equipment, power-supply wiring, equipment interconnecting wiring, and grounding of information technology equipment and systems in an information technology (IT) equipment room
- For further information, see NFPA 75-2017, *Standard for the Fire Protection of Information Technology Equipment*
- Articles 725, 770, 800 and 805 apply to nonpower interconnection of IT equipment located outside the IT or computer room, such as for personal computers, workstations, printers, and part of a building management system
- Generally, Article 250 apply to grounding and bonding requirements for IT equipment *(except as modified in Article 645)*

Requirements for IT Equipment Rooms *(cont.)*

- Important for designers, installers, and user to fully understand the parameters that define an IT room as detailed in 645.4
- Six (6) special conditions are imposed in 645.4 before the requirements and allowances of Article 645 *(including those provisions for grounding)* are permitted to be applied for the IT room under consideration
- See **645.4** for the **specific qualifying conditions** that must be meet before the alternative wiring methods to Chapter 3 and Parts I and III of Article 725 for signaling wiring and Parts I and V of Article 770 for optical fiber cabling would be permitted in an IT equipment room
- Only electrical equipment and wiring associated with the operation of the IT room can be installed in the IT room

Article 100 Definitions

- ***Information Technology Equipment (ITE):*** Equipment and systems rated 1000 volts or less, normally found in offices or other business establishments and similar environments classified as ordinary locations, that are used for creation and manipulation of data, voice, video, and similar signals that are not communications equipment as defined in Part I of Article 100 and do not process communications circuits as defined in 805.2.
- **Informational Note:** For information on listing requirements for both information technology equipment and communications equipment, see UL 60950-1-2014, *Information Technology Equipment - Safety - Part 1: General Requirements or UL 62368-1-2014, Audio/Video Information and Communication Technology Equipment Part 1: Safety Requirements.*

Article 100 Definitions *(cont.)*

- ***Information Technology Equipment Room:*** A room within the information technology equipment area that contains the information technology equipment.
- ***Nonlinear Load:*** A load where the wave shape of the steady-state current does not follow the wave shape of the applied voltage.
- **Informational Note:** Electronic equipment, electronic/electric-discharge lighting, adjustable-speed drive systems, and similar equipment may be nonlinear loads.



1737

Equipment Grounding and Bonding Requirements for IT Systems

- All exposed non-current-carrying metal parts of IT equipment shall be bonded to the equipment grounding conductor (EGC) in accordance with Parts I, V, VI, VII, and VIII of Article 250 or shall be double insulated
- Where signal reference structures are installed, they are required to be bonded to the EGC provided for the IT equipment
- Any auxiliary grounding electrode(s) installed for IT equipment must be installed in accordance with 250.54
- Additional requirements or modifications of the general rules in Article 250 are given in Article 645
- See 645.15

Objectionable Currents

- An additional reference to grounding of IT equipment is found in 250.6(A) ***Arrangement to Prevent Objectionable Current***
- General requirement is that equipment grounding conductors and grounding electrode conductors be installed to prevent objectionable current through the grounding path(s)
- *NEC* does not define ***objectionable current***
- Any current through equipment grounding conductors or grounding electrode conductors that would in any way impair the performance of their intended function would be ***"objectionable"***
- *Note:* Small currents that do not impact the function of these conductors is not considered "objectionable"

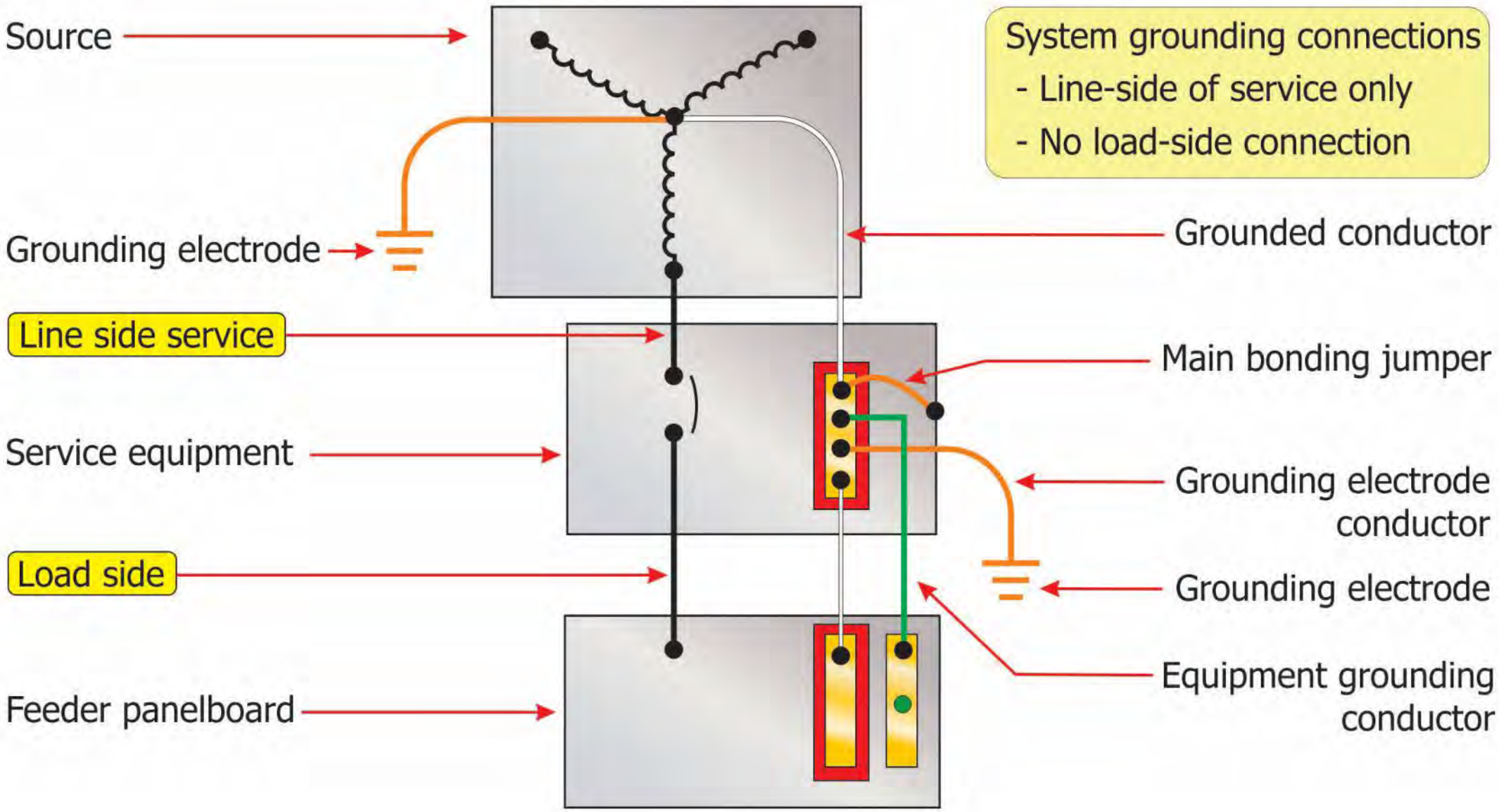
Objectionable Currents *(cont.)*

- Steps that can be taken to **stop objectionable current** are found at 250.6(B):
  - Disconnect one or more but not all grounding connections
  - Change locations of grounding connections
  - Interrupt continuity of the conductor or conductive path causing the objectionable current
  - Take other suitable remedial and **approved** action
- ***Approved*** is defined in Article 100 as "acceptable to the authority having jurisdiction (AHJ)"
- Currents that introduce noise or data errors in electronic equipment are not to be considered as "objectionable"

Grounded Conductor

- Neutral or grounded system conductor cannot be reconnected to ground past the service disconnecting means
- With any system, re-grounding of the neutral conductor or system grounded conductor on the load side of the service or disconnecting means creates **parallel paths** for neutral current over each parallel path that is established such as over conduit, piping systems, cable shields and cable trays
- *See 250.24(A)(5)*

250.24(A)(5) System Grounding Connections



Copyright © IAEI 2020

Purpose of Grounding Electrical Equipment

- Grounding *(Connecting to earth)*
  - Limits the voltages due to lightning, line surges or unintentional contact with higher voltage lines
  - Stabilize voltage to ground during normal operation
- A broad, general performance requirement is provided in **250.4(A)(2)** on grounding of electrical equipment *(including IT equipment)* which states:
  - Normally non-current-carrying conductive materials enclosing electrical conductors or equipment, or forming part of such equipment, shall be connected to earth so as to limit the voltage to ground on these materials.

Purpose of Grounding Electrical Equipment *(cont.)*

- The need for an **effective ground-fault current path** is discussed at 250.4(A)(5) which states:
  - Electrical equipment *(including IT equipment)*, wiring, and other electrically conductive materials likely to become energized shall be installed in a manner that creates a **low-impedance circuit**
  - Must facilitate the operation of the overcurrent device or ground detector for high-impedance grounded systems
  - Must be capable of safely carrying the maximum ground-fault current likely to be imposed from any point on the wiring system where a ground fault may occur to the electrical supply source
  - Also states that the earth is **not permitted** as a ground-fault current path

Isolated Equipment Grounding Conductors

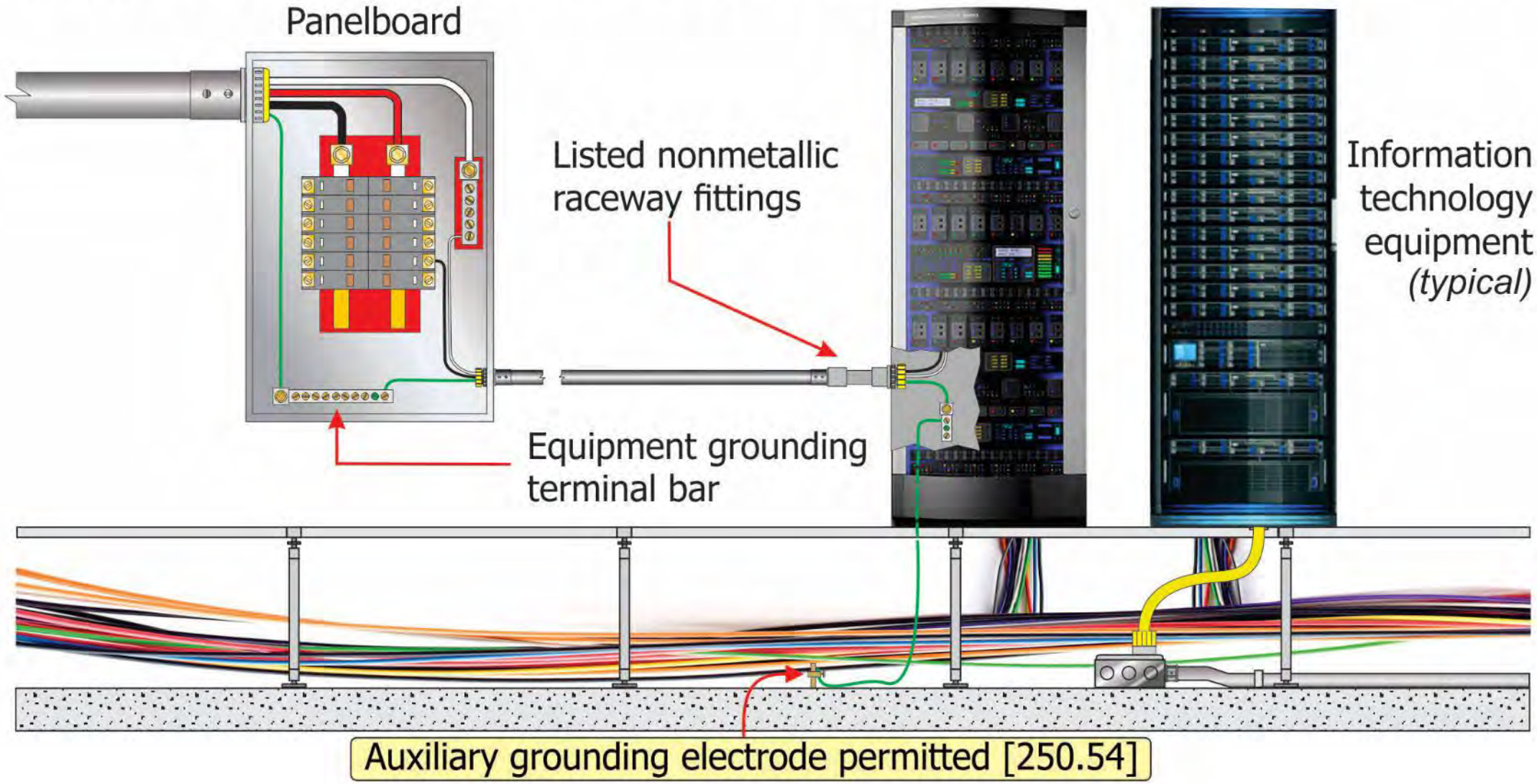
- The terms ***safety grounds*** and ***clean grounds*** are not used in the *NEC*, but are often used in the IT industry to differentiate between the required EGC of a branch circuit and the isolated EGCs often installed for IT equipment
- The ***safety ground*** is also referred to as the ***dirty ground*** as it is felt to carry **unwanted electrical noise** *(electromagnetic interference)* from a variety of sources
- Isolated equipment grounding conductor(s) *(allowed under the provisions of 250.146(D), 250.96(B), and 408.40 Ex.)* is often referred to as the ***clean ground*** installed for information technology equipment

Isolated Equipment Grounding Conductors *(cont.)*

- The *NEC* does not address the issue of who makes the decision about what the circumstances are that would justify the use of isolated equipment grounding
- Usually, the owner, design engineer, or equipment manufacturer specifies the circuit to have isolated equipment grounding conductor(s)

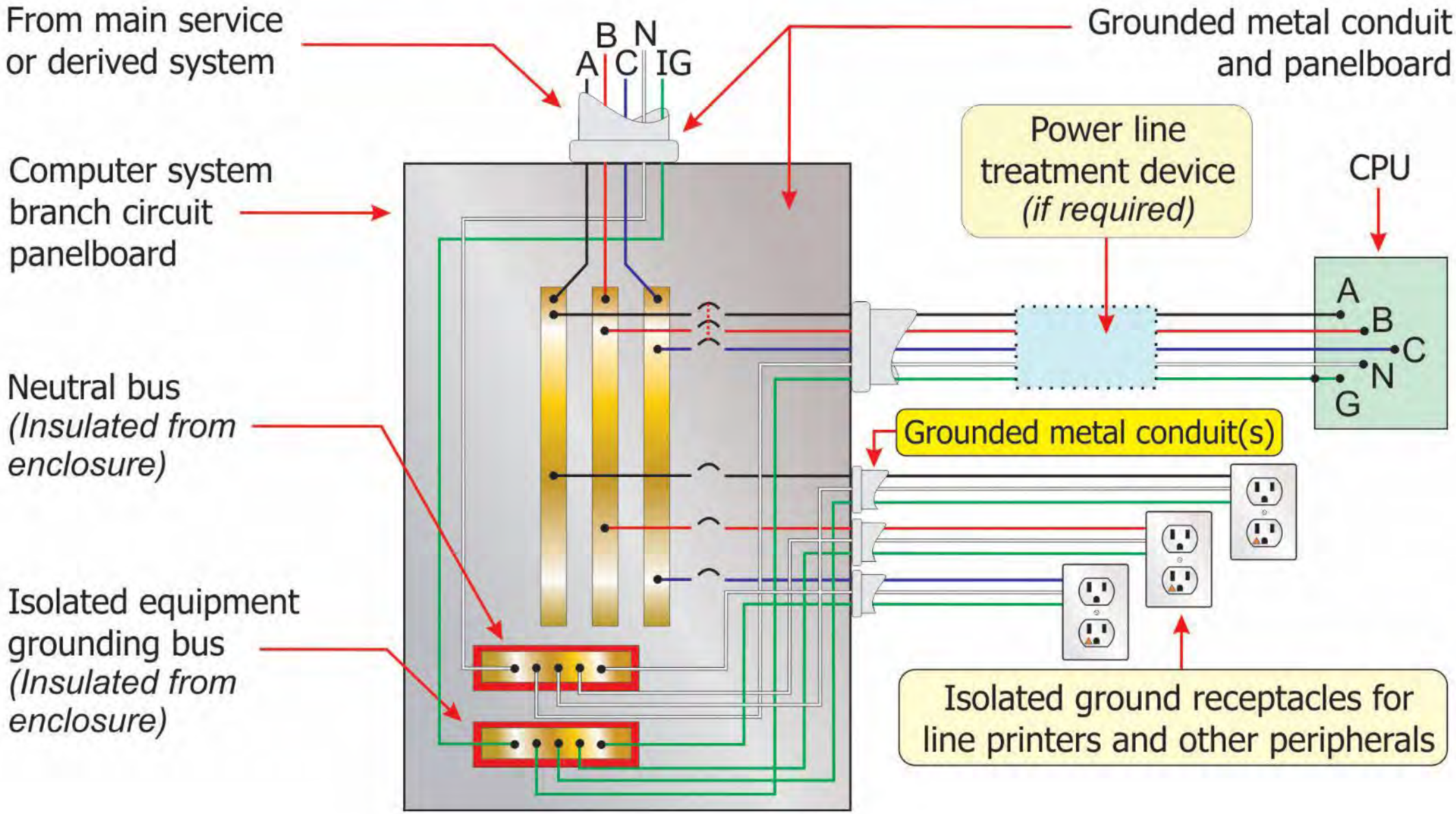
250.96(B) Isolated Equipment Grounding

Listed nonmetallic raceway fitting(s) permitted in metal conduit but insulated equipment grounding conductor is required to be connected to the equipment

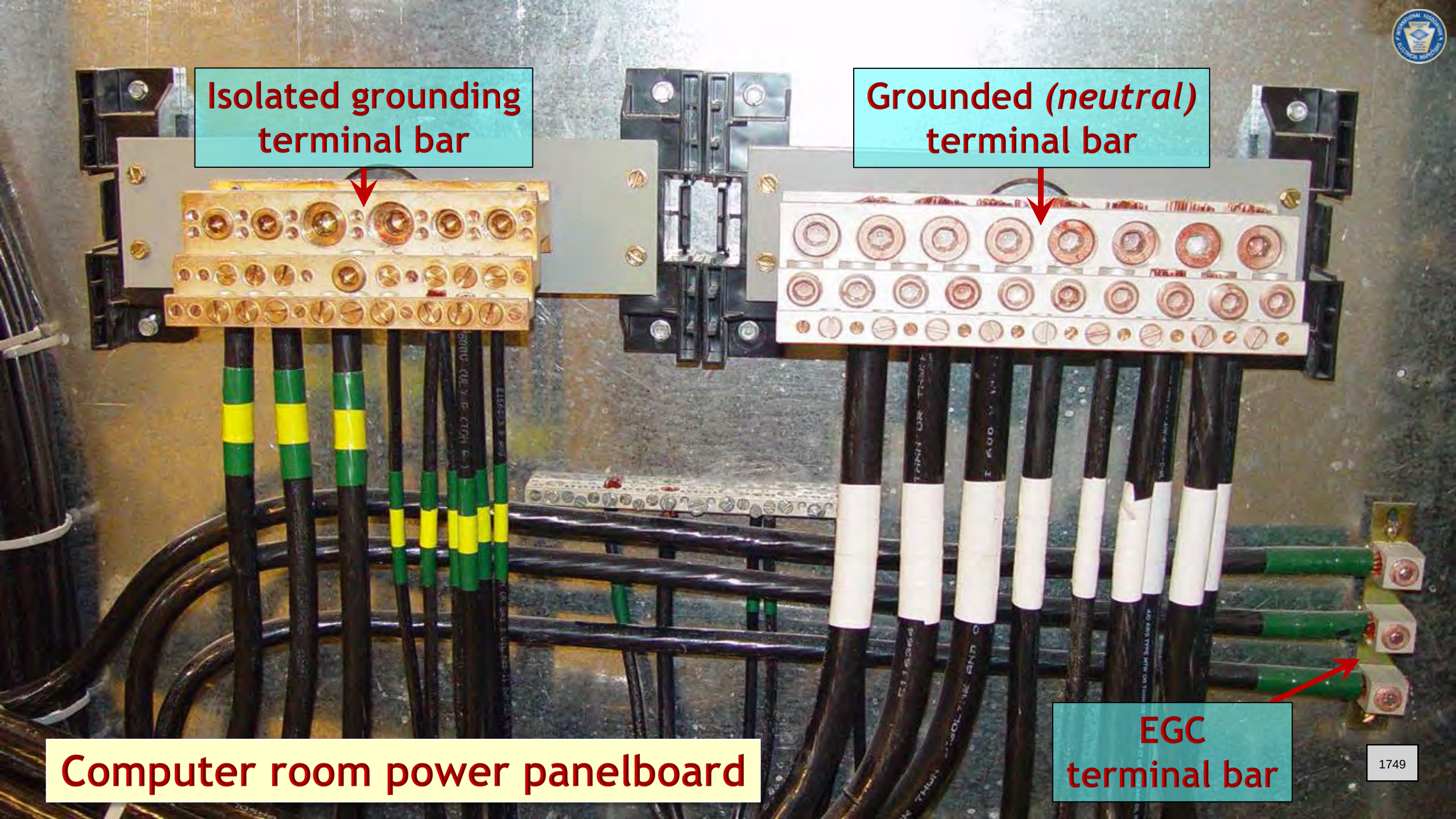


Copyright © IAEI 2020

Insulated Grounding Connections for Equipment



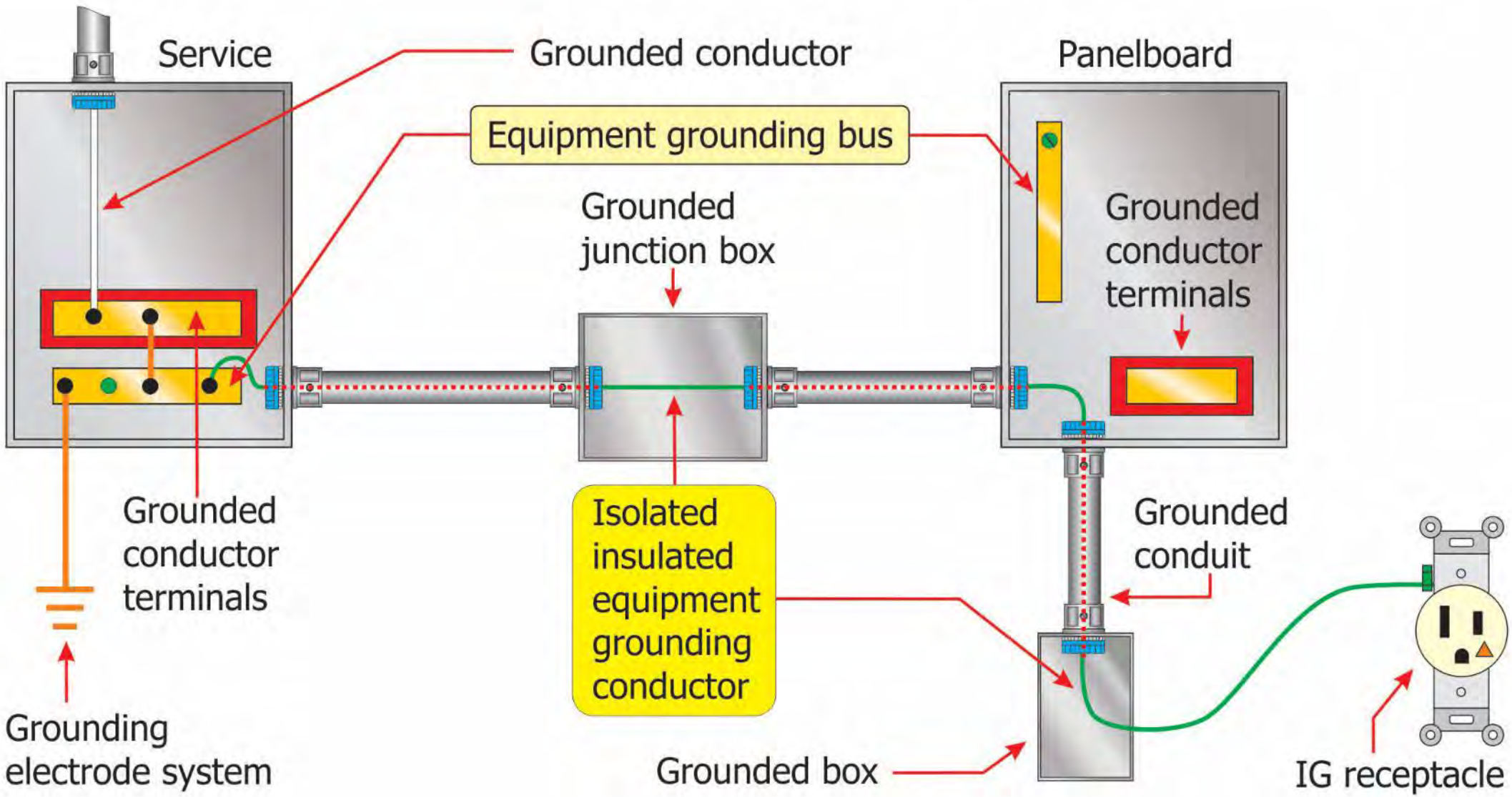
Copyright © IAEI 2020


Isolated grounding terminal bar
Grounded (neutral) terminal bar
EGC terminal bar
Computer room power panelboard
1749

Isolated Ground Receptacles

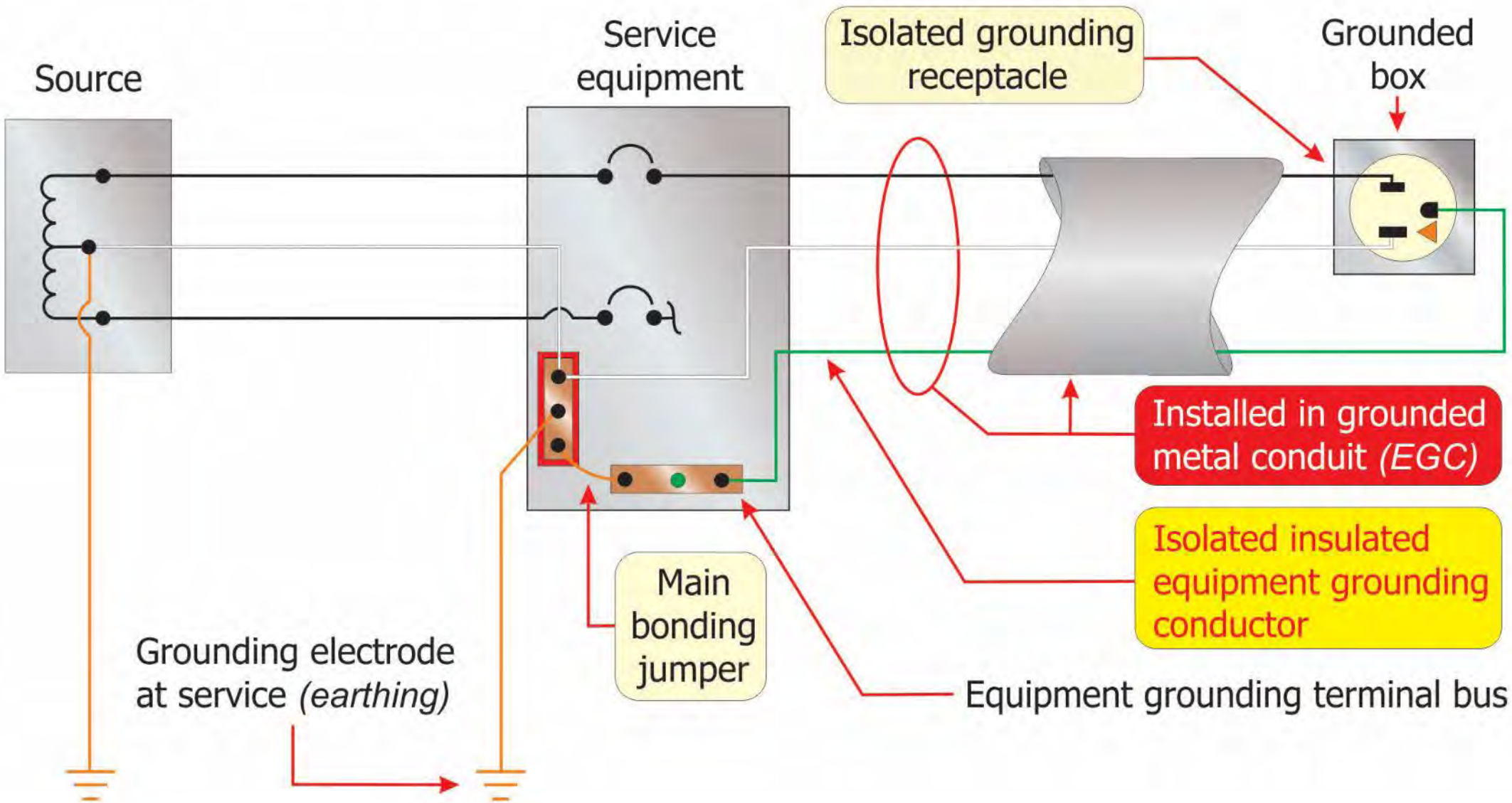
- Equipment grounding conductors for **isolated ground receptacles** are permitted to pass through one or more panelboard(s) without connection to the panelboard(s) equipment grounding terminal bar(s)
- This isolated EGC is also permitted to pass through boxes, wireways, or other enclosures without being connected to such enclosures
- Isolated EGCs are required to be connected to the first of any of the following points:
  - Source of separately derived system
  - Separate building disconnecting means
  - Service equipment
- *See 250.146(D)*

250.146(D) Isolated Grounding Receptacle Connections



Copyright © IAEI 2020

Isolated Grounding Receptacle Connections



Copyright © IAEI 2020


PDU4I-B
PP4I-B2
HR 33
CT 26
110V
CT 27,29 20BV.
PDU4C-A
PP4C-A1
HR 29
CT 30
110V
CT 31,32 20BV.
Home Fan 3H CAB 010
008
009

Grounding of Separately Derived Power Systems for IT Systems

- A requirement modifying the Article 250 requirements is located at **645.14**, which specifies:
  - **Separately derived power systems** shall be installed in accordance with the provisions of Parts I and II of Article 250
  - Power systems derived within **listed information technology equipment** that supply information technology systems through receptacles or cable assemblies supplied as part of this equipment **shall not be considered separately derived** for the purpose of applying 250.30 *(Grounding Separately Derived AC Systems)*

Information Technology Equipment Grounding and Bonding

- IT Equipment grounding and bonding requirements ***[645.15]***
  - All exposed non-current-carrying metal parts of an IT system are to be **bonded to the EGC** in accordance with Parts I, V, VI, VII, and VIII of Article 250
  - IT equipment permitted to be **double-insulated** *(not required to be bonded to the EGC)*
  - Where **signal reference structures** are installed, they are required to be **bonded to the EGC** provided for the IT equipment
  - Any auxiliary grounding electrode(s) installed for IT equipment must be installed in accordance with 250.54

Reducing Ground Loop Effects

- The term ***ground loop*** is not defined in the *NEC*
- The information technology industry uses this term to describe conditions where ground current can **flow on multiple paths**
- It is felt that this ground current creates voltage differences that become "electrical noise" *(electromagnetic interference)* flowing in a circular fashion, hence the term ***ground loop***
- Differences in ground *(earth)* potential will cause small currents *(electromagnetic interference)* and can couple with data signals
- These currents do not pose a shock or fire hazard but do affect equipment performance

Reducing Ground Loop Effects *(cont.)*

- Connecting computers and terminals on different power circuits that are grounded to building steel while the shielded communications cable between the computer and terminal is connected together and through the equipment *(completing the ground loop)* can cause this situation as well
- Other connections through equipment grounding paths can add additional ground loops
- Many computer data signals operate at 5 volts or less, which makes the system more susceptible to acquiring electrical interference from power circuits if cables are run closely together or “ground loops” exists

Ground Loop Solutions

- One method for solving ground loop problems is to **supply all related IT equipment from the same power supply**
- The equipment grounding means of the branch-circuit wiring will serve to keep the ground (earth) potential the same
- This solution can be impractical where the computer is located a long distance from peripherals and is supplied by different power supplies or different panelboards that, in turn, are supplied by different feeders or different separately derived systems

Ground Loop Solutions *(cont.)*

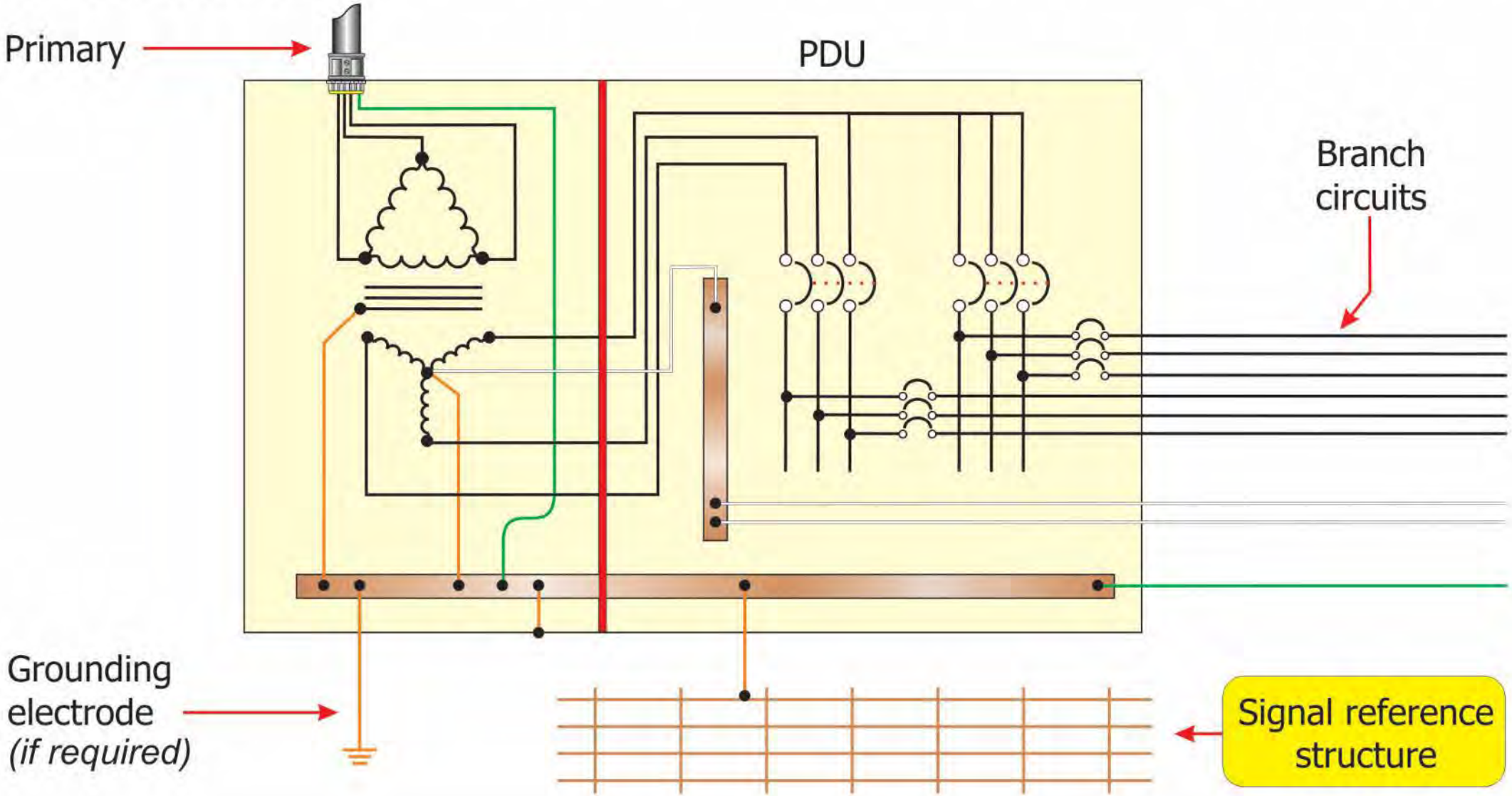
- Other known solutions to the problem of ground loops include:
  - **Single point grounding:** *(may not be suitable at very high frequency or where interconnecting shielded cable is used between equipment separated by a long distance)*
  - **Balun coils:** *(an insulated wire on a non-magnetic core) (Note: Balun coils are not effective at all frequencies)*
  - **Modems:** *(which are normally used as interfaces with telephone or data circuits)*
  - **Fiber optic transmission** over completely non-conducting paths
  - **Optical isolators**
  - **Interface devices:** *(surge arresters and surge protective devices)*

Equalizing Potential in Computer Rooms

- For the purposes of grounding IT equipment, an ***equipotential plane*** is described as a mass *(or masses)* of conducting material that *(when bonded together)* provide a uniformly low impedance to current flow over a large range of frequencies
- ***Signal reference structures or grids*** are defined as "a system of conducting paths among interconnected equipment that reduces noise-induced voltages to levels that minimize improper operation"
- Keeping all electrical equipment at or near the same potential is a basic safety requirement
- Keeping all equipment at the same potential (with much less difference in potential allowed) is necessary in an attempt to minimize disruptions in the operation of IT equipment

645.15 Signal Reference Grid Structures

Signal reference structure is required to be bonded to the equipment grounding conductor provided for the IT equipment



Copyright © IAEI 2020

Advantages of an Equipotential Plane

- Advantages of an **equipotential plane** include:
  - Low impedance return path for radio frequency (RF) electromagnetic interference currents
  - Containment of electromagnetic fields between their source *(cables and similar)* and the plane
  - Increasing filtering effectiveness of contained electromagnetic fields
  - Shielding of adjacent circuits or equipment

Forms of Equipotential Planes

- **Equipotential plane structures** can be established in several forms including:
  - Conductive grids embedded in, or attached to, a concrete floor
  - Metallic screen or metal strips under floor tile
  - Ceiling grid above the equipment
  - Supporting members or grid of raised access flooring typical in computer rooms

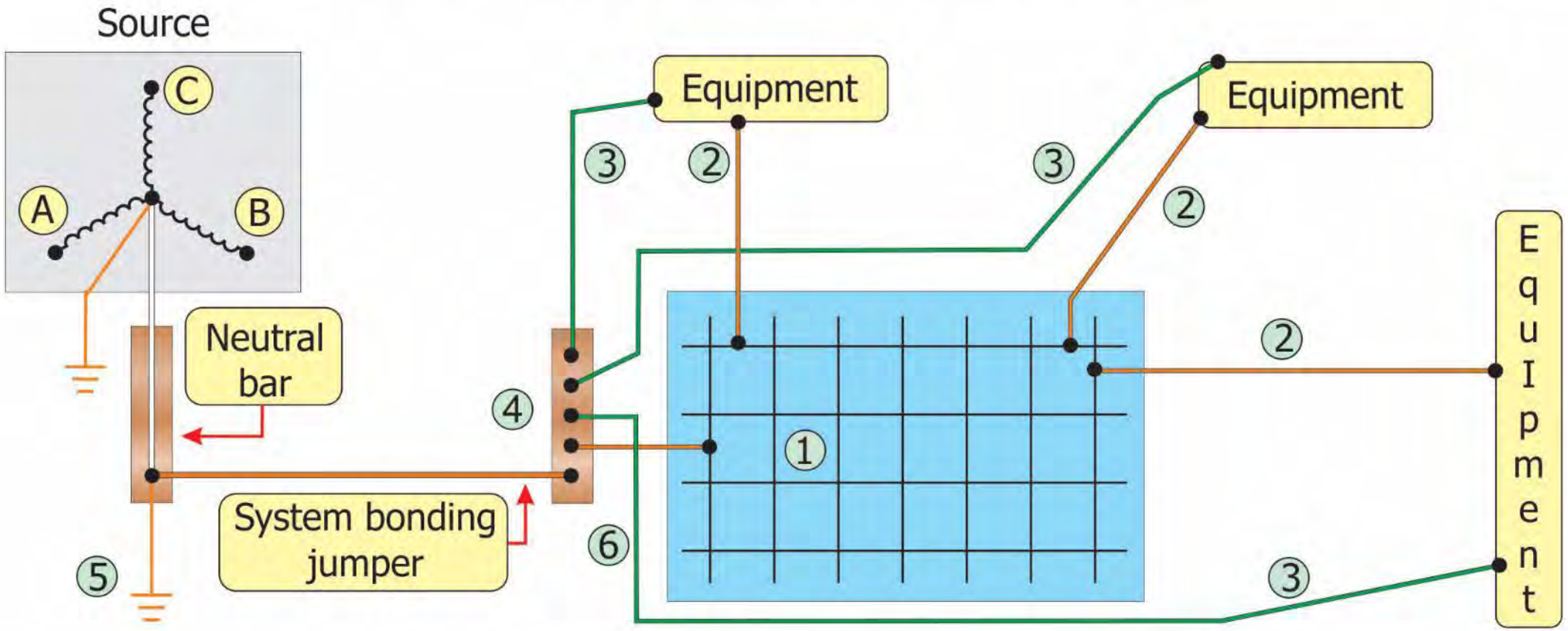
Purpose of Signal Reference Grid

- A ***signal reference grid*** is a structure such as a computer room floor or a copper mesh grid installed under the computer room floor
- IT equipment is connected to the signal reference grid to equalize potential between components at various frequencies
- While at 60 Hz the equipment grounding conductors may suffice, at higher frequencies the grid is necessary
- All equipment in the room *(including equipment that is wall-mounted)* should be connected to the grid
- The *NEC* is silent on this subject likely due to this being primarily an **operational *(performance)* consideration** and not necessarily safety related

Purpose of Signal Reference Grid *(cont.)*

- As with other bonding or grounding methods used for IT equipment, such bonding cannot substitute for the EGC required to be installed with the branch-circuit conductors
- The signal reference grid can be thought of as **overlaying the EGCs**
- Signal reference grids serve as a signal reference plane over a broad range of frequencies
- Correctly referred to as ***broadband grounding systems*** *(not a Code defined term)*
- Main purpose of the signal reference grid is to reduce, eliminate or control the tendency of conductors connected to computers to **resonate at higher frequencies**

Signal Reference Grid Connections



① 2' x 2' high-frequency signal ground grid floor of computer room ② Signal reference bonding conductor *(strap)(short as possible)* ③ Run in power supply raceway individual grounds *(green conductor)* ④ Power supply panelboard equipment grounding bus ⑤ Service or system grounding electrode - 60 hertz ground ⑥ Signal reference grid conductor

Copyright © IAEI 2020



1767


1768

Signal Reference Structures

- Where signal reference structures are installed, they are required to be bonded to the equipment grounding conductor provided for the information technology equipment
- *See NEC 645.15*

Establishing a Single-Point Ground Reference

- Deciding whether to use **single-point grounding** or **multipoint grounding** typically depends on the **frequency range of equipment**
- Single-point grounding typically applied to analog circuits with signal frequencies **up to 300 kHz**, while digital circuits with signal frequencies in the **MHz or higher** ranges should utilize multipoint grounding
- Single-point grounding concept is similar to the equipotential bonding grid used for swimming pools, agricultural buildings, and hospital patient care spaces
- The intent is to maintain potential (voltage) differences among various IT equipment as low as possible

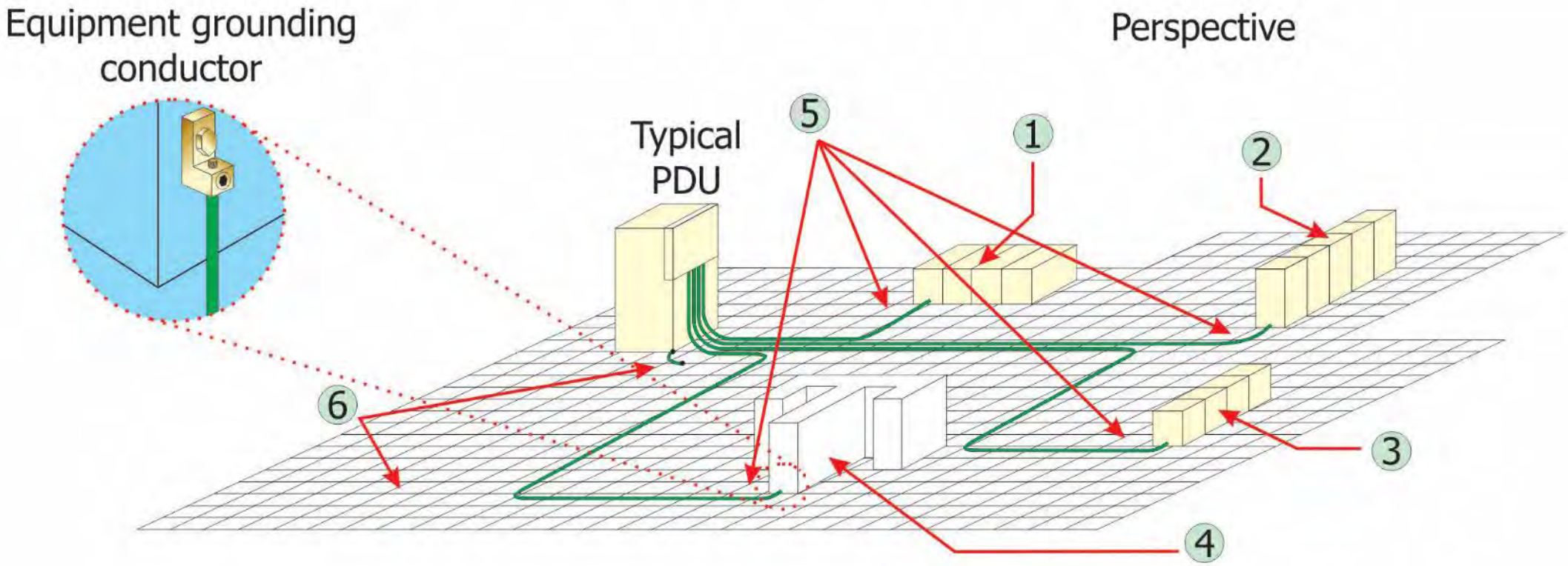
Establishing a Single-Point Ground Reference *(cont.)*

- Single-point grounding includes a set of **bonding conductors** that are in addition to the required equipment grounding conductors *(sometimes referred to as **safety grounds**)*
- Establishing a single-point grounding reference should never be installed instead of the required equipment grounding conductors
- Single-point grounding that is installed must be bonded to the power system equipment grounding conductors
- Single-point-grounding conductors are often connected from all equipment to an auxiliary *(enhanced)* grounding electrode in the vicinity of IT equipment

Establishing a Single-Point Ground Reference *(cont.)*

- Auxiliary grounding electrodes are provided in 250.54
- A bonding conductor must be installed from this auxiliary grounding electrode to the grounding electrode system for the electrical system
- The equipment grounding conductor can provide this function, or a separate bonding conductor can be installed *(see 250.54)*
- Auxiliary grounding electrode must never be isolated from the electrical system grounding electrode or be permitted to serve in place of the equipment grounding conductors *(safety grounds)*

Signal Reference Grid Connections



Computer units connected to a signal reference grid and to A-C ground

1 through 4 are typical computer system modules

5 is the "green wire" safety equipment grounding conductor

6 is the signal reference grounding grid for raised floor structure

Copyright © IAEI 2020

Surge Protection: Surge Arrestors

- Surge arresters are used primarily on systems over 1000 volts
- ***Surge Arrester:*** A protective device for limiting surge voltages by discharging or bypassing surge current; it also prevents continued flow of follow current while remaining capable of repeating these functions. *[Article 100]*
- Requirements for installing surge arrestors over 1000 volts can be found in **Article 242** entitled ***Overvoltage Protection*** *(new for the 2020 NEC)*
- Permitted to be installed either at the service equipment or on the load side of the service equipment
- Surge arresters must be made **inaccessible to other than qualified persons** unless listed for installation in accessible locations

Surge Protection: Surge Arrestors *(cont.)*

- The conductor used to connect the surge arrester to line, bus, or equipment and to an EGC or grounding electrode connection point **shall not be any longer than necessary** and shall **avoid unnecessary bends** *[242.48]*
- Surge-arrester conductors should be short and be run as straight as practicable, avoiding any sharp bends and turns, which increase the impedance
- When used in combination in a coordinated manner, they provide protection by limiting overvoltage, reducing stress and unnecessary failures in components and reducing component failures in equipment caused by surges
- Surge arresters divert surge currents rather than absorb them

Surge Arrester Equipment Grounding Conductor

- The arrester shall be connected to one of the following:
  - Grounded service conductor
  - Grounding electrode conductor
  - Grounding electrode for the service
  - Equipment grounding terminal in the service equipment
- The conductor between the surge arrester and the line and the surge arrester and the grounding connection **shall not be smaller than 6 AWG** copper or aluminum
- *See NEC 242.50 and 242.52*

Surge-Protective Device (SPD)

- Surge protective devices (SPDs) are available as stand-alone equipment or as a recognized component of listed equipment *(such as switchboards or panelboards)*
- Surge arresters rated 1 kV or less and surge protective devices are covered in **Article 242** *(new for the 2020 NEC)*

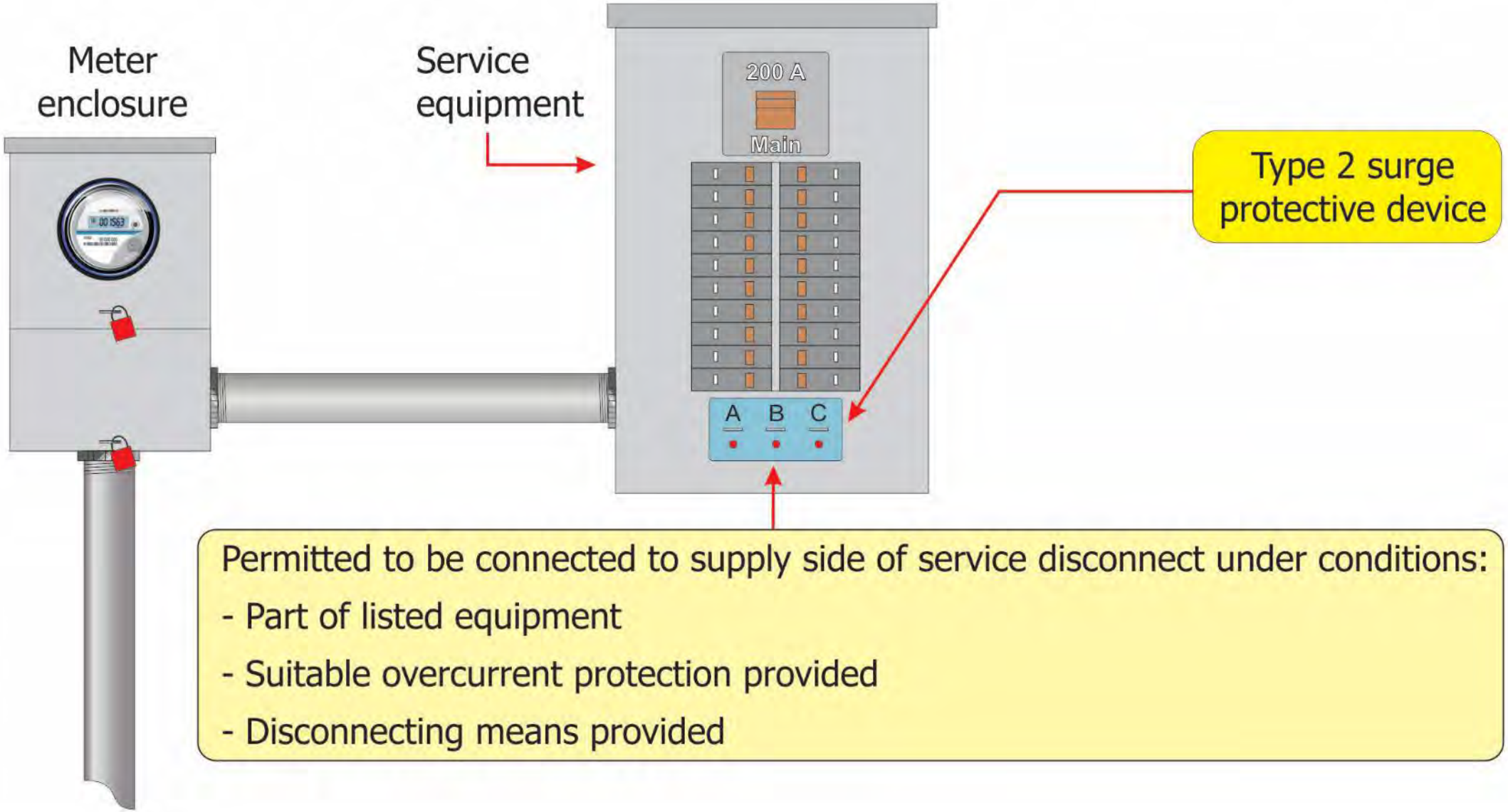
Surge-Protective Device (SPD) *(cont.)*

- ***Surge-Protective Device (SPD):*** A protective device for limiting transient voltages by diverting or limiting surge current; it also prevents continued flow of follow current while remaining capable of repeating these functions and is designated as follows:
  - **Type 1:** Permanently connected SPDs intended for installation between the secondary of the service transformer and the line side of the service disconnect overcurrent device
  - **Type 2:** Permanently connected SPDs intended for installation on the load side of the service disconnect overcurrent device, including SPDs located at the branch panel

Surge-Protective Device (SPD) *(cont.)*

- ***Surge-Protective Device (SPD):*** A protective device for limiting transient voltages by diverting or limiting surge current; it also prevents continued flow of follow current while remaining capable of repeating these functions and is designated as follows: *(cont.)*
  - **Type 3:** Point of utilization SPDs
  - **Type 4:** Component SPDs, including discrete components, as well as assemblies
- *See definition in Article 100*

230.82(8) Surge Protective Device *(SPD)* Connections



Permitted to be connected to supply side of service disconnect under conditions:

- Part of listed equipment
- Suitable overcurrent protection provided
- Disconnecting means provided

Copyright © IAEI 2020

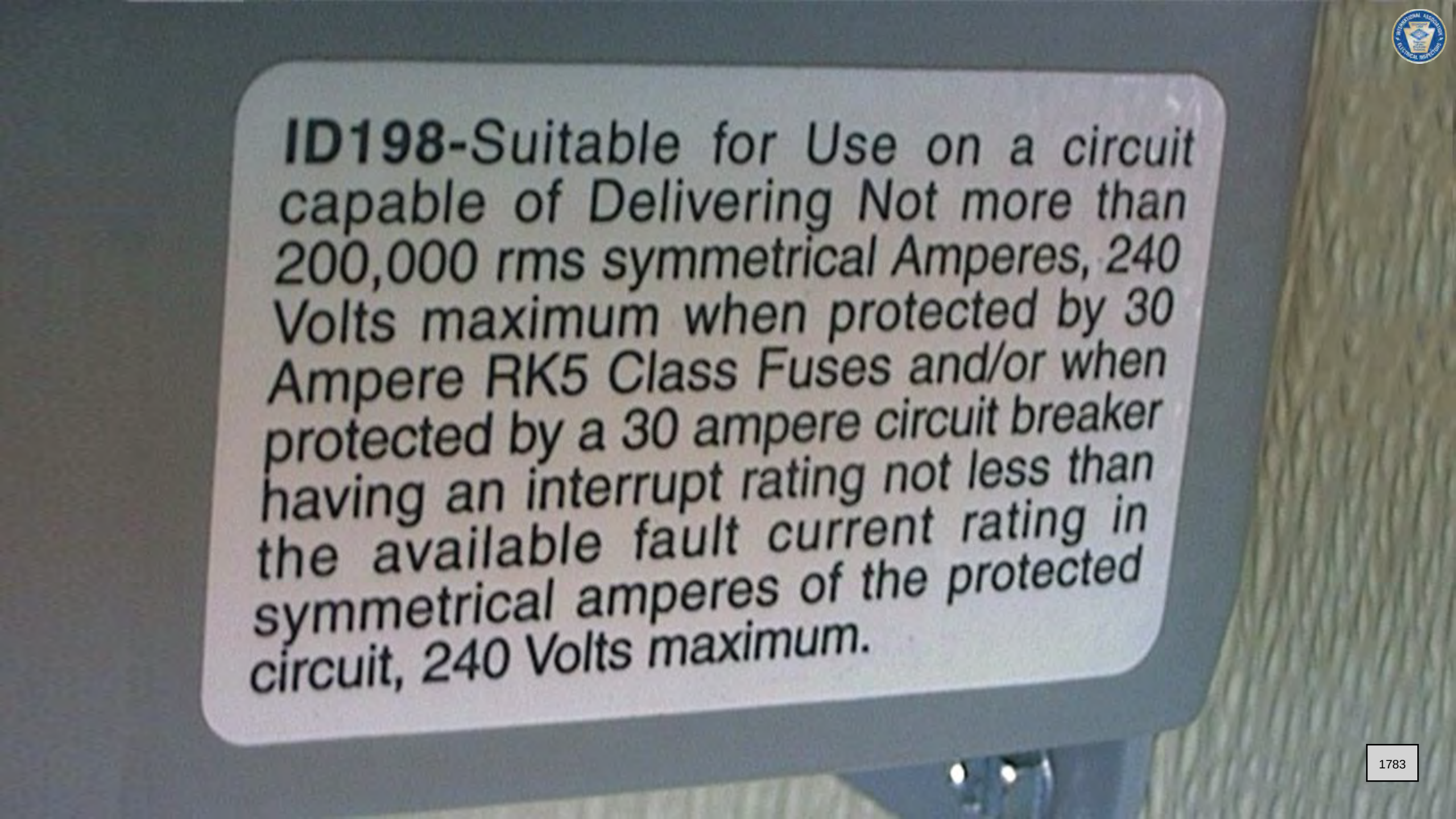


Copyright © IAEI 2020

1781

Courtesy of Schneider Electric


MODEL #:
SPE-3Y 120/208C
11/16/99
INNOVATIVE TECHNOLOGY INC.
MADE IN AMERICA
SERIAL #:
CE6005-600117
ID198-Suitable for Use on a circuit capable of Delivering Not more than 200,000 rms symmetrical Amperes, 240 Volts maximum when protected by 30 Ampere RK5 Class Fuses and/or when protected by a 30 ampere circuit breaker having an interrupt rating not less than the available fault current rating in symmetrical amperes of the protected circuit, 240 Volts maximum.
ID198-Suitable for Use on a circuit capable of Delivering Not more than 200,000 rms symmetrical Amperes, 240 Volts maximum when protected by 30 Ampere RK5 Class Fuses and/or when protected by a 30 ampere circuit breaker having an interrupt rating not less than the available fault current rating in symmetrical amperes of the protected circuit, 240 Volts maximum.
1782


ID198-Suitable for Use on a circuit capable of Delivering Not more than 200,000 rms symmetrical Amperes, 240 Volts maximum when protected by 30 Ampere RK5 Class Fuses and/or when protected by a 30 ampere circuit breaker having an interrupt rating not less than the available fault current rating in symmetrical amperes of the protected circuit, 240 Volts maximum.
1783

Harmonic Currents

- Harmonics in the power source voltage to IT equipment can interfere with proper operation of some IT equipment
- Harmonics can also create extra losses, excessive ground leakage current in line filters, and couple unwanted signals into low signal level conductors
- Harmonic currents are produced by equipment classed as a ***nonlinear load***
- ***Nonlinear Load:*** "A load where the wave shape of the steady-state current does not follow the wave shape of the applied voltage." *(see Article 100)*
- Electronic equipment, electronic/electric-discharge lighting, adjustable-speed drive systems, and similar equipment may be nonlinear loads

Harmonic Currents *(cont.)*

- Harmonic currents appear as reflected waveforms that distort the basic sine wave produced and provided by the electric utility *(supply source)*
- These reflected waveforms are multiples of the fundamental root frequency (60 Hz) sine wave
- The odd multiples, such as the 3rd (180 Hz), 5th (300 Hz), 7th (420 Hz) add to the distortion of the sine wave and will appear as a single distorted waveform on an oscilloscope
- When the load of information technology equipment is distorted and contains harmonics, the harmonic currents interact with the power source impedance to create voltage drops in currents that are present

Harmonic Currents *(cont.)*

- Line voltage distortion from this cause is the result of IT load characteristics interacting with the power source impedance
- This is not correctable at the source except to the extent that source impedances can be reduced at each harmonic by filters
- **Even harmonics** will cancel, while **odd harmonics** are additive
- Capacitors in parallel with the load may help, but may also cause unwanted resonance
- Another alternative is a specifically tuned sine filter with capacitance and reactance tuned to the harmonic frequency to mitigate the effects

Harmonic Currents *(cont.)*

- The normal ac circuit has a fundamental root frequency of 60 Hz (cycles per second)
- Even and odd harmonics can be imposed on neutral conductors
- Even harmonics will cancel out while the odd harmonic currents are additive
- Odd harmonics:
    - 3rd – 180 Hz
    - 5th – 300 Hz
    - 7th – 420 Hz
    - 9th – 540 Hz

Harmonics and the Neutral Conductor

- Skin effects are evident with harmonic content in the neutral conductors
- These harmonic currents (flowing at higher frequencies than 60 Hz) tend not to utilize the total conductor, but flow mainly on the skin of the conductor
- This amounts to additional heating effects the conductor must be capable of carrying

K-Rated Transformers and Other Equipment

- There are special transformers and equipment available for use where harmonic currents are present
- These K-factor transformers are built with larger center tap of (XO) connections
- They include larger cores and windings and larger enclosures to more readily dissipate heat generated from harmonic currents
- They are available from K–4 to K–20 ranges

K-Rated Transformers and Other Equipment *(cont.)*

- Panelboards and other equipment are also available for use where nonlinear *(harmonic)* loads are present
- They usually include a 200% rated neutral bus and larger enclosure
- Multi-conductor cables are also available with larger neutral conductors *(also known as super neutral cables)* for branch-circuit wiring
- Design engineers often specify oversize neutrals to handle the extra nonlinear load to reduce excessive voltage drop or heating effects

CHAPTER TWENTY

LOW-VOLTAGE AND INTERSYSTEM GROUNDING AND BONDING


dish
dish
NETWORK
500

Low-Voltage and Intersystem Grounding and Bonding

- General requirements for grounding of low-voltage circuits and systems **less than 50 volts** are covered in **250.20(A)**
- Typical low-voltage systems falling into this category can include:
  - Motor control circuits
  - Class 1, 2, or 3 circuits
  - Remote control or signaling circuits
    - Low-voltage circuits for electric door release equipment
    - Doorbell circuits

Article 100 Definitions

- ***Grounding Electrode Conductor:*** A conductor used to connect system grounded conductor or the equipment to a grounding electrode or to a point on the grounding electrode system.
- ***Bonded (Bonding):*** Connected to establish electrical continuity and conductivity.
- ***Bonding Conductor or Jumper:*** A reliable conductor to ensure the required electrical conductivity between metal parts required to be electrically connected.
- ***Intersystem Bonding Termination*:** A device that provides a means for connecting intersystem bonding conductors for communications systems to the grounding electrode system.

“Grounded Conductor” Deleted

- The use of proper terminology is essential in applying grounding and bonding *Code* rules
- The term **“Grounding Conductor”** was deleted in the **2011 *NEC***
- This definition was very close to the definition of grounding electrode conductor
- The term “grounding conductor” had been used throughout Chapter 8 communication article in the *NEC*
- Revisions to text were made accordingly to either identify the conductor as a **grounding electrode conductor**, **equipment grounding conductor**, or as a **bonding conductor**, etc.

Grounding Low Voltage Circuits and Systems

- The *NEC* requires ac circuits of **less than 50 volts** to be grounded under any of the following conditions:
  - Where supplied by transformers, if the transformer supply system exceeds 150 volts to ground
  - Where supplied by transformers, if the transformer supply system is ungrounded
  - Where installed outside as overhead conductors
- Where low-voltage circuits or systems do not fall into the requirements as outlined above, grounding these systems is optional
- *See NEC 250.20(A)*

Low-Voltage Motor Control Circuits

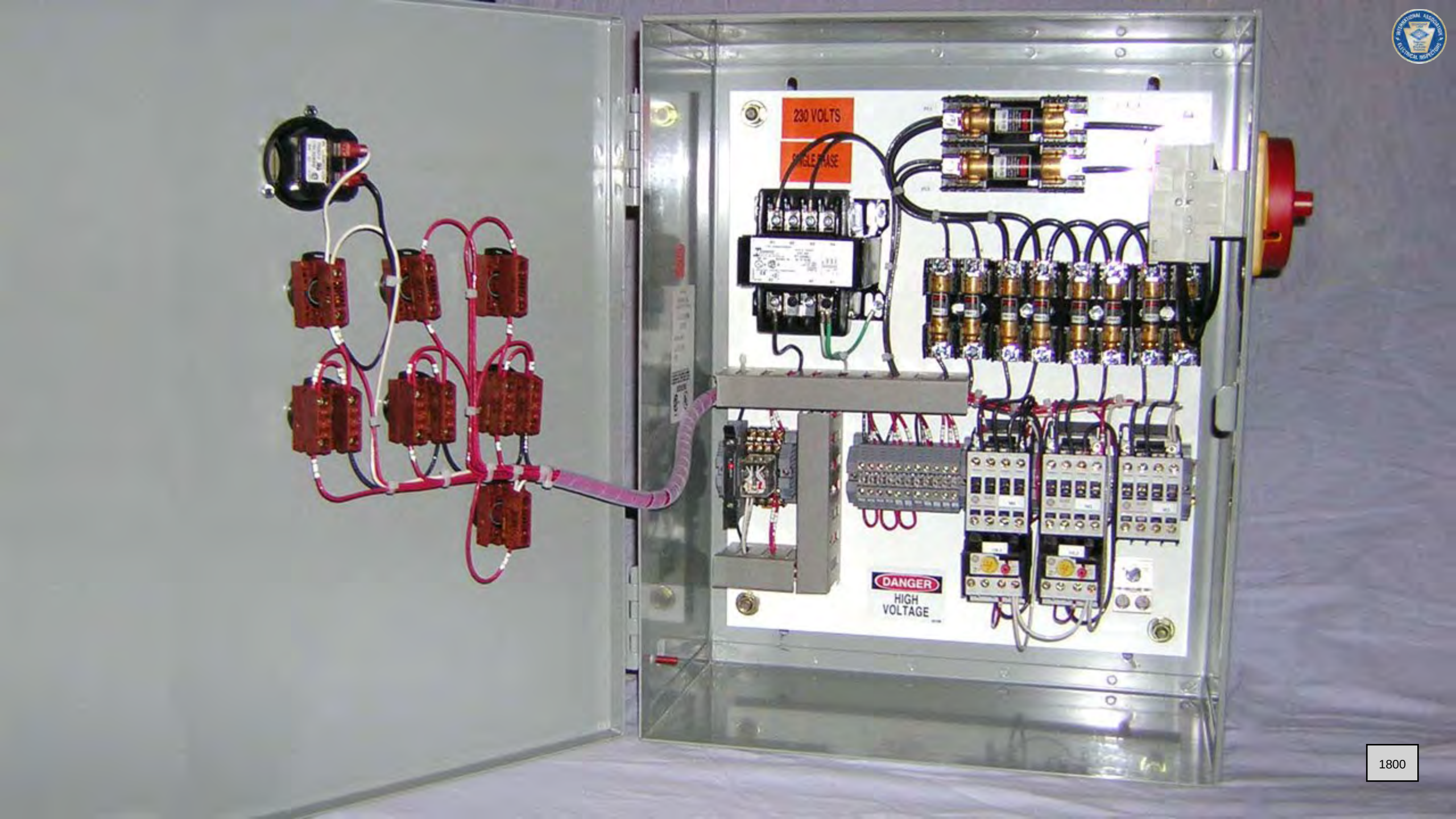
- Low-voltage motor control circuits are required to be grounded if any of the conditions in 250.20(A)(1) or 250.20(A)(2) *(previous slide)* exist
- Motor controllers in **industrial control panels** and **individual combination motor control units** are often supplied with control-circuit transformers or power supplies that are factory grounded on the low voltage secondary side by the manufacturer
- If the motor control circuits are **field-installed** and wired, then grounding **may or may not be required**, depending on the voltage or characteristics of the circuit on the primary side of the control circuit transformer
- General installation requirements for motor control circuits are covered in **Part VI of Article 430**

Low-Voltage Motor Control Circuits *(cont.)*

- ***Control Circuit:*** The circuit of a control apparatus or system that carries the electric signals directing the performance of the controller but does not carry the main power current. *[see Article 100]*
- Overcurrent protection of motor control circuit transformers or power supply conductors are provided as specified in 430.72(C)(1) through (C)(5)
- Where a motor control circuit transformers supplies "… a Class 1 power-limited circuit, Class 2, or Class 3 remote-control circuit complying with the requirements of Article 725, protection shall comply with Article 725" *[see 430.72(C)(1)]*

Motor-Control Circuit Transformers

- ***Control Circuit Transformer.*** Where a motor-control circuit transformer is provided, the transformer shall be protected in accordance with 430.72(C)(1), (C)(2), (C)(3), (C)(4), or (C)(5)
- ***Compliance with Article 725.*** Where the transformer supplies a Class 1 power-limited circuit, Class 2, or Class 3 remote-control circuit conforming with the requirements of Article 725, the protection shall comply with Article 725 *[430.72(C)(1)]*
- ***Compliance with Article 450.*** Protection shall be permitted to be provided in accordance with 450.3 *[430.72(C)(2)]*


230 VOLTS
DANGER
HIGH
VOLTAGE

Motor-Control Circuit Transformers *(cont.)*

- ***Less Than 50 Volt-Amperes.*** Control circuit transformers rated less than 50 volt-amperes (VA) and that are an integral part of the motor controller and located within the motor controller enclosure shall be permitted to be protected by primary overcurrent devices, impedance limiting means, or other inherent protective means *[430.72(C)(3)]*
- ***Primary Less Than 2 Amperes.*** Where the control circuit transformer rated primary current is less than 2 amperes, an overcurrent device rated or set at not more than 500 percent of the rated primary current shall be permitted in the primary circuit *[430.72(C)(4)]*
- ***Other Means.*** Protection shall be permitted to be provided by other approved means *[430.72(C)(5)]*

Intrinsically Safe Circuits and Systems

- Branch circuits supplying intrinsically safe systems must include an EGC used for grounding the metal enclosure(s) and other metal parts and equipment of the system *(regardless of the voltage)*
- Definitions *[Article 100, Part III]*
  - ***Intrinsically Safe Circuit:*** A circuit in which any spark or thermal effect is incapable of causing ignition of a mixture of flammable or combustible material in air under prescribed test conditions.
  - ***Intrinsically Safe System:*** An assembly of interconnected intrinsically safe apparatus, associated apparatus, and interconnecting cables in that those parts of the system that may be used in hazardous *(classified)* locations are intrinsically safe circuits.

Intrinsically Safe Circuits and Systems *(cont.)*

- Article 504 covers the requirements for intrinsically safe (I.S.) apparatus, wiring, and systems for hazardous *(classified)* locations
- Sections 504.50 and 504.60 cover the grounding and bonding requirements for these systems
- Intrinsically safe apparatus *(if of metal)* must be bonded in the hazardous *(classified)* location in accordance with 501.30(A), 502.30(A), 503.30(A), 505.25, or 506.25, as applicable *[504.60(A)]*
- Associated apparatus and cable shields shall be grounded in accordance with the required control drawing described at 504.10(A) *[504.60(B)]*
- Control drawing are required for these systems to provide specific information and instructions *(including grounding and bonding information)*

Intrinsically Safe Circuits and Systems *(cont.)*

- Users of intrinsically safe apparatus in hazardous *(classified)* locations must comply with the provisions of 250.100 as well
- 250.100 - Bonding in Hazardous *(Classified)* Locations
  - ***Regardless of the voltage*** of the electrical system, the electrical continuity of non-current-carrying metal parts of equipment, raceways, and other enclosures in any hazardous *(classified)* location as defined in 500.5, 505.2, and 506.2 shall be ensured by any of the bonding methods specified in 250.92(B)(2) through (B)(4)
  - One or more of these bonding methods must be used whether or not equipment grounding conductors of the wire type are installed

1805

Intrinsically Safe Grounding Requirements

- ***Intrinsically Safe Apparatus, Enclosures, and Raceways.*** Intrinsically safe apparatus, associated apparatus, cable shields, enclosures, and raceways *(if of metal)* **shall be connected to the equipment grounding conductor** *[504.50(A)]*
- ***Associated Apparatus and Cable Shields.*** Associated apparatus and cable shields **shall be grounded** in accordance with the required control drawing *[see 504.10(A)] [504.50(B)]*
- ***Informational Note:*** Supplementary connection(s) to the grounding electrode may be needed for some associated apparatus *(example; zener diode barriers)* if specified in the control drawing
- See ANSI/ISA RP 12.06.01-2003, Wiring Methods for Hazardous *(Classified)* Locations Instrumentation - Part 1: Intrinsic Safety

Intrinsically Safe Grounding Requirements *(cont.)*

- For **intrinsically safe systems**, where connection to a **grounding electrode** is required, the electrodes described below must be used *(if present)*:
  - 250.52(A)(1) Metal underground water pipe
  - 250.52(A)(2) Metal frame of building
  - 250.52(A)(3) Concrete-encased electrode
  - 250.52(A)(4) Ground ring
- Must comply with 250.30(A)(4) *(grounding electrodes for separately derived systems)*
- *See 504.50(C)*

Intrinsically Safe Grounding Requirements *(cont.)*

- Grounding electrodes specified below **shall not be used** if any of the electrodes specified at 250.52(A)(1), (A)(2), (A)(3) and (A)(4) *(previous slide)* are present
  - 250.52(A)(5) Rod/pipe electrodes
  - 250.52(A)(7) Plate electrodes
  - 250.52(A)(8) Other local metal underground
- *See 504.50(C)*

Intrinsically Safe Grounding Requirements *(cont.)*

- The choice of which grounding electrode(s) must be used is governed by the same provisions specified in **250.30(A)(4)** for **separately derived systems**
- The electrode(s) for the separately derived system must be the same grounding electrode(s) utilized by the building or structure
- If located outdoors, the grounding electrode(s) shall be in accordance with 250.30(C) *(Outdoor Source)*
- The size of this grounding electrode conductor is generally specified by the manufacturer's control drawing

Communications Systems
Grounding and Bonding Requirements

- Communication System article found in *NEC* Chapter 8 are:
  - **General Requirements for Communications Systems** Article 800
  - **Communications Circuits** Article 805
  - **Radio and Television Equipment** Article 810
  - **Community Antenna Television and Radio Distribution Systems** Article 820
  - **Network-Powered Broadband Communications Systems** Article 830
  - **Premises-Powered Broadband Communications Systems** Article 840

Communications Systems Grounding and Bonding Requirements *(cont.)*

- A new Article 800 was created to consolidate what were **common requirements** found in the Chapter 8 articles
- Previous Article 800 is now new Article 805
- General and common requirements for all communications systems grounding and bonding are found in the new **800.100 – 800.106 (Part III)**
- Article 800, General Requirements for Communications Systems, covers the general requirements for communication systems
- For the specific requirements unique to communication circuits, there were requirements included and placed in a new Article 805
- Articles 805, 810, 820, 830 and 840 will contain any modification to these general requirements

Common Grounding and Bonding Rules for Communication Circuits

- Grounding and bonding requirements for communications systems are found in Article 800, Part III and specifically in 800.100 and 800.106
- The bonding conductor or grounding electrode conductor shall be:

(1) ***Insulation.*** Listed and shall be permitted to be insulated, covered, or bare

(2) ***Material.*** Copper or other corrosion-resistant conductive material, stranded or solid

Common Grounding and Bonding Rules for Communication Circuits *(cont.)*

- Grounding and bonding requirements for communications systems are found in Article 800, Part III and specifically in 800.100 and 800.106
- The bonding conductor or grounding electrode conductor shall be: *(cont.)*

(3) ***Size.*** Not be smaller than 14 AWG

Have a current-carrying capacity not less than the grounded metallic sheath member of the communications cable, the protected conductor of the communications cable, or the outer sheath of coaxial cable, as applicable

Not be required to exceed 6 AWG

Common Grounding and Bonding Rules for Communication Circuits *(cont.)*

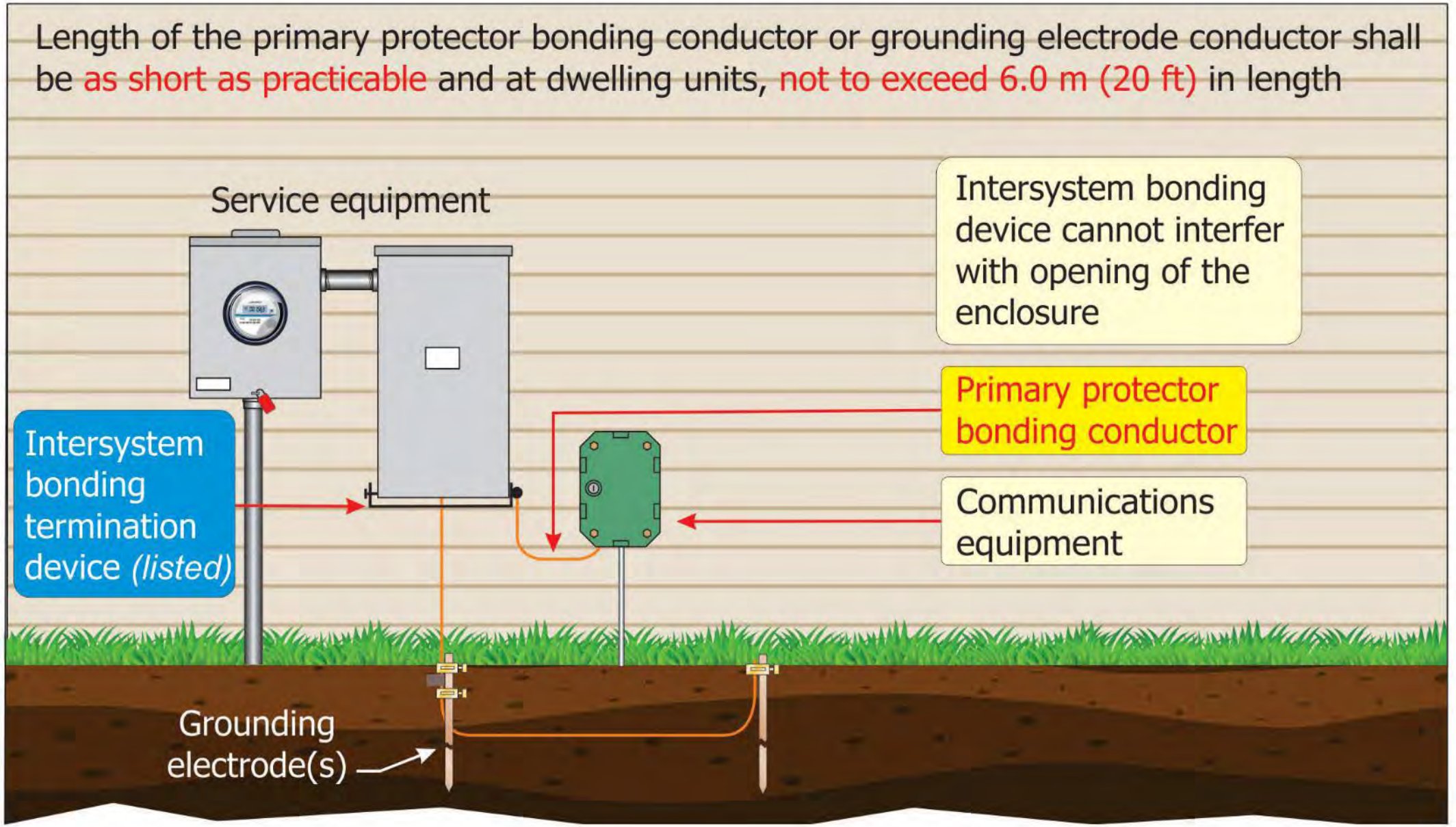
- Grounding and bonding requirements for communications systems are found in Article 800, Part III and specifically in 800.100 and 800.106
- The bonding conductor or grounding electrode conductor shall be: *(cont.)*

(4) ***Length.*** As practicable *[In one- and two-family dwellings, the bonding conductor or grounding electrode conductor shall be as short as practicable, not to exceed 6.0 m (20 ft) in length]*

(5) ***Run in Straight Line.*** Run in as straight a line as practicable

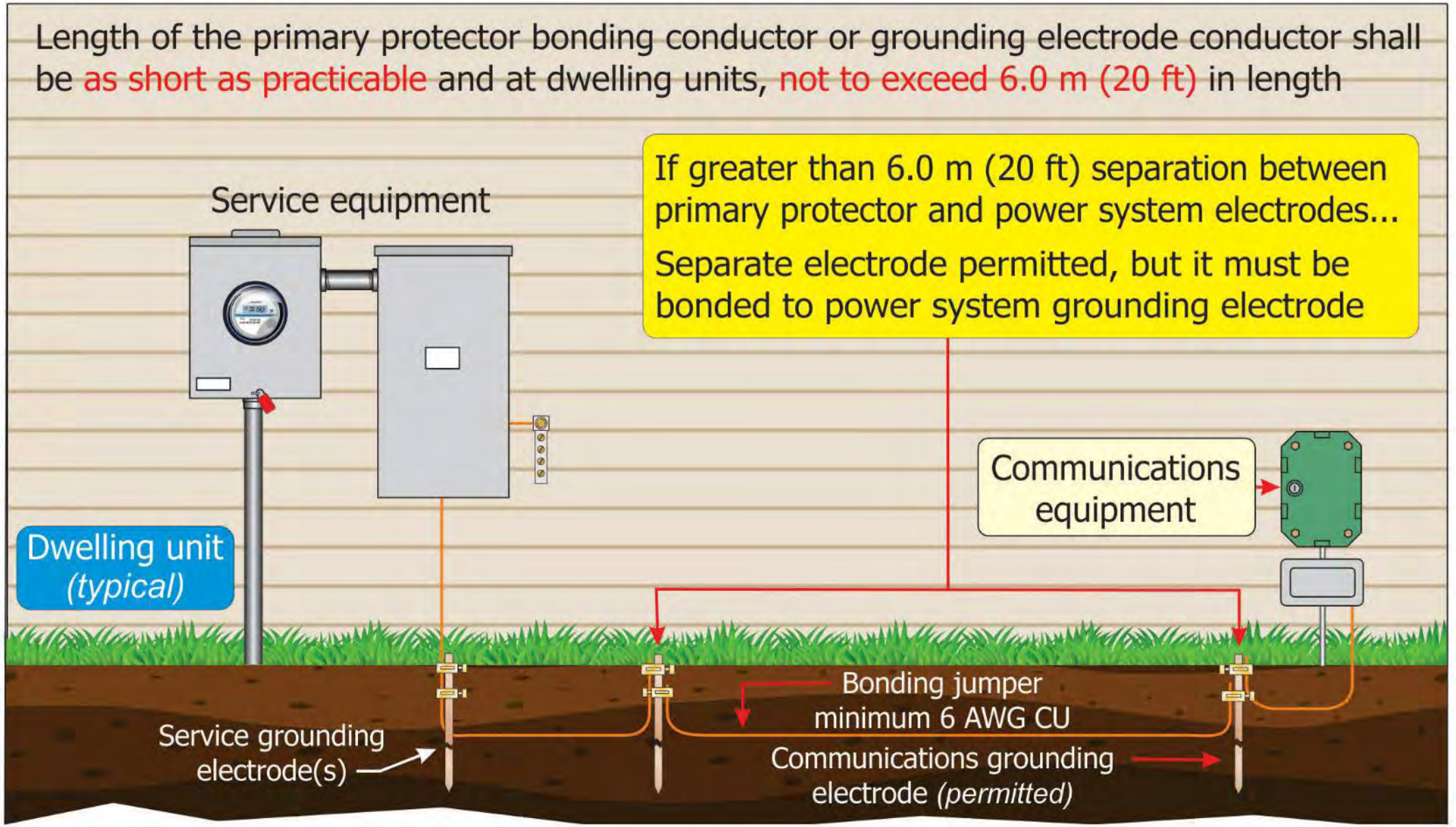
800.100(A)(4) Communications Systems Bonding Conductor

Length of the primary protector bonding conductor or grounding electrode conductor shall be as short as practicable and at dwelling units, not to exceed 6.0 m (20 ft) in length



Copyright © IAEI 2020

800.100(A)(4) Ex. Communications Systems Bonding Conductor



Copyright © IAEI 2020

Common Grounding and Bonding Rules for Communication Circuits *(cont.)*

- Grounding and bonding requirements for communications systems are found in Article 800, Part III and specifically in 800.100 and 800.106
- The bonding conductor or grounding electrode conductor shall be: *(cont.)*

(6) ***Physical Protection.*** Protected where exposed to physical damage

Where the bonding conductor or grounding electrode conductor is installed in a metal raceway, both ends of the raceway shall be bonded to the contained conductor or to the same terminal or electrode to which the bonding conductor or grounding electrode conductor is connected

- *See 800.100(A)*

Grounding Electrodes to be Used

- For communications systems, the goal is to establish a **close connection to a grounding electrode** either directly or through the intersystem bonding termination
- Section 800.100(B) requires provisions for connection to ground by one of three means provided in (B)(1) through (B)(3):

  (1) ***In Buildings or Structures with an Intersystem Bonding Termination.*** If the building or structure served has an intersystem bonding termination *(as required by 250.94)*, the bonding conductor shall be connected to the **intersystem bonding termination**

Grounding Electrodes to be Used *(cont.)*

- Section 800.100(B) requires provisions for connection to ground by one of three means provided in (B)(1) through (B)(3): *(cont.)*

  (2) ***In Buildings or Structures With Grounding Means.*** If an intersystem bonding termination (IBT) is established, 250.94(A) shall apply

  If the building or structure served has **no IBT**, the bonding conductor or grounding electrode conductor shall be connected to the nearest accessible location on one of the following:

  (1) The building or structure grounding electrode system as covered in 250.50
  (2) The grounded interior metal water piping system, within 1.5 m (5 ft) from its point of entrance to the building, as covered in 250.52


WARNING
IF THIS CLAMP OR
WIRE IS LOOSE OR MUST
MOVED PLEASE CALL
REPAIR
VICE

Grounding Electrodes to be Used *(cont.)*

- Section 800.100(B) requires provisions for connection to ground by one of three means provided in (B)(1) through (B)(3): *(cont.)*

  (2) ***In Buildings or Structures With Grounding Means.*** If an intersystem bonding termination (IBT) is established, 250.94(A) shall apply

  If the building or structure served has **no IBT**, the bonding conductor or grounding electrode conductor shall be connected to the nearest accessible location on one of the following: *(cont.)*

  (3) The power service accessible means external to enclosures using the options identified in 250.94(A), Exception

  (4) The nonflexible metallic power service raceway

  (5) The service equipment enclosure

1822

Grounding Electrodes to be Used *(cont.)*

- Section 800.100(B) requires provisions for connection to ground by one of three means provided in (B)(1) through (B)(3): *(cont.)*

  (2) ***In Buildings or Structures With Grounding Means.*** If an intersystem bonding termination (IBT) is established, 250.94(A) shall apply

  If the building or structure served has **no IBT**, the bonding conductor or grounding electrode conductor shall be connected to the nearest accessible location on one of the following: *(cont.)*

  (6) The GEC or the GEC metal enclosure of the power service

  (7) The GEC or the grounding electrode of a building or structure disconnecting means that is grounded to an electrode as covered in 250.32

Grounding Electrodes to be Used *(cont.)*

- Section 800.100(B) requires provisions for connection to ground by one of three means provided in (B)(1) through (B)(3): *(cont.)*

  (3) ***In Buildings or Structures Without an Intersystem Bonding Termination or Grounding Means.*** If the building or structure served has no IBT or grounding means, as described in 800.100(B)(2), the GEC shall be connected to one of the following:

  (1) To any one of the electrodes of 250.52(A)(1), (A)(2), (A)(3), or (A)(4)

  (2) If the building or structure served has no IBT or has no grounding means, to any one of the grounding electrodes of 250.52(A)(5), (A)(7), and (A)(8).

Grounding Electrodes to be Used *(cont.)*

- Section 800.100(B) requires provisions for connection to ground by one of three means provided in (B)(1) through (B)(3): *(cont.)*

  (3) ***In Buildings or Structures Without an Intersystem Bonding Termination or Grounding Means.*** If the building or structure served has no IBT or grounding means, as described in 800.100(B)(2), the GEC shall be connected to one of the following: *(cont.)*

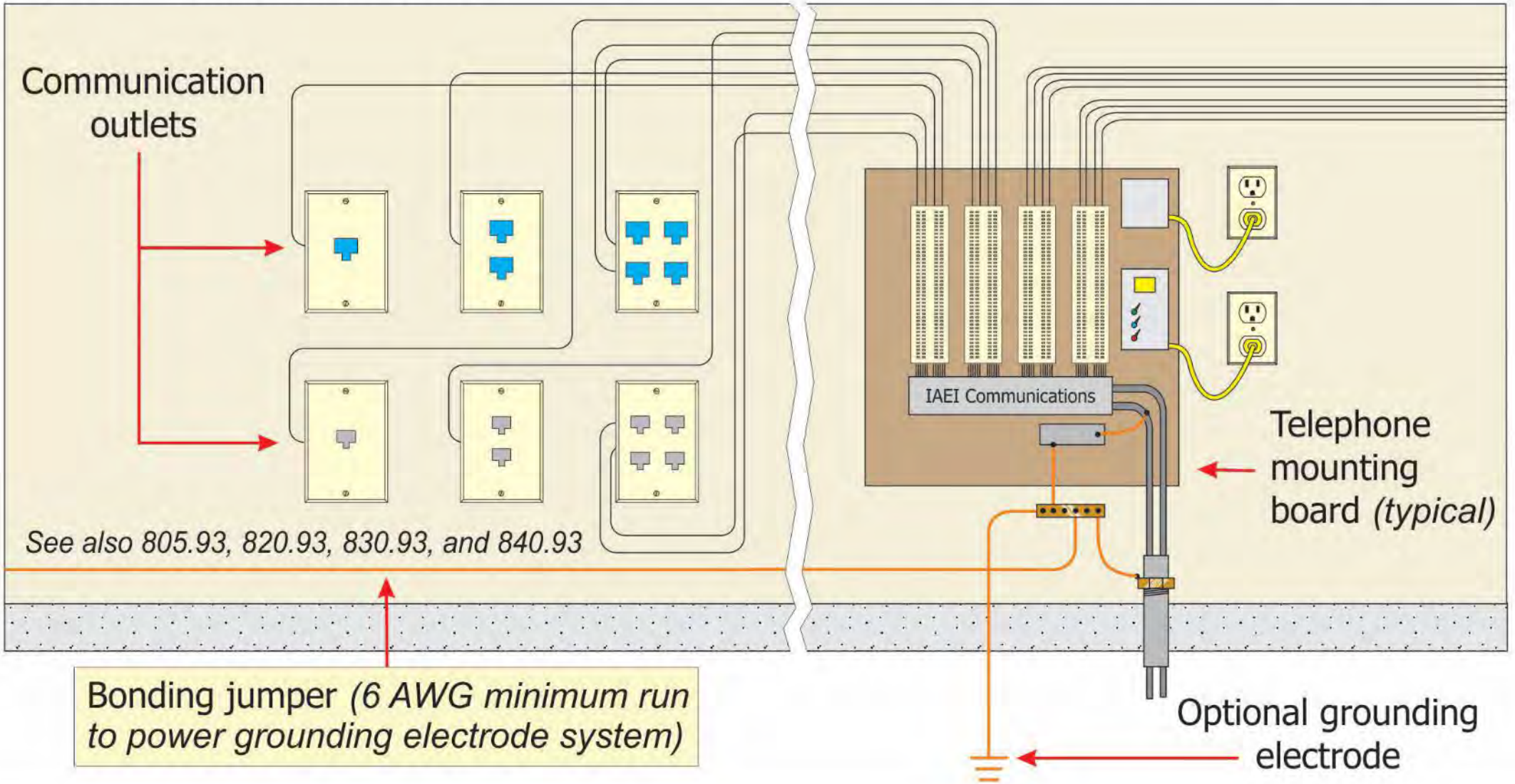
  (3) For communications circuit (Article 805) or NPBCC systems (Article 830), to a ground rod pipe not less than 1.5 m (5 ft) in length and 12.7 mm (½ in.) in diameter, driven *(where practicable)* into permanently damp earth and separated from lightning protection system conductors as covered in 800.53 and at least 1.8 m (6 ft) from electrodes of other systems

Grounding Electrodes to be Used *(cont.)*

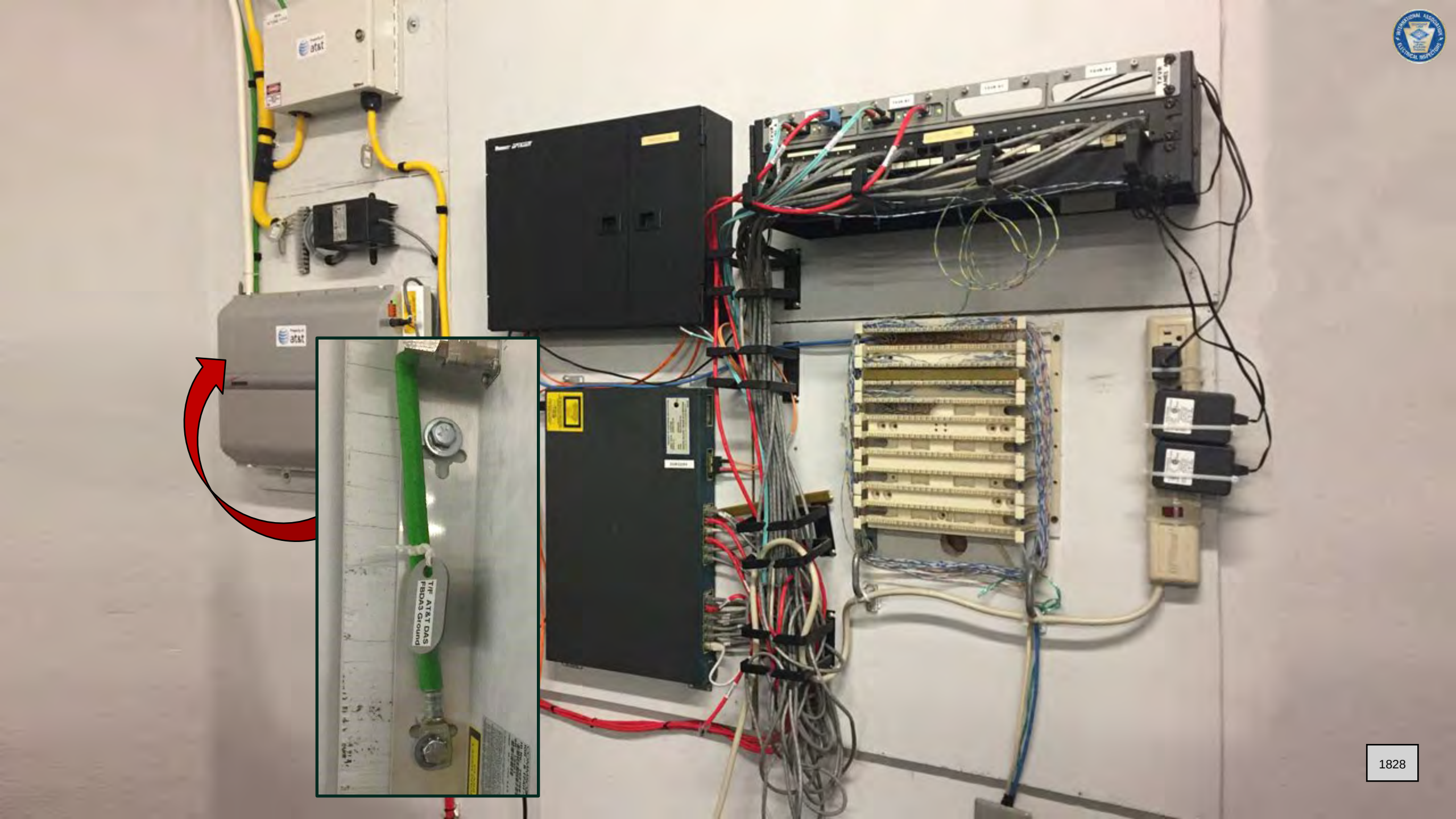
- Steam pipes, hot water pipes or lightning protection system conductors **shall not be employed as electrodes** for protectors and grounded metallic members *[800.100(B)(3)]*
- Connections to grounding electrode must comply with **250.70** *(Methods of Grounding and Bonding Conductors to Electrodes) [800.100(C)]*
- A **bonding jumper not smaller than 6 AWG copper** or equivalent shall be connected between the grounding electrode and the power grounding electrode system at the building or structure served where separate electrodes are used *(exception for mobile homes) [800.100(D)]*

800.100(D) Communications Systems Grounding and Bonding

A bonding jumper *(not smaller than 6 AWG copper or equivalent)* required between grounding electrode and power grounding electrode system at the building or structure served *(where separate electrodes are used)*



Copyright © IAEI 2020


T/F AT&T DAS
FBDA3 Ground

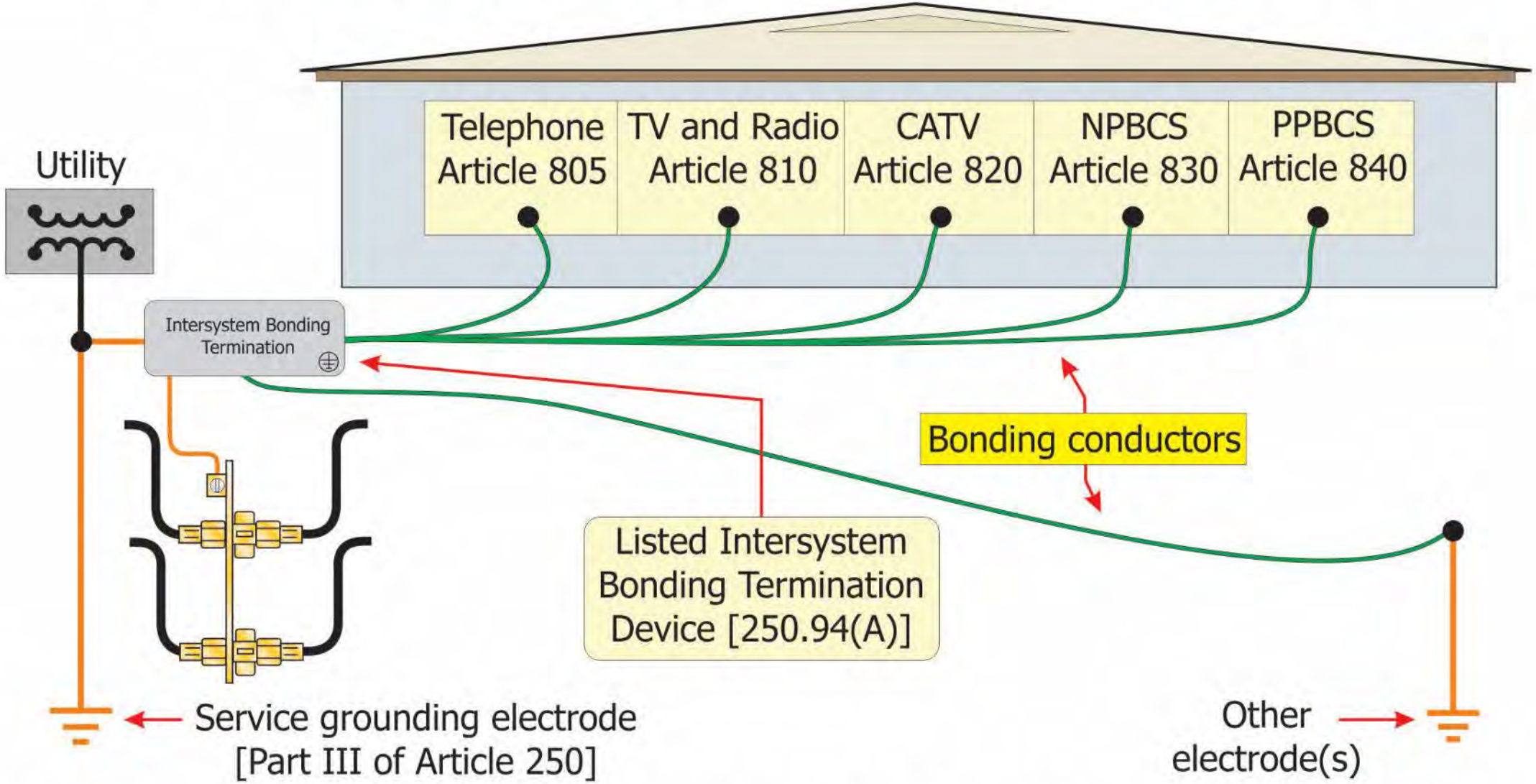
Purpose of Intersystem Grounding & Bonding

- The systems and circuits covered in Chapter 8 of the *Code* are generally required be grounded *(earthed)* and bonded to the electrical power system grounding electrode(s) or electrode system for the building or structure
- Grounding to a grounding electrode affords reasonable protection from spike and surge currents as well as brief elevated potentials due to lightning strikes
- Bonding the electrodes of the two systems together limits **differences of potential** during normal operation and during spike or surge events on the systems and lightning strikes at close proximities
- Bonding the electrodes of the two systems together limits **potential differences** and shock hazards that could result from isolated grounding connections

Intersystem Bonding Termination

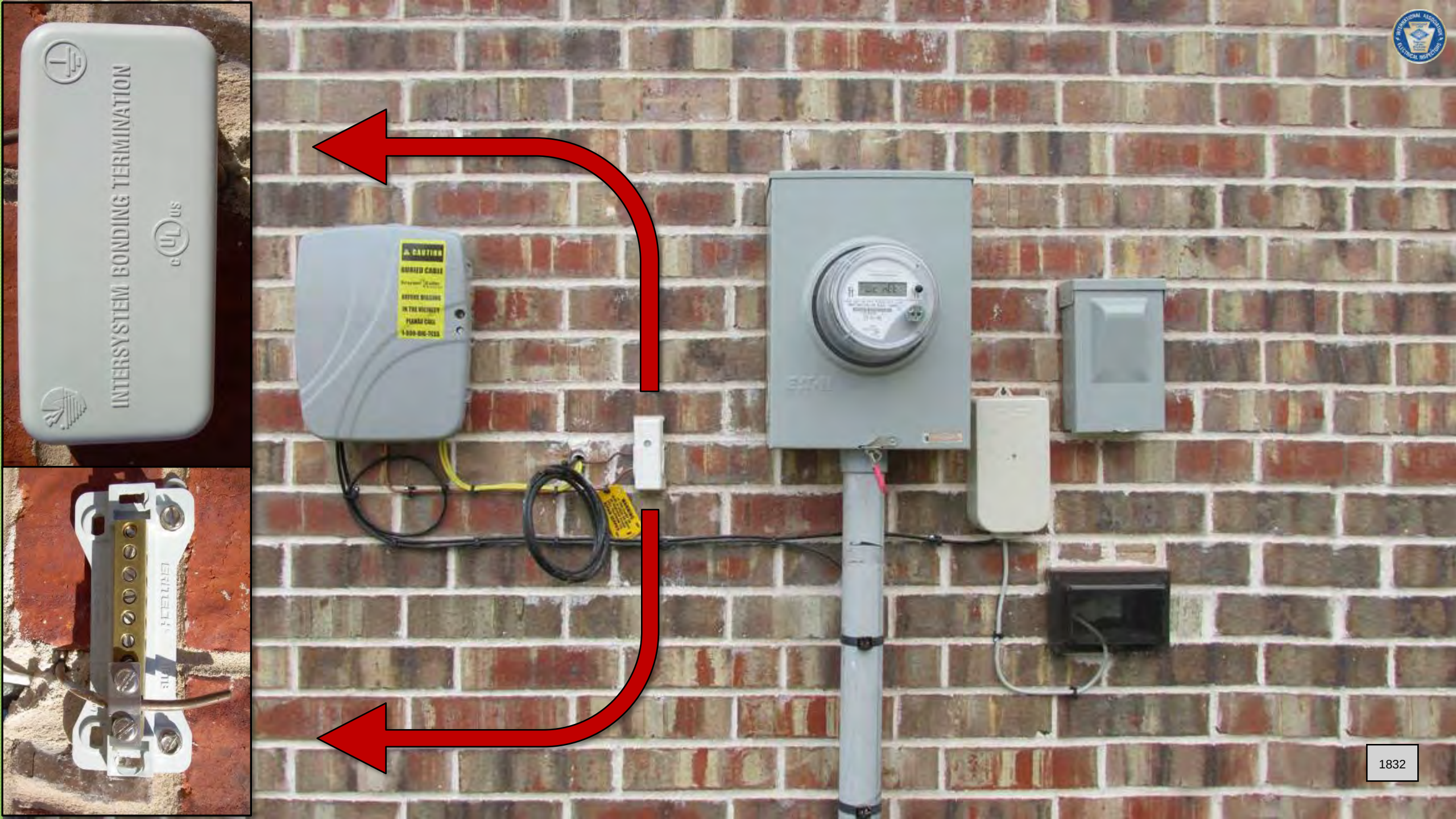
- ***Intersystem Bonding Termination:*** A device that provides a means for connecting intersystem bonding conductors for communication systems to the grounding electrode system.
- *See Article 100*

250.94 Intersystem Bonding Termination Required



Connect intersystem grounding electrode conductor or bonding conductors to intersystem bonding termination as required in 250.94(A) or (B) *(for new installations)*

Copyright © IAEI 2020


INTERSYSTEM BONDING TERMINATION
CAUTION
BURIED CABLE
1-800-DIG-TESS
1832

Intersystem Bonding for Communication Systems

- An intersystem bonding termination (IBT) for connecting intersystem bonding and grounding electrode conductors required for communication systems to be provided **external to enclosures** at the service equipment or meter enclosure and at the disconnecting means for any additional buildings or structures
- The intersystem bonding termination shall be one of the following:
  - Be accessible for connection and inspection
  - Have the capacity for connection of **not less than three** intersystem bonding conductors
  - Not interfere with opening a service or metering equipment enclosure

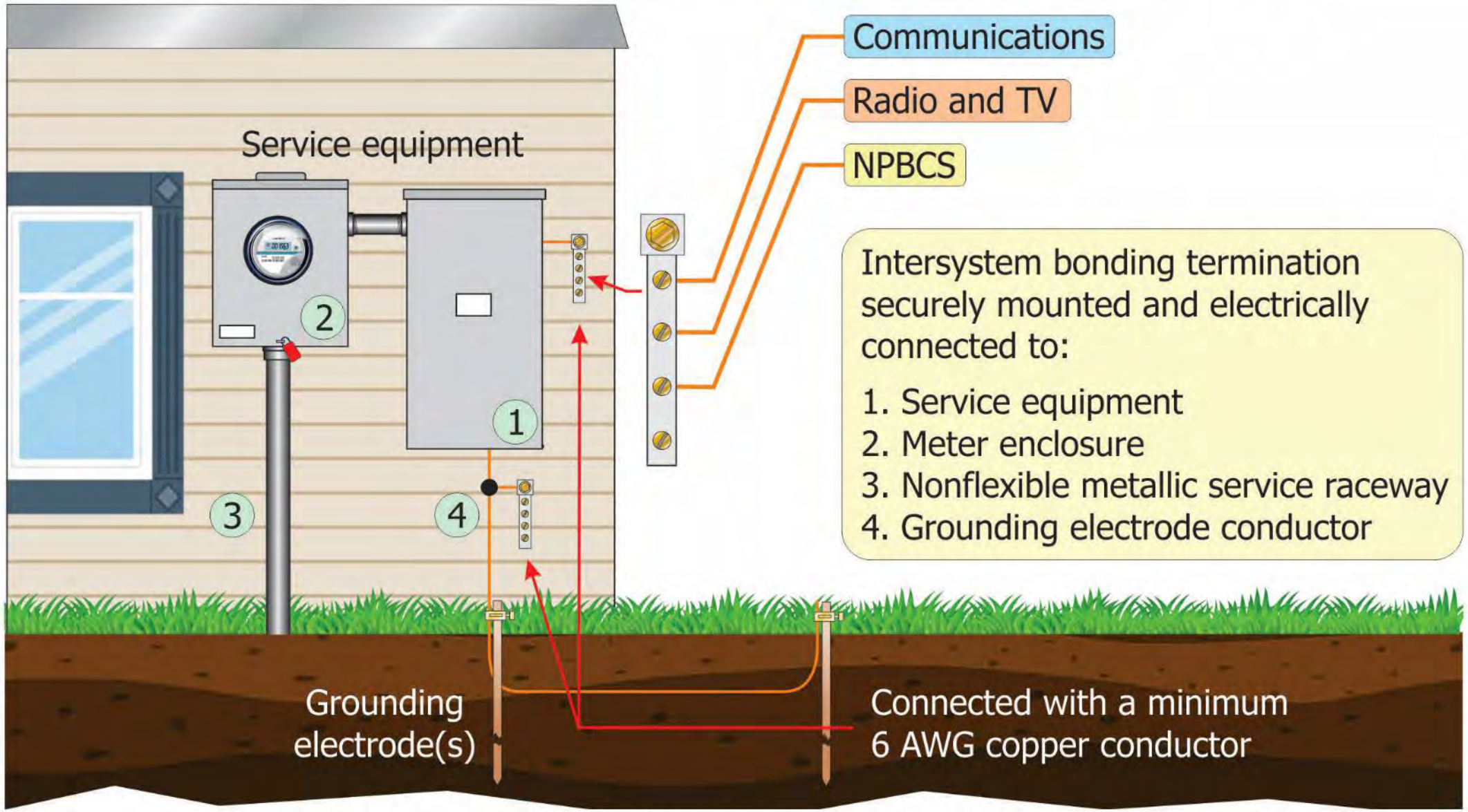
Intersystem Bonding for Communication Systems *(cont.)*

- The intersystem bonding termination shall be one of the following: *(cont.)*
  - A set of terminals securely mounted and electrically connected to:
    - Service equipment
    - Meter enclosure
    - Exposed nonflexible metallic service raceway
    - The grounding electrode conductor
  - Connections above permitted with a minimum 6 AWG copper conductor

Intersystem Bonding for Communication Systems *(cont.)*

- The intersystem bonding termination shall be one of the following: *(cont.)*
  - A set of terminals securely mounted and electrically connected to:
    - The disconnecting means for an additional building or structure *(mounted at the disconnecting means and connected to the metallic enclosure or to the GEC with a minimum 6 AWG copper conductor)*
  - These terminals shall be listed as grounding and bonding equipment
- *See 250.94 for intersystem bonding terminations*

250.94(A) Bonding for Communication Systems



Intersystem bonding termination required to be external to enclosures

Copyright © IAEI 2020

Intersystem Bonding termination is required to be:

- External to the enclosure
- Accessible for connection and inspection



- Capable of connection of not less than three intersystem bonding conductors
- Shall not interfere with the opening of any service or metering equipment enclosure

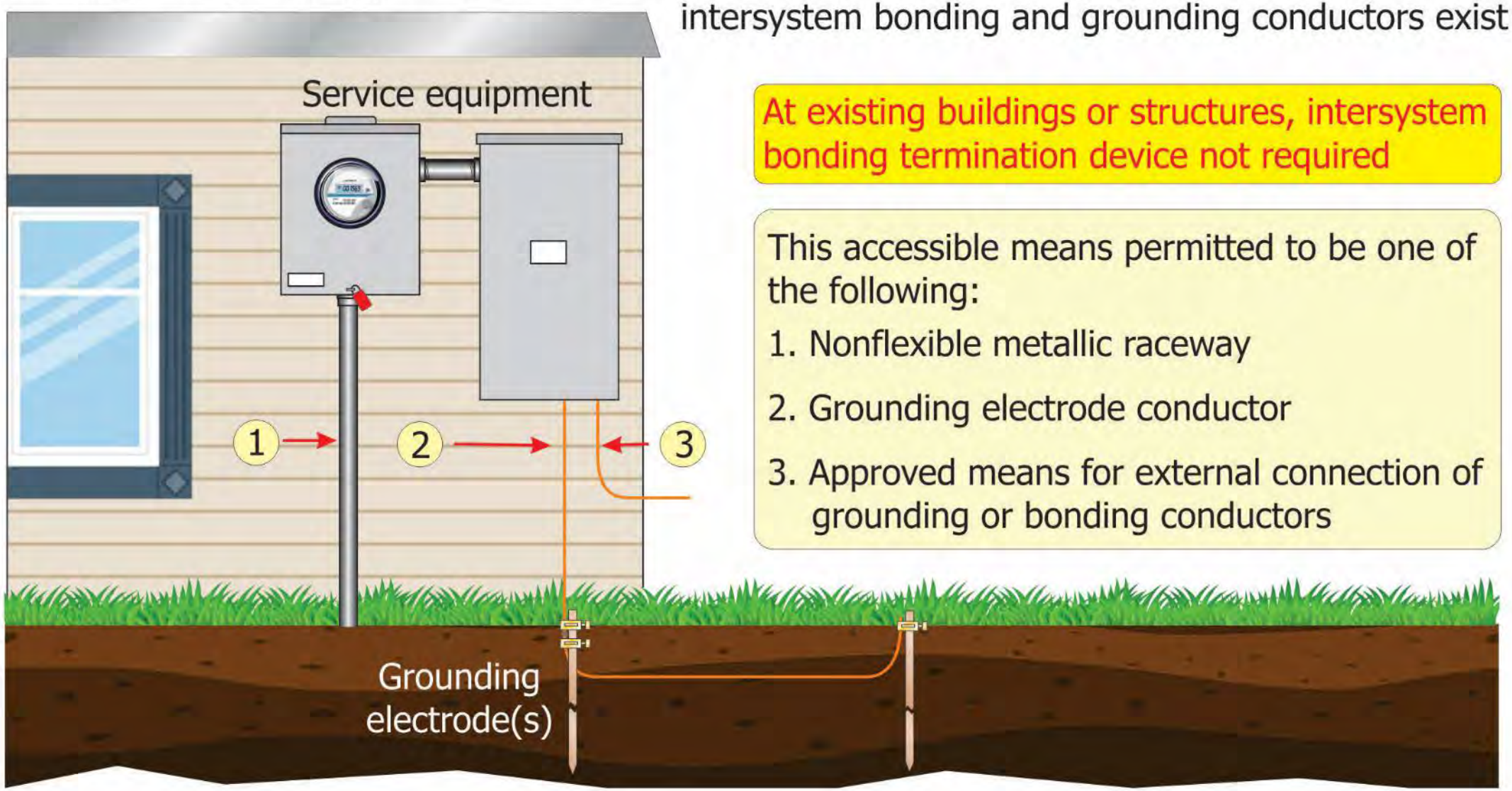
Copyright © IAEI 2020

Intersystem Bonding for Communication Systems *(cont.)*

- The intersystem bonding termination shall be one of the following: *(cont.)*
  - *See **250.94(A) Exception** for permission to delete the intersystem bonding termination at **existing buildings or structures** where any of the intersystem bonding and grounding electrode conductors required by 770.100(B)(2), 800.100(B)(2), 810.21(F)(2), 820.100, and 830.100 exist*

250.94(A) Exception: Bonding for Communication Systems

At existing installations, an accessible means external to enclosures for connecting intersystem bonding and grounding electrode conductors permitted at the service equipment where any intersystem bonding and grounding conductors exist



At existing buildings or structures, intersystem bonding termination device not required

This accessible means permitted to be one of the following:

1. Nonflexible metallic raceway
2. Grounding electrode conductor
3. Approved means for external connection of grounding or bonding conductors

Copyright © IAEI 2020

Intersystem Bonding for Communication Systems *(cont.)*

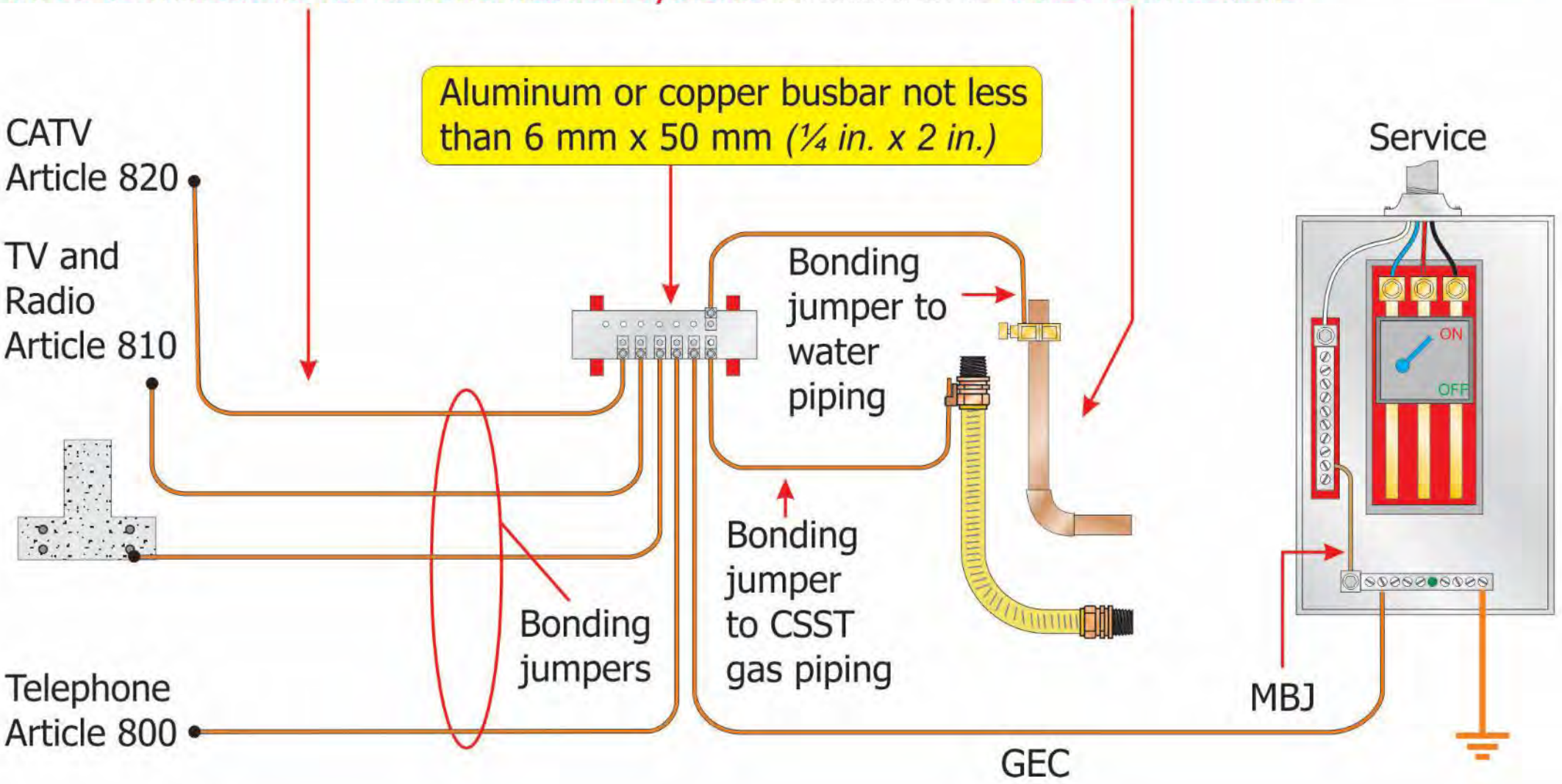
- Section **250.94(B)** titled, **"Other Means"** adds permitting intersystem bonding connections to an **aluminum or copper busbar** that will accommodate at least three terminations for communication systems as well as **"other connections"**
- An exception for both 250.94(A) and (B) offers relief from an intersystem bonding connection means ***"where communications systems are not likely to be used"***
- Aligns with the common practice for the communication room with many systems to use a copper or aluminum busbar for the purposes of grounding and bonding all the various communications equipment and connecting to the building grounding electrode system

Intersystem Bonding for Communication Systems *(cont.)*

- Section **250.94(B)** titled, **"Other Means"** adds permitting intersystem bonding connections to an **aluminum or copper busbar** that will accommodate at least three terminations for communication systems as well as **"other connections"** *(cont.)*
- This also allows connection of non-communications systems where required by other *Codes (such as bonding of CSST gas piping)* as long as the required **three terminations** for the communications systems are also provided
- Busbar to be an aluminum or copper busbar not less than 6 mm thick × 50 mm wide ***(¼ in. thick × 2 in. wide)***

250.94(B) Bonding for Communication Systems

250.94(B) Other Means. Connections to an aluminum or copper busbar not less than 6 mm thick × 50 mm wide *(¼ in. thick × 2 in. wide)* and of sufficient length to accommodate at least three terminations for communication systems in addition to other connections



Copyright © IAEI 2020

Article 805 - Communication Circuits

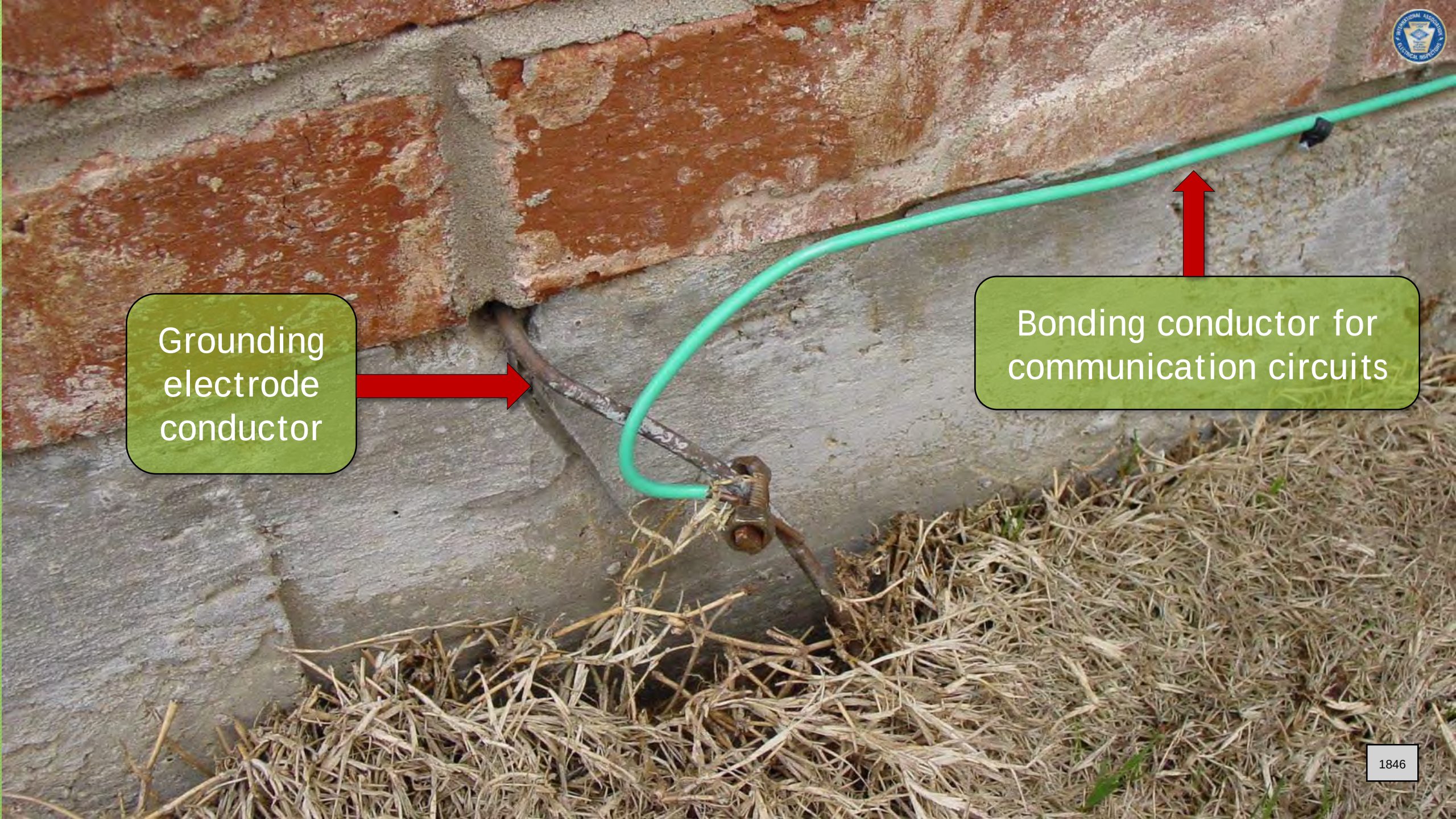
- Article 805 contains requirements for methods of installation and maintenance for such circuits and systems as:
  - Telephone
  - Telegraph *(except radio)*
  - Outside wiring for fire alarm and burglar alarm
  - Similar central station systems
  - Telephone systems not connected to a central station system but using similar types of equipment

Article 805 Communications Cable Grounding Requirements

- The **metallic sheaths** of communications cables entering buildings shall be grounded as **close as practicable** to the point of entrance or shall be **interrupted by an insulating joint** or equivalent device located as close as practicable to the point of entrance
- If the metallic shields of the cables are grounded, required to be grounded by a conductor meeting the requirements of **805.93(A)** *(which references back to 800.100)*
- Following the general requirements found in 800.100(A)

Article 805 Communications Cable Grounding Requirements *(cont.)*

- This conductor for grounding of the metallic shields of communication cables is required to be:
  - Copper or other corrosion resistant conductor
  - Solid or stranded
  - Not smaller than 14 AWG
  - As straight a line as practicable
  - Protected from physical damage *(often accomplished by installing in a raceway)*
    - If installed in a **ferrous metal raceway**, both ends of the raceway to be bonded to the bonding conductor or grounding electrode conductor


Grounding electrode conductor
Bonding conductor for communication circuits
1846

Article 810 - Radio and Television Equipment

- **Masts** and **metal structures** supporting antennas and **antenna discharge units** shall be grounded in accordance with 810.21
- Where required, each lead-in conductor from an outdoor antenna shall be provided with a **listed antenna discharge unit**
- The bonding conductor or grounding electrode conductor for a radio or TV antenna system is required to be connected to an **electrode or other suitable grounding connection point** as specified by 810.21(F)(1) through (F)(3)
- These requirements are the same as the general requirements found in Article 800 and discussed previously

Article 810 – Radio and Television Equipment *(cont.)*

- The bonding conductor or grounding electrode conductor shall be:
  - Copper, aluminum, copper-clad steel, copper-clad aluminum, bronze, or similar corrosion-resistant material *[810.21(A)]*
  - Not smaller than 10 AWG copper, 8 AWG aluminum, or 17 AWG copper-clad steel or bronze *[810.21(H)]*
  - Protected where exposed to physical damage *[810.21(D)]*
  - Run in as straight a line as practicable *[810.21(E)]*
- See 810.21(A) through (K) for complete requirements for bonding conductors or grounding electrode conductors for receiving stations

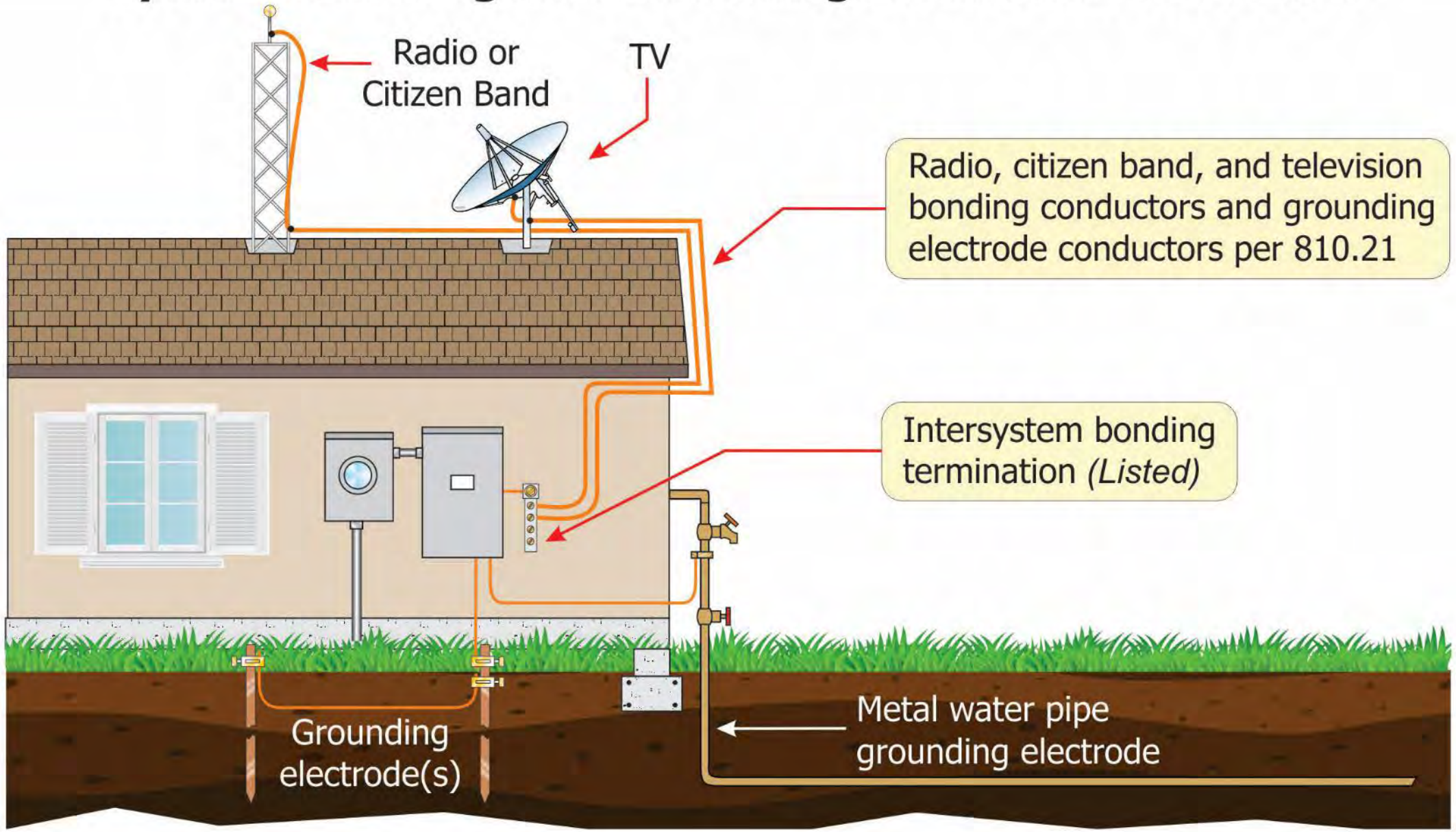
Article 810 - Amateur Transmission and Receiving Stations

- Lead-in antenna conductors shall be installed in such a manner that affords a degree of **protection against accidental contact by personnel** *[810.13]*
- Lead-in conductors to radio transmitters shall be located or installed so as to make **accidental contact** with them **difficult** *[810.56]*
- Where transmitting or receiving stations are installed each conductor of a lead-in for outdoor antennas are generally required to be provided with an antenna discharge unit or other suitable means that will drain static charges from the antenna system *[810.57]*

Article 810 - Amateur Transmission and Receiving Stations *(cont.)*

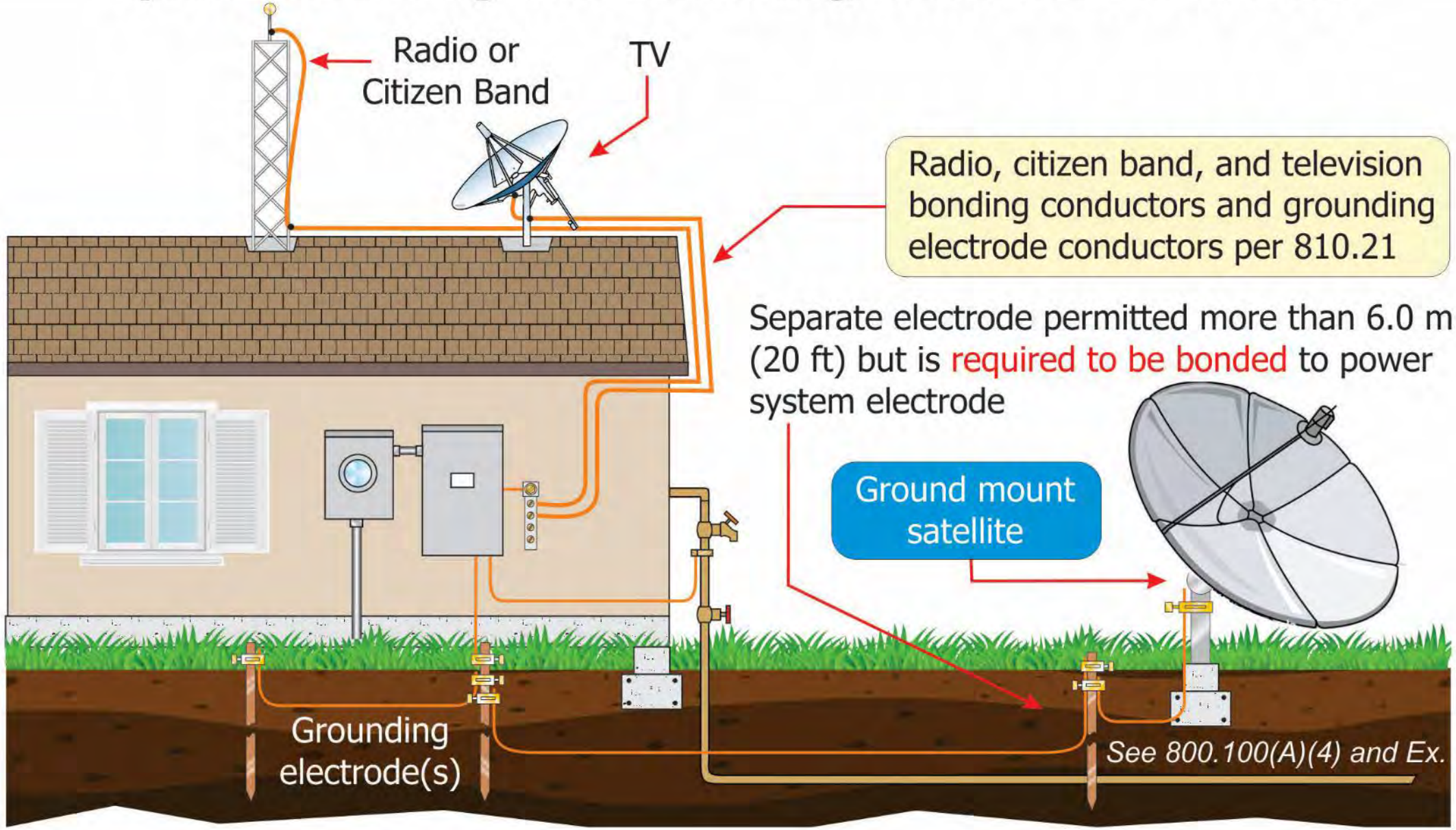
- There are two bonding conductors or grounding electrode conductors required for this specific equipment:
  - An **operating** bonding conductor or grounding electrode conductor
  - A **protective** bonding conductor or grounding electrode conductor
- These bonding conductors or grounding electrode conductors for amateur transmitting and receiving stations are required to be installed in accordance with 810.58(A), (B), or (C)

810.21 Radio, TV, and Citizen Band Antenna Systems Bonding and Grounding Electrode Conductors



Copyright © IAEI 2020

820.100, 800.100 Radio, TV, and Citizen Band Antenna Systems Bonding and Grounding Electrode Conductors



Copyright © IAEI 2020

Article 820 - Coaxial (CATV) Cable Grounding Requirements

- CATV systems are usually wired with conductors that are coaxial and have **shields inherent to the cable assembly**
- Outer conductive shield of coaxial cable shall be grounded at the building premises **as close to the point of cable entrance or attachment as practicable** *[820.93(A) and (B)]*
- Where these shields are required to be grounded, selecting a grounding location to achieve the **shortest practicable bonding conductor or grounding electrode conductor** will help limit potential differences between CATV and other metallic systems
- *See NEC 820.93 and 820.93(A) through (D)*

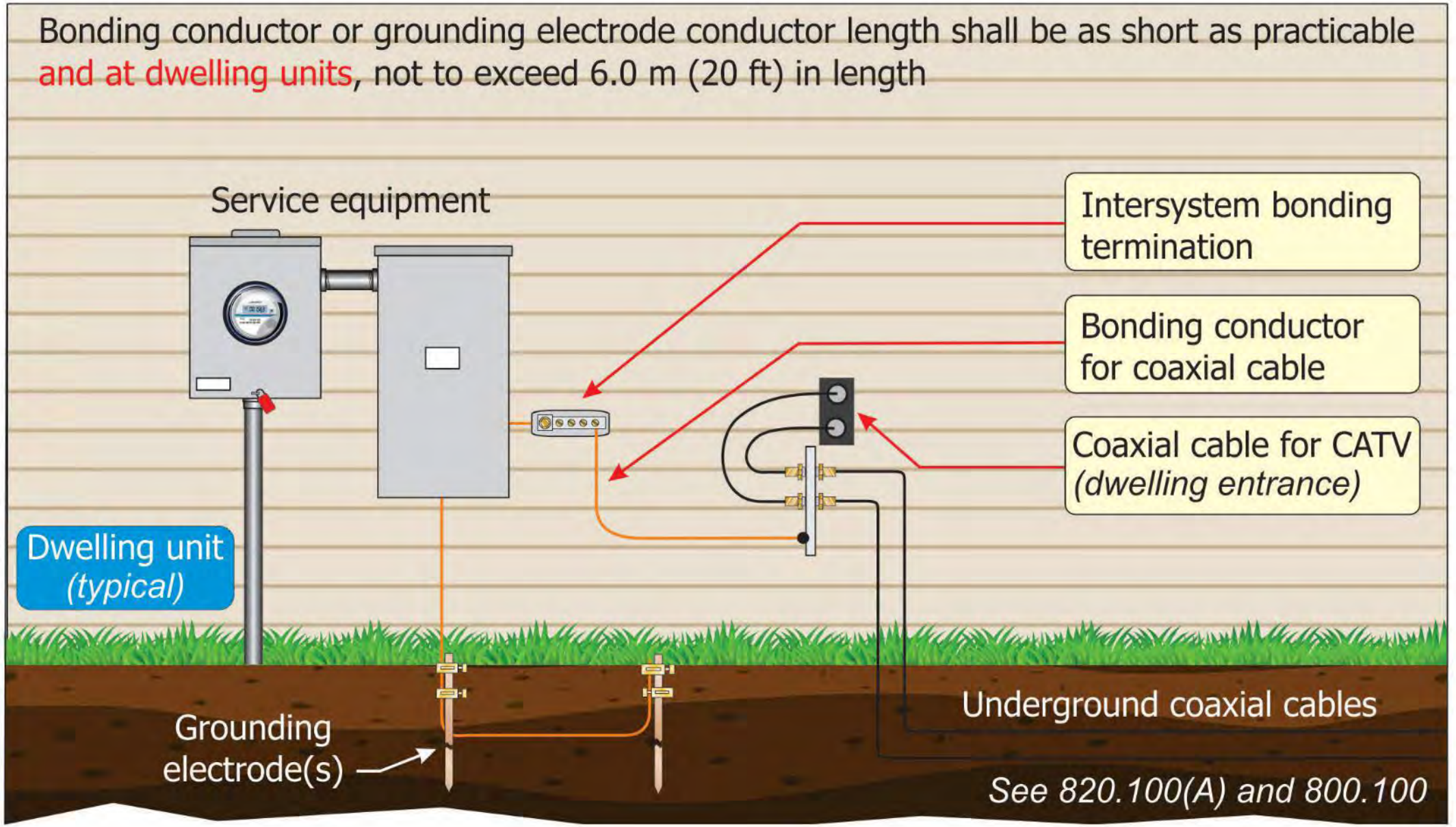
Coaxial (CATV) Cable Shield Grounding

- ***Shield Grounding*** - Where the outer conductive shield of a coaxial cable is grounded, no other protective devices shall be required *[820.93(A)]*
- ***Shield Protection Devices*** - Grounding of a coaxial drop cable shield by means of a protective device that does not interrupt the grounding system within the premises shall be permitted *[820.100(B)]*
- *See 820.93 and 820.100*

Coaxial (CATV) Cable Shield Grounding *(cont.)*

- **Grounding Outer Conductive Shields of Coaxial Cables**
  - Coaxial cables entering buildings or attached to buildings shall comply with 820.93(A) or (B)
  - Where the outer conductive shield of a coaxial cable is grounded, no other protective devices shall be required
- **Entering Buildings or Terminating on Outside of Buildings**
  - In installations where the coaxial cable **enters the building** or is **terminated outside of the building**, the outer conductive shield shall be grounded in accordance with 820.100 *[820.93(A) or (B)]*
  - The grounding or interruption shall be as close as practicable to the point of entrance

Coaxial Cable Bonding and Grounding Electrode Conductor



Copyright © IAEI 2020


1857


WARNING
Do not disconnect or remo
cable. If cable is loose o
needs to be remov
contact AT&T Wireless
1858

Coaxial (CATV) Cable Shield Grounding *(cont.)*

- Shields of the coaxial cable shall be bonded or grounded as specified below:
  - **In Buildings or Structures with an intersystem bonding termination**
    - If the building or structure served has an intersystem bonding termination (IBT) *(as required by 250.94)* the bonding conductor shall be connected to the IBT *[800.100(B)(1)]*
  - **In Buildings or Structures with Grounding Means**
    - If an IBT is established, 250.94(A) shall apply
    - If the building or structure served has **no IBT**, the bonding conductor or grounding electrode conductor to be connected to nearest accessible location on one of the following: *(see next slide)*

Coaxial (CATV) Cable Shield Grounding *(cont.)*

- If the building or structure served has **no intersystem bonding termination**, the bonding conductor or grounding electrode conductor to be connected to nearest accessible location on one of the following:
  1. Building or structure grounding electrode system as covered in 250.50
  2. Grounded interior metal water piping system, within 1.5 m (5 ft) from its point of entrance to the building, as covered in 250.52
  3. Power service accessible means external to enclosures using the options identified in 250.94(A), Exception
  4. Nonflexible metallic power service raceway
  5. Service equipment enclosure

Coaxial (CATV) Cable Shield Grounding *(cont.)*

- If the building or structure served has **no intersystem bonding termination**, the bonding conductor or grounding electrode conductor to be connected to nearest accessible location on one of the following: *(cont.)*

  6. Grounding electrode conductor or the grounding electrode conductor metal enclosure of the power service, or…
  7. Grounding electrode conductor or to the grounding electrode of a building or structure disconnecting means that is connected to an electrode as covered in 250.32

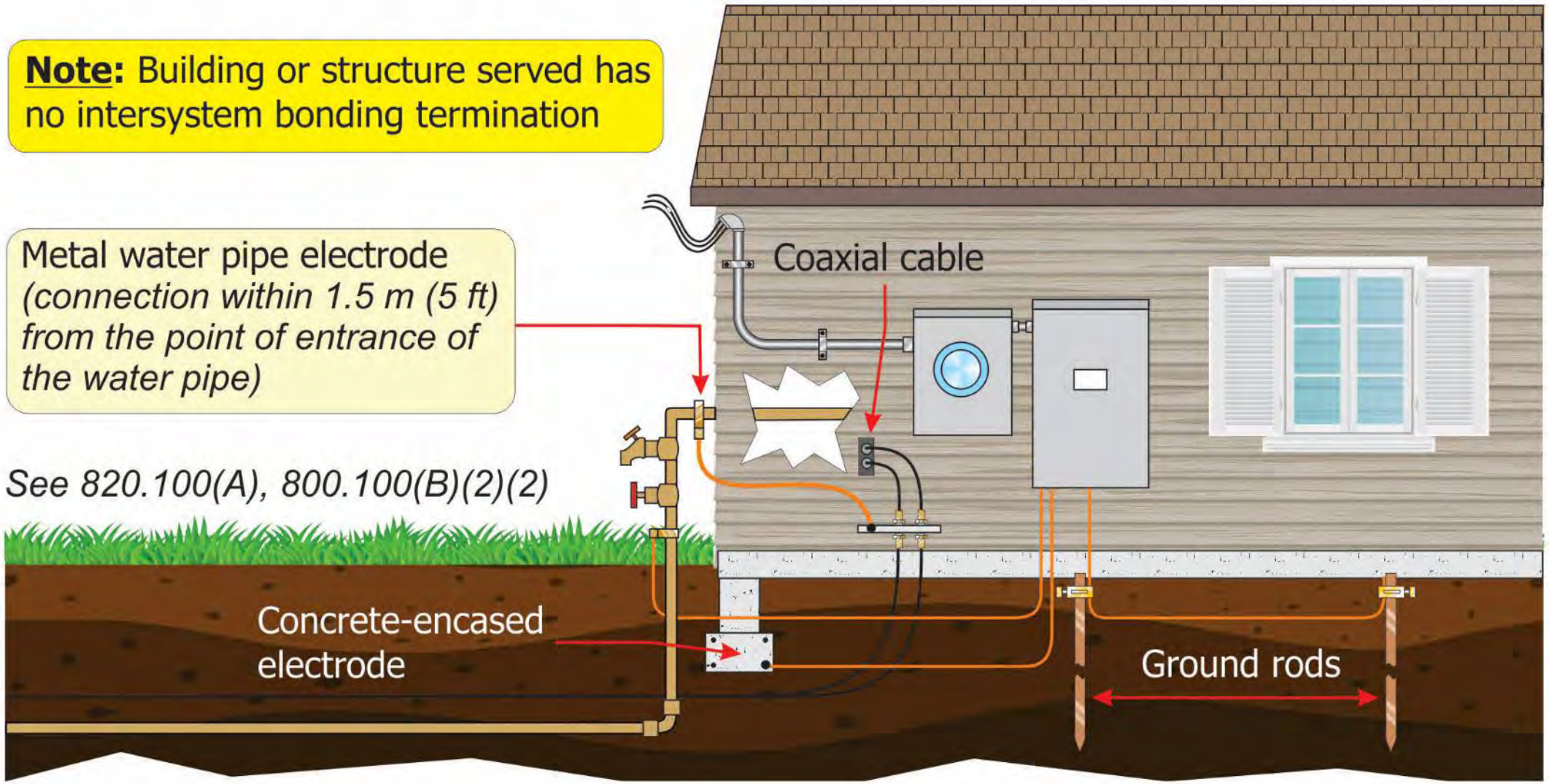
Coaxial Cable Bonding or Grounding Electrode Conductor

If the building served has no intersystem bonding termination, the bonding conductor or grounding electrode conductor is generally permitted to be connected to most electrodes described at 250.52(A)

Note: Building or structure served has no intersystem bonding termination

Metal water pipe electrode *(connection within 1.5 m (5 ft) from the point of entrance of the water pipe)*

See 820.100(A), 800.100(B)(2)(2)

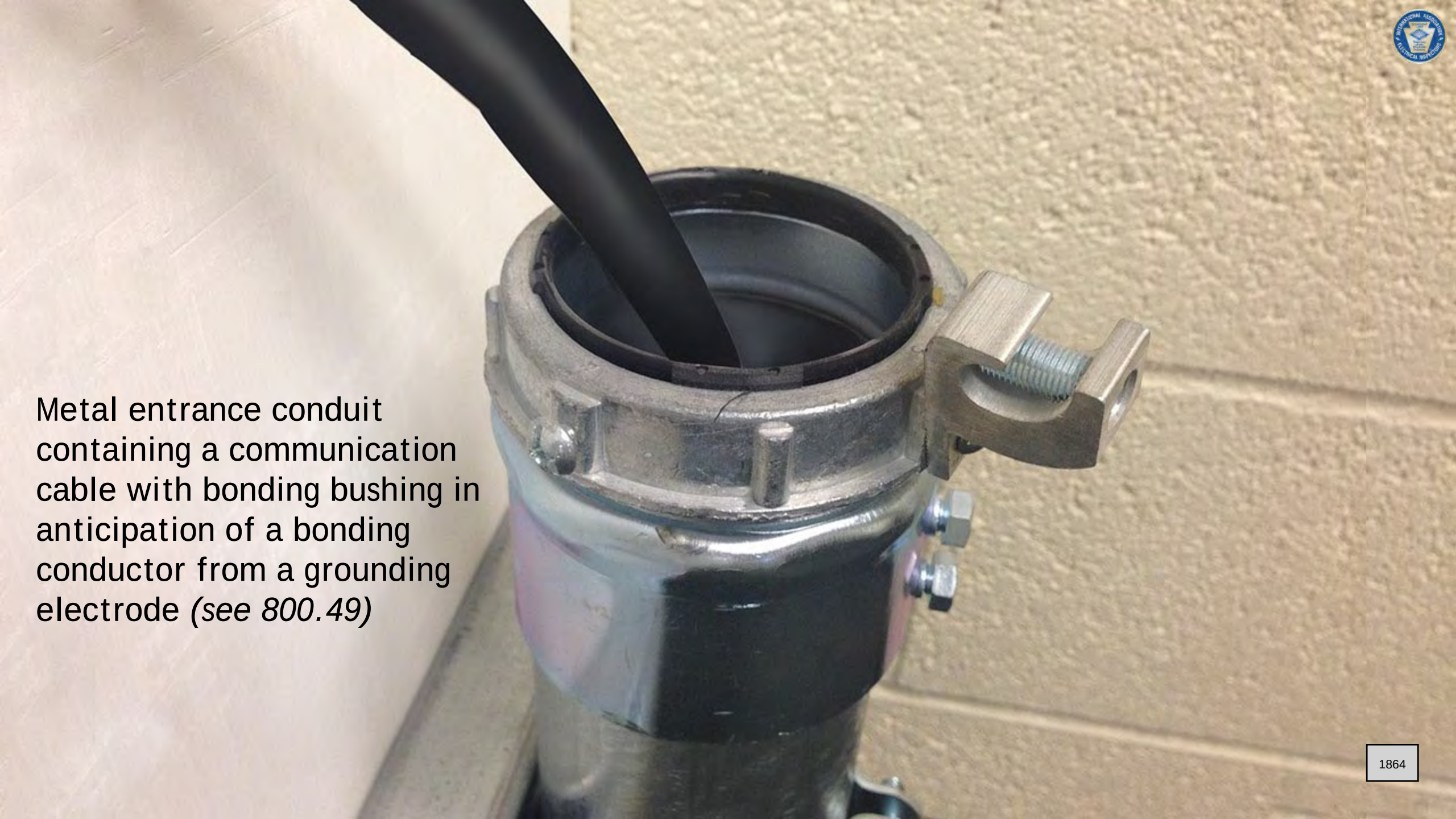


Copyright © IAEI 2020

Metallic Entrance Conduit Grounding

- Metallic conduit *[such as Rigid metal conduit (RMC) or intermediate metal conduit (IMC)]* containing entrance coaxial cable is required to be **connected** by a bonding conductor or grounding electrode conductor **to a grounding electrode** in accordance with 800.100(B)

- *See 800.49*



Metal entrance conduit containing a communication cable with bonding bushing in anticipation of a bonding conductor from a grounding electrode *(see 800.49)*

Coaxial (CATV) Cable Electrode(s)

- Selecting a grounding location to achieve the **shortest practicable grounding electrode conductor** helps limit potential differences between CATV and other metallic systems
- Bonding together of all separate electrodes **limits potential differences** between them and between their associated wiring systems
- See 800.100(B) for general requirements for the bonding conductor or grounding electrode conductor for coaxial cable installations

Article 830 - Network-Powered Broadband Communication Systems

- Grounding requirements for network-powered broadband communications system are provided in Part IV of Article 830 *[830.93(A) and (B)]*
- Network-powered broadband communications systems provide any combination of voice, audio, video, data, and interactive services through a network interface unit (NIU) *[830.1]*
- The informational note after the scope of Article 830 indicates that a typical basic network-powered broadband communications system configuration "includes a cable supplying power and broadband signal to a network interface unit that converts the broadband signal to the component signals

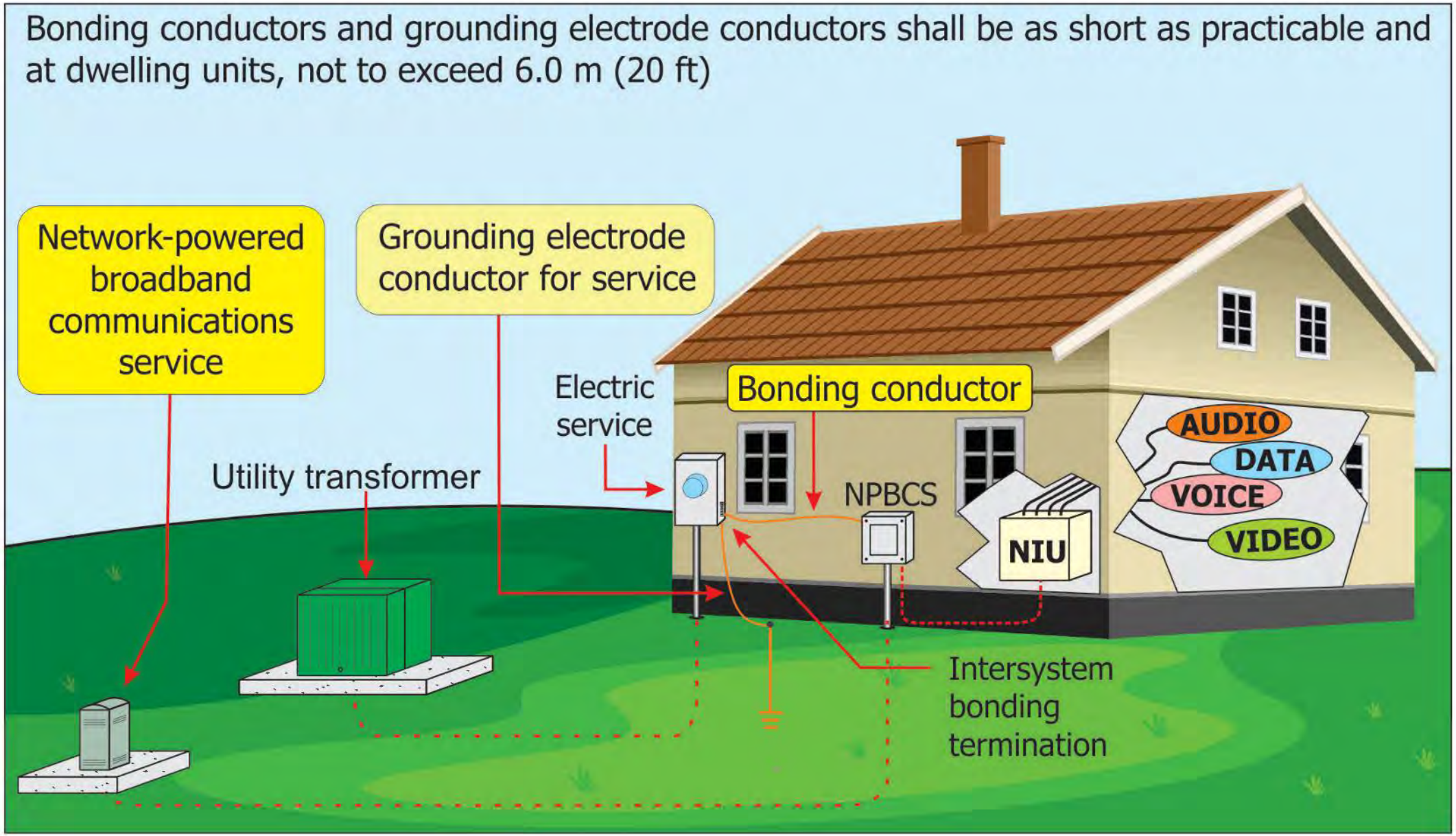
Article 830 - Network-Powered Broadband Communication Systems *(cont.)*

- Typical cables are coaxial cable with both broadband signal and power on the center conductor, composite metallic cable with a coaxial member(s) or twisted pair members for the broadband signal and twisted pair members for power, and composite optical fiber cable with a pair of conductors for power
- Larger systems may also include network components such as amplifiers that require network power

Network-Powered Broadband Communication Systems *(cont.)*

- The **shields** of network-powered broadband communications cables used for communications or powering shall be grounded in accordance with 800.100 ***(grounded at the building)*** as close as practicable to the point of entrance or attachment of the network interface unit *(NIU) [see 830.93(A)]*
- Metallic cable members not used for communications or powering shall be grounded in accordance with 800.100 or **interrupted by an insulating joint** or equivalent device as close as practicable to the point of entrance or attachment of the NIU *[see 830.93(A)]*
- Selecting a grounding location to achieve the shortest practicable grounding conductor helps **limit potential differences** between the network-powered broadband communications circuits and other metallic systems

830.93, 800.100(A)(4) NPBCS Bonding Conductor Length



Copyright © IAEI 2020

NPBCS Electrodes and Separate Electrodes

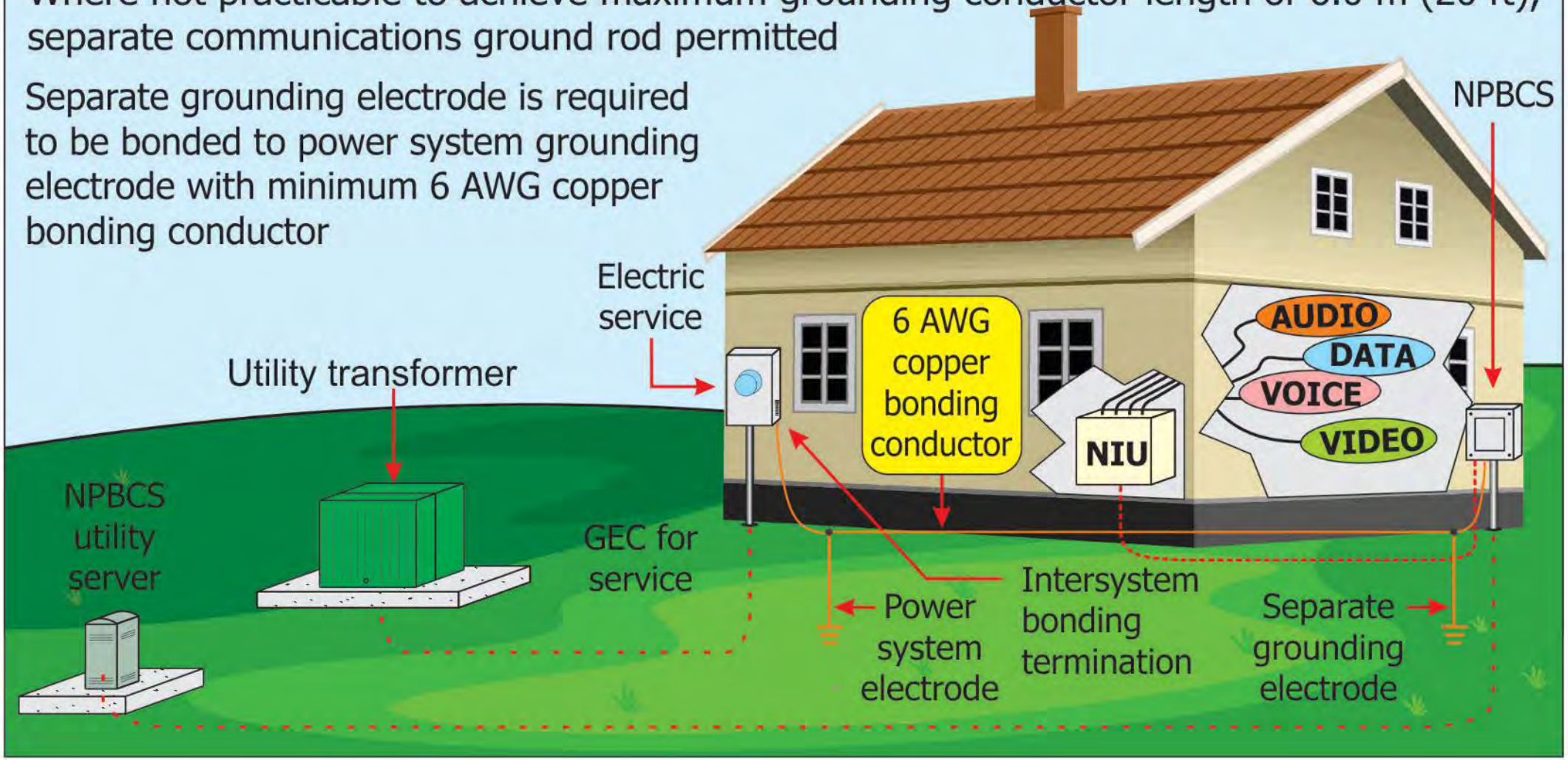
- Grounding conductors are to be kept as **short as practicable** and shall generally be connect to the power grounding electrode system
- In one-family and multifamily dwellings, the grounding conductor shall be as short as practicable, **not to exceed 6.0 m (20 ft) in length**
- In one- and two-family dwellings where it is not practicable to achieve an overall maximum grounding conductor length of 6.0 m (20 ft), a **separate communications ground rod is permitted** to be installed
- The NPBCS ground rod **required to be bonded** to the power grounding electrode system *(min. 6 AWG copper)*
- *See 800.100(A) through (D)*

830.93, 800.100(A)(4) Ex. NPBCS Bonding Conductor Length

Bonding conductors and grounding electrode conductors shall be as short as practicable and at dwelling units, not to exceed 6.0 m (20 ft)

Where not practicable to achieve maximum grounding conductor length of 6.0 m (20 ft), separate communications ground rod permitted

Separate grounding electrode is required to be bonded to power system grounding electrode with minimum 6 AWG copper bonding conductor



Copyright © IAEI 2020

Lightning and Other Hazards

- Protection of the network powered broadband equipment from **high voltages** *(over 300 volts to ground)* due to lightning or other sources of surges is found in **830.90** for **primary electrical protection**
- Primary electrical protection is required on all network-powered broadband communications conductors that are **neither grounded nor interrupted** and are run partly or entirely in aerial cable **not confined within a block**
- Primary electrical protection is also required on all **aerial or underground** network-powered broadband communications conductors that are **neither grounded nor interrupted** and are located **within the block** containing the building served
- An exception indicates that primary protection is not required where electrical protection is provided on the **derived circuits**

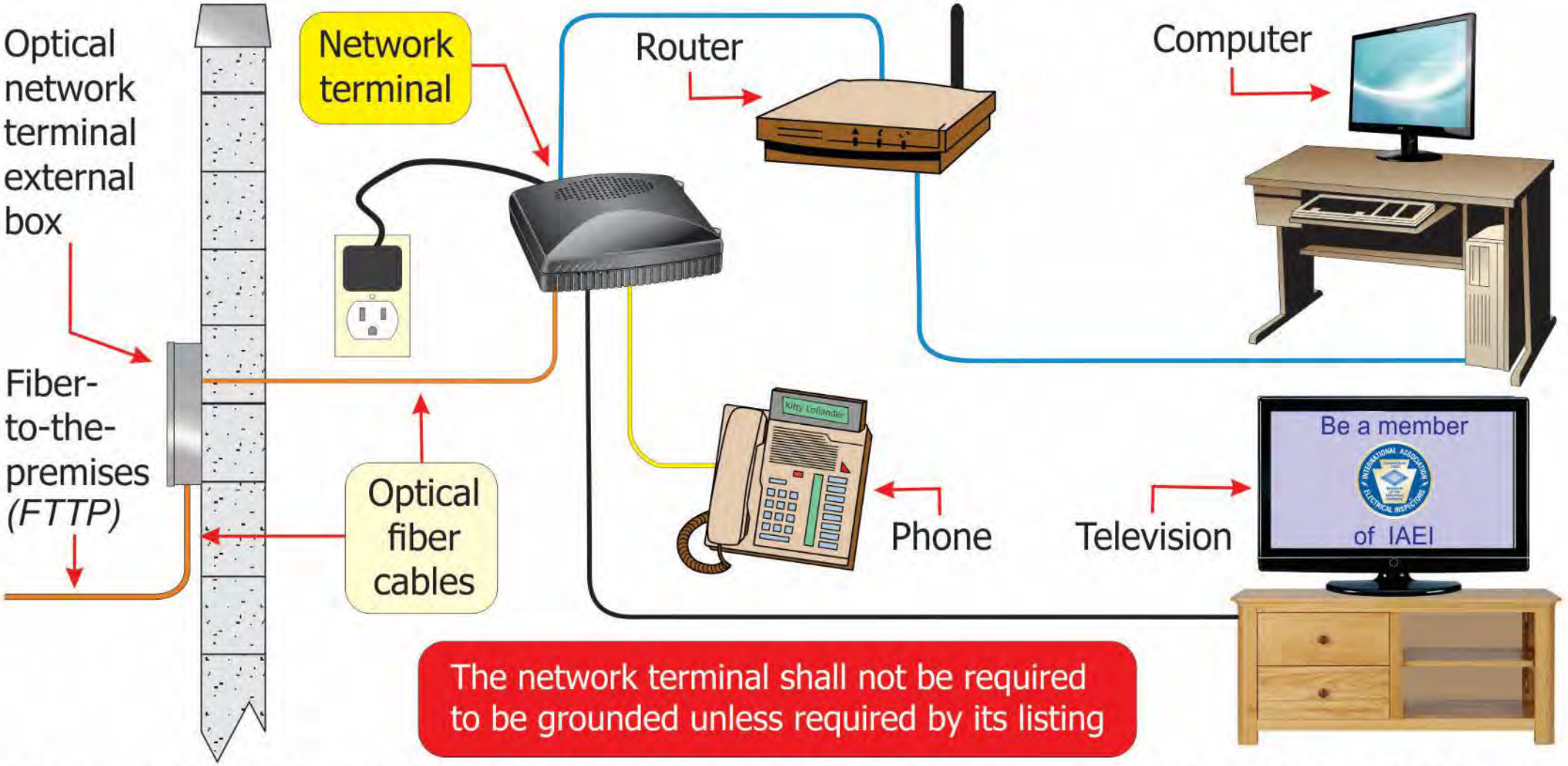
Article 840 - Premises-Powered Broadband Communications Systems

- Grounding of PPBCS are covered at Part IV of Article 840
- Basic system configuration consists of optical fiber, twisted pair, or coaxial cable to the premises supplying a broadband signal to a network terminal that converts the broadband signal into component electrical signals *(such as telephone, video, high-speed Internet, and interactive services)*
- Powering for network terminal and network devices typically accomplished through a **premises power supply** *(built into network terminal or provided as a separate unit)*
- In the event of a power interruption, a battery backup unit or an uninterruptible power supply (UPS) is typically part of the powering system

Article 840 - Premises-Powered Broadband Communications Systems *(cont.)*

- A basic premises-powered broadband communications system configuration consists of an optical fiber cable to the premises
- Part IV of Article 840 provides requirements where the premises powered network system **does not leave the building** and **where it leaves the building** outside a lightning zone of protection
- Grounding required for protection of the network terminal, conductive optical fiber cables, multipair communications cables, antenna lead-in conductors, and coaxial cables shall comply with 800.100 and 800.106
- *See 840.101 and 840.102*

840.101(C) PPBCS Grounding and Bonding



If the coaxial cable shield is separately grounded as described in 840.101(A)(1) or (A)(2), the use of a cord and plug for the connection to the network terminal grounding connection shall be permitted

Copyright © IAEI 2020

Summary of Grounding of Communication Circuits

- Grounding and bonding requirements for voice, data, and video systems covered by *NEC* Chapter 8 are **minimum requirements for safety**
- Grounding and bonding requirements for systems, circuits, and enclosures in addressed in *NEC* Chapter 2 *(Wiring and Protection)*
- Chapter 8 is **independent** from the requirements of Chapter 2 *(unless specifically referenced from particular articles found in Chapter 8)*
- Specified requirements are found in Chapter 8 along with **specific requirements for grounding and bonding** required for safety for these special communication systems
- Proper grounding and bonding is essential for safety and operation of these special communication systems

Summary of Grounding of Communication Circuits *(cont.)*

- One of the most important requirements of the *Code* is to bond the electrodes or electrodes of different systems together
- Failure to do so can result in shock hazards, fire hazards, and damage to electronic components of these communication systems
- For information on enhanced grounding electrodes and grounding and bonding for sensitive electronic equipment, see Chapters 7 and 19 of the Soares Grounding and Bonding material

CHAPTER TWENTY-ONE

GROUNDING OF SYSTEMS OR CIRCUITS OF OVER 1000 VOLTS

Grounding of Systems or Circuits of Over 1000 Volts

- The *NEC* indicates that where systems or circuits of over 1000 volts (1 kV) are grounded, they must comply with all the applicable requirements of 250.1 through 250.178 and with 250.182 through 250.194
- The specific requirements in Part X of Article 250 supplement or modify the preceding requirements in Article 250
- *See 250.180*
- Standard industry practice is to refer to the voltage in terms of kilovolts (kV) instead of volts *(1000 volts equals 1 kV)*
- Power systems that are over 1 kV are either grounded or ungrounded
  - If grounded, the system may be solidly grounded or grounded through an impedance

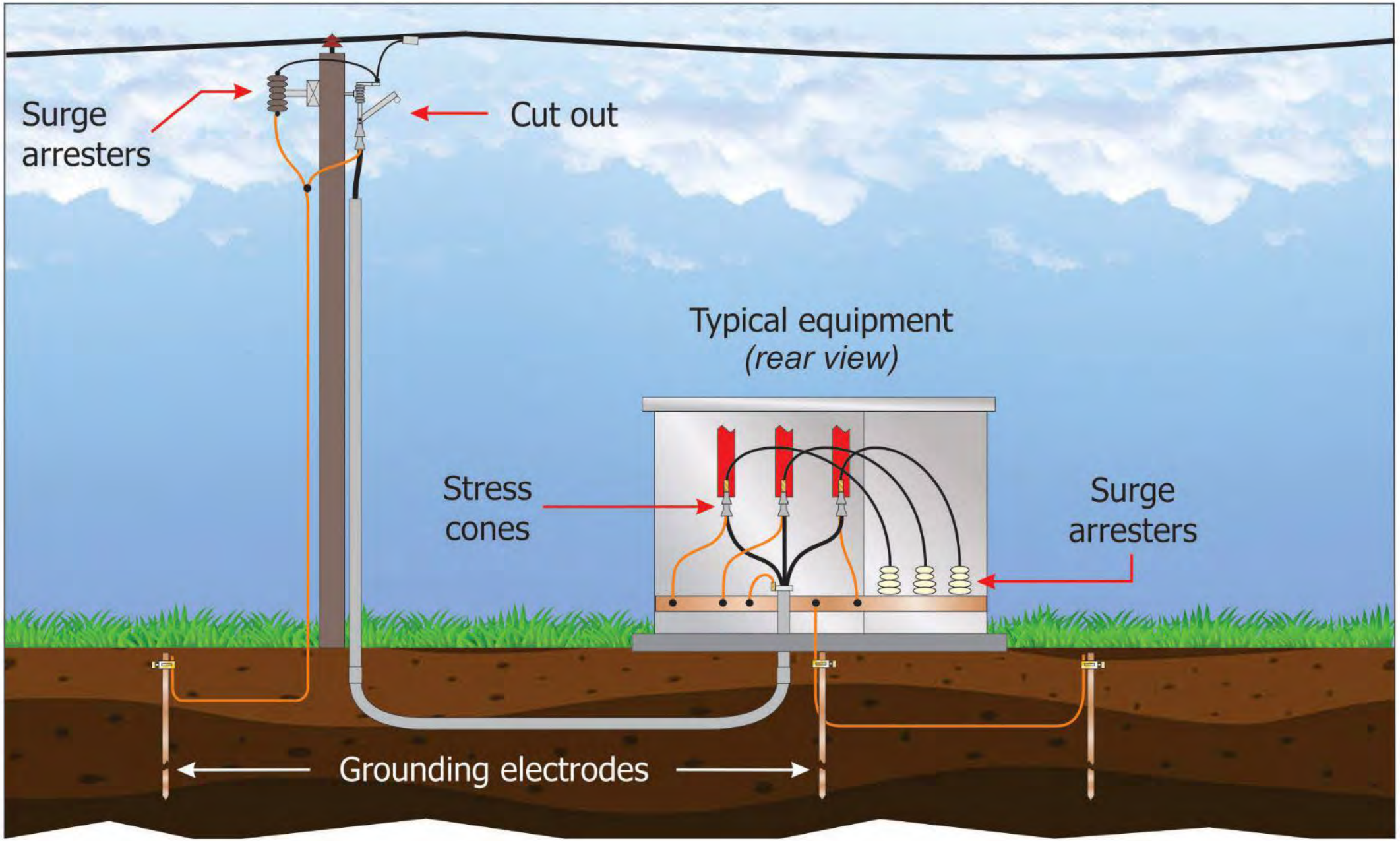
Grounding of Systems or Circuits of Over 1000 Volts *(cont.)*

- Many medium-voltage systems in the **2.4 to 15 kV** range are commonly either **low-resistance grounded** or are **high-resistance grounded**
- Only difference between low- and high-resistance grounding is the **value of the resistor** that, in turn, controls the amount of ground-fault current permitted during a ground-fault event
- The other common method is to solidly ground the system *(especially if exposed to lightning)*

Grounding of Systems or Circuits of Over 1000 Volts *(cont.)*

- Medium voltage systems **above 15 kV** are typically either **solidly grounded** or **ungrounded**
  - For ungrounded systems, even though there is not an effective ground *(earth connection)* provided to a system conductor, there is still a relationship to earth through the **surge *(lightning)* arresters**
  - Surge *(lightning)* arresters are installed where outdoor lines are open and commonly subjected to lightning surges and to transient overvoltages

Grounding Through Surge Arresters



Copyright © IAEI 2020

Grounded Systems Rated 2.4 kV to 13.8 kV

- Grounding may be achieved through **solid connections to earth** or connection through a **grounding impedance** *(typically a resistor)* purposely installed in the equipment-grounding path at the source

- Choice depends on **available ground-fault current**, the **size of the system**, **tolerance for outages**, and **tolerance for damage** from ground faults

- Common for **industrial systems** to **ground the neutral** of systems rated 2.4 kV and above **through a resistor**

Systems Rated 15 kV or More

- Such systems are installed **indoors** and **outdoors**
- Typically, these systems serve some types of **rotating equipment** such as centrifugal chillers
- Usually these systems are **solidly grounded**, which permits the use of surge arresters rated at phase-to-ground voltage or grounded-neutral type that cost less and provide better protection from overvoltage
- Just as in systems under 1 kV, these medium voltage systems will have different voltage levels for various utilization purposes

Systems Rated 15 kV or More *(cont.)*

- Some medium voltage levels are only for distribution to allow greater levels of power to be sent without having to use large conductors
- As each voltage level system is created, **grounding must be reestablished** by some means **at each voltage level** as was previously described for systems of 1000 volts or less



1886



1887


Nelson
Nelson
1888



1889



1890

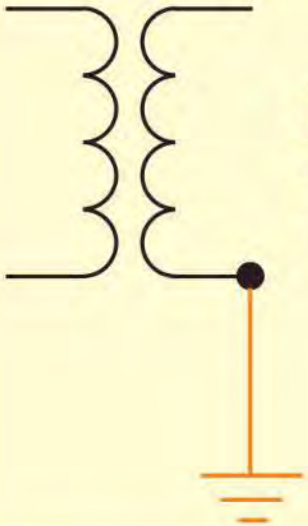


1891

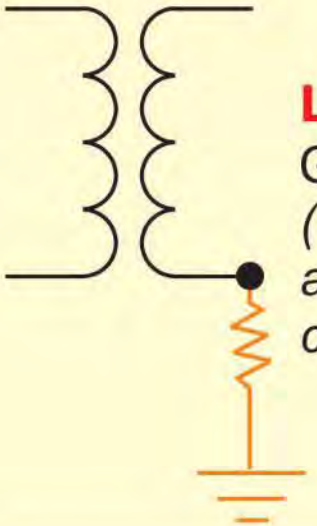
Methods of Grounding (Over 1 kV)

- Effectively grounded through surge arresters
- Reactance grounded through an inductor
- Low resistance grounded
- High resistance grounded
- Solidly grounded

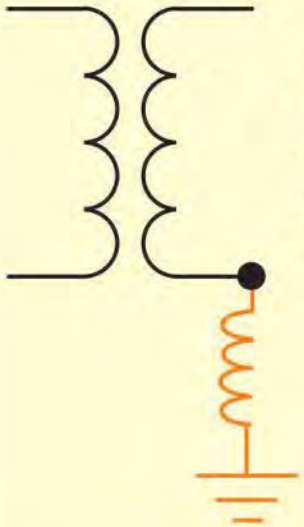
Methods of Grounding Systems Over 1000 Volts



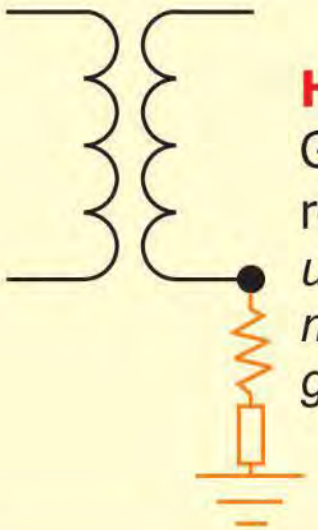
Solidly grounded - Grounded directly without impedance inserted



Low-resistance grounded - Grounded through a resistor *(Typically allowing 50 to 600 amperes of ground-fault current)*



Reactance grounded - Grounded through an inductor



High-resistance grounded - Grounded through high resistance *(Typical designs usually provide for a maximum of 10 amperes ground-fault current)*

Copyright © IAEI 2020

High-Resistance Grounding



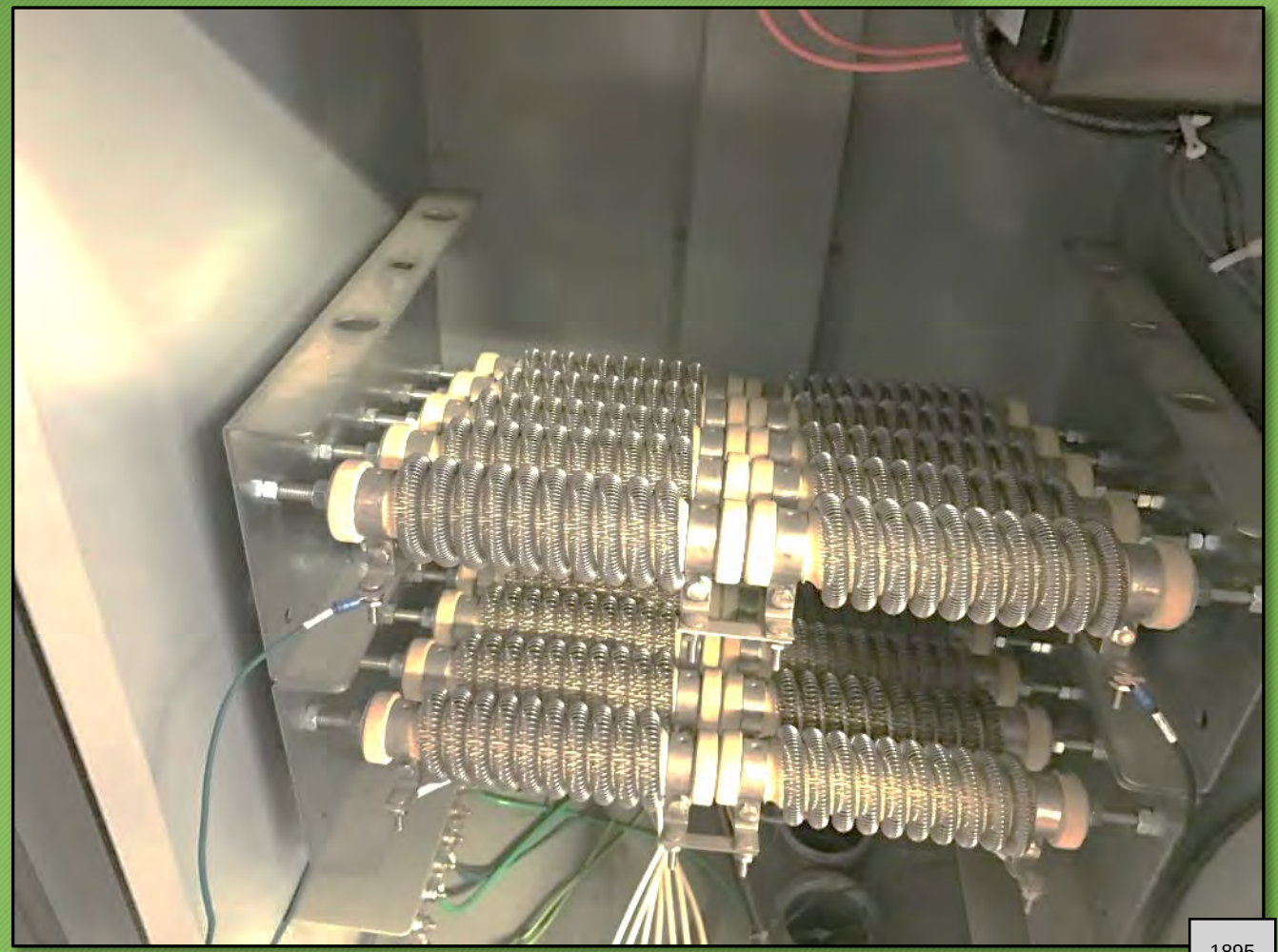
- High-resistance grounding
- Photo shows a Post Glover high-resistance ground cabinet installed next to a closed transition generator control cabinet
- High-resistance grounding is only for the generator

1894

Photo courtesy Denver Water Facility-Rob Bowman

High-Resistance Grounding





1895

Photo courtesy Denver Water Facility-Rob Bowman


Post Glover
"The Resistor Specialists"
HIGH RESISTANCE GROUNDING SYSTEM
Part No.: PL48YF1E00-P
Serial No.: SO56258-1-1
Volts (L-L): 480
Volts (L-N): 277
Amps @ 25°C: 2 - 10
Ohms @ 25°C: 138.5 - 27.7
Time: Continuous
Temp. Rise: 385 °C
Temp. Coeff. Res.: 0.013% / °C
Hz: 60
Number of Phases: 3
Volume of Oil: 0
Type of Cooling: Natural
Altitude: N/A
Enclosure Type: 1
Weight: 289 lbs.
Additional Information:
IEEE Std 32-1990
Month/Year: 04/2012
c UL us
LISTED
Inst Manual HR105-11
MADE IN THE USA

1896

Grounding of Outdoor Substations

- The grounding of outdoor substations involves:
  - grounding the fence and other supporting structures
  - all immediate equipment and conductor enclosures
  - grounding of the neutral
- A ground bus or grid should be established extending about **900 mm (3 ft)** outside the periphery of the fence
- The bus should be connected to many ground rods around its periphery and, in addition, should be connected to a metallic underground water piping system *(where present)*
- The ground bus should have a minimum size of **4/0 AWG copper** or for higher capacity systems, be approximately 25 percent of the capacity of the system

Grounding of Outdoor Substations *(cont.)*

- With the known system capacity, the **grid conductor** rating may then be sized based on the capacity of bare conductors in free air
- Copper bus rated based on **1000 amperes per square inch**
- Connections from the fence and from all equipment within the fence *(transformer enclosures, steel structures,* switchgear enclosures, and switching equipment including operating mechanisms for *gang-operated disconnects, etc.)* should be not less than **4/0 AWG** or less than 25 percent of the capacity of the secondary conductor

Grounding of Outdoor Substations *(cont.)*

- Substation grounding systems must comply with Part III of Article 250
- See ANSI/IEEE 80-2013, IEEE *Guide for Safety in AC Substation Grounding*, for further reference in the design and considerations for substation grounding
- *See NEC 250.191 and Informational Note*
- Section 250.194 provides more prescriptive requirements for **substation fences** and other metal structures



1900


KEEP OUT!
NO ENTRAR!
1901

Grounding of Outdoor Substations *(cont.)*

- To be sure of having a good, permanent neutral ground, it is best to connect the **neutral conductor** to **two points** on the ground bus
- A grounding bus and connections are effective only if the mechanical construction is sound and as **permanent as possible**
- It is preferable to properly **braze**, **weld**, or **exothermically weld** all connections and to protect all cable from mechanical injury
- **Irreversible compression** connections using special tools and connectors is a common industry practice as well
- No connection should be soldered

Grounding and Bonding of Fences and Other Metal Structures

- **Metallic fences** and other metal structures in or surrounding a substation with exposed electrical conductors and equipment **shall be grounded and bonded** to limit step, touch, and transfer voltages
- In most substations, the **fence and equipment are in close proximity**; therefore, it is best to connect the fence grounding system and the substation ground grid together
- These fences are **accessible to the general public** and must be grounded to limit the rise of voltage potential on the fence to the surrounding earth
- For situations where step and touch voltage potential considerations indicate additional grounding and bonding design is necessary, alternate designs performed under engineering supervision is permitted


DANGER
HIGH
VOLTAGE
KEEP OUT!
Authorized Personnel only.
¡NO ENTRAR!
El personal autorizado solo.
Grayson-Collin Electric Cooperative
903-482-7100
GCEC
Grayson Collin
Electric Cooperative
1-903-482-7100
1-800-967-5235
Allahubbard Substation
8150 CR 134 - Celina, TX 75009


WARNING
Hazardous voltage inside.
KEEP OUT!
Authorized Personnel only.
May shock, burn or cause death.
In case of emergency call:
ADVERTENCIA
El voltaje peligroso adentro.
¡NO ENTRAR!
El personal autorizado soló.
Puede sacudir, poder quemar o puede casusar la muerte.
En caso de la llamada de la Emergencia:
Grayson-Collin Electric Cooperative
903-482-7100
GCEC
1905

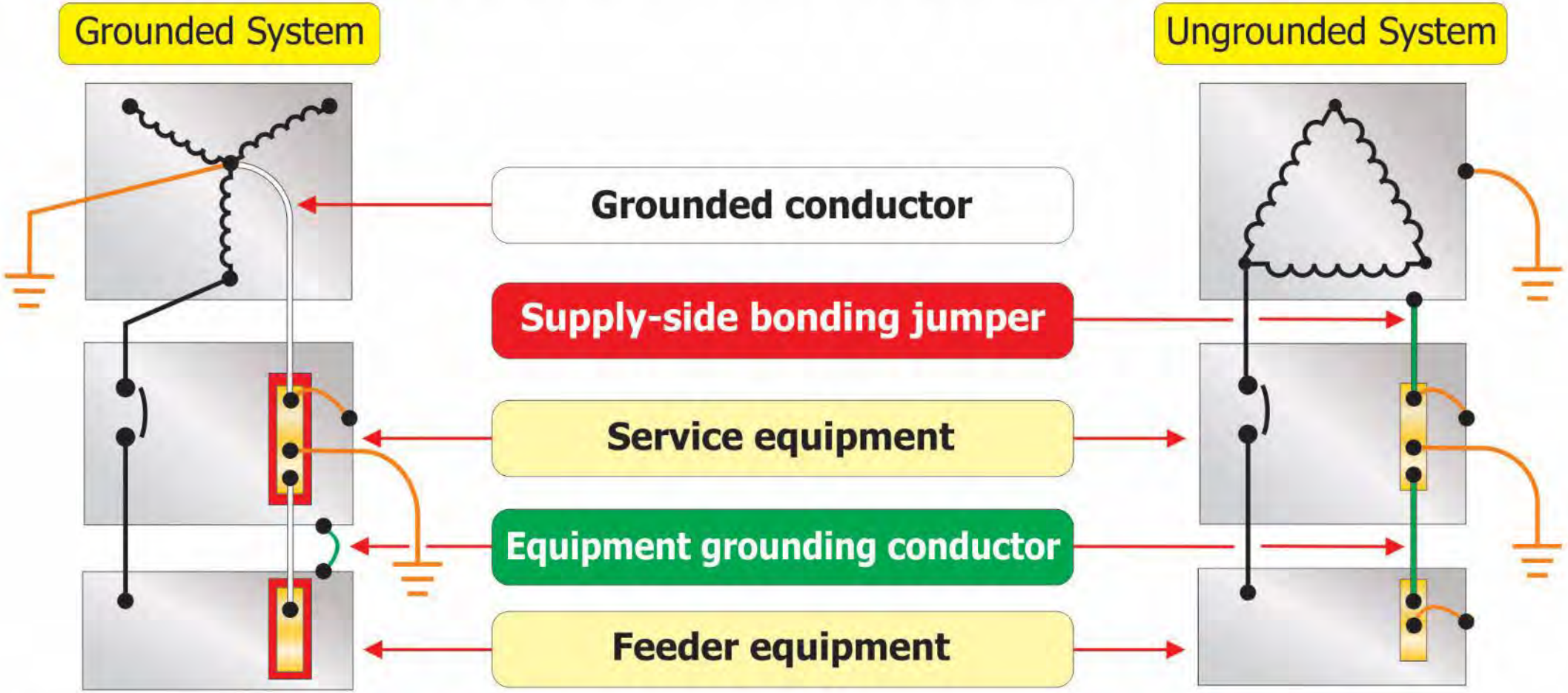
Ground-Fault Circuit Conductor Brought to Service Equipment

- In previous editions of the *Code*, the clear requirement for bringing the neutral conductor to the service equipment to provide the effective ground fault return path as set in 250.24(C) stopped at the 1000-volt threshold
- Up until the 2014 *NEC* cycle, this left a major shortcoming in the *NEC* for grounded systems over 1000 volts
- Some inspection authorities were able to enforce the requirement based on 250.4(A)(5) from the performance requirements
- Requirements in **250.186** cover those installations over 1000 volts and makes it clear for the *NEC* side of the installation to the service point that a **wire-type conductor** of suitable capacity must be installed

Ground-Fault Circuit Conductor Brought to Service Equipment *(cont.)*

- This wire-type conductor is to be installed between the service equipment and the service point interconnection with the utility to provide the ground fault current *path (just like the requirements for services 1000 volts and under)*
  - Services *(over 1000 volts) required* to have a **grounded conductor** brought to the service for a **grounded system** *[250.186(A)]*
  - Ungrounded systems *(over 1000 volts)* will require a **supply-side bonding jumper** brought to the service *[250.186(B)]*
- Same basic requirements of 250.24(C) would apply to services over 1 kV
- Primary concern is to provide a very **low impedance ground-fault return path** from any point on the wiring system where a ground fault may occur to the electrical supply source

Ground-Fault Circuit Conductor Brought to Service Equipment



Services operating at over 1000 volts required to have a **grounded conductor** brought to the service for a grounded system *[see 250.186(A)]*

Ungrounded systems of over 1000 volts required to have a **supply-side bonding jumper** brought to the service disconnecting means *[see 250.186(B)]*

Copyright © IAEI 2020

Grounded Systems

- The requirements in 250.186 provide prescriptive language for a grounded (neutral) conductor(s) *[250.186(A)]*, or a supply side bonding jumper *[250.186(B)]*, to be routed with the ungrounded conductors to each service disconnecting means
  - **Grounded (neutral) conductor** to be terminated on a **neutral terminal or bus** in the service equipment
  - **Supply side bonding jumper** to be terminated on the **equipment grounding bus** in the service equipment
- This installation would be required where an ac system operating at over 1000 volts is grounded at any point and is provided with a grounded (neutral) conductor or other ground fault return conductor from the utility at the service point

Grounded Systems *(cont.)*

- Where the supply conductor is a **grounded (neutral) conductor**, a **main bonding jumper** is required to bond the grounded (neutral) conductor(s) to each service disconnecting means enclosure
- Required size of the grounded (neutral) conductor or supply side bonding jumper shall not be smaller than specified in **Table 250.102(C)(1)**
- Grounded (neutral) conductor or supply side bonding jumper is not required to be larger than the largest ungrounded service-entrance conductor(s) when installed in a single raceway or for overhead conductors

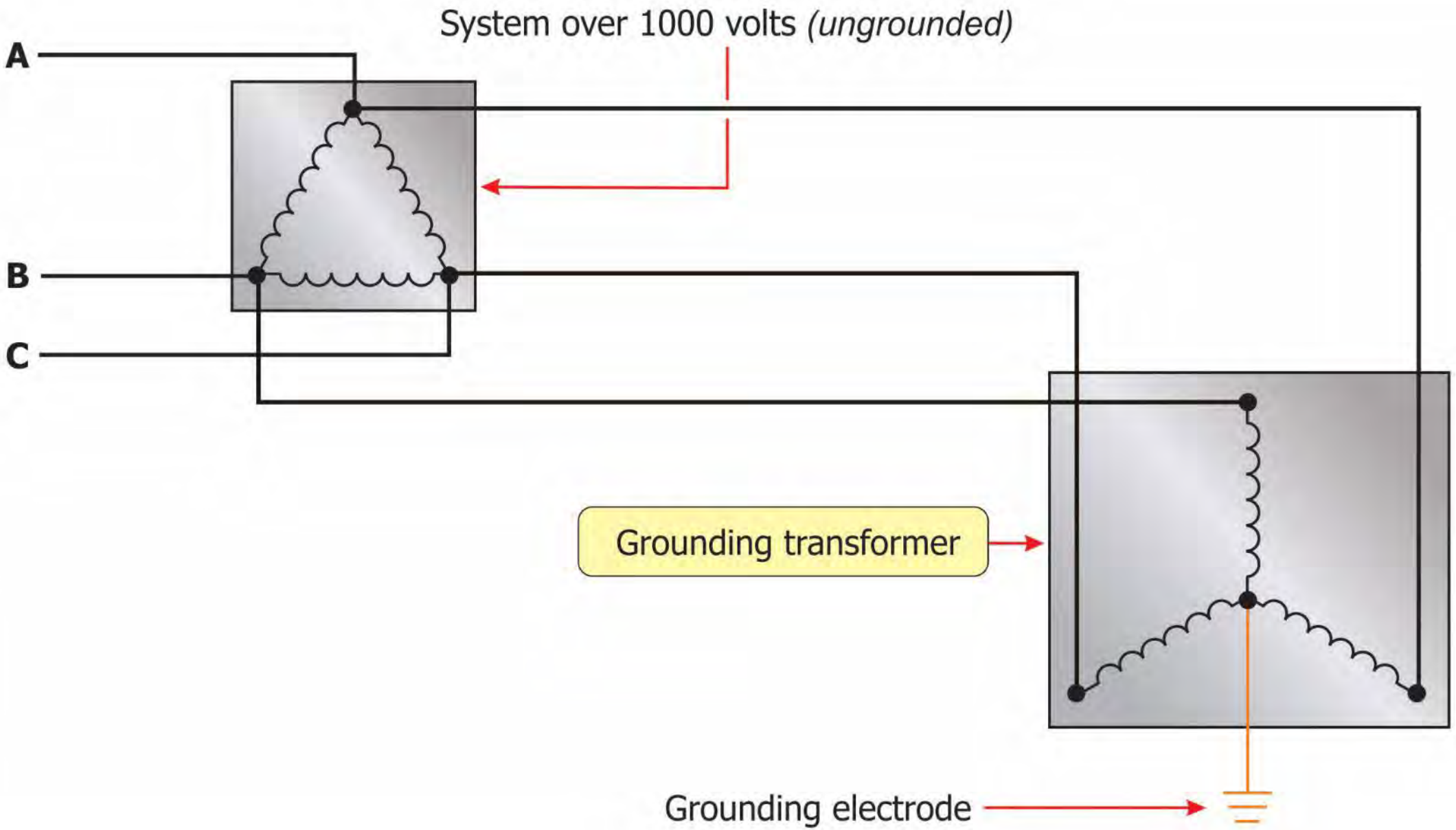
Ungrounded Systems

- For ungrounded systems operating at greater than 1 kV, a **supply-side bonding jumper** must be routed with the ungrounded conductors to each service disconnecting means *(bonded to the equipment grounding conductor terminal bar)*
- Sizing of this supply-side bonding jumper is generally the same as for the grounded conductor of a grounded system
- *See NEC 250.186(A) and (B)*

Derived Neutral Systems

- Section 250.182 permits a system neutral point derived from a grounding transformer to be used for establishing a ground reference for ungrounding systems over 1000 volts
- This application is for **ungrounded systems** where there is still a need to detect and clear single phase-to-ground faults
- Ground-fault protection may be provided through the transformer *(include zigzag, wye-delta, or T-connected)*
- Ground-fault protection provided through the transformer can produce positive tripping with relatively low magnitudes of ground-fault current

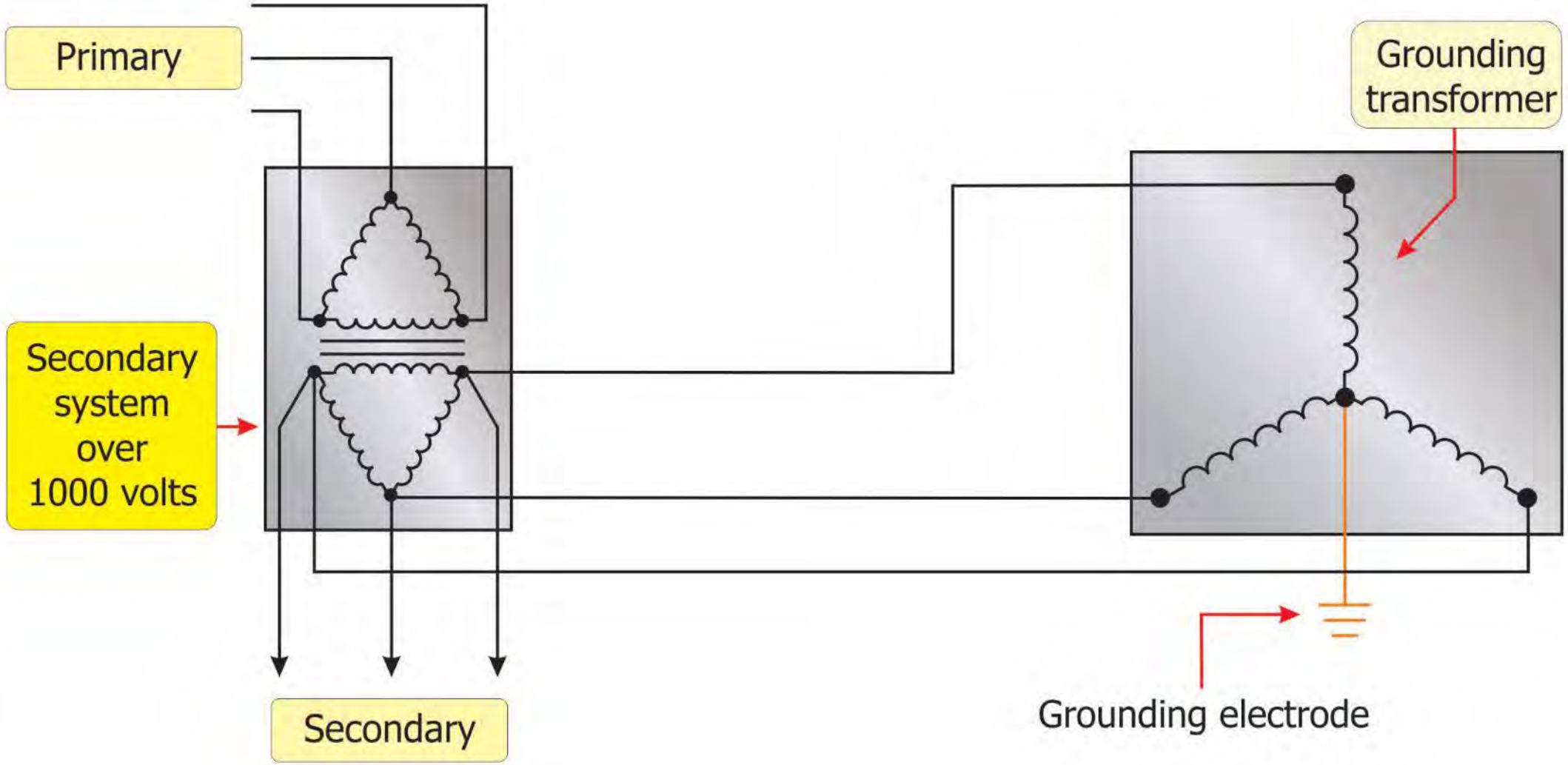
Grounding Transformers



Copyright © IAEI 2020

Grounding Transformers

Electrical systems grounded through grounding transformer



Copyright © IAEI 2020

Solidly Grounded Neutral System

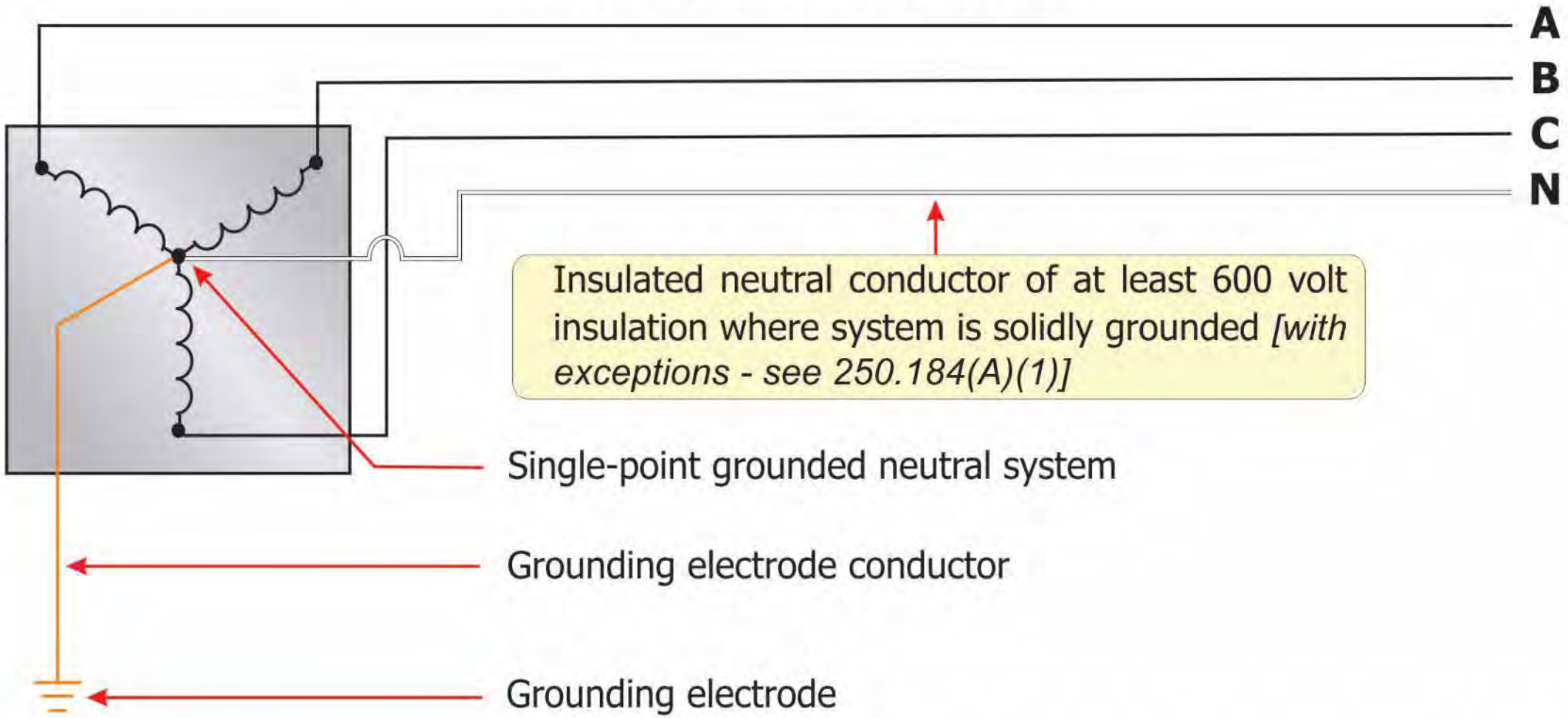
- The *Code* permits **solidly grounded neutral systems** and provides for two options:
  - ***Single-point grounding***
  - ***Multiple-point grounding***
- Neutral conductor of solidly grounded systems generally permitted to have:
  - Insulation level of not less than 600 volts or…
  - To be bare
- *See 250.184*

Single Point Grounded Neutral System

- This method permitted in accordance with 250.184(B)
- Single-point grounded neutral systems permitted to be supplied from either a separately derived system or a multigrounded neutral system provided that the equipment grounding conductor of the single-point grounded system is connected to the grounded neutral point at the source
- Grounding electrode is required for the system
- A main or system bonding jumper required to be installed from the system neutral to the source enclosure as well as to the grounding electrode conductor
- *See the remainder of the requirements in 250.184(B)*

250.184(B) Single-Point Grounded Neutral System

Electrical systems over 1000 volts



Grounding electrode conductor to connect grounding electrode to system neutral conductor

Neutral conductor only required where phase-to-neutral loads are supplied

Copyright © IAEI 2020

Multigrounded Neutral Conductor

- Multiple-point neutral grounding *(also known as grounding the neutral conductor at the source and at additional points along the system)* is permitted under specific conditions and meeting specific requirements
- The following shall apply where a multiple grounded neutral system is used:
  - Neutral conductor of a solidly grounded neutral system permitted to be grounded at more than one point
  - Grounding permitted at one or more of the following locations:
    - Transformers supplying conductors to a building or other structure
    - Underground circuits where the neutral is exposed (bare conductor)
    - Overhead circuits installed outdoors

Multigrounded Neutral Conductor *(cont.)*

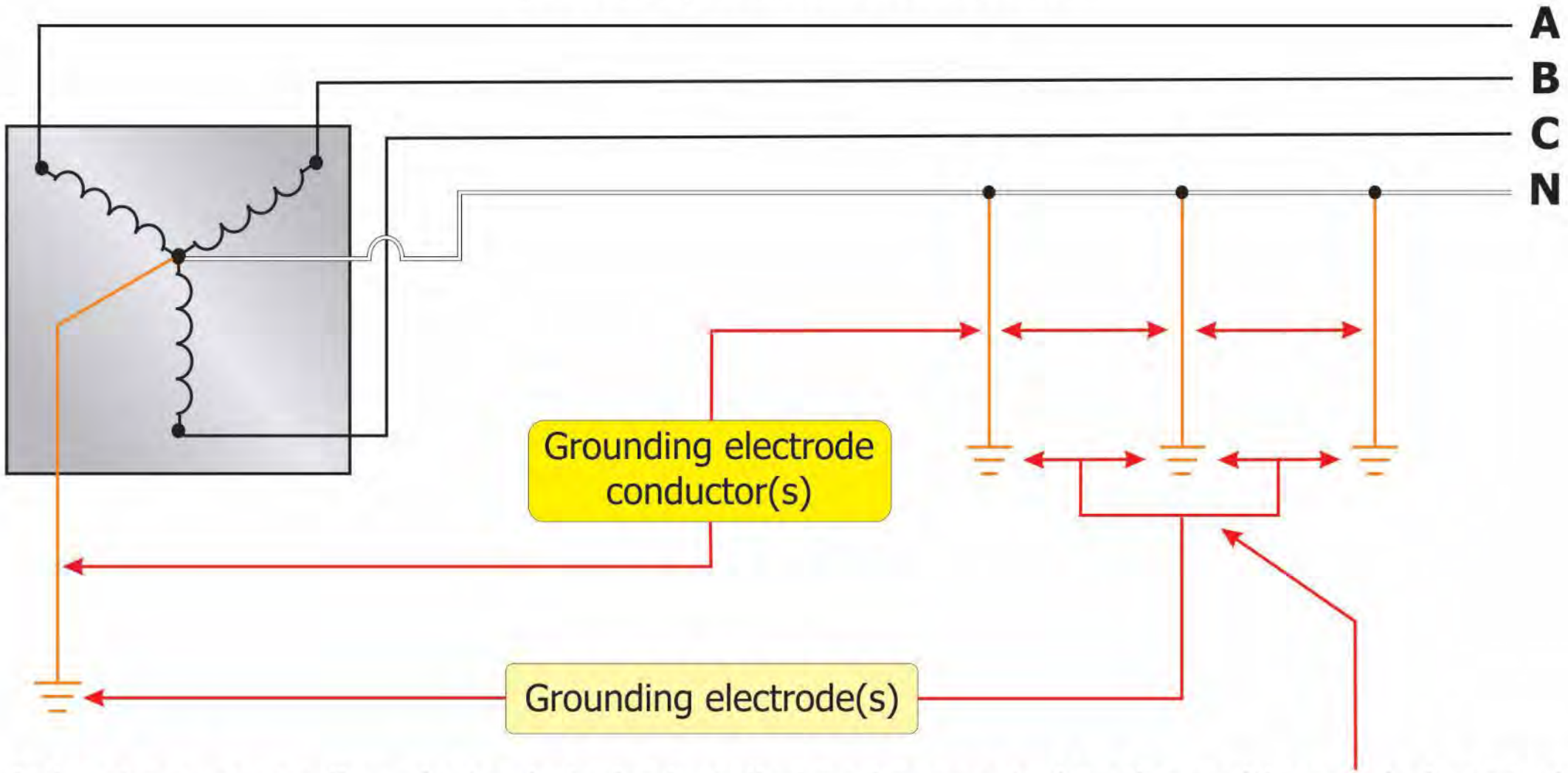
- The following shall apply where a multiple grounded neutral system is used: *(cont.)*
  - Multigrounded neutral conductor to be grounded at each transformer and at other additional locations by connections to a grounding electrode
  - At least one grounding electrode must be installed and connected to the multigrounded neutral circuit conductor **every 400 m (1300 ft)**
  - Maximum distance between any two adjacent electrodes shall not be more than **400 m (1300 ft)**
  - In a multigrounded shielded cable system, the shielding shall be grounded at each cable joint that is exposed to personnel contact

Multigrounded Neutral Conductor *(cont.)*

- The following shall apply where a multiple grounded neutral system is used: *(cont.)*
  - In a multipoint grounded system, an **exception** permits a grounding electrode to not be required to bond the neutral conductor in an uninterrupted conductor **exceeding 400 m (1300 ft)** if the only purpose for removing the cable jacket is for bonding the neutral conductor to a grounding electrode
  - The reason for this new exception was to **preserve the integrity of the cable jacket** from the elements to mitigate premature cable failure
  - This was determined to be more important than the advantages of the multi-point grounding
  - *See 250.184(C) Exception*

250.184(C) Multigrounded Neutral Systems

Electrical systems over 1000 volts



At least one grounding electrode to be installed and connected to the multigrounded neutral conductor every 400 m (1300 ft) *(maximum distance between grounding electrodes)*

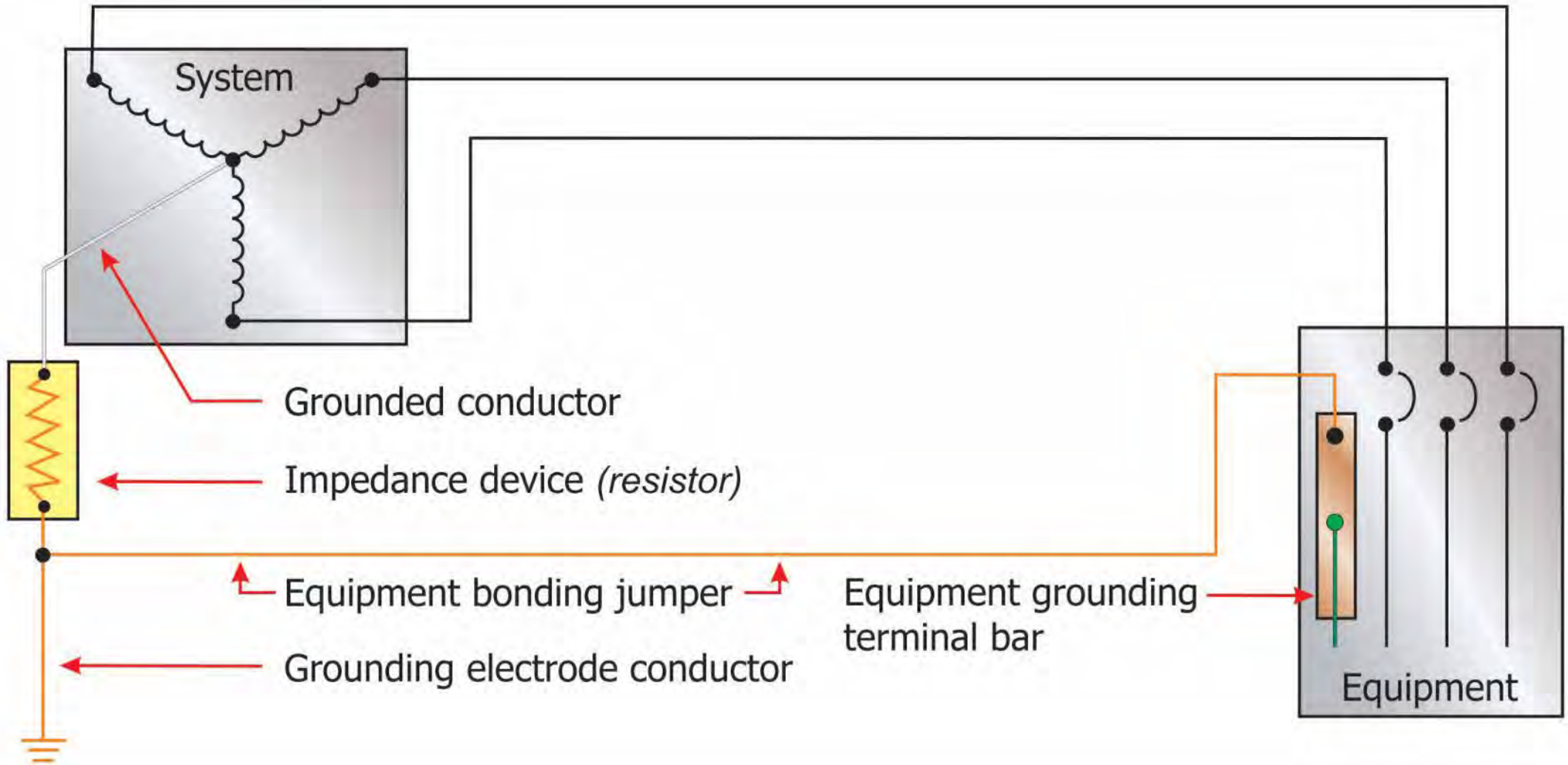
Copyright © IAEI 2020

Impedance Grounded Systems

- Impedance grounding can be accomplished by reactance grounding, low-resistance grounding, or high-resistance grounding
- Neutral conductor only required to be insulated for the **maximum phase to neutral voltage**
  - *(Previously, the neutral conductor was required to be fully rated for the phase-to-phase voltage)*
- Since the impedance device can be some distance away from the transformer or disconnecting means, this can be a cost savings to the designer and installer
- *See 250.187(A) through (D)*

250.187 Impedance Grounded Systems Over 1000 Volts

Neutral conductor for an impedance grounded neutral systems over 1000 volts must be insulated to the maximum neutral voltage rather than the same insulation as the phase conductors



Copyright © IAEI 2020

Portable or Mobile Equipment

- Special requirements apply to systems that supply **portable or mobile equipment rated over 1000 volts** other than substations installed on a temporary basis
- Portable or mobile equipment is to be supplied by a system with a **neutral conductor grounded through an impedance**
- Delta-connected supply system must have a neutral point and associated neutral conductor derived *(usually by use of zig-zag or grounding transformers)*
- Exposed non-current-carrying metal parts of mobile or portable equipment must be connected by an **equipment grounding conductor** to the point at which the system neutral impedance is grounded
- *See 250.188*

Surge Protection Devices Under 1000 Volts

- Where surge arresters *(more typically called **Surge Protection Devices** or **SPDs**)* are used on secondary systems of 1000 volts or less, connections to the service grounded conductor and to the grounding electrode conductor must be as **short as practicable** *[see 242.24]*
- Line and equipment ground conductors shall not be smaller than 14 AWG copper or 12 AWG aluminum *[242.28]*
- Note: a change in the 2020 *NEC* moved the requirements previously found in Articles 280 and 285 to a new Article 242 *(Overvoltage Protection)*

Surface Protection Devices Under 1000 Volts *(cont.)*

- The SPD grounding electrode conductor must be connected to one of the following:
  - Grounded service conductor
  - Grounding electrode conductor
  - Grounding electrode for the service
  - Equipment grounding terminal in the service equipment
- *See 242.12(B)*

Surge Protection Devices Over 1000 Volts

- For systems **over 1000 volts**, if a surge arrester protects the primary of a transformer *(supplying a secondary distribution system)*, the surge arrester grounding electrode conductor may be interconnected to the secondary neutral, provided that in addition to the direct grounding connection at the arrester, the grounded conductor of the secondary has elsewhere a grounding connection to a continuous metallic underground water piping system
- Applies where there is an urban type water pipe area where there are not less than **four secondary connections** to the underground metallic water piping system **per 1.6 km (1 mile)**
- If the above condition is met, the direct connection of the arrestor to ground *(earth)* may be omitted
- *See 242.54 for complete requirements*

1927

Cable Shields and Stress Reduction Means

- Medium and high-voltage cables above 2000 volts generally are required to be **shielded**
- Shielding is usually in the form of either a **conductive tape** or **stranded shield conductors**
- Purpose of the shielding is to evenly distribute voltage stresses through the insulation and **bleed off to ground** any capacitive voltage built up at the termination points
- See 311.44 for shielding requirements for insulated conductors operating at **over 2000 volts**

Cable Shields and Stress Reduction Means *(cont.)*

- Required to have an ozone resistant insulation and be shielded
- All metallic shields required to be connected to a grounding electrode conductor, grounding busbar, or grounding electrode
- Nonshielded insulated conductors listed by a qualified testing laboratory are permitted for use up to **2400 volts** under specific conditions
- Nonshielded, ozone-resistant insulated conductors with a maximum phase-to-phase voltage of **5000 volts** shall be permitted in Type MC cables in **industrial establishments** where the conditions of maintenance and supervision ensure that only qualified persons service the installation
- *See 311.44, Ex. No. 1 and Ex. No. 2*

1929

Cable Shields and Stress Reduction Means



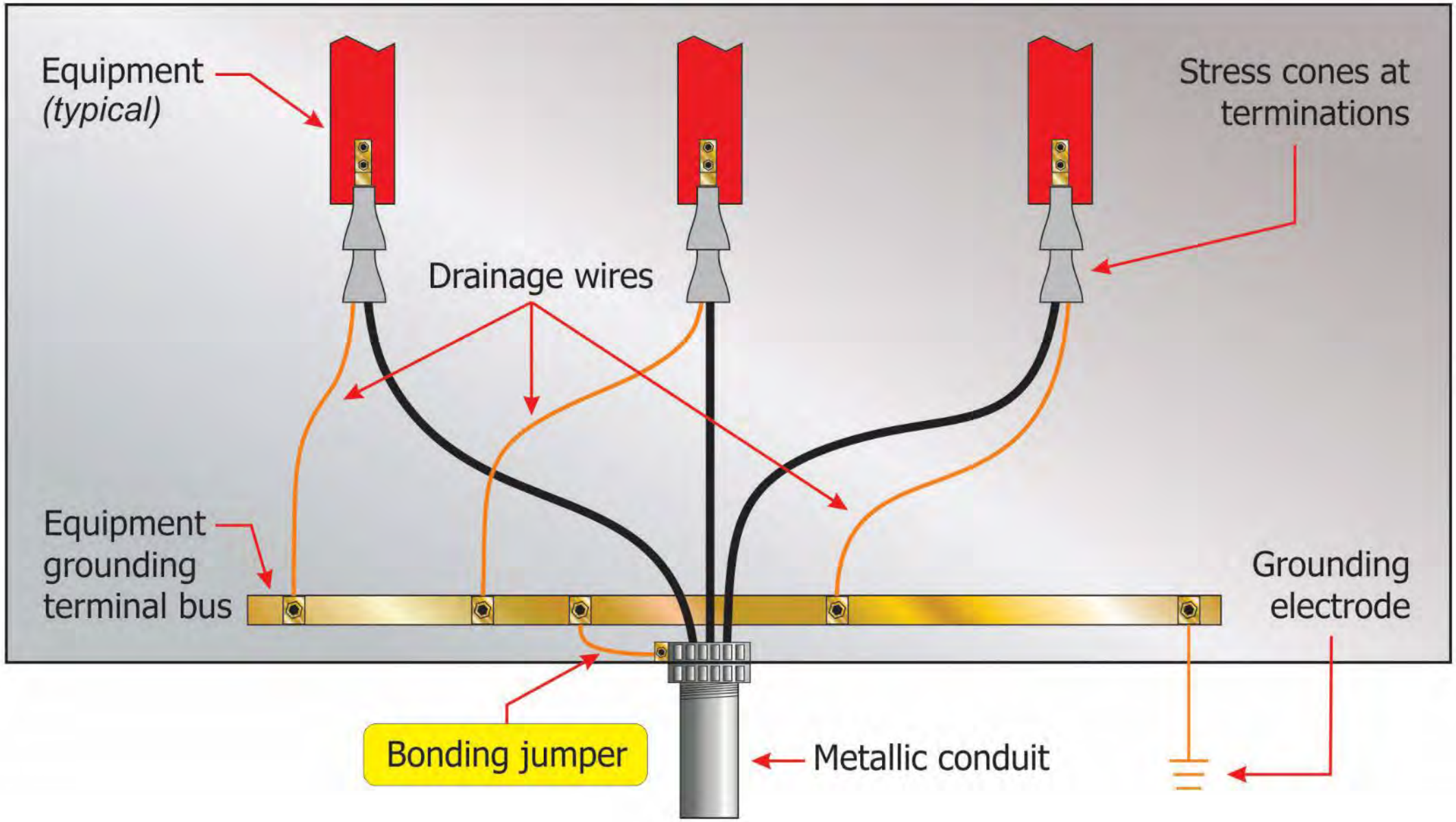
15,000-volt switch showing the terminations and stress reduction means and bleed wires connected to ground *(earth)*

1930



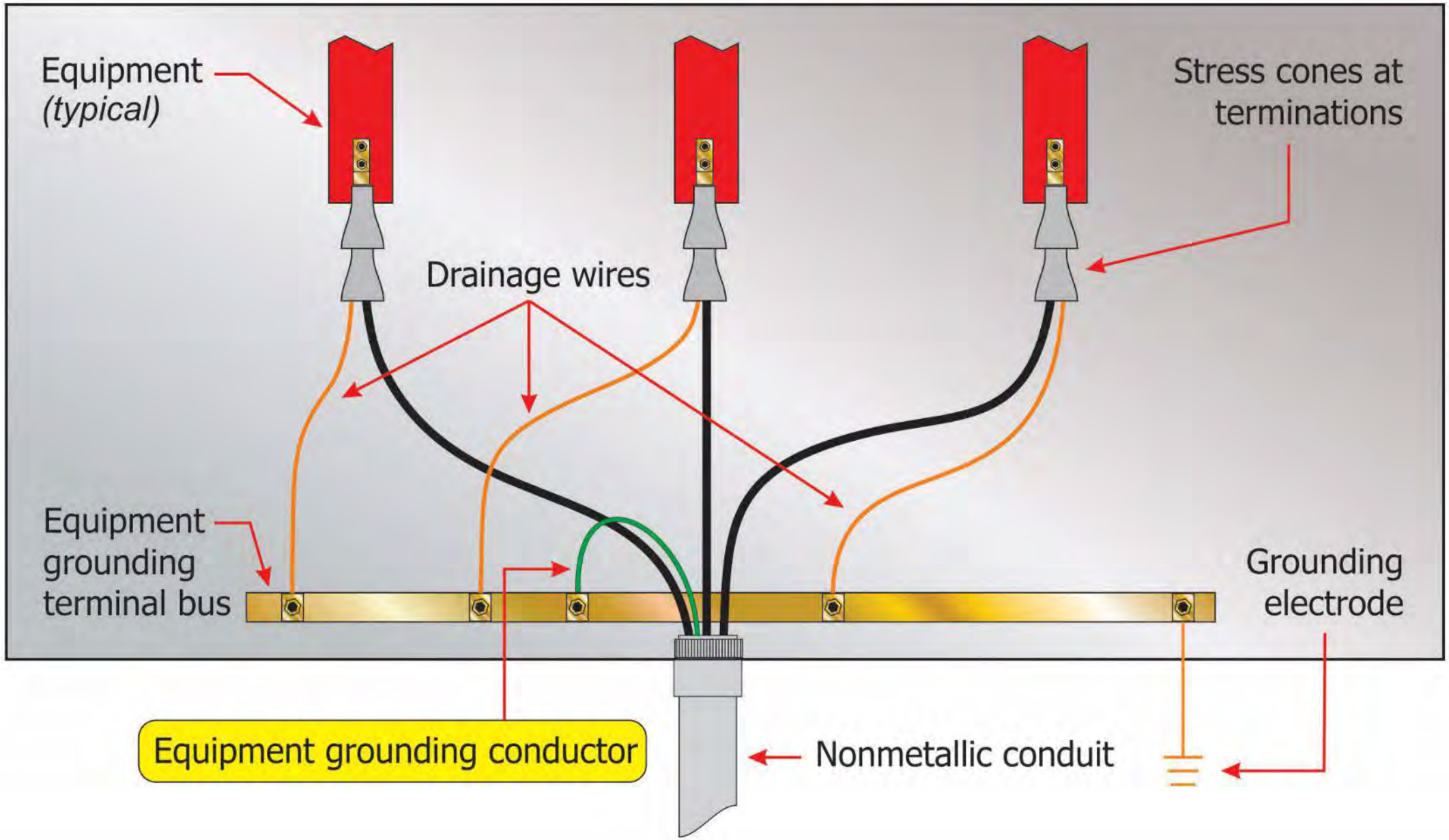
1931

311.44 Stress Reduction Means and Cable Shield Grounding



Copyright © IAEI 2020

311.44 Stress Reduction Means and Cable Shield Grounding

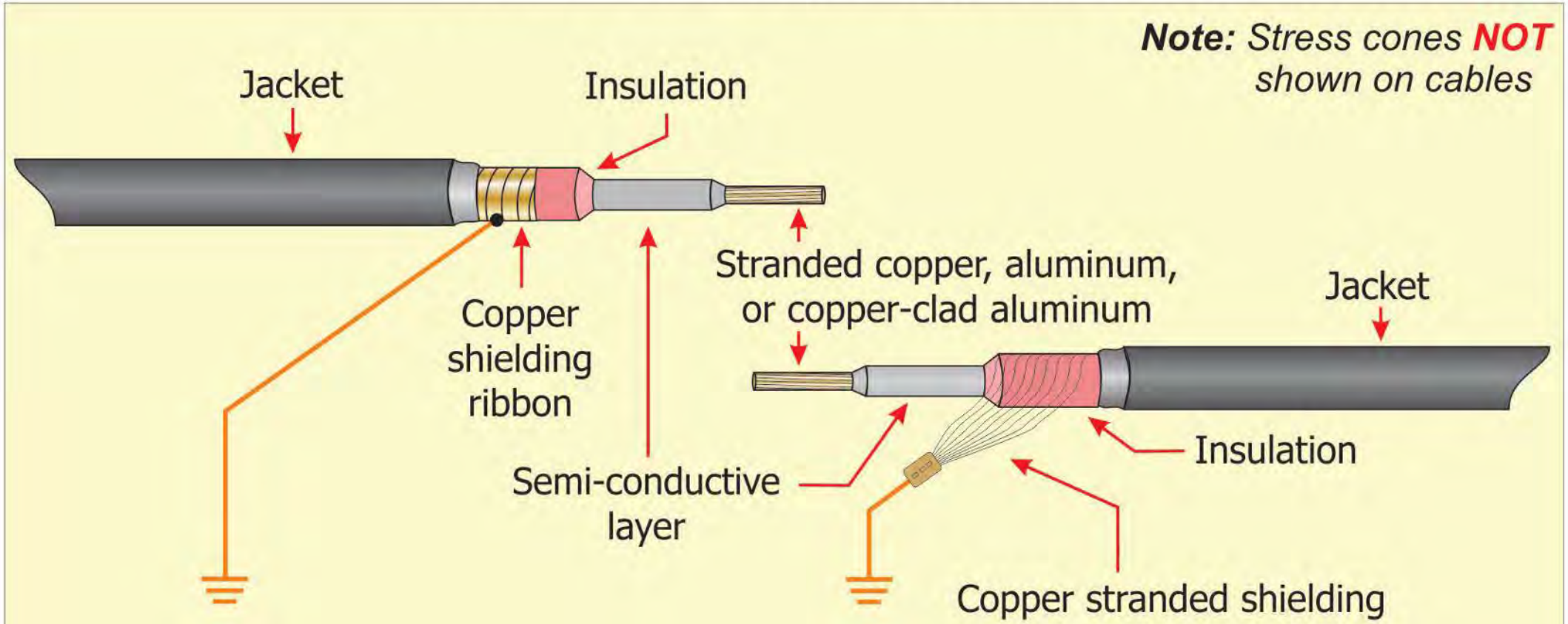


Copyright © IAEI 2020

Cable Shields and Stress Reduction Means *(cont.)*

- Cable insulation and shielding
  - Metallic and semi-conducting insulation shielding components of shielded cables shall be removed for a distance dependent on the circuit voltage and insulation
  - Stress reduction means shall be provided at all terminations of factory-applied shielding
  - Metallic shielding components such as tapes, wires, or braids, or combinations thereof, shall be connected to an equipment grounding conductor, an equipment grounding busbar, or a grounding electrode
- *See 300.40*

311.44 Conductor Shielding



- Solid dielectric insulated conductors operated above 2000 volts are required to be shielded
- Non-shielded, ozone-resistant insulated conductors up to 5000 volts permitted in industrial establishments with qualified persons
- See exceptions for listed cables up to 2400 volts and airfield lighting cable

Copyright © IAEI 2020



1936

Photo courtesy of Scott Humphrey

Cable Shield Used as an EGC

- Generally, circuits over 1000 volts installed with medium voltage cable require a **separate equipment grounding conductor** to be installed along with the circuit conductors
- The **metallic shield** is **designed for stress reduction** and many times does not have the cross-sectional area or current carrying capacity to perform as an equipment grounding conductor
- Section **250.190(C)(2)** provides specific requirements where the stress reduction shield on medium voltage cables can be used as an equipment grounding conductor

CHAPTER TWENTY-TWO

FUNDAMENTALS OF LIGHTNING PROTECTION



1938

The Lightning Discharge

- Lightning is an atmospheric electrical discharge which may occur:
  - Within a cloud
  - Between clouds
  - Between a cloud and earth *(or items located on the earth)*
  - In the case of very tall structures, between items on or attached to the earth and the clouds

The Lightning Discharge *(cont.)*

- Four basic types of cloud-to-ground lightning discharges are:
  - (1) Downward negative lightning
  - (2) Upward negative lightning
  - (3) Downward positive lightning
  - (4) Upward positive lightning
- Upward negative and upward positive discharges are generally only associated with very tall structures *(greater than 300 feet tall)* or objects of moderate heights located in higher elevations

The Lightning Discharge *(cont.)*

- The exact details of the process by which a cloud becomes electrically charged are not yet fully understood, but they are…
- Generally associated with charge separation resulting from the updraft of air in the center of a thunderstorm cell and the velocity of particles falling through the cloud
- It is speculated that the lightning discharge is initiated by the emission of positive corona from precipitation particles *(such as raindrops)* which have been deformed by strong electric fields
- An electrostatic charge will be induced on the earth and on items located on the earth due to the charge in the cloud and the charge in what is referred to as the **"stepped leader"**

The Lightning Discharge *(cont.)*

- The final step of the **stepped leader** is often referred to as the **striking distance**
- The striking distance is a function of the charge in the leader channel
- It is often characterized by the following relationship:

$$D = 10 \times I^{0.65}$$

  - "D" is the striking distance in meters
  - "I" is the peak current in the strike in kiloamperes

The Lightning Discharge *(cont.)*



(*Courtesy of National Geographic*)

Picture of lightning striking a tree showing:

- Branching of stepped leader
- Streamers from objects in vicinity of the flash
- Luminosity of the return stroke
- Striking distance associated with the flash

NFPA 780 Definitions

- Important to define a number of terms used when talking about, designing, or inspection lightning protection systems
- Some of the terms defined on the following slides are the same or similar to those in the *NEC*, but they have different definitions and meaning when applied to lightning protection systems
- The following terms and the associated definitions are from **NFPA 780 *(Standard for the Installation of Lightning Protection Systems)***
- Numbers provided are the definition number for the term in NFPA 780–2020

NFPA 780 Definitions *(cont.)*

- ***3.3.1 Air Terminal.*** A strike termination device that is a receptor for attachment of flashes to the lightning protection system and is listed for the purpose.
- ***3.3.2 Bonded, Inherently.*** Bonding between metal bodies, building framework, and lightning protection system components that are joined through construction.
- ***3.3.3 Bonding.*** An electrical connection between an electrically conductive object and a component of a lightning protection system that is intended to significantly reduce potential differences created by lightning currents.
- ***3.3.4 Cable.*** A conductor formed of a number of wires stranded together.
- ***3.3.5 Catenary Lightning Protection System.*** A lightning protection system consisting of one or more overhead ground wires.

NFPA 780 Definitions *(cont.)*

- ***3.3.8 Conductor.***
  - ***3.3.8.1 Bonding Conductor.*** A conductor used for potential equalization between grounded metal bodies or electrically conductive objects and a lightning protection system.
  - ***3.3.8.2 Counterpoise Conductor.*** A bare underground electrical conductor providing an area of protection from the effects of lightning for underground raceway(s) or cable(s).
  - ***3.3.8.3 Down Conductor.*** A main conductor used to connect roof conductors to grounding electrodes.
  - ***3.3.8.4 Ground Loop Conductor.*** A main-size loop conductor installed within 12 ft (3.6 m) vertically of the base of the structure to provide a common ground potential.

NFPA 780 Definitions *(cont.)*

- ***3.3.8 Conductor.*** *(cont.)*
  - ***3.3.8.5 Loop Conductor.*** A conductor encircling a structure that is used to interconnect grounding electrodes, main conductors, or other electrically conductive bodies.
  - ***3.3.8.6* Main Conductor.*** A conductor intended to be used to carry lightning currents between strike termination devices and grounding electrodes.
  - ***3.3.8.7 Roof Conductor.*** A main conductor used to interconnect strike termination devices.
- ***3.3.11 Fastener.*** An attachment device used to secure the conductor to the structure.

NFPA 780 Definitions *(cont.)*

- ***3.3.18 Grounding Electrode.*** The portion of a lightning protection system, such as a ground rod, ground plate electrode, or ground conductor, that is installed for the purpose of allowing lightning current flow into the earth.
- ***3.3.26 Lightning Protection System.*** A complete system of strike termination devices, conductors (which could include conductive structural members), grounding electrodes, interconnecting conductors, surge protective devices, and other connectors and fittings required to complete the system.
- ***3.3.35 Sideflash.*** An electrical spark, caused by differences of potential, that occurs between conductive metal bodies or between conductive metal bodies and a component of a lightning protection system or ground.

NFPA 780 Definitions *(cont.)*

- ***3.3.40 Strike Termination Device.*** A conductive component of the lightning protection system capable of receiving a lightning strike and providing a connection to a path to ground. Strike termination devices include air terminals, metal masts, permanent metal parts of structures as described in 4.6.1.4, and overhead ground wires installed in catenary lightning protection systems.
- ***3.3.41 Striking Distance.*** The distance over which the final breakdown of the initial lightning stroke to ground or to a grounded object occurs.
- ***3.3.43 Surge.*** A transient wave of current, potential, or power in an electric circuit. Surges do not include longer duration temporary overvoltages (TOV) consisting of an increase in the power frequency voltage for several cycles.

NFPA 780 Definitions *(cont.)*

- ***3.3.44 Surge Protective Device (SPD).*** A device intended for limiting surge voltages on equipment by diverting or limiting surge current that comprises at least one nonlinear component while remaining capable of repeating these functions.
- ***3.3.51 Zone of Protection.*** The space adjacent to a lightning protection system that is substantially immune to direct lightning flashes.

Purpose of a Lightning Protection System

- In general, the purpose of a lightning protection system is to provide one or more points on a building or structure that will have a **high probability for a lightning discharge to connect**
- Provides a **low impedance path** to a grounding electrode system that is capable of dissipating the energy of the strike into the earth swiftly and safely
- Minimize significant internal arcing that may result in fires or significant overvoltages that may damage internal equipment

Purpose of a Lightning Protection System *(cont.)*

- Lightning protection systems meet this objective through the installation of the following subsystems:
  - (1) Strike termination network
  - (2) Down conductor network
  - (3) Grounding electrode network
  - (4) Equipotential bonding network
  - (5) Surge protection
- Lightning protection systems cannot prevent the lightning event from occurring nor do they “attract” lightning from greater distances than the conventional calculated attractive area of a structure

1952

Purpose of a Lightning Protection System *(cont.)*

- The two principle lightning protection standards in the United States are NFPA 780 *(Standard for the Installation of Lightning Protection Systems)* and **UL 96A *(Standard for Safety Installation Requirements for Lightning Protection Systems)***
- These U.S. lightning protection standards generally describe a **minimum-acceptable set of design and installation requirements** which may be supplemented as necessary by the lightning protection system designer or the authority having jurisdiction (AHJ)

NFPA 780

- NFPA 780 *(Standard for the Installation of Lightning Protection Systems)* defines its purpose as, "**to provide for the safeguarding of persons and property from hazards arising from exposure to lightning**"
- Provides specific minimum-acceptable requirements for a number of applications such as:
  - Ordinary structures
  - Structures containing flammable vapors
  - Heavy-duty stacks
  - Watercraft
  - Alternate energy *systems (such as photovoltaic and wind generators)*

1954

NFPA 780 *(cont.)*

- The scope of NFPA 780 covers traditional lightning-protection-system installation requirements for:
  1. Ordinary structures
  2. Miscellaneous structures and special occupancies
  3. Heavy-duty stacks
  4. Structures containing flammable vapors, flammable gases, or liquids which give off flammable vapors
  5. Structures housing explosive materials
  6. Wind turbines
  7. Watercraft
  8. Airfield lighting circuits
  9. Solar arrays

1955

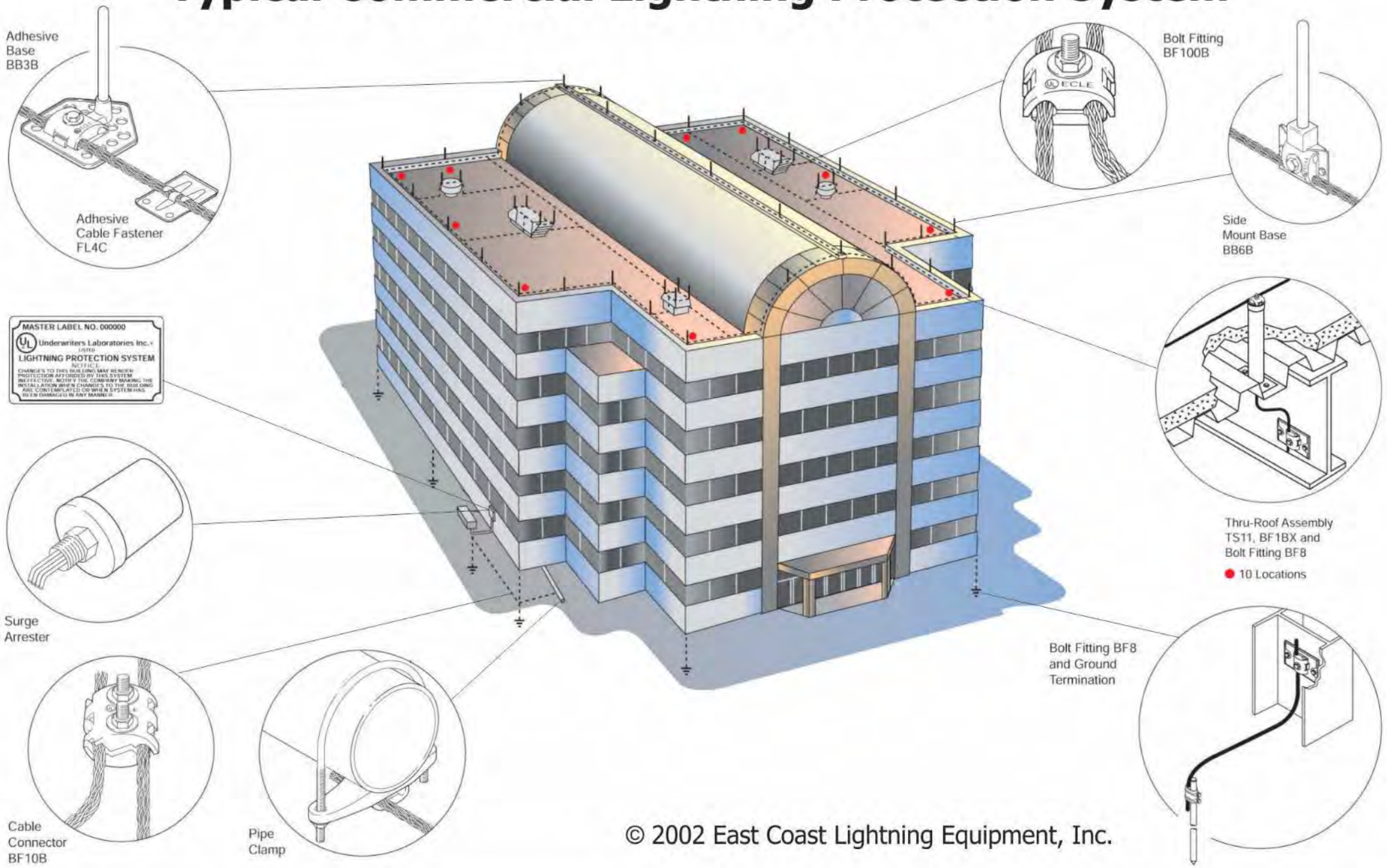
NFPA 780 *(cont.)*

- NFPA 780 is not applicable to lightning-protection-system installation requirements for electric generating, transmission, and distribution systems
- The document also does not cover lightning-protection-system installation requirements for early streamer emission systems or charge dissipation systems
- NFPA 780 also contains 15 informative (non-mandatory) annexes
  - Annex A provides explanatory material expanding some of the specific text in the body of the standard

The Lightning Protection System

- Primary components of a lightning protection system are:
  - (1) Strike termination network
  - (2) Down conductor network
  - (3) Grounding electrode network
  - (4) Equipotential bonding network
  - (5) Surge protection
- The following slide illustrates the relationship each component has with respect to a complete lightning protection system

Typical Commercial Lightning Protection System



© 2002 East Coast Lightning Equipment, Inc.

Copyright © IAEI 2020



1959

Strike Termination Network

- One must know the difference between the terms “strike termination device” and “air terminal”
- ***Strike Termination Device:*** “A component of a lightning protection system that is intended to intercept lightning flashes and connect them to a path to ground.”
  - Includes air terminals, metal masts, permanent metal parts of structures with a thickness equivalent to 5 mm (3/16 in.) thick steel, and overhead ground wires
- ***Air Terminal:*** “A strike termination device that is a receptor for attachment of flashes to the lightning protection system and is listed for the purpose.”

1960

Strike Termination Network *(cont.)*

- Key distinction between an **air terminal** and other **strike termination devices** is that the air terminal is listed in accordance with **UL 96** *(Standard for Safety Lightning Protection Components)* for the purpose of providing a lightning strike termination
- The following slide provides examples of various configurations and materials of air terminals available to the lightning protection system designer

Strike Termination Network - Air Terminals



Examples of available air terminal configurations

(*Courtesy of East Coast Lightning Equipment of Winsted, CT)*

Strike Termination Network *(cont.)*

- All parts of a protected structure must be provided with **strike termination devices** at locations as required to ensure vulnerable parts of the structure are within a **"protected area"** or a zone of protection
- NFPA 780 identifies **three methods** by which the placement of strike termination devices can be determined:
  - Protective angle method
  - Rolling sphere method *(most common method)*
  - Mesh method *(not recognized in US) (modified mesh method recognized)*

Strike Termination Network *(cont.)*

- **Protection Angle Method**
  - Oldest method used for the determination of the protective area of a lightning protection strike termination device
  - This method commonly attributed to Benjamin Franklin
  - Not until W. H. Preece published the results of his experiments measuring the electric field around a vertical air terminal in 1880 that an accurate protective zone was proposed
  - The 1-to-1 *(45 degree)* protective angle proposed by Preece is still valid today for structures up to 15 m (50 ft) tall
  - NFPA 780 allows a **2-to-1 *(60 degree)* protective angle** for strike termination devices at heights of 7.5 m (25 ft) or less

1964

Strike Termination Network *(cont.)*

- **Rolling Sphere Method**
  - Most universally used method for determining the protected area of a lightning protection system
  - Final striking distance of the **stepped leader** is modeled to serve as the **radius of a sphere**
  - It is assumed that lightning can strike any point on the surface of the sphere
  - Where the sphere is tangent to the earth and resting against a strike termination device, all space in the **vertical plane between the two points of contact** and **under the sphere** considered to be in the zone of protection

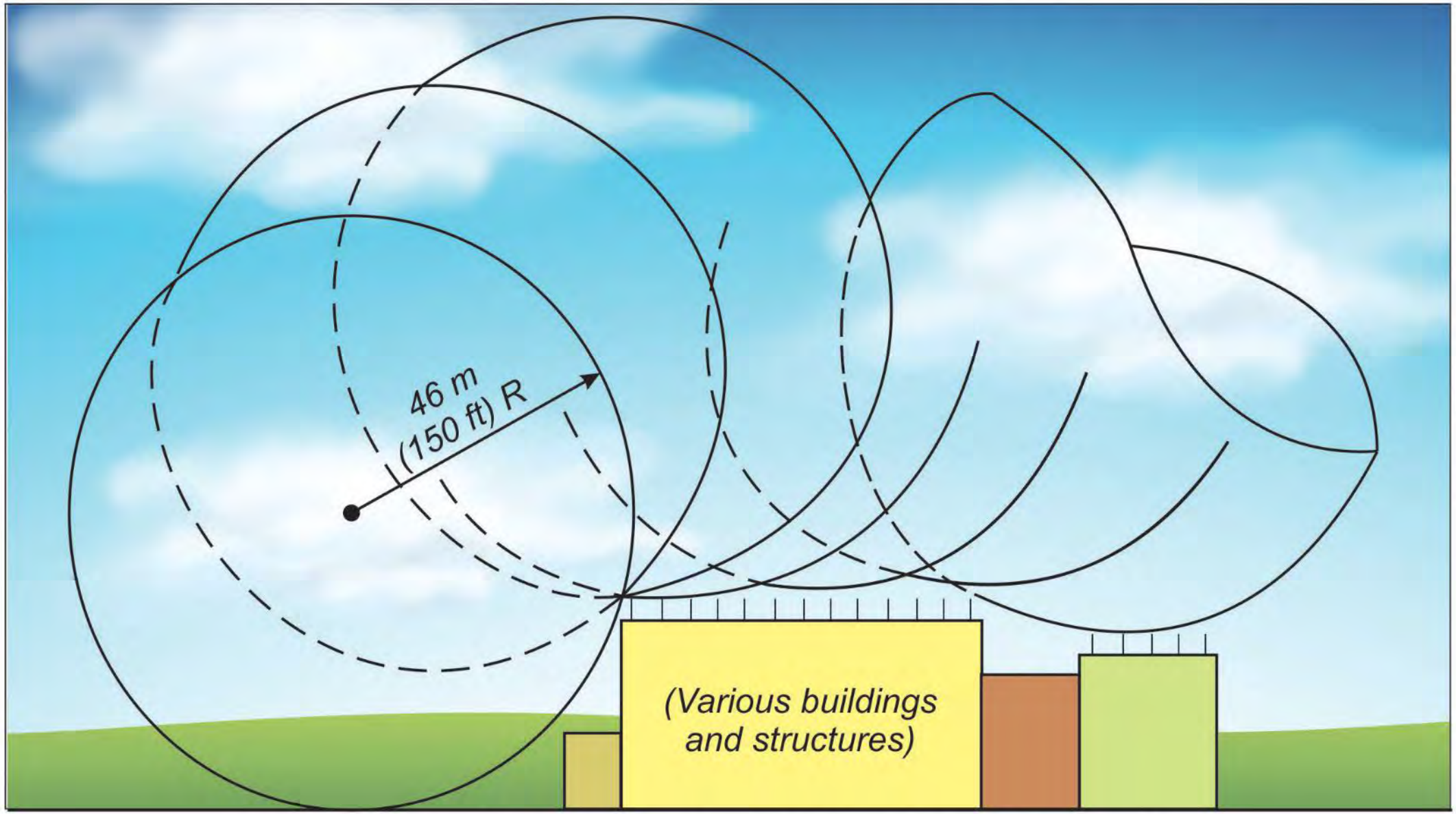
1965

Strike Termination Network *(cont.)*

- **Rolling Sphere Method** *(cont.)*
  - A zone of protection is also provided in the **space between strike termination devices** and in the **vertical plane under the sphere** when the sphere is resting on two or more strike termination devices for the spheres rolling over the structure
  - A striking distance of **45 m (150 ft)** is used in United States lightning protection standards for **ordinary applications**
  - The striking distance is reduced to **30 m (100 ft)** for structures requiring **increased protection efficiency**, such as structures housing flammable vapors and gases and structures housing explosives materials

1966

Strike Termination Devices - Rolling Sphere Method



Zone of protection as determined by the rolling sphere method

Copyright © IAEI 2020


Strike Termination Device
STOP
1968

Strike Termination Network *(cont.)*

- **Modified Mesh Method**
  - The mesh method of lightning protection for placement of strike termination devices is not recognize in the United States
  - This method is recognized by IEC 62305-313 and is well established in many European standards
  - The mesh method basically utilizes a **grid of conductors** to form a plane on the surface *(roof or other part)* for the lightning to connect
  - The use of air terminals or other strike termination devices project the conductive element at least 250 mm (10 in.) above the protected structure
  - United States lightning protection standards do recognize what will be described in this chapter as a **modified mesh method**

1969

Strike Termination Network *(cont.)*

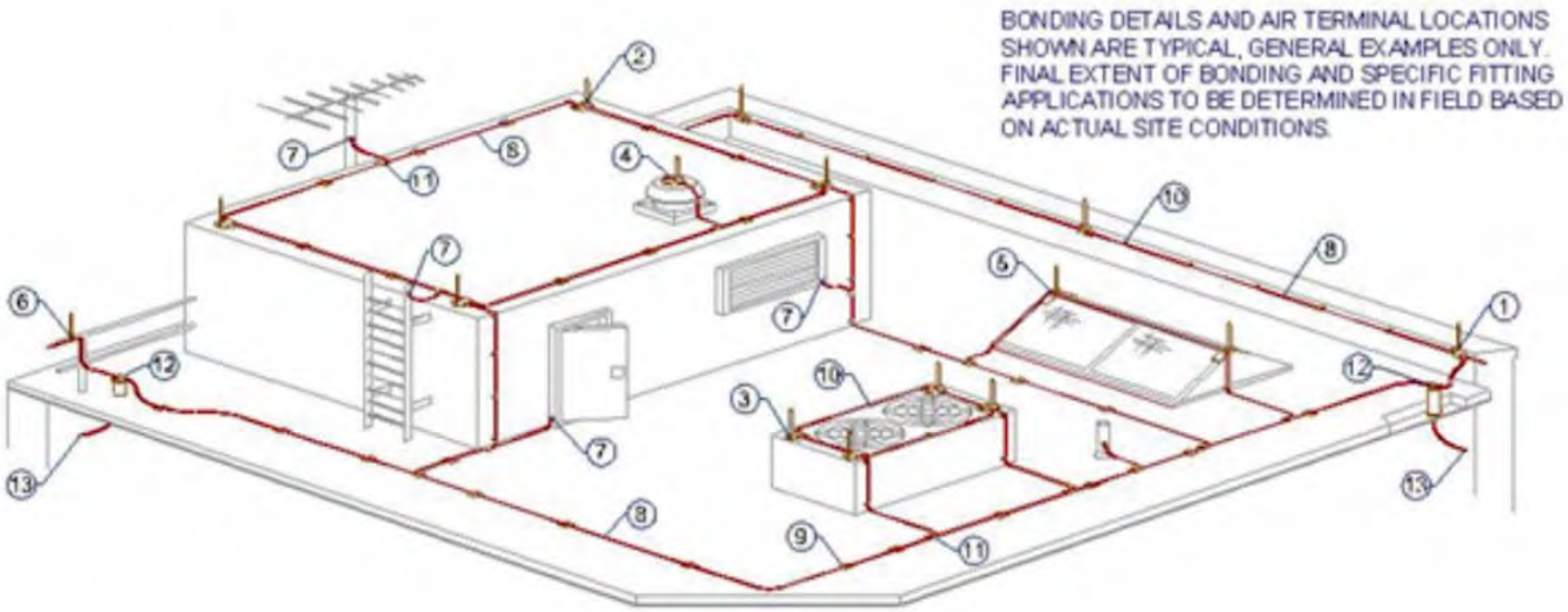
- **Modified Mesh Method** *(cont.)*
  - Air terminals required to be located within **600 mm (2 ft)** of the ridge ends on pitched roofs or at edges and outside corners of flat or gently sloping roofs
  - The spacing between the air terminals on ridges and around the perimeter of a flat roof shall not exceed **6.0 m (20 ft)**
  - Air terminals projecting **600 mm (2 ft)** or more above the roof structure may be spaced at **7.5 m (25 ft)** intervals
  - For flat or gently sloping roofs exceeding **15 m (50 ft)** in length or width, additional strike termination devices shall be provided in the interior of the roof at intervals not exceeding **15 m (50 ft)**

1970


1971


1972

Typical Roof Lightning Protection Layout



1. VERTICALLY MOUNTED AIR TERMINAL ON PARAPET SPACE 20 FEET MAXIMUM. SEE AIR TERMINAL DETAIL.
2. HORIZONTALLY MOUNTED AIR TERMINAL ON ROOF SPACE 20 FEET MAXIMUM. SEE AIR TERMINAL DETAIL.
3. AIR TERMINALS MOUNTED ON MECHANICAL EQUIPMENT ENCLOSURE.
4. AIR TERMINAL MOUNTED ON EXHAUST FAN ('DEAD-END' METHOD).
5. AIR TERMINAL ON SKYLIGHT WITH SADDLE TYPE AIR TERMINAL BASE.
6. AIR TERMINAL MOUNTED ON GUARDRAIL WITH PIPE RAILING BASE.
7. BOND WINDOW, DOOR FRAMES, V.T.R.'S, LADDERS, AND ANTENNAS, OR ANY METALLIC OBJECTS WITH BONDING LUGS AND SECONDARY CONDUCTOR.
8. MAIN LIGHTNING CONDUCTOR.
9. ADEHSIVE CABLE HOLDER EVERY 3 FEET MAXIMUM SPACING.
10. CABLE CLIP WITH STAINLESS STEEL SCREWS EVERY 3 FEET MAXIMUM SPACING.
11. CABLE CONNECTOR.
12. THRU-ROOF CONNECTOR.
13. LIGHTNING DOWN CONDUCTOR.

Strike termination device layout for flat roof with typical protrusions

Copyright © IAEI 2020

Strike Termination Devices

- The strike termination network may consist of:
  - Masts *(remote of or attached to the structure)*
  - Overhead ground wires
  - Arrangement of air terminals and interconnecting roof conductors located around the perimeter of flat or gently sloping roofs or along the ridges of peaked roofs
- The strike termination network may consist of masts *(remote of or attached to the structure)*
- Masts may be metallic or wooden poles, or they may be in the form of a metal tower

1974

Strike Termination Devices *(cont.)*

- Wooden poles must be provided with an air terminal and a minimum of one down conductor *(second down conductor recommended)*
- Masts will often extend up at least **12 m (40 ft)** and the **impedance** *(primarily from inductance)* of a single conductor can lead to a **significant voltage drop** at high frequencies over the length of the conductor
- Impedance and voltage drop reduces the effectiveness of the lightning protection system
- Second conductor adds an additional level or reliability since it is possible that a single conductor can be damaged over its normal lifetime



1976

Main Conductor – Network General

- The material used for **main conductors** may be either copper or aluminum
- Care must be taken to minimize the probability of corrosion and contact with dissimilar metals *(generally exposed to the outdoor elements)*
- In no case can a copper conductor be installed on an aluminum surface or an aluminum conductor be installed on a copper surface
- Aluminum materials must not be used within **450 mm (18 in.)** of the point where the lightning protection system conductor comes into contact with the earth

Main Conductor - Network General *(cont.)*

- NFPA 780 defines a **main conductor** by:
  - Type of material *(copper or aluminum)*
  - Size of each strand *(in. / mm^2 or AWG)*
  - Weight per specified length, *[grams per meter or lbs per 300 m (1000 ft)]*
  - Cross-sectional area *(circular mils)*

1978

Main Conductor - Network General *(cont.)*

- The overall height of the structure is used to size the main conductor
- Ordinary buildings or structures **23 m (75 ft) or less** are specified to use **Class I materials**
- Buildings or structures **over 23 m (75 ft)** are to use **Class II materials**
- Example:
  - If a building *(such as a church)* has a steeple over 23 m (75 ft) but the rest of the building is less than 23 m (75 ft), NFPA 780 allows the use of Class I materials for all except the steeple *(requires Class II materials)*

Main Conductor – Network General *(cont.)*



(Courtesy of East Coast Lightning Equipment of Winsted, CT)



(Courtesy of Harger Lightning Protection of Grayslake, IL)

Examples of main conductor network lightning protection conductors

Main Conductor Network *(cont.)*

- For those not familiar with the **Class I** and **Class II** conductor sizes, the following relationship to building wire sizes is provided
- **Class I copper cable** has a cross sectional area of **57,400 circular mils** *(between a 3 AWG and 2 AWG conductor)*
- **Class II copper cable** has an area of **115,000 circular mils** (between a 1/0 AWG and 2/0 AWG conductor)
- Lightning protection conductors appear to be larger *(due to the weave stranding and the way the conductor is formed)*
- The following table *(Table 22-1 of the Soares textbook)* provides a summary of the NFPA 780-2020 requirements for a main conductor showing the difference in requirements for **Class I** and **Class II** materials

NFPA 780 - Minimum Size Main Conductors

Material	Main Conductor	Thickness	Cross section area	Weight per unit length	Size of each strand
Class I	Copper cable Structure ≤ 75 ft		(29 mm²) 57,400 cm	(278 g/m) 187 lb per 1000 ft	17 AWG
	Aluminum cable Structure ≤ 75 ft		(50 mm²) 98,600 cm	(141 g/m) 95 lb per 1000 ft	14 AWG
	Copper solid strip Structure ≤ 75 ft	(1.30 mm) 0.051 inches	(29 mm²) 57,400 cm		
	Aluminum solid strip Structure ≤ 75 ft	(1.63 mm) 0.064 inches	(50 mm²) 98,600 cm		
Class II	Copper cable Structure > 75 ft		(58 mm²) 115,000 cm	(558 g/m) 375 lb per 1000 ft	15 AWG
	Aluminum cable Structure > 75 ft		(97 mm²) 192,000 cm	(283 g/m) 190 lb per 1000 ft	13 AWG
	Copper solid strip Structure > 75 ft	(1.63 mm) 0.064 inches	(58 mm²) 115,000 cm		
	Aluminum solid strip Structure > 75 ft	(2.61 mm) 0.1026 inches	(97 mm²) 192,000 cm		

NFPA 780 - Standard for the Installation of Lightning Protection Systems

Copyright © IAEI 2020

Main Conductor - Roof Conductors

- Each **strike termination device** must be provided with a minimum of **two paths to ground**
- Exception to this rule *(NFPA 780 and UL 96A)* for a strike termination device located below the main roof level with length of the **"dead end"** run less than **4.9 m (16 ft)**
- The "dead end" run must maintain a horizontal or downward coursing to the nearby roof conductor or down conductor
- Application of this exception is most often found in the protection of the end of the ridge on dormers

1983

Main Conductor - Roof Conductors *(cont.)*

- A main conductor *(properly sized)* shall be used to interconnect the strike termination devices ***(roof conductors)*** to the grounding electrode network ***(down conductors)***
- Routing of the main conductors shall be such that the paths from the strike termination devices are **downward**, **horizontal**, or **rising**, *(at no more than ¼ pitch to connections with their respective grounding electrodes)*
- No bend of a conductor shall form an included angle of less than **90 degrees**, nor shall it have a radius of bend less than **200 mm (8 in.)**
- "U" or "V" *(down and up)* pockets must be avoided, as sharp bends in the primary current conductor will add unnecessary **inductance *(impedance)*** to the conductor circuit

1984


1985

Main Conductor - Down Conductors

- The primary function of the **down conductor(s)** is to provide a low-impedance path to conduct the majority of the lightning current from the strike termination network to the grounding electrode network
- Down conductors are the primary path, but other conductive metallic paths will also have some current during a lightning event
- Even though the majority of the current will typically be divided among the **installed down conductors**, tens of thousands of amperes on a single down conductor would not be uncommon for small structures where the number of down conductors may be limited
- Even for a very small amount of impedance on a down conductor, a significant voltage could be developed from the top of the down conductor *(roof level)* to the bottom of the down conductor *(grounding electrode network)*

1986

Main Conductor - Down Conductors *(cont.)*

- Significant care should be taken to minimize the impedance of the down conductor network
- This is achieved by installing the down conductor as direct as possible, minimizing bends where practicable
- Any bends that must be included in the down conductors should be as gradual as possible and should never include a bend radius of less than 200 mm (8 in.)
- Increasing the number of down conductors in parallel will act to both decrease the overall impedance of the down conductor network as well as decrease the current density on any one conductor



1988

Main Conductor - Down Conductors *(cont.)*

- A minimum of **two down conductors** shall be provided for any installation from the strike termination network
- Additional down conductors are required for structures having a perimeter exceeding **76 m (250 ft)**
- Additional down conductors should be added as necessary to ensure the average distance between down conductors does not exceed **30 m (100 ft)**
- Down conductors must be installed as widely separated as practicable
- Down conductors should be located close to the **corners of structures** where practicable *(corners provide a higher probability of streamer development and therefore a likely point for a lightning strike)*

1989

Main Conductor - Down Conductors *(cont.)*

- Another consideration for down conductor placement is the **proximity to human traffic**
- Locating the down conductors in high traffic density areas is not recommended due to the higher probability of step and touch potential risks
- Where down conductors are located in public areas they should be **protected against physical damage** and consideration should also be given to utilizing a protection technique that will limit the probability of contact by humans
- Location of strike termination devices, the direct routing of the conductors, local earth conditions, security against displacement, the location of large metallic bodies in the structure and in the earth, and the location of underground metallic piping systems should be considered as well

1990

Main Conductor - Down Conductors *(cont.)*

- The use of the **frame of a structural steel** framed building as the down conductor network is encouraged
- This will generally provide **lower impedance** than will conventional main-sized conductors due to the physical size and mass of the steel frame members and the number of members that will act as parallel conductors
- In this case, the strike-termination network components will typically be connected to the **frame of the structure** using a **through-roof connector** such as the device shown in the next photos
- Methods allowed for connection to the structural steel are clamping, bolting or threading and tapping, and welding, brazing, or exothermic welding of the conductor directly to the structural steel is also allowed

1991


1992

Main Conductor Network - Down Conductors *(cont.)*



Example of an interior connection to the steel frame as a down conductor from the through-roof connector

1993



(*Courtesy of East Coast Lightning Equipment of Winsted, CT)*

Grounding Network - General

- The purpose of a **lightning protection grounding network** is to provide:
  - A **low-impedance connection with the earth** and away from the building walls and foundation…
  - And to **dissipate the energy** from the lightning currents in such a manner as to **minimize the peak voltage** that will appear on the lightning protection system
- The grounding electrode network must also be designed so as to reduce the risk due to touch and step potentials for humans and nearby conductive structures

1995

Grounding Network – General *(cont.)*

- For a properly designed and installed lightning protection system, the largest contributor to the overall voltage that will be developed on the lightning protection system is the **grounding electrode component**
- A properly designed, low impedance grounding electrode network will **lower the overall voltage developed** and reduce the hazards due to:
  - Touch potentials
  - Internal side flashes
  - The threat to internal electrical equipment

1996

Grounding Network - Grounding Electrodes

- Lightning protection grounding electrodes may be made of solid copper, copper-clad steel, or stainless steel
- Each down conductor must be terminated to a grounding electrode *(or point on the GE system)* dedicated to the lightning protection system
- The normal or structural electrical or telecommunication system grounding electrodes cannot be utilized as a lightning protection grounding electrode
- Electrical grounding electrodes, along with all incoming or exiting metallic piping must be bonded to the lightning protection grounding system
- *See 250.106*

1997

Grounding Network - Grounding Electrodes *(cont.)*

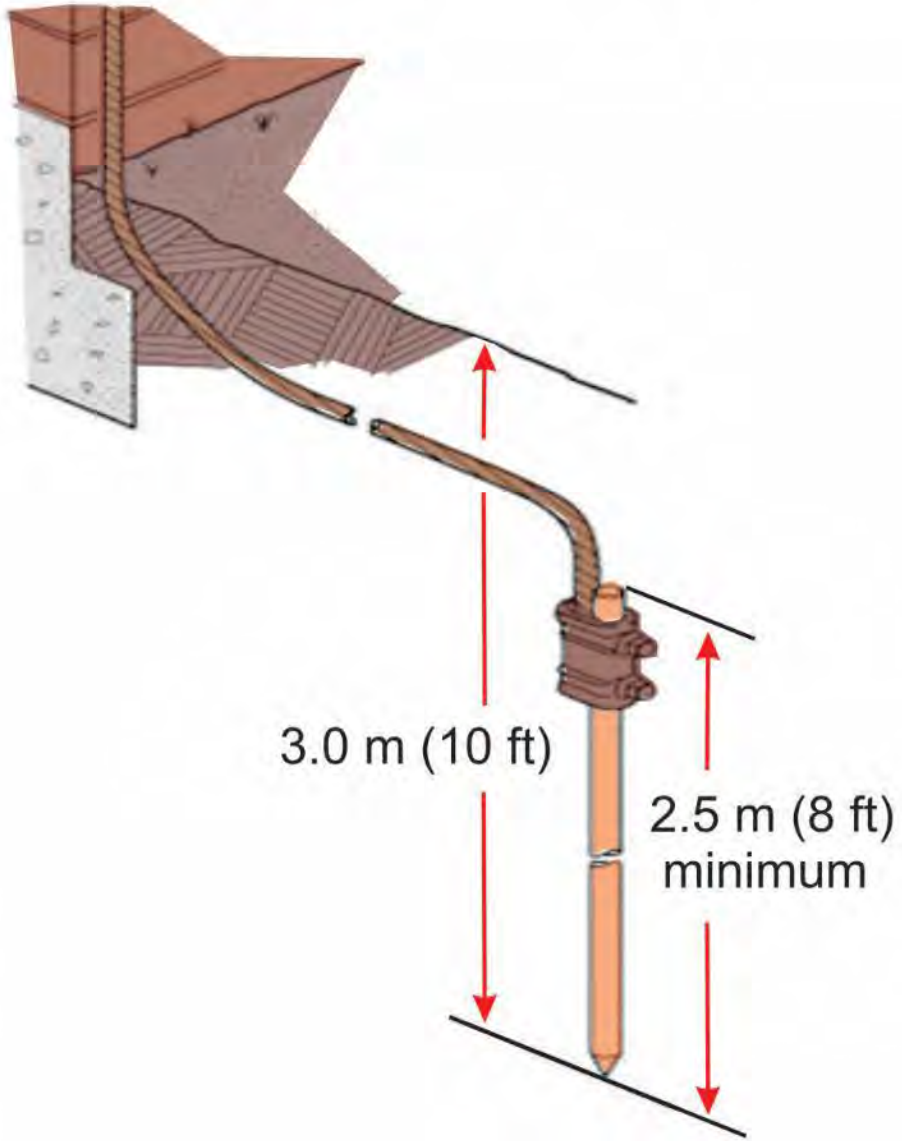
- Connections between the down conductors and grounding electrodes may be made by the following:
  - Bolting
  - Brazing
  - Welding
  - High compression connectors listed for grounding and bonding
  - Clamps suitable for direct burial may also be used
- Grounding electrodes shall be installed below the frost line where possible

Grounding Network - Acceptable Grounding Electrodes

- Grounding electrodes identified as suitable for use in lightning protection installations are:
  - Ground rods
  - Ground plate electrodes
  - Concrete-encased electrodes
  - Radial electrodes *(not less than 3.7 m (12 ft) in length and not less than 450 mm (18 in.) below grade)*
  - Ground ring electrodes
- Combinations of these devices may be used
- NFPA 780 construction and installation requirements for these electrodes similar to *NEC* at 250.52(A)

1999

Typical Single Ground Rod Installation For Lightning Protection



Ground rods installed per NFPA 780 for the lightning protection systems shall be:

- 13 mm (½ in.) diameter
- 2.5 m (8 ft) in length (minimum)
- Installed vertically not less than 3.0 m (10 ft) into the earth

NFPA 780- Standard for the Installation of Lightning Protection Systems

Copyright © IAEI 2020


Copper Plate
Grounding Electrode
2001
(Photo courtesy of Bonded Lightning
Protection of Argyle, TX)

Grounding Network - Acceptable Grounding Electrodes *(cont.)*



Installation of a ground ring electrode

2002

Grounding Network-Ground Potential Rise

- When an impulse current is injected onto a grounding electrode, an **impulse voltage** is developed
- This voltage *(known as a ground potential rise)* will exist as long as the current is flowing
- Should independently grounded systems or systems utilizing metallic piping in contact with the earth exist in a structure, this ground potential rise could create a sufficient difference of potential to cause breakdowns through unintended paths
- This could include arcing through the air, through the earth, or through internal systems
- The result could be fire, equipment damage, and possibly human injury

Grounding Network-Ground Potential Rise *(cont.)*

- Must ensure that all incoming and exiting conductors of the structure are bonded to a **common grounding system**
- All grounding electrodes and other conductive elements in the earth supplying the structure be interconnected to provide a **common ground potential** *[NFPA 780, 4.14]*
- This interconnection shall include lightning protection, electric service, telephone, and antenna system grounds, as well as underground metallic piping systems
- Where corrosion is an issue, the bond between the incoming piping system and the lightning protection grounding system may be made through a **spark gap**

Equipotential Bonding

- Ground potential rise justifies the need to have a **ground-level equipotential bonding system**
- Roof level conductors provide a **roof-level equipotential bonding system**
- There may be some conditions where additional bonding is necessary in the structure
- When lightning currents flow through a down conductor, a voltage is developed between the top and bottom of the down conductor as a result of the **impedance** of the cable
- This voltage created will produce an **electric field**
- The current flowing though the conductor will also create a **magnetic field** around the conductor

Equipotential Bonding *(cont.)*

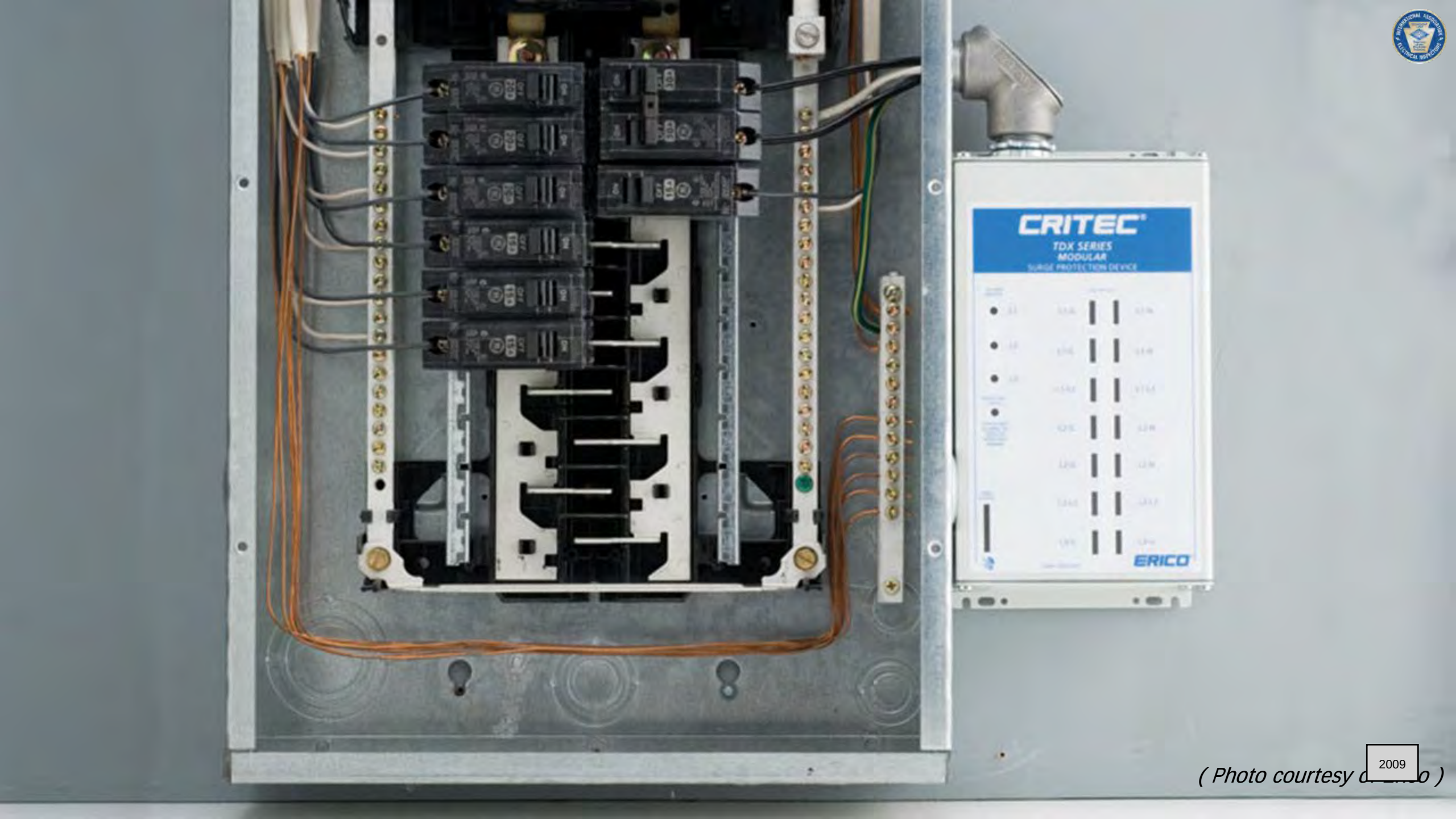
- These electromagnetic fields can result in coupling in adjacent or nearby conductors
- If the voltage difference between a lightning protection main conductor and an adjacent conductor exceeds the breakdown voltage of air, a **side flash** will occur
- NFPA 780, 4.16.2 provides a formula in which it simplifies the calculations required to determine the probability of side flash

Surge Protection

- Surges can occur from a number of sources including lightning
- Among these are:
  - Direct strikes to incoming conductors *(power, communication, data, etc.)*
  - Strikes near an incoming conductor
  - Ground potential rises as a result of a strike to or near the structure
- Magnetic and capacitive coupling from a lightning strike occurring up to **450 m (1500 ft) away** can induce a transient voltage surge capable of damaging electrical and electronic systems
- The protection of internal electrical and electronic systems will require that measures be taken for the protection against lightning electromagnetic pulses *(LEMP)*

Surge Protection *(cont.)*

- Potential equalization measures are required for incoming electrical services *(including data and communication services)*
- Potential equalization measures are normally implemented through the use of **spatial shielding** and the use of **surge protective devices *(SPDs)***
- All lightning protection standards require protection against incoming surges at a minimum
- In most cases, this leads to requirements for equipotential bonding and the installation of SPDs
- SPDs should be installed in such a manner that they can be tested or monitored *(as applicable)*



2009

(Photo courtesy of Erico)


Lucent
190A1-100 PROTECTOR
GD
2010

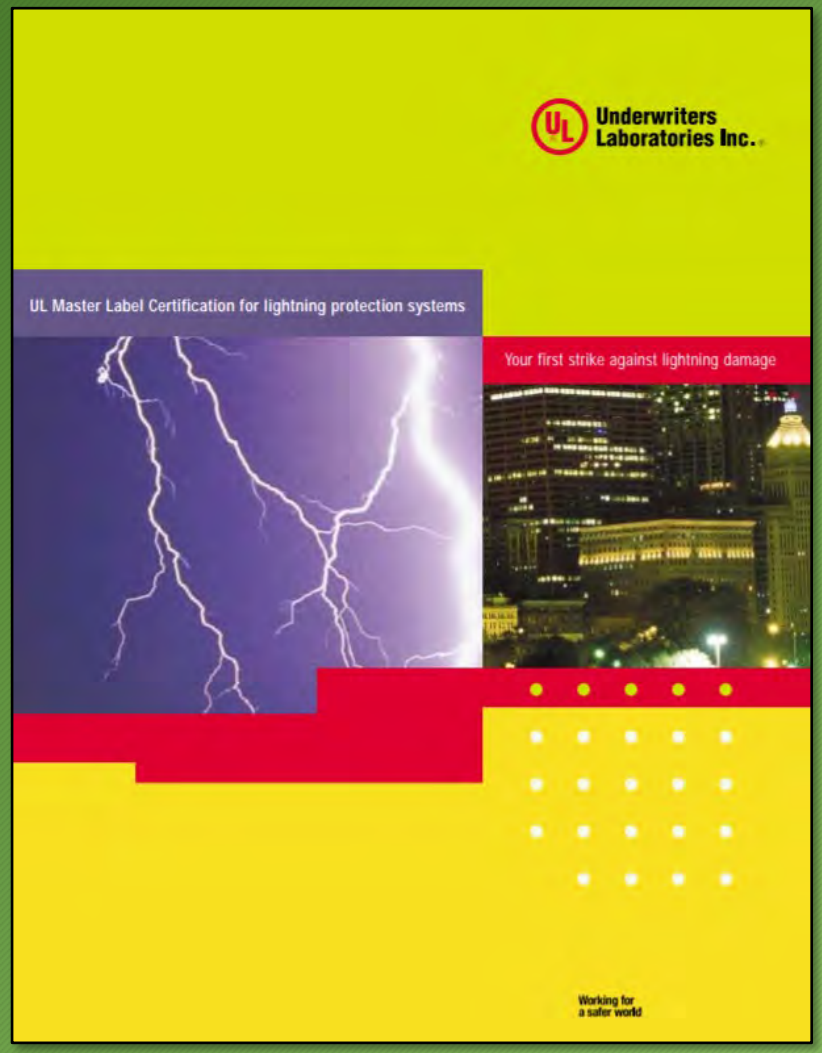
Quality Control Programs

- There are two well recognized quality control programs in the United States for lightning protection system installations:
  - **Underwriters Laboratories (UL) Master Label program**
  - **Lightning Protection Institute (LPI) Certified System program**
- Each of these programs requires the use of components qualified to **UL 96 – *Standard for Safety for Lightning Protection Components***

UL Master Label Program

- The Underwriters Laboratories LLC (UL) Master Label program is the best known of all lightning protection quality control programs
- The UL Master Label program helps ensure that proper materials and workmanship are utilized during the design and installation of lightning protection systems
- UL has been testing and certifying lightning protection equipment since 1908
- In 1923, UL began issuing Master Labels for lightning protection system installations
- A UL Master Label Certificate is issued for a structure upon successful completion of an inspection by a UL Field Engineer

UL Master Label Program *(cont.)*



- A UL Master Label Certificate is issued for a structure upon successful completion of an inspection by a UL Field Engineer

NEC vs. NFPA 780 Grounding and Bonding

- Little difference exists between permitted grounding electrodes identified in *NEC* 250.52 and those identified in NFPA 780, 4.13
- The exception being that NFPA 780 allows the use of **radials**
- Other exceptions are in the required burial depth and spacing of **ground rods** as previously discussed and the burial depth of the ground ring or plate type electrodes
- The issues of the higher frequency components and higher current densities in the lightning threat warrant the need to provide a larger area covered by the grounding system to decrease the maximum potential within the earth surface developed under discharge conditions

NEC vs. NFPA 780 Grounding and Bonding *(cont.)*

- Primary difference between the grounding requirements identified in the two NFPA documents is in the definition of the term ***grounding electrode***
- The *NEC* defines ***grounding electrode*** as "a conducting object through which a direct connection to the earth is established"
- NFPA 780 defines the term as "the portion of a lightning protection system, such as a ground rod, ground plate, or ground conductor, that is installed for the purpose of providing electrical contact with the earth"
- The **"for the purpose"** clause is an important distinction in the lightning protection community
- Intent is that all metallic conductors entering or exiting the structure must be interconnected with the lightning protection grounding system to eliminate the dangerous effects of ground potential rises

NEC vs. NFPA 780 Grounding and Bonding *(cont.)*

- Another key difference in the NFPA standards is the **bonding requirements of gas lines** to the lightning protection grounding system
- NFPA 70 *(NEC)*, 250.52(B), NFPA 780, and NFPA 54, 7.13.2 *(NFPA Fuel Gas Code)* all agree that **gas piping shall not be used as a grounding electrode**
- Each of these standards also has **specific gas piping bonding requirements** that are derived from the scope and application of the individual NFPA standard
- *NEC* 250.104(B) acknowledges that gas piping that is "likely to be energized" shall be bonded to the EGC for the circuit that is likely to energize the piping system, the service equipment enclosure, etc.

CHAPTER TWENTY-THREE

TABLES AND APPENDIX INFORMATION

2017

Soares Chapter Twenty-Three Tables

- Chapter 23 of the Soares Book on Grounding and Bonding includes several tables that are vital and useful in studying the subject of grounding and correctly applying the *NEC* rules in that regard
- In addition, several tables are included to assist the installer or inspector of electrical systems in properly designing, installing, and maintaining these systems
- By carefully utilizing the information in these tables, the electrical system will benefit from additional safety and should serve the owner for years to come
- See Soares textbook for table information

Appendix A

- Herbert G. Ufer, P.E. (Ufer Ground)
- See *"Origin of Concrete-Encased Electrode"* in Appendix A of the Soares Grounding and Bonding textbook
- Additional information about the history of grounding electrical systems and equipment for safety is available at www.iaei.org
- See *"The History and Mystery of Grounding"* at:

  http://www.iaei.org/products/pdfs/historyground.pdf

Appendix B – National Electrical Grounding Research Project (NEGRP)

- NEGRP began in 1995
- NEGRP adopted a similar and ongoing research originated by the International Association of Electrical Inspectors, Southern Nevada Chapter *(IAEI/SNC grounding study)* which began in 1992
- Project was initiated to study the effectiveness of various types of buried grounding electrodes in differing geographies around the United States

Appendix B – National Electrical Grounding Research Project (NEGRP) *(cont.)*

- During the term of the project, electrode resistance, earth resistivity, soil temperature, soils moisture and other measurements were recorded for more than twenty types of buried grounding electrodes in ten sites, situated in six geographic locations around the continental U.S.
- After being buried for extended periods, some electrodes at selected sites were exhumed for corrosion analysis and observation

Appendix B – National Electrical Grounding Research Project (NEGRP) *(cont.)*

- Major goals of the NEGRP:
  - Produce data and other information which would be useful to the electrical industry
  - Aid in the design of new systems
  - Aid in the analysis of existing system performance
  - Help explain failures of grounding electrodes

Appendix B – National Electrical Grounding Research Project (NEGRP) *(cont.)*

- See Soares Book on Grounding and Bonding (Chapter 23 – Appendix B) for information on the following:
  - Conductance of earth varies by location
  - Earth resistivity proves to be a valuable indicator of electrode performance
  - Earth resistivity and electrode resistance appear to be inverse to temperature
  - Observations

National Electrical Grounding Research Project *(NEGRP)* Site Names

SITE NAME	SITE LOCATION	INSTALLATION DATE	REMOVAL DATE
PA	(Pawnee) Las Vegas, NV	May 1992	2003
LM	(Lone Mountain) Las Vegas, NV	June 1992	2004
BA	(Balboa) Henderson, NV	Aug 1992	2001
PE	(Pecos) Las Vegas, NV	Dec 1992	2004
CH	(Charleston) Las Vegas, NV	Dec 1992	NA
VA	Staunton, VA	June 1997	NA
TX	Dallas, TX	June 1998	NA
NY	Hibernia, NY	Sept 1998	2006
IL	Northbrook, IL	Sept 1998	NA
CA	(Moffet Field) Mountain View, CA	Jan 2002	NA

Copyright © IAEI 2020

National Electrical Grounding Research Project (NEGRP)
Earth Resistivity

SITE	EARTH RESISTIVITY			EARTH RESISTIVITY		
	10 ft. Depth			20 ft Depth		
	MIN	MAX	AVG	MIN	MAX	AVG
NY	15378	24014	19527	11011	23363	20409
VA	7603	19533	9930	8235	15090	10269
BA	3217	31597	8736	1915	25278	11474
IL	2313	3497	2821	1896	2306	2098
TX	1563	4577	3319	1655	8158	3242
PE	766	12868	1734	306	14056	1651
CH	708	9575	2084	575	13175	2079
CA	517	4577	2763	460	9000	2118
LM	153	9000	2527	766	9506	4638
PA	77	9575	1362	613	9958	3158

Table 2 shows the earth resistivity values consisting of ten years of data for each site. Arranged by minimums first, sorted in descending order

Copyright © IAEI 2020

National Electrical Grounding Research Project (NEGRP)
Site Descriptions

SITE	LOCATION	SOIL
PA	(Pawnee) Las Vegas, NV - Central Valley	Water table ranging from 10 to 20 ft. generally clayey silt
LM	(Lone Mountain) Las Vegas, NV - North Valley	Normally dry, silty, sandy clays
BA	(Balboa) Henderson, NV - South Valley	Normally dry, rock and gravel
PE	(Pecos) Las Vegas, NV - North Valley	Normally dry , silt and sand to 6 ft., silty clays 6 to 11 ft.
CH	(Charleston) Las Vegas, NV - East Valley	Normally dry, sand, and gravel, surface froth

(Cont. on next slide)

Copyright © IAEI 2020

National Electrical Grounding Research Project (NEGRP)
Site Descriptions

SITE	LOCATION	SOIL
VA	Staunton, VA	Sand, and silt to a depth of approximately 6 feet, silty clays 6 to 11 ft.
TX	Dallas, TX	Normally dry, sandy soil to a depth of 5 to 6 ft. increasingly stiff sandstone to 11 ft.
NY	Hibernia, NY	Water table at 10 ft to 11 ft. gravel, sand and clays with occasional cobbles to 11 ft. depth
IL	Northbrook, IL Illinois	Periodically covered with rainwater runoff, contains silts and clays to a depth of 11 ft.
CA	(Moffet Field) Mountain View, CA	Normally dry, sand, silt with inorganic and organic clays

Copyright © IAEI 2020

Type of Electrodes

TYPE	MATERIAL	LENGTH	INSTALLATION
A	No. 2 AWG Stranded Copper Wire	50 ft	Centered in 12 in. of sand at 36 in. below grade measured to the conductor. Buried horizontally in sand backfill.
B	No. 4 Uncoated Steel Reinforcing Bar	20 ft	Within, and near the bottom of a concrete foundation consisting of 12 in. by 12 in. of 2500 psi concrete. The top of the concrete was located 6 in. below grade.
C	No. 4 Solid Copper Wire	25 ft	Centered in 6 in. by 6 in. of ERICO® Ground Enhancement Material, (GEM™) located at 20 in., to the bottom of the concrete. Installed horizontally.
D	No. 4 Solid Copper Wire	25 ft	Centered in 6 in. by 6 in. of 2500 psi concrete. Located at 20 in. to the bottom of the concrete. This electrode is designed to represent the thickened edge of post tensioned concrete construction and is installed horizontally.
E	Copper Bonded Steel Rod	8 ft	5/8 in. diameter, centered in a 9 in. diameter, 9 ft. deep boring in earth, encased in ERICO® (GEM™) backfill, installed vertically.

Copyright © IAEI 2020

Type of Electrodes *(cont.)*

TYPE	MATERIAL	LENGTH	INSTALLATION
F	Copper Bonded Steel Rod	8 ft	5/8 in. diameter, installed horizontally centered in a trench, encased in ERICO® (GEM™) backfill, 24 in. to the bottom of the (GEM™) backfill material.
G	Copper Bonded Steel Rod	8 ft	5/8 in. diameter, directly buried in a trench 36 in. deep, installed horizontally.
H	Copper Bonded Steel Rod	8 ft	5/8 in. diameter, driven vertically in earth.
I	Galvanized Steel Rod	10 ft	3/4 in. diameter, driven vertically in earth.
J	Galvanized Steel Rod	10 ft	3/4 in. diameter 10 ft. directly buried horizontally at a depth of 36 in.
K	Copper Grounding "Pole" Plate	N/A	For Las Vegas sites, 30 in. depth., T&B® Blackburn™ Model PBH, .025 in. thickness, 7 in. wide by 7 3/8 in. long, with connection capable of up to 4 AWG stranded wire. For National sites, buried at 36 in., T&B® Blackburn™ GP-114, 14 in. diameter, .025 in. thickness.

Copyright © IAEI 2020

Type of Electrodes *(cont.)*

TYPE	MATERIAL	LENGTH	INSTALLATION
L	Lyncole® XIT™, Copper Tube	10 ft	Vertical chemically charged electrode assembly in an 11 ft. deep, 9 in. diameter boring.
M	Steel and Concrete	N/A	Arrangement designed to represent a light pole base with (6) ea., 2 ft. long No. 4 reinforcing steel vertical, tied with 3 ea., No. 2 steel horizontal hoops separated 12 in., vertically in a 2 ft., deep 36 in. diameter excavation, encased in 2500 psi concrete.
N	No. 4 AWG Solid Copper Wire	20 ft Coil	20 ft. of wire rolled into a coil approximately 18 in. diameter, installed in a 2 ft. round by 2 ft. deep excavation in concrete 2500 psi.
O	No. 4 AWG Solid Copper Wire	20 ft Coil	20 ft. of wire rolled into a coil approximately 18 in. diameter, installed in a 2 ft. round by 2 ft. deep excavation encased in ERICO® (GEM™) backfill, installed vertically.
P	Wood Pole With Copper Grounding Pole Plate to 6 AWG Solid Copper Wire	8 ft	Approximately 18 in. diameter, with Blackburn GP-114 copper grounding pole plate attached at bottom using No. 6 AWG solid copper wire wrapped in a spiral for 6 ft., at approximately 6 in. spacing between wraps.

Copyright © IAEI 2020

Type of Electrodes *(cont.)*

TYPE	MATERIAL	LENGTH	INSTALLATION
Q	Copper Bonded Steel Rod	8 ft	1/2 in. diameter, rod installed horizontally, directly buried at 30 in. depth in 6 in. by 12 in. sand
R	LEC® Chemrod	10 ft	Vertically charged electrode assembly in an 11 ft. deep 9 in. diameter boring encased in Ground Augmentation Fill (GAF™).
S	Lyncole® XIT™	10 ft	Horizontal chemically charged electrode assembly installed at a depth of 36 in.
T	Galvanized Steel Water Pipe	8 ft	3/4 in. diameter galvanized (water) pipe, driven vertically in earth.
V	4/0 AWG - 7 Strand Copper Wire	8 ft	4/0 AWG- 7 strand bare copper cable, directly buried horizontally 36 in. deep.
W	Assembly of Copper Bonded Rods	N/A	Dominion Virginia Power Co., ground cage, (proprietary) using multiple 8 ft. long, 5/8 in. diameter copper bonded rods installed vertically in a mortar backfill.
X	Stainless Steel Rod	8 ft	5/8 in. diameter stainless steel ground rod driven vertically in earth.

Copyright © IAEI 2020

Type of Electrodes *(cont.)*

TYPE	MATERIAL	LENGTH	INSTALLATION
Y	LEC® Chemrod	10 ft	LEC® Chemrod™ charged electrode assembly installed at a depth of 36 in., encased in GAF™ backfill.
Z	Copper Plated Steel Mesh	8 ft	Wire Mesh consisting of No. 6 copper plated steel on 4 in. centers measuring 2 ft. wide. Directly buried in earth.
AA	Copper Tube	10 ft	ERICO® Horizontal Model Chemical Electrode. Installed with backfill (GEM™).
AB	Copper Tube	11 ft	Harger® Vertical Model Chemical Electrode, installed in backfill (Ultrafill™)
AC	Copper Tube	10 ft	ERICO® Vertical Model Electrode. Installed in backfill (GEM™)
AD	Copper Tube	10 ft	Lyncole® Vertical Model Sectional Chemical Electrode, installed in Lynconite II backfill.
AE	Copper Tube	10 ft	Lyncole® Horizontal Model Sectional Electrode, installed in Lynconite II backfill.

Copyright © IAEI 2020

Type of Electrodes *(cont.)*

TYPE	MATERIAL	LENGTH	INSTALLATION
DC1	Rod	8 ft	DC1A,B, and C are 5/8 in. copper bonded steel rod, installed vertically.
DC2	Pipe	8 ft	DC2A, B, and C are ¾ in. by 8 ft. galvanized steel pipe.
DM	Copper Tube	10 ft	DM1A, 2A,and 3A are 5/8 in. copper bonded steel rods, installed vertically. DM1B, 2B, and 3B are 3/4 in.galvanized steel pipe, installed vertically.

Notes:

1. GEM is Ground Enhancement Material, a conductive backfill material manufactured by Erico.

2. The XIT rod is a type of chemical ground rod, 2" in diameter, manufactured by Lyncole Industries.

3. GAF is Grounding Augmentation Fill, a conductive backfill material manufactured by Lightning Eliminators & Consultants.

4. The Chem-Rod is a type of chemical ground rod, 2.625" in diameter, manufactured by Lightning Eliminators & Consultants.

Copyright © IAEI 2020

NEGRP Electrodes Exceeding 25 Ohms

PERCENTAGE OF MEASUREMENTS 25 OHMS OR GREATER										
TYPE	PA	LM	BA	PE	CH	VA	TX	NY	IL	CA
A	1%	7%	100%	38%	72%					
B	1%	4%	93%	5%	3%	99%	74%	100%		31%
C	50%		52%		59%					
D	5%	3%	95%	67%	87%					
E	1%	2%					2%	100%		
F	25%	2%	93%	2%		52%	1%	100%		8%
G	6%	92%	100%	52%	87%	99%	22%	100%		33%
H	3%		99%			75%		100%	11%	28%
I	1%		98%		1%					
J		2%	100%		28%					
K	80%	94%	100%	95%	97%	100%	21%	100%	79%	100%
L	40%	29%	13%		13%	15%		74%		
M	7%	68%	100%	60%	3%					
N	12%	11%	100%	88%	6%					
O	3%	12%	100%	55%						
P	3%	17%	100%							
Q	48%	44%	100%	48%	90%					
R			3%					42%		
S	2%			14%		19%		100%		
T						97%		100%		35%
V						99%	5%	100%		52%
W						4%		100%		
X						62%		100%		
Y						8%		100%		
Z						76%		100%		39%
AA										
AB										8%
AC										
AD										
AE										

ELECTRODE NOT INSTALLED IN THIS SITE

LESS THAN 25 OHMS

Copyright © IAEI 2020

NEGRP Electrodes Exceeding 50 Ohms

PERCENTAGE OF MEASUREMENTS 50 OHMS OR GREATER										
TYPE	PA	LM	BA	PE	CH	VA	TX	NY	IL	CA
A			61%	5%	13%					
B			7%			6%	1%	87%		
C	46%		7%		29%					
D	4%		11%	9%	77%			32%		
E	1%	1%						32%		
F	18%		8%			2%		95%		
G	3%	76%	97%	6%	51%	86%	1%	100%		8%
H	2%		49%			1%		100%		9%
I			1%		1%					
J			100%		5%					
K	78%	77%	100%	84%	39%	100%	3%	100%	18%	91%
L	25%	2%								
M		25%	98%	2%	3%					
N			95%	3%	3%					
O		8%	65%							
P		1%	100%							
Q	1%	4%	97%	3%	13%					
R			2%							
S								66%		
T						5%		100%		
V						17%	1%	100%		
W										
X						4%	7%	100%		
Y								13%		
Z						1%		92%		
AA										
AB										
AC										
AD										
AE										

ELECTRODE NOT INSTALLED IN THIS SITE

LESS THAN 50 OHMS

Copyright © IAEI 2020

Appendix C - Metric Conversion Reference

- In recognition of the global use of the metric system of measurement, IAEI has incorporated metric units into our publications in accordance with the International System of Units (SI)
- Metric units appear first, followed by inch-pound units in parentheses [for example, 6 m (20 ft)]
- See *NEC* 90.9(B) for *hard* conversion
- See *NEC* 90.9(C) for *soft* conversion
- See Soares textbook Appendix C for metric conversion reference chart

SOARES Grounding and Bonding

Based on the 2020 NEC®

End of Part III – Grounding and Bonding Specific Applications

International Association Of Electrical Inspectors

Presented by the International Association of Electrical Inspectors

Ohio Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: Department of Industrial Compliance

Organization: STATE OF OHIO

Address: 6606 Tussing

E-mail: michael.thompson@com.ohio.gov Telephone: 614-728-5293

Website: com.ohio.gov

Conference Sponsor (if applicable)_____ Conference Email:_____

Check here if Course Renewal:_____ Prior course number _____ (*i.e. BBS2018-429*)

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: NEC 2020 Soares Grounding and Bonding Fundamentals Presented by The IAEI Association

Course instructor: Michael Thompson

Course description: We will study and go through the IAEI 3part Power point presentation on grounding and bonding course study to help with the inspection and plan review processes Part 2

Instructional hours per session: 6 hrs Number of Sessions: 1 each

Course Date(s) and Location: Department of Commerce in Reynoldsburg

Special Content:

Code Administration: X
Existing Buildings: X
Electrical Instruction: X
Plumbing Instruction:_____

Conference Course: _____
Conference Name: _____
Conference location:_____

Course to be offered online? X **On Demand**_____ **Webinar**_____

Course Website: Might use Microsoft TEAMS on course if travel becomes a issue

Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation)*:
Microsoft Teams attendance

Course applicable for the following certifications

Residential Certifications Only: _____ Commercial Certifications: X

Administrative Course, All Certifications: X

Application materials included:

X Course Outline or Course Learning Objectives
X Presentation Materials/Slides (not required for roundtable courses)
_____ Assessment Materials (for online courses)
X Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

2020 NEC Soares Grounding Part 2.

7:30 – 8:00- Greetings.

8:00 am 8:10 am – To go over purpose of this class and the power point. The class will follow along with the PDF book of Soares Grounding.

Chapter 7 THE GROUNDING ELECTRODE SYSTEM

Chapter 8 GROUNDING ELECTRODE CONDUCTORS (GEC)

Chapter 9 GROUNDING ELECTRICAL SERVICES

Chapter 10 MAIN BONDING JUMPERS AND BONDING AT SERVICES

Chapter 11 GROUNDING SEPARATELY DERIVED SYSTEMS

Chapter 12 GROUNDING AND BONDING AT BUILDINGS AND STRUCTURES SUPPLIED BY FEEDERS OR BRANCH CIRCUITS

Chapter 13 BONDING ENCLOSURES AND EQUIPMENT

Chapter 14 EQUIPMENT GROUNDING CONDUCTORS

Chapter 15 ENCLOSURE AND EQUIPMENT GROUNDING

8:10 -9:20 - Chapter 7 THE GROUNDING ELECTRODE SYSTEM

9:20 – 9:30 break

9:30- 10:30 – Chapter 8 GROUNDING ELECTRODE CONDUCTORS (GEC)

10:30 – 12-00 – Chapter 3 To Ground or Not to Ground the System, Chapter 10 MAIN BONDING JUMPERS AND BONDING AT SERVICES

12:00- 1:00 Lunch

1:00 pm– 2:00 pm - Chapter 11 GROUNDING SEPARATELY DERIVED SYSTEMS, Chapter 12 GROUNDING AND BONDING AT BUILDINGS AND STRUCTURES SUPPLIED BY FEEDERS OR BRANCH CIRCUITS

2:00 -2:30 – Chapter 13 BONDING ENCLOSURES AND EQUIPMENT

2:30 -2:45 Break

2:30 -3:30 - Chapter 14 EQUIPMENT GROUNDING CONDUCTORS, Chapter 15 ENCLOSURE AND EQUIPMENT GROUNDING

SOARES Grounding and Bonding

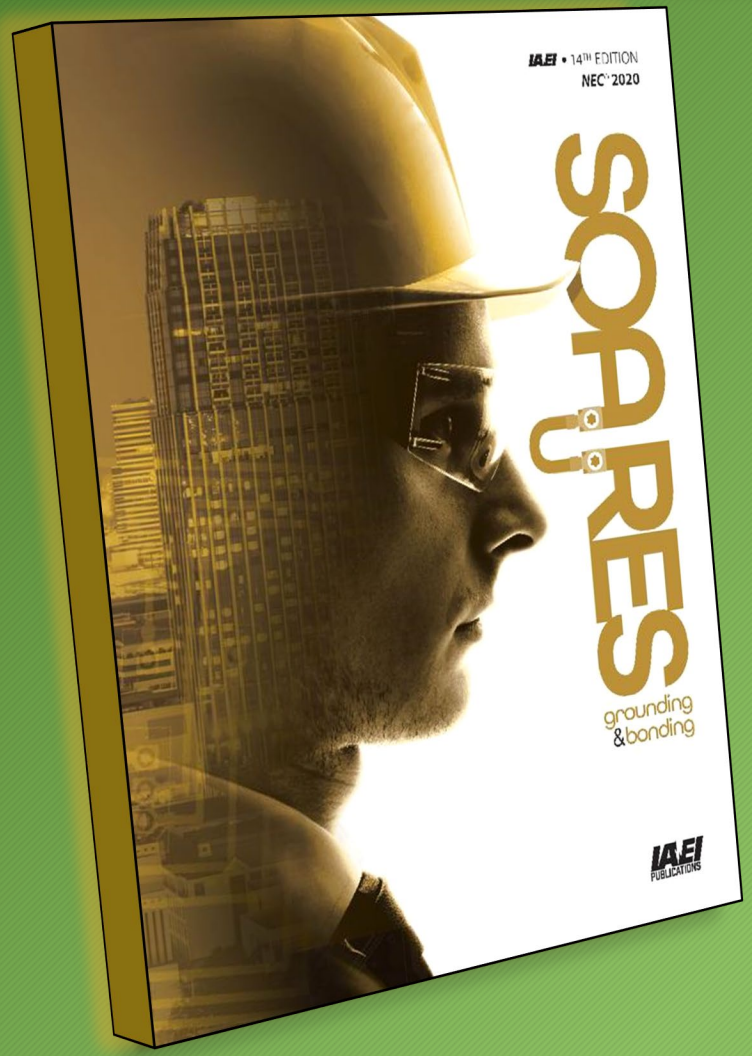
Based on the 2020 NEC®

Part II of III – Grounding and Bonding Common Applications

International Association Of Electrical Inspectors

Presented by the International Association of Electrical Inspectors

Soares Grounding and Bonding



- IAEI's *Soares Grounding and Bonding*
- 14th Edition
- Based on the requirements of the ***2020 National Electrical Code***
- Dedicated to the memory of Eustace Soares

Soares Chapter Index Links – Part II

Chapter 7	The Grounding Electrode System
Chapter 8	Grounding Electrode Conductors
Chapter 9	Grounding Electrical Services
Chapter 10	Bonding at Services and Main Bonding Jumper
Chapter 11	Grounding Separately Derived Systems
Chapter 12	Grounding and Bonding at Buildings or Structures Supplied by Feeders or Branch Circuits
Chapter 13	Bonding Enclosures and Equipment
Chapter 14	Equipment Grounding Conductors
Chapter 15	Enclosure and Equipment Grounding

Click on any chapter to link directly to that chapter

Seminar and Course Objectives

- Provide basic fundamental information on electrical circuits, electric shock, and overcurrent device operation
- Cover the subject of grounding of electrical systems and equipment for safety in a concise, yet thorough, manner
- Present information on the fundamentals of grounding for systems, services, feeders, branch circuits, and equipment
- Provide information for sizing bonding and grounding conductors and equipment, grounding electrodes and grounding electrode conductors

Seminar and Course Objectives *(cont.)*

- Cover requirements for grounding separately derived systems
- Grounding at additional buildings or structures
- Provide information on grounding special systems, such as for hazardous *(classified)* locations, agricultural buildings, health care facilities, swimming pools, and electric signs
- Provide information on electronic equipment and limited energy system grounding and bonding requirements
- Provide basic fundamentals on lighting protection

CHAPTER SEVEN

THE GROUNDING ELECTRODE SYSTEM



2047

The Grounding Electrode System

- Grounding electrodes provide essential function of connecting the electrical system and electrical equipment to the earth
- The earth is considered to be at **zero potential**
- Grounding electrode(s) serves and is used to:
  - Ground the electrical system and equipment to earth *(grounded systems)*
  - Connect non-current-carrying metallic portions of electrical equipment to the earth *(grounded and ungrounded systems)*
- Notice that the concepts for connecting the "system" and connecting the "equipment" are purposefully separate *[see 250.4(A) and (B)]*

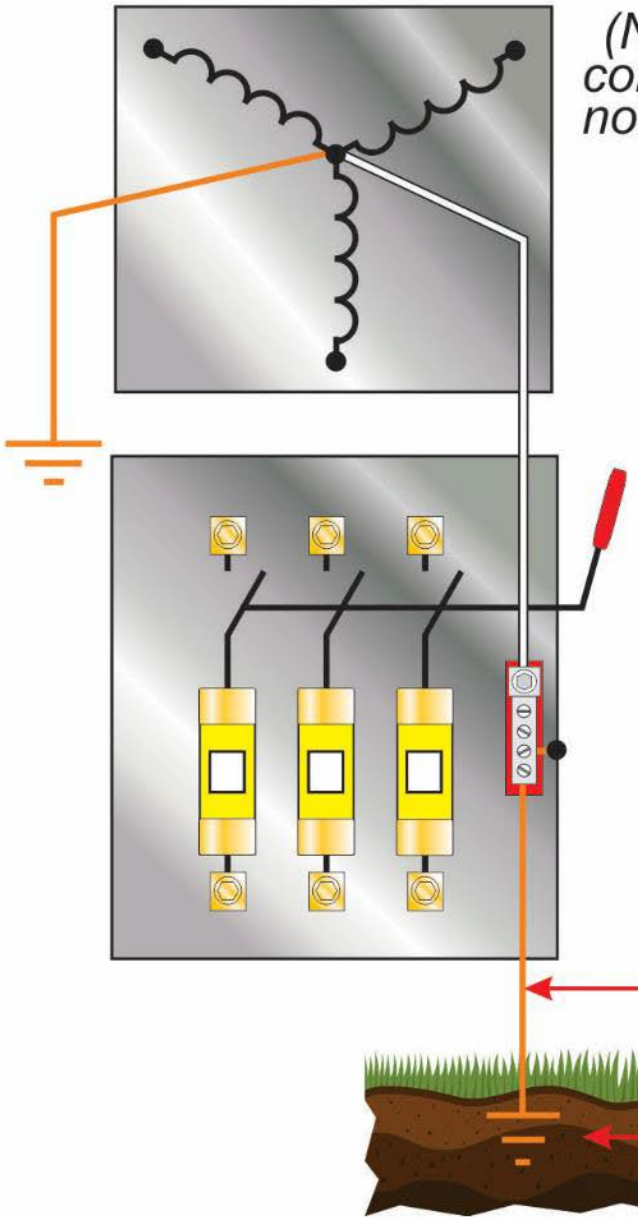
The Grounding Electrode System *(cont.)*

- Primary purpose of the grounding electrode(s) is to maintain the electrical equipment at the **earth potential** present where the grounding electrode(s) is located
- Grounding electrode(s) serves the function of **dissipating overvoltages** into the earth
- Overvoltages can be caused by high-voltage conductors being accidentally connected to the lower-voltage system such as by a failure in a transformer or by an overhead conductor dropping on the lower-voltage conductor
- Overvoltages can also be caused from lightning

Article 100 Definitions

- ***Grounding Electrode:*** A conducting object through which a direct connection to earth is established.
- The details and descriptions of the various grounding electrodes acceptable for grounding are contained in 250.52(A)
- The definition of ***grounding electrode*** is intended to work cooperatively with the list of electrodes identified in 250.52(A)

Functions of the Grounding Electrode System



Grounding Electrode - A conducting object through which a direct connection to earth is established.

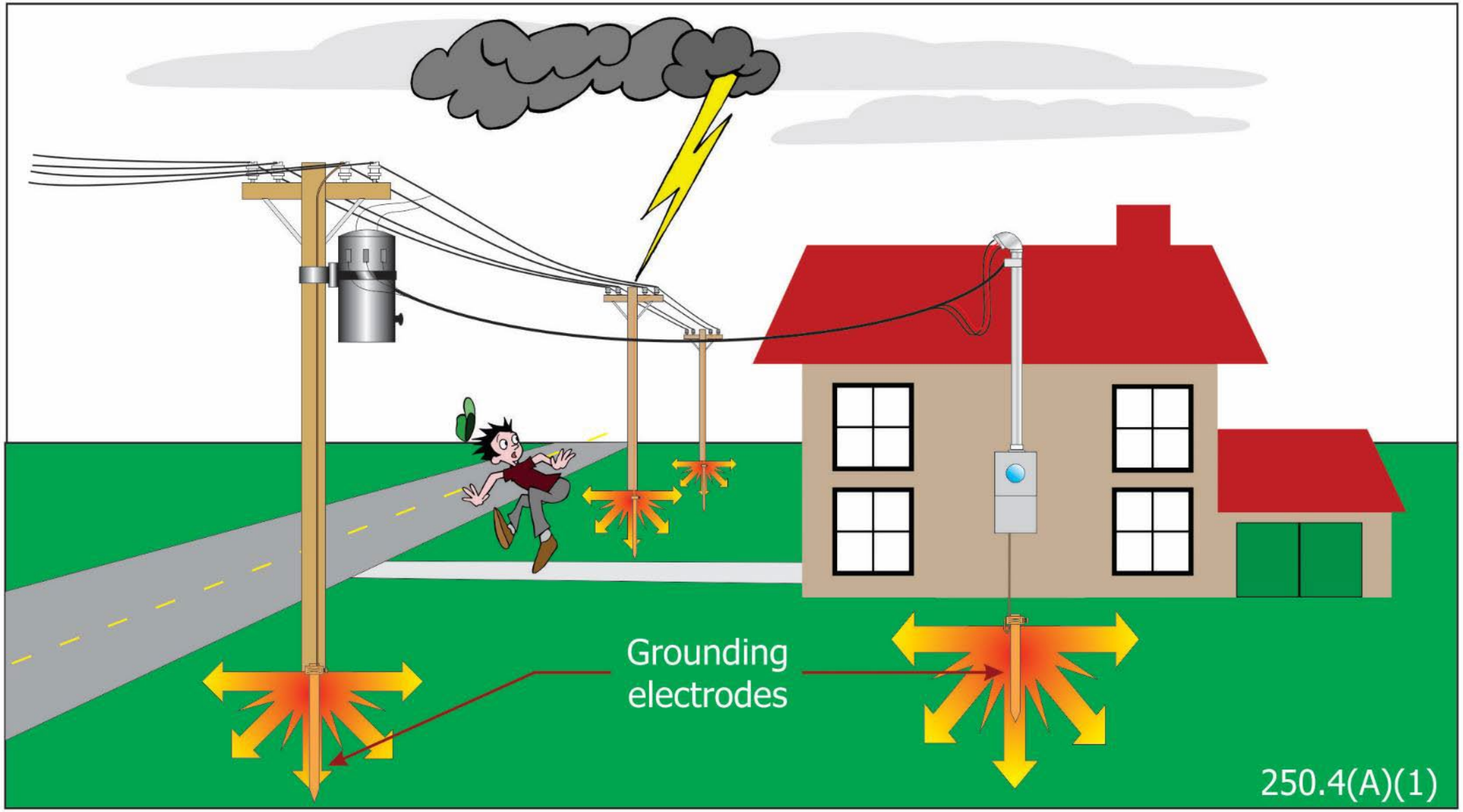
1. Connects the electrical system to earth
2. Connects electrical equipment to earth
3. Attempts to maintain equipment at the earth voltage potential

The grounding electrode system has very little effect in clearing ground faults ***(not its function)***

Copyright © IAEI 2020


2052

Dissipation of Over-Voltages



Copyright © IAEI 2020

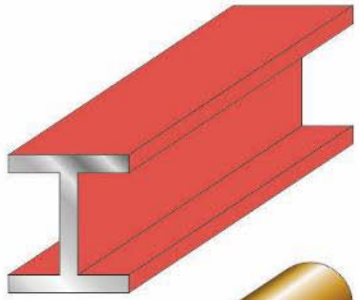
Grounding Electrode System

- All grounding electrodes **that are present** at each building or structure served are required to be bonded together to form the grounding electrode system *(see 250.50)*
- Where **metallic water piping** [250.52(A)(1)], **metallic in-ground support structure** [250.52(A)(2)], or a **concrete-encased electrode** [250.52(A)(3)] is part of the construction of the building or structure, it is required to be used as a grounding electrode for the electrical system
- None of these three items are required to be installed, only used where they are installed as part of the construction of the building or structure
- Exception to 250.50 has provisions for existing buildings or structures

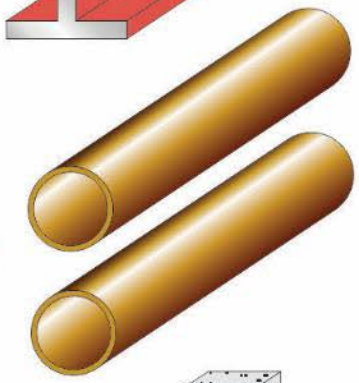
250.50 Grounding Electrode System

- Where present, grounding electrodes required to be used to form the grounding electrode system
- Includes electrodes that are an inherent component of the building construction *(metal structure, etc.)*
- By exception, existing concrete-encased electrodes not required to be used where doing so involves disturbing concrete footings of existing structures or buildings

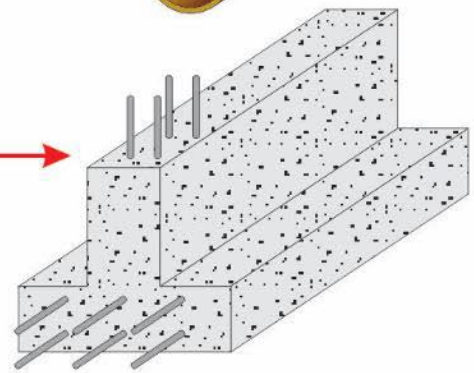
Metal in-ground support structure →



Metal underground water pipe →



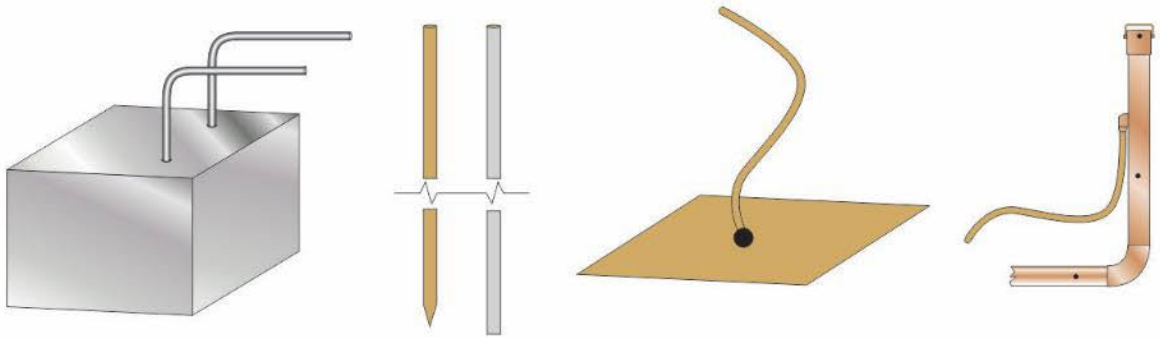
Concrete-encased electrode →



Other listed electrodes ←

Other metal structures

Rods, pipes, or plates



Ground ring 2 AWG copper minimum →



Copyright © IAEI 2020

Grounding Electrodes for Grounding

- Section 250.52(A) includes the details and descriptions of grounding electrodes that are **required to be used** for the grounding electrical systems ***(when present)***
- Section 250.52(B) includes items that are **not permitted** to be used as grounding electrodes for electrical systems and equipment
- Installation provisions for the electrodes described in 250.52(A) are provided in 250.53 titled “Grounding Electrode System Installation”

Grounding Electrodes for Grounding

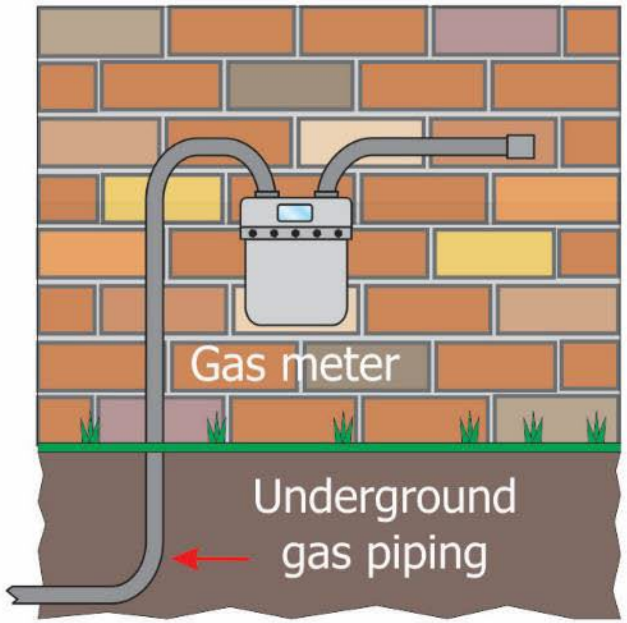
- Section 250.52(A) includes the details and descriptions of grounding electrodes that are **required to be used** for the grounding electrical systems *(where present)*:

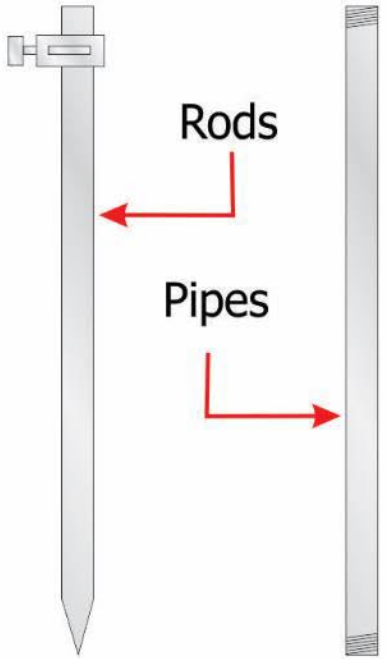
  (A)(1) Metal Underground Water Pipe
  (A)(2) Metal In-ground Support Structure(s)
  (A)(3) Concrete-Encased Electrode
  (A)(4) Ground Ring
  (A)(5) Rod and Pipe Electrode
  (A)(6) Other Listed Electrodes
  (A)(7) Plate Electrodes
  (A)(8) Other Local Metal Underground Systems or Structures

The Grounding Electrode System

- Section 250.52(B) lists (3) items **NOT permitted** to be used as part of the grounding electrode system:
  - (1) Metal underground gas piping systems
  - (2) An aluminum electrode *(such as an aluminum ground rod)*
  - (3) The structure and structural reinforcing steel for a permanently installed swimming pool

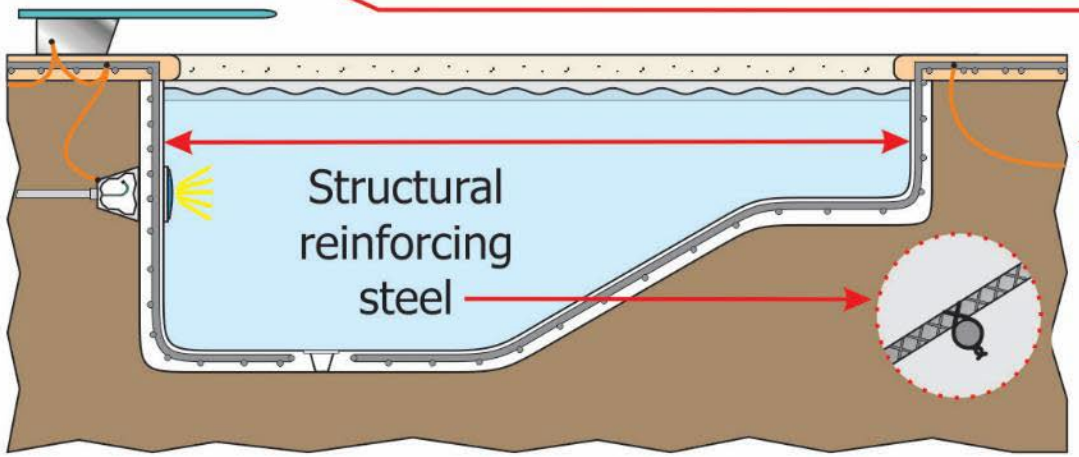
250.52(B) Not Permitted as Grounding Electrodes





Not permitted as grounding electrodes:

- Aluminum electrodes
- Underground gas piping
- Structural reinforcing steel of in-ground swimming pools



← Aluminum electrodes are not permitted as a grounding electrode

Underground gas piping is not permitted as a grounding electrode

← Structural reinforcing steel *(rebar forming shell)* of an in-ground swimming pool not permitted as a grounding electrode

Copyright © IAEI 2020

Metal Underground Water Piping Systems

- Section 250.52(A)(1) requires **metal underground water piping systems** to be used for the grounding electrical systems *(where present)*
- Must be in direct contact with the earth for 3.0 m **(10 ft) or more** and electrically continuous
- Includes any metal well casing bonded to the pipe
- Can be made electrically continuous by bonding around insulating joints or insulating pipe
- Must not be coated or otherwise insulated from direct contact with the earth

250.52(A)(1) Metal Underground Water Pipe









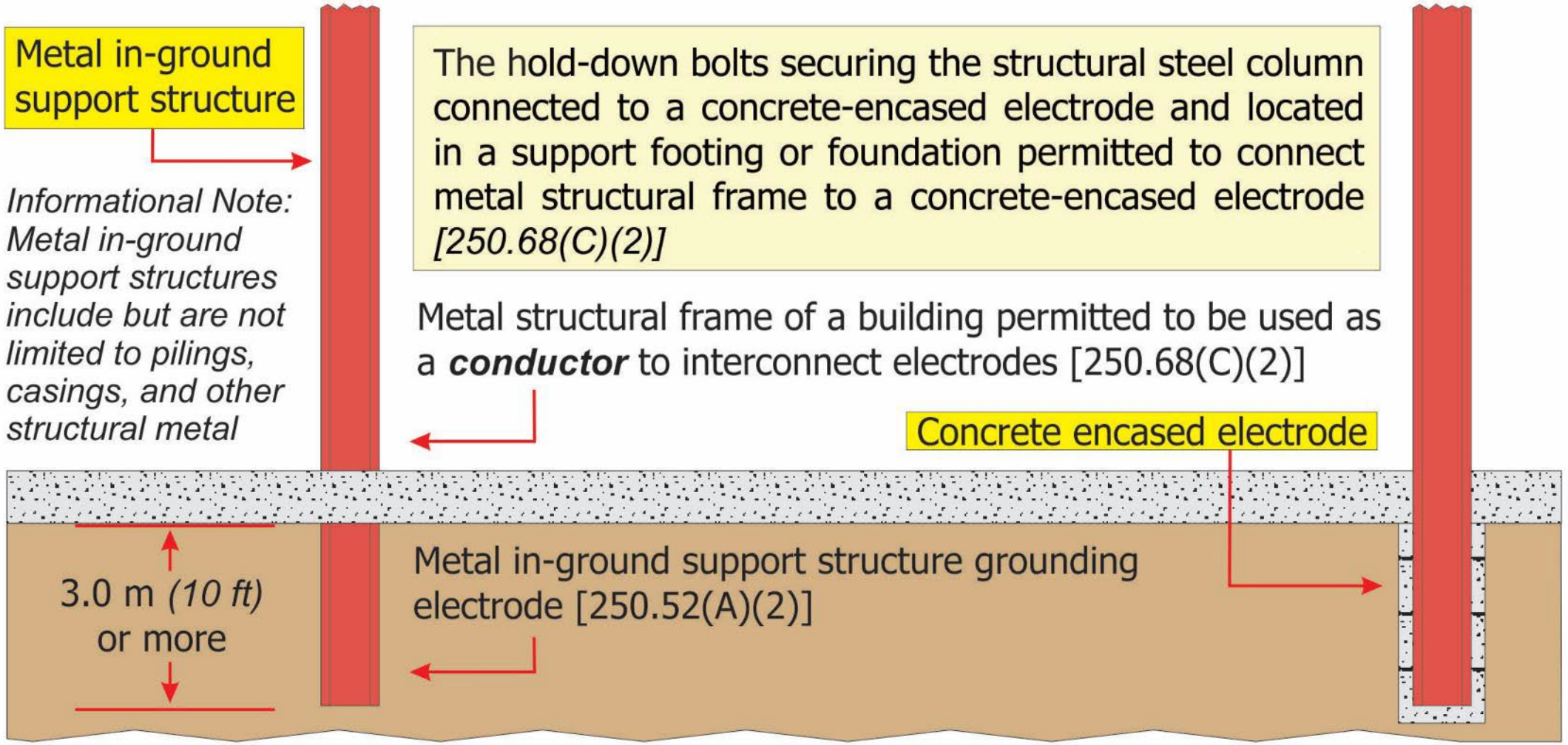
2061

Metal In-Ground Support Structure(s)

- Section 250.52(A)(2) requires a **metal in-ground support structure** to be used for the grounding electrical systems *(where present and qualifies)*
- Must be 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, **permitted to bond only one** into the grounding electrode system
- Could include *(but are not limited to)* pilings, casing, and other structural metal

250.52(A)(2) Metal In-Ground Support Structures

One or more structural 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)* qualifies as a grounding electrode *(if multiple are present, only one required to be used)*



Copyright © IAEI 2020



2064

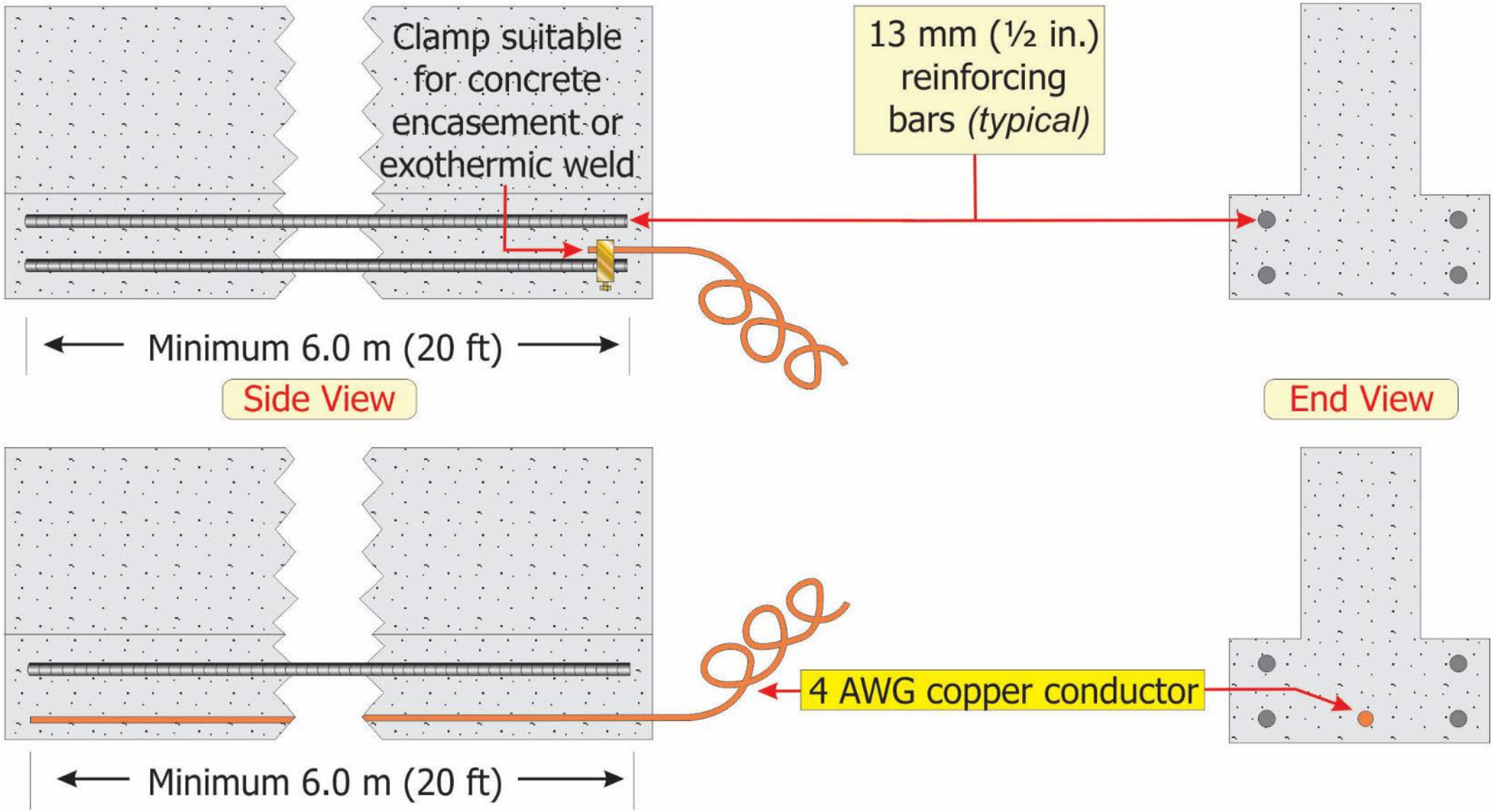

2065


Connection of a structure column to a footing or concrete-encased electrode found at 250.68(C)(2)
Building steel setting on a concrete slab with hold-down bolts connected to concrete-encased electrode does not qualify the building steel as a grounding electrode
2066

Concrete-Encased Electrode

- Section 250.52(A)(3) requires concrete-encased electrodes to consist of:
  - At least **6.0 m (20 ft)** of bare copper conductor not smaller than **4 AWG** or one or more bare or electrically conductive coated steel reinforcing bars or rods of not less than **13 mm (½ in.) in diameter**
  - Installed in **one continuous 6.0 m (20 ft) length**, or multiple pieces connected together by the usual steel tie wires, exothermic welding, welding, etc. to create a 6.0 m (20 ft) or greater length
  - Metallic components encased by at least **50 mm (2 in.) of concrete**
  - Located **horizontally** within portions of a concrete foundation or footing in **direct contact with the earth** or within **vertical** structural components in direct contact with the earth

250.52(A)(3) Concrete-Encased Electrode



Copyright © IAEI 2020

Concrete-Encased Electrode

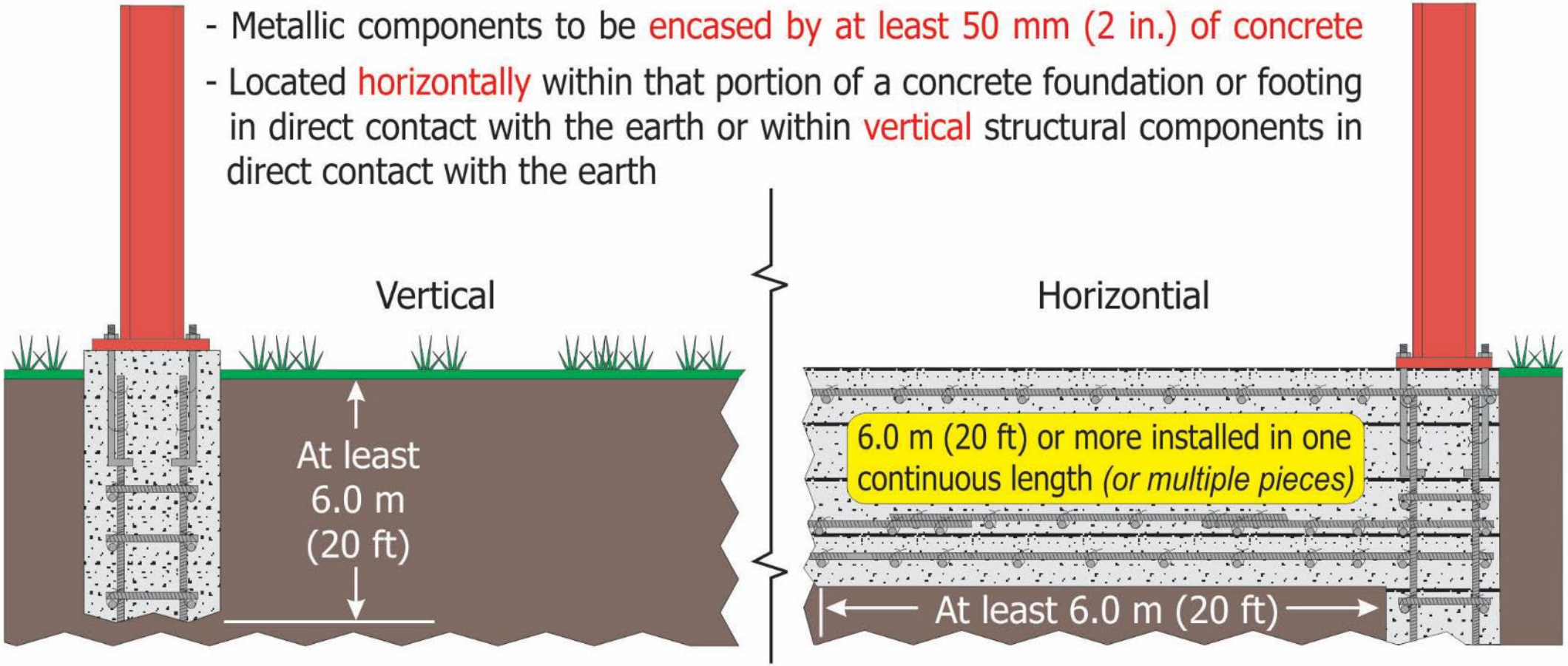




250.52(A)(3) Concrete-Encased Electrode

Concrete-encased electrode to consist of:

- At least 6.0 m (20 ft) of bare copper conductor not smaller than 4 AWG or one or more bare or electrically conductive coated steel reinforcing bars or rods, not less than 13 mm (½ in.) in diameter,
- Installed in one continuous 6.0 m (20 ft) length, or multiple pieces connected together by the usual steel tie wires, exothermic welding, etc. to create a 6.0 m (20 ft) or greater length
- Metallic components to be encased by at least 50 mm (2 in.) of concrete
- Located horizontally within that portion of a concrete foundation or footing in direct contact with the earth or within vertical structural components in direct contact with the earth



Copyright © IAEI 2020

Concrete-Encased Electrode

- Reviewing the definition of **"Grounding Electrode"** reveals that it is the **concrete** that is the electrode in contact with the earth *(not the bare copper conductor or the reinforcing bar)*
- The concrete provides the continuity from the grounding electrode conductor to the earth
- While the minimum length of copper conductor or rebar is addressed, what is really needed is a **minimum of 6.0 m (20 ft) of concrete** in a footing or foundation that contains this rebar or copper conductor
- Another item to note is **what constitutes a foundation or a footing?**
  - This is determined by the adopted building code *(not defined in the NEC)*

Concrete-Encased Electrode





Concrete-Encased Electrode

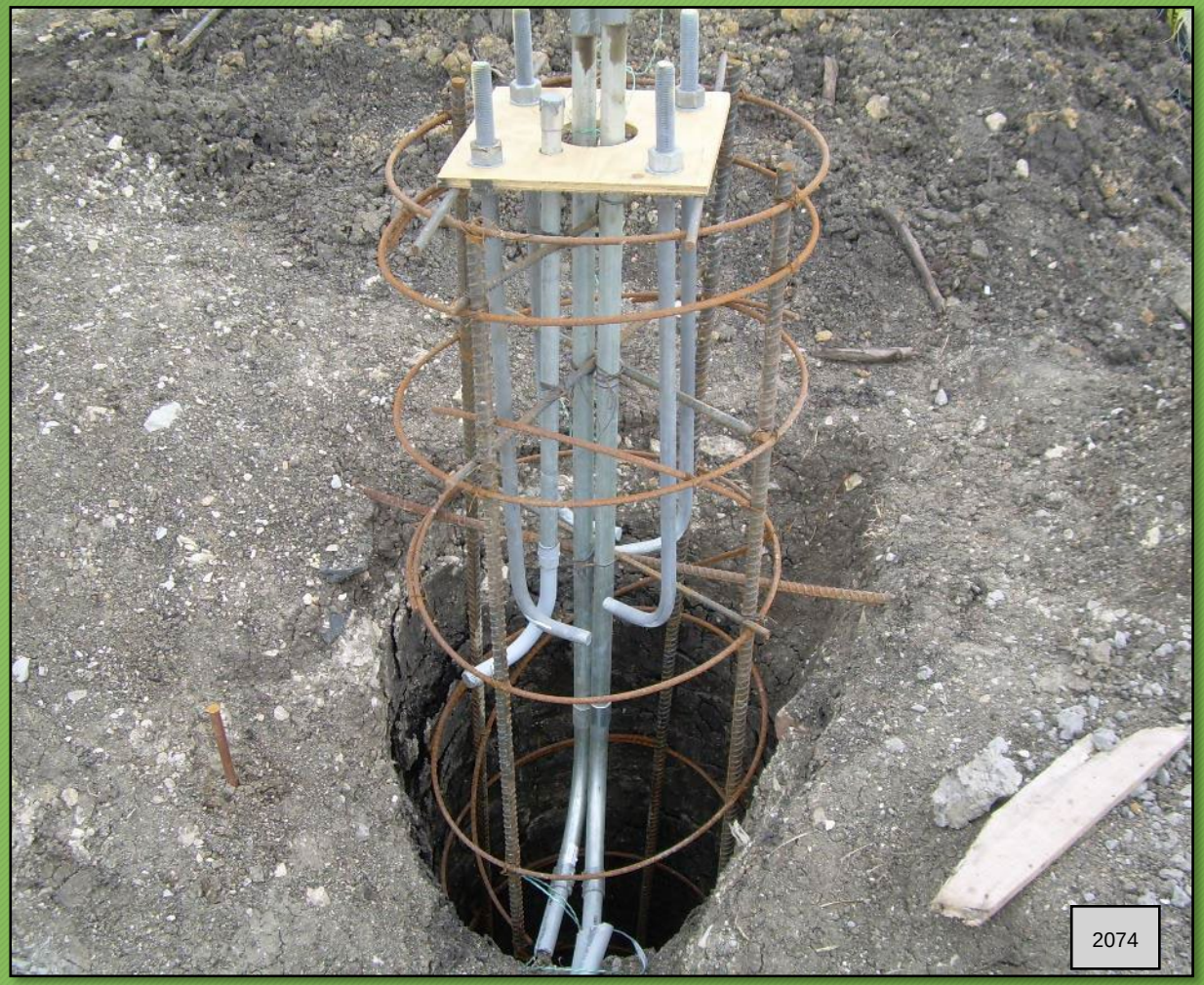




2073

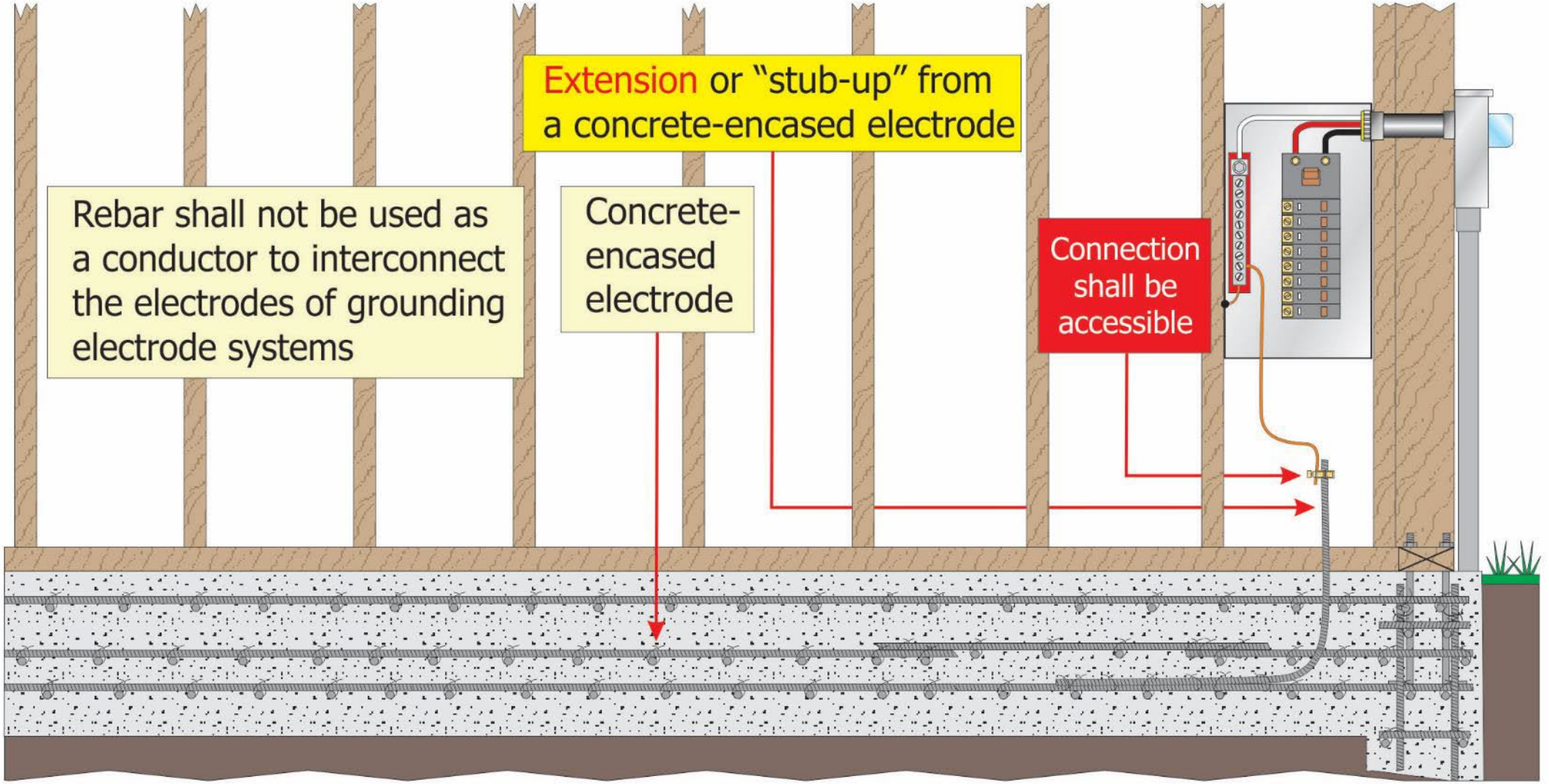
Concrete-Encased Electrode





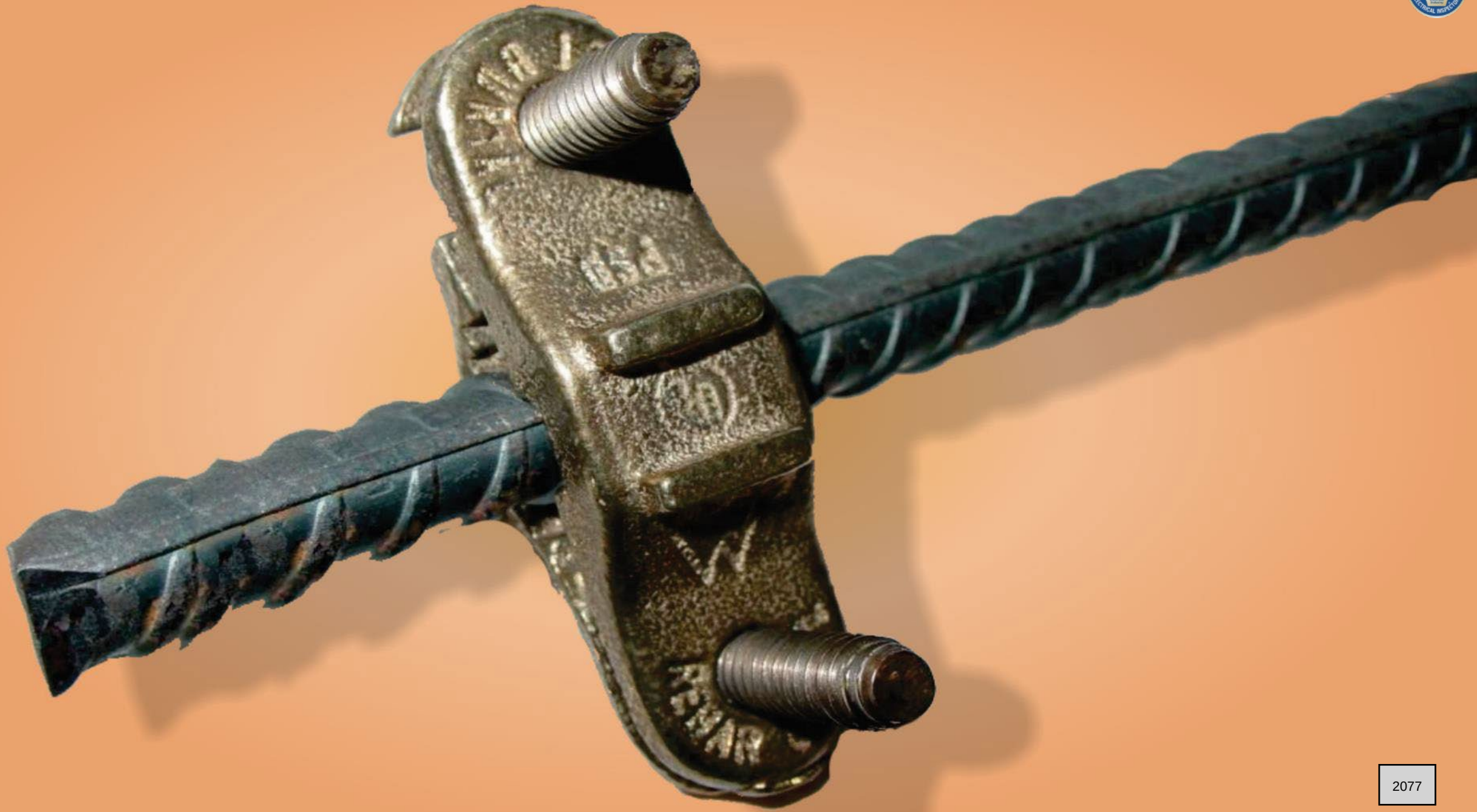
250.68(C)(3) Concrete-Encased Electrode Extension

A rebar extension from a concrete-encased electrode is recognized for connection to the grounding electrode conductor from the grounding electrode



Copyright © IAEI 2020


Ground clamp identified
to be used with rebar



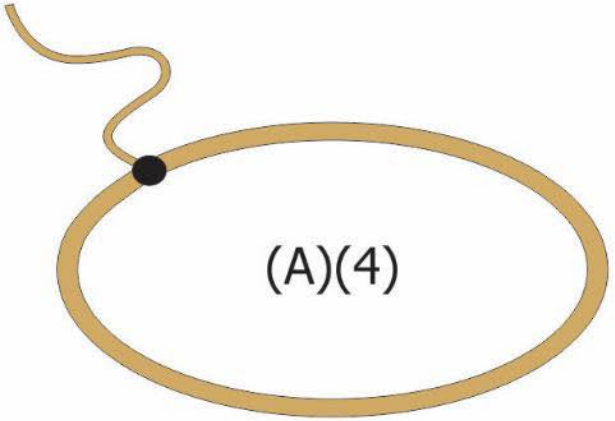
2077

Grounding Electrode Required

- Where the grounding electrodes described in 250.52(A) are **not present**, a grounding electrode must be installed
- Where none of these grounding electrodes exist, one or more of the grounding electrodes specified in 250.52(A)(4) through (A)(8) shall be installed and used
- These **“made” electrodes** can consist of rod, pipe, and plate electrodes, or other listed electrodes, or local metal underground systems or structures
- See 250.50 and 250.52(A)(4) through (A)(8)

250.52(A) Installed Grounding Electrodes

Where none of the grounding electrodes described in 250.52(A)(1) through (A)(7) are present, one or more of the grounding electrodes specified in 250.52(A)(4) through (A)(8) shall be installed and used [250.50]



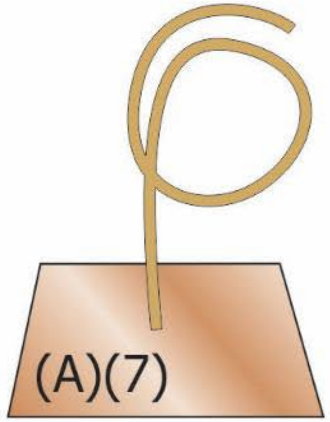
(A)(4) Ground ring (2 AWG minimum)

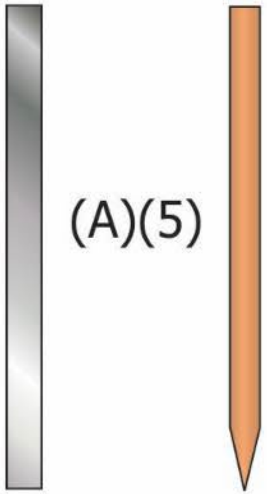
(A)(5) Rod and pipe electrodes

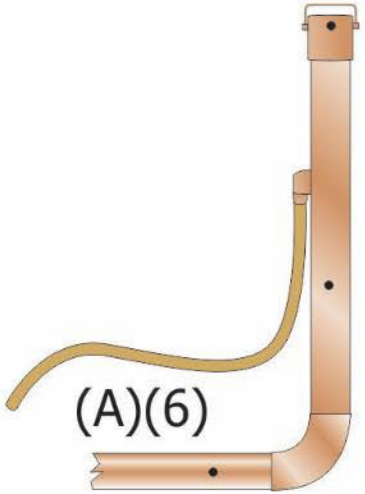
(A)(6) Other listed electrodes

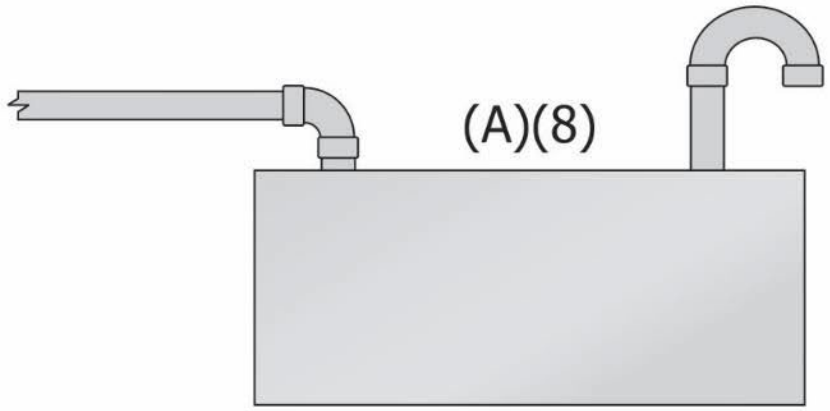
(A)(7) Plate electrodes

(A)(8) Local underground systems or sturctures





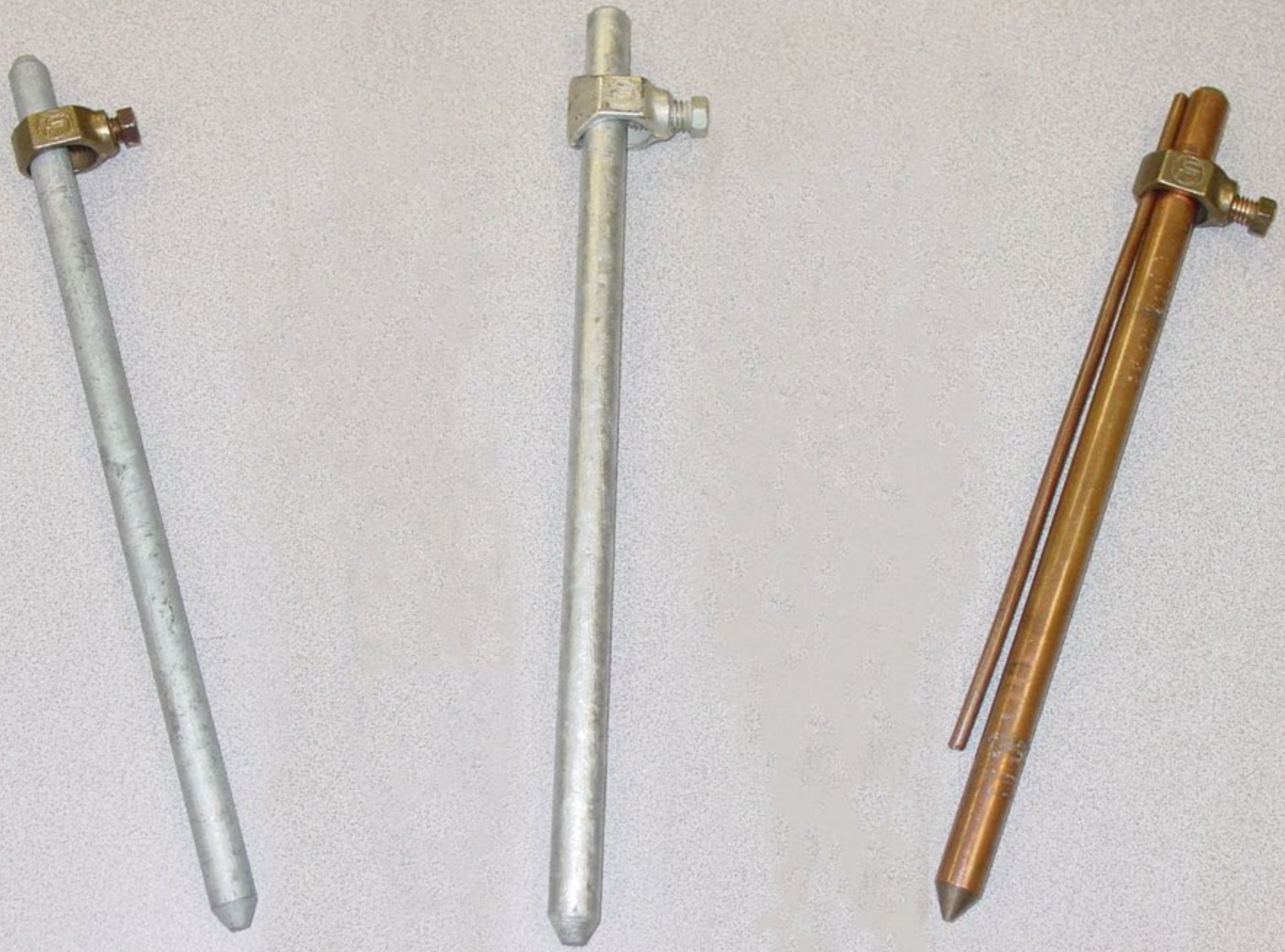




Copyright © IAEI 2020

250.52(A)(5) Rod or Pipe Electrodes

- Requirements or conditions a **rod and pipe electrode** must meet to qualify as a grounding electrode are as follows:
  - Not be less than 2.44 m (8 ft) in length
  - **Pipe or conduit grounding electrodes** must consist of the following materials:
    - Not smaller than metric designator 21 (trade size ¾)
    - Where of steel, outer surface must be galvanized or otherwise metal-coated for corrosion protection
  - **Rod-type grounding electrodes** must consist of the following materials:
    - Stainless or copper or zinc coated steel
    - At least 15.87 mm (⅝ in.) in diameter, unless listed



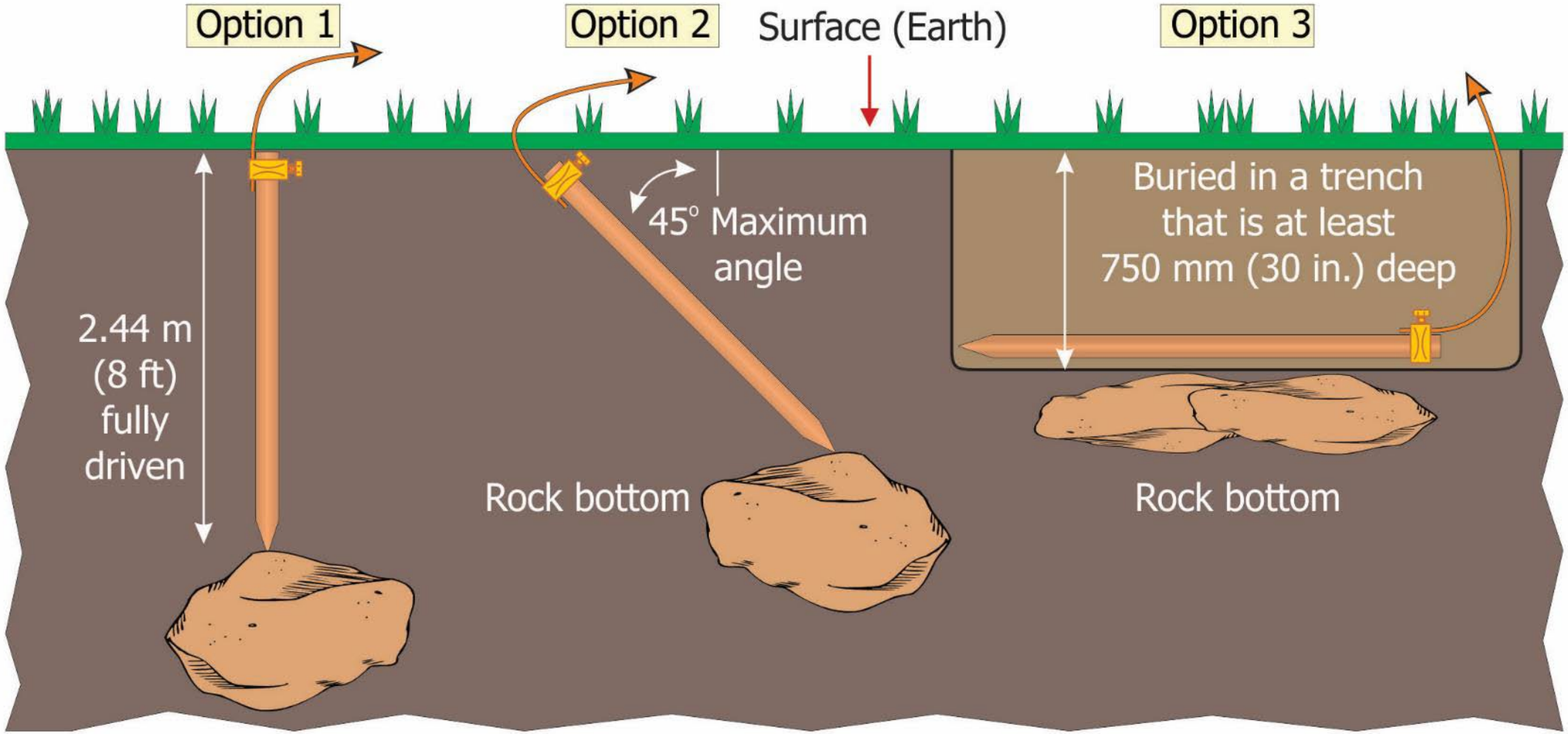
2081

Installation of Rod and Pipe Electrodes

- **Rod and pipe electrodes** required to be installed with least **2.44 m (8 ft)** is in contact with the soil
- Required to be **driven vertically** unless rock bottom is encountered
- If rock bottom is encountered *(preventing rod or pipe from being driven 2.44 m (8 ft) vertically)*, rod or pipe permitted to be installed at an **oblique angle** of not more than **45 degrees** from vertical
- Where driven at an angle cannot be achieved, only then can the rod or pipe be **buried in a trench** that is at least **750 mm (30 in.)** deep
- See 250.53(G)

250.53(A)(4) Installation of Rod or Pipe Electrodes

Rod or pipe electrodes must be installed such that at least 2.44 m (8 ft) of length is in contact with the soil (earth)



Copyright © IAEI 2020

Size of Bonding Jumper for Grounding Electrode System

- **Bonding jumper(s)** used to connect grounding electrodes of the grounding electrode system together required to be installed in accordance with the requirements of 250.64(A), (B), and (E)
- Bonding jumper(s) used to bond grounding electrodes together required to be sized in accordance with 250.66
- Sizes based on the size of ungrounded service-entrance conductors
- Connections to be made in a manner specified in 250.70
- See 250.53(C)

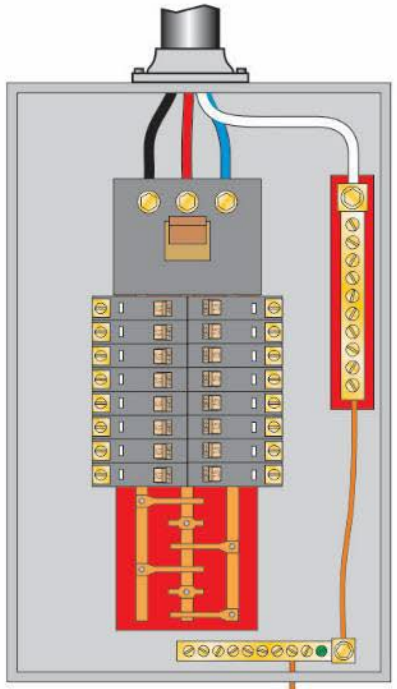
Size of Bonding Jumper for Grounding Electrode System *(cont.)*

- Conductor(s) connecting grounding electrodes together is a **bonding conductor** *(not a grounding electrode conductor)*
- These bonding conductors not required to be installed in "one continuous length" *(as per grounding electrode conductors)*
- Conditions for sizing the grounding electrode conductor at **250.66(A), (B), and (C)** apply for sizing of these bonding jumpers

250.53(C) Bonding Jumper(s) for Grounding Electrode System

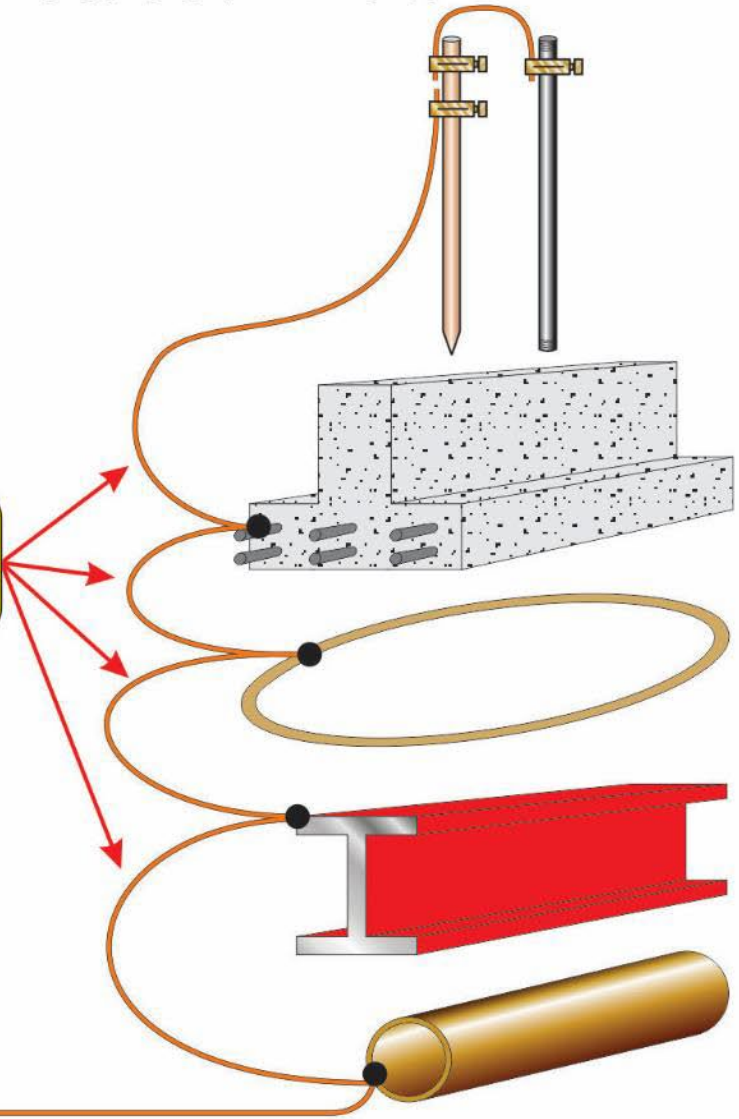
Bonding jumper(s) used to connect grounding electrodes together to form the grounding electrode system shall be installed in accordance with 250.64(A), (B) , and (E), and sized in accordance with 250.66

Service equipment



Size bonding jumpers in accordance with 250.66, Table 250.66, and/or 250.66(A), (B), and (C)

Bonding jumpers between grounding electrodes

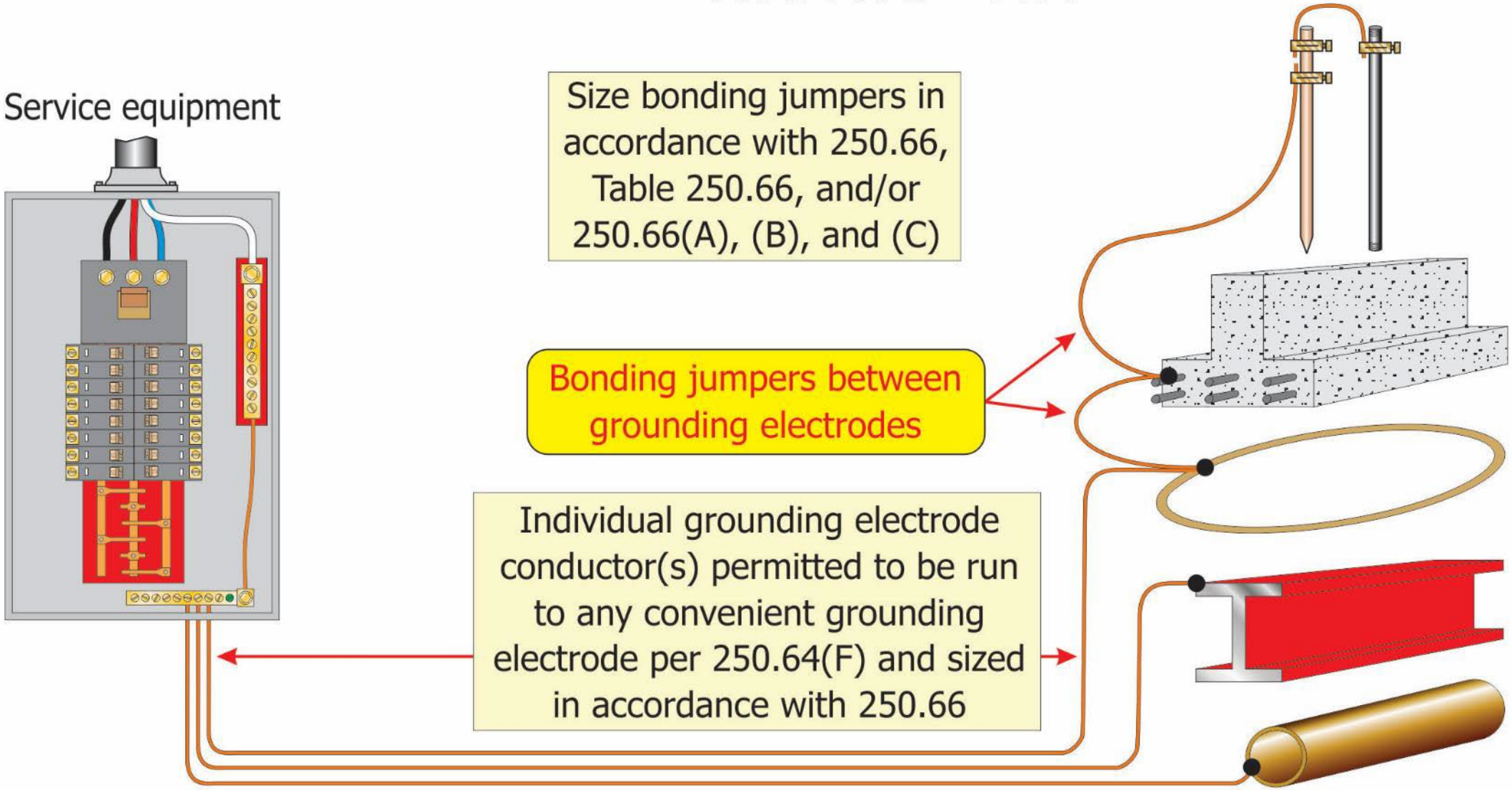


Grounding electrode conductor sized per 250.66

Copyright © IAEI 2020

250.64(F) Individual Grounding Electrode

Grounding electrode conductor(s) and bonding jumpers interconnecting grounding electrodes shall be installed in accordance with 250.64(F)(1), (F)(2), or (F)(3)



Copyright © IAEI 2020

Supplemental Electrode

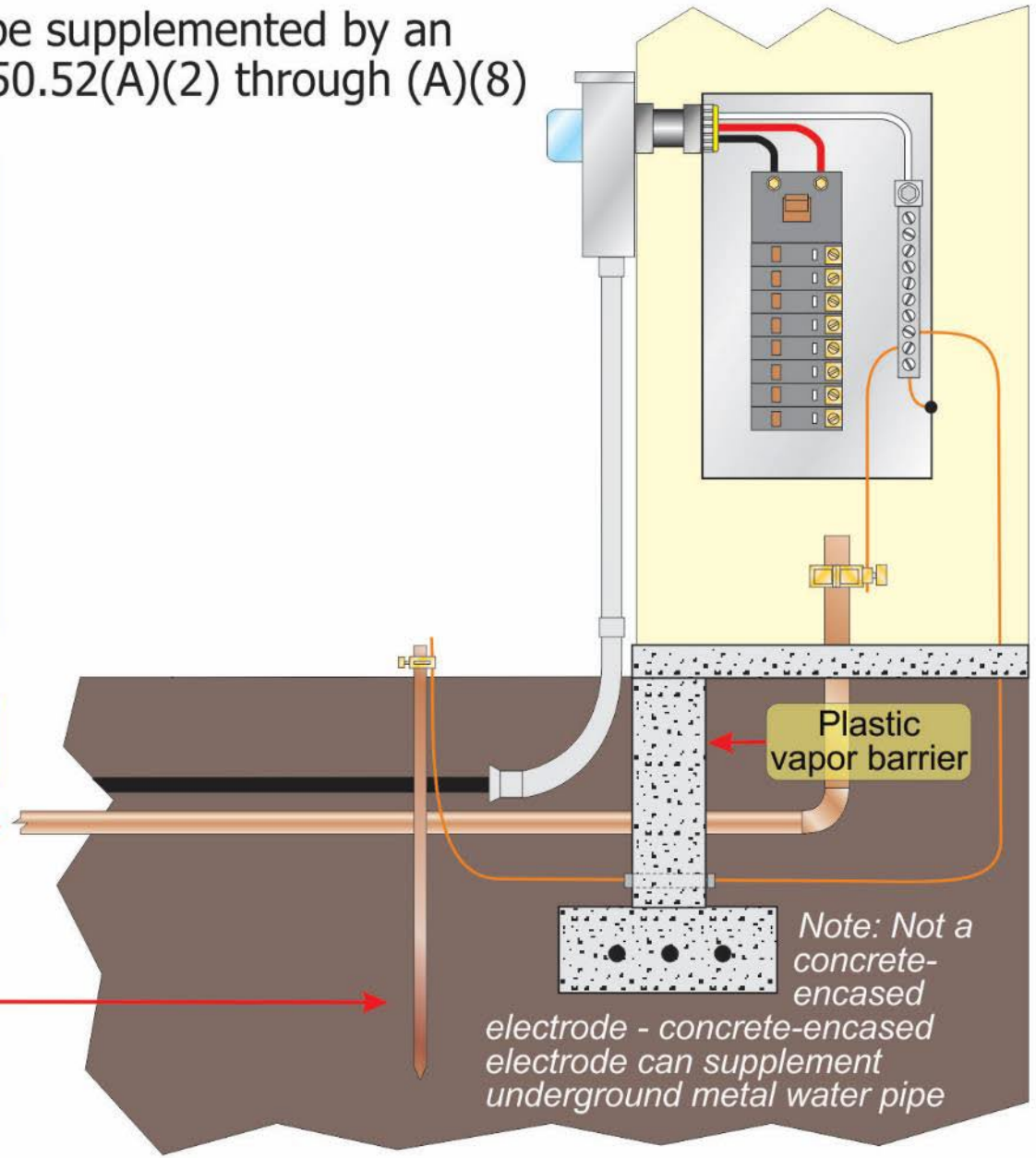
- An **underground metal water pipe** electrode is required to be supplemented by an additional grounding electrode
- Any of the electrodes described in 250.52(A)(2) through (A)(8) are permitted to be used *(not limited to just a ground rod)*
- If the supplemental electrodes are of the rod, pipe, or plate types, these must be supplemented as well or must meet the 25 ohms rule at 250.53(A)(2), Exception
- See 250.53(D)(2)

250.53(D)(2) Supplemental Electrode Connection

Metal underground water pipe is required to be supplemented by an additional electrode of the type specified in 250.52(A)(2) through (A)(8)

Supplemental grounding electrode shall be bonded to one of the following:

- Grounding electrode conductor
- Grounded service-entrance conductor
- Nonflexible grounded service raceway
- Any grounded service enclosure
- As provided by 250.32(B)



If the supplemental grounding electrode is a single rod, pipe, or plate, must be supplemented as well or must meet 25-ohm rule *[250.53(A)(2) and Exception]*

Copyright © IAEI 2020

Other Listed Electrodes

- The definition of a “Grounding Electrode” in Article 100 opens up the possibilities of a **“conductive object”** that can be a grounding electrode
- 250.52(A) contains the descriptions of what “conductive objects” that are considered acceptable electrodes
- **Other listed grounding electrodes** are available and permitted
- These products provide a viable alternative when the soil conditions are so poor that the typical electrode(s) will not provide the effectiveness needed
- See 250.52(A)(6)

250.52(A)(6) Other Listed Electrodes

- Other listed grounding electrodes shall be permitted to be used such as a chemical grounding electrode system
- Required to be listed as grounding and bonding equipment [UL 467]



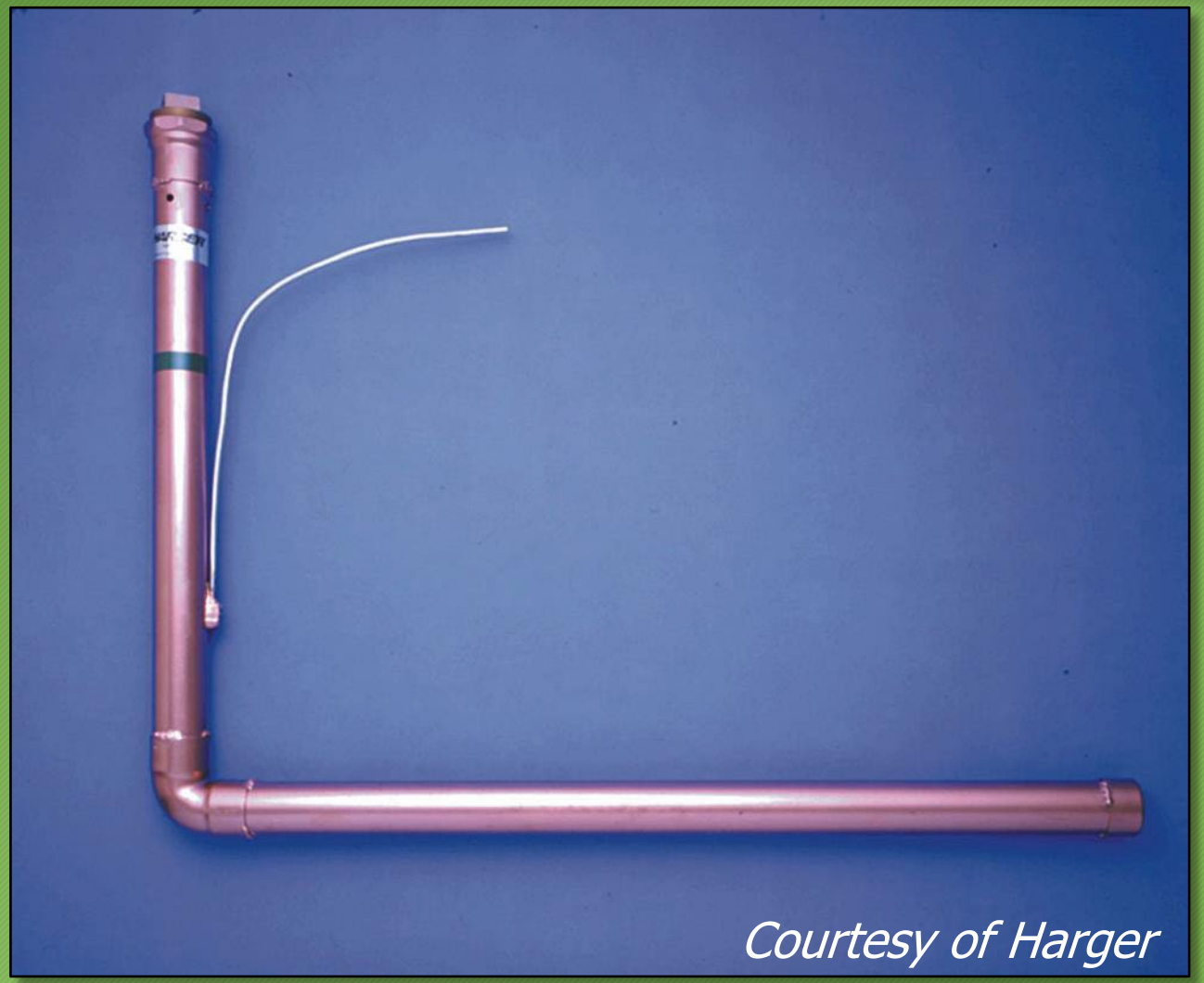
Courtesy of ERICO International

Enhanced Grounding Electrodes

- Minimum requirements for grounding electrodes for use in grounding services, systems, and equipment are covered in Part III of Article 250
- Ever-increasing installations using **information technology equipment** and **sensitive electronics** sometimes drive the need to exceed the minimum requirements established for safety of persons and property
- Installing electrodes or electrode systems that are extensive in nature and designed to establish and maintain a **lower level of resistance** to earth through the electrode or electrode system can accomplish this need
- Listed products are available to accomplish this additional grounding when desired for the electrical system
- Provisions for **other listed electrodes** are addressed at 250.52(A)(6)

250.52(A)(6) Other Listed Electrodes

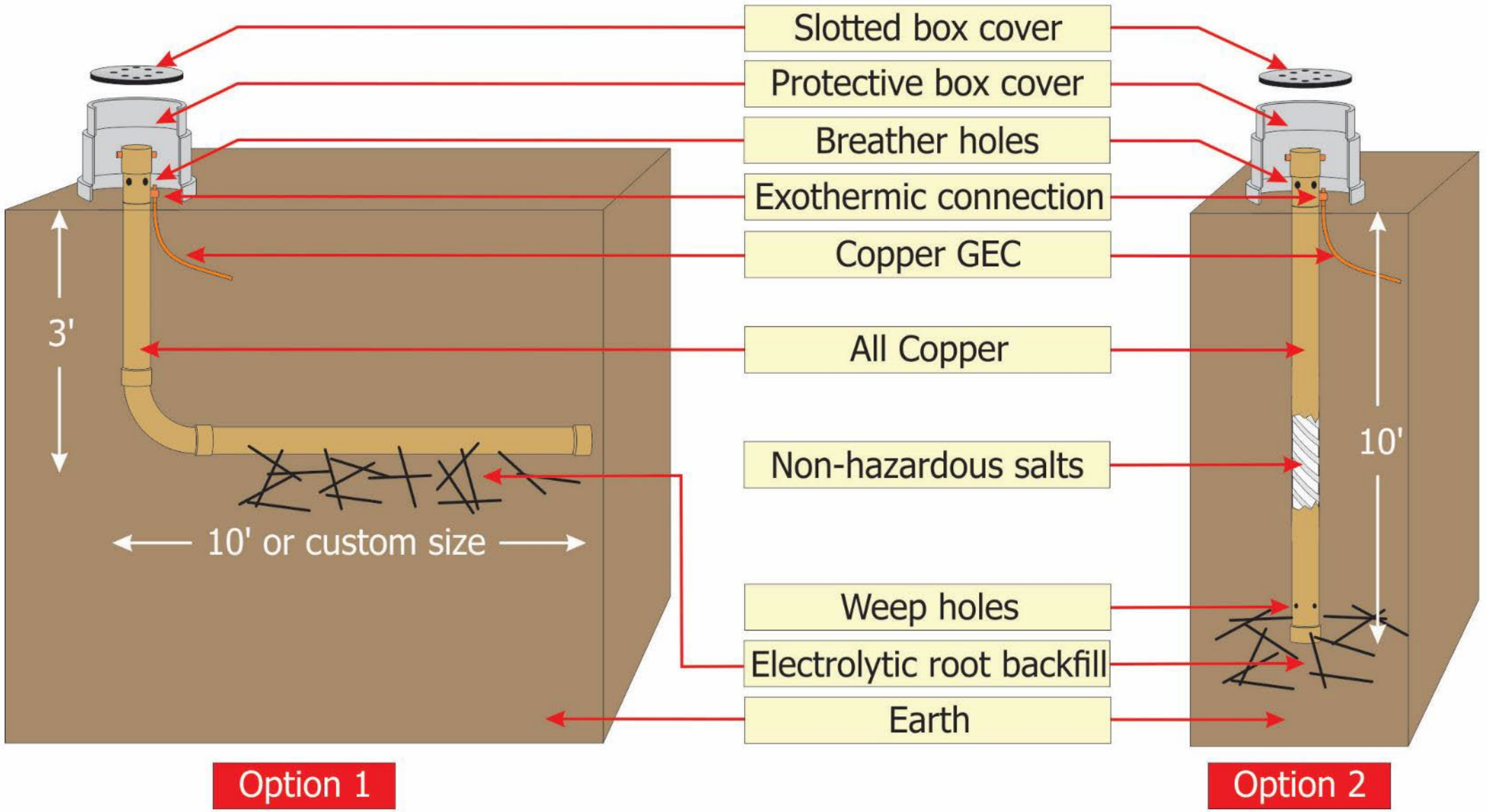




Courtesy of Harger

Enhanced Grounding Electrodes

Enhanced Grounding Electrode - Anatomy



Concept courtesy of Lyncole XIT

Copyright © IAEI 2020

Ground Electrode System Monitoring

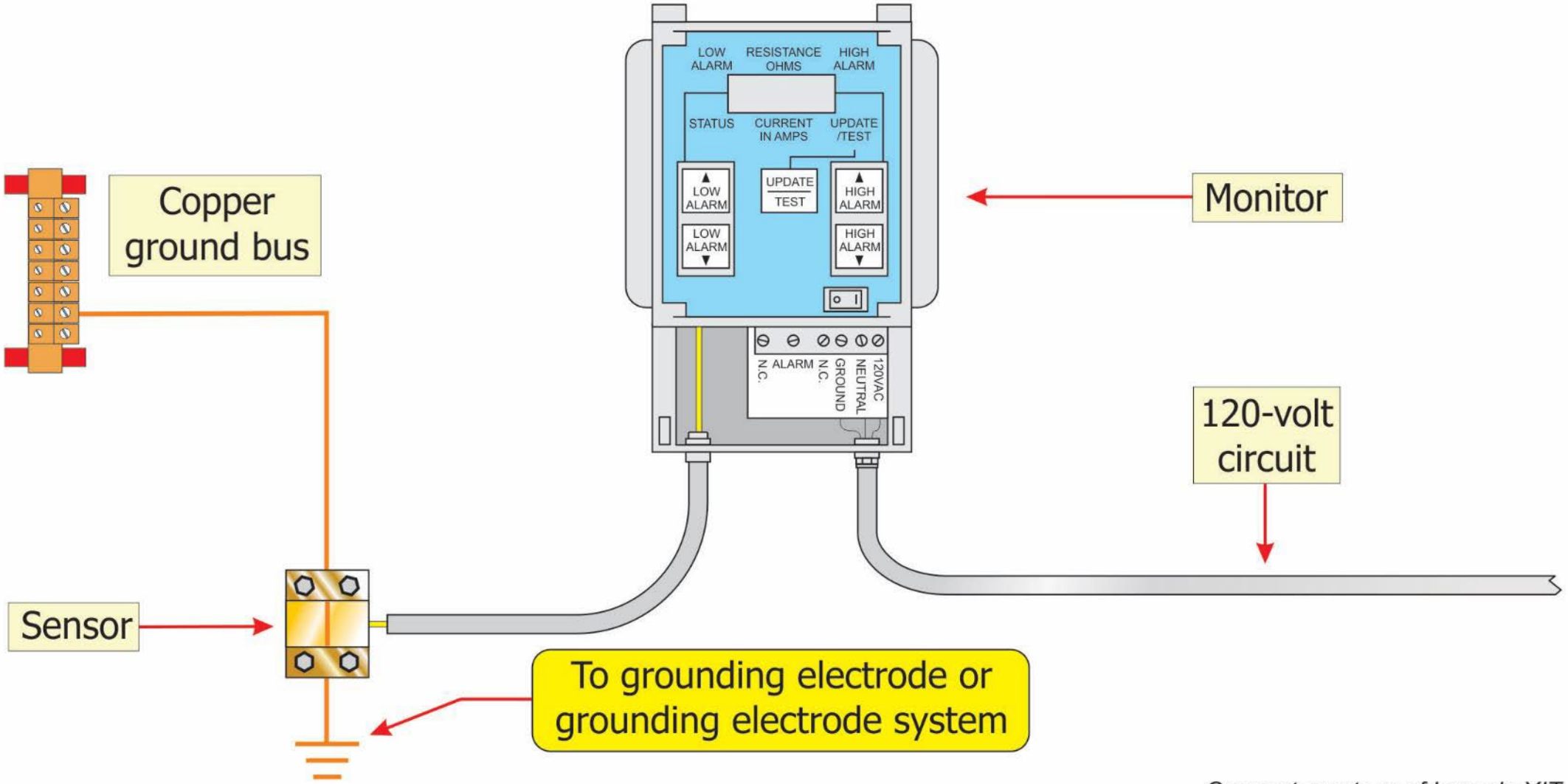
- **Grounding electrode system monitoring** has become common where **information technology equipment** and other **sensitive electronic equipment** are utilized
- Not required by the *Code*
- Often desired as an **essential performance option** for data centers and similar facilities
- Measures grounding system performance on an ongoing basis
- Provides an early warning of ground system degradation or loss of integrity so remedial action can be taken
- Grounding is an integral part of safety as well as center of lightning protection and surge suppression systems

Ground Electrode System Monitoring *(cont.)*

- Features of **grounding electrode system monitoring systems** include but are not limited to:
  - Ongoing monitoring of ground system resistance and current
  - Remote reading and control capability
  - Local audible alarm
  - High and low alarm values
  - Adjustable sampling rate

Ground Resistance Monitor System

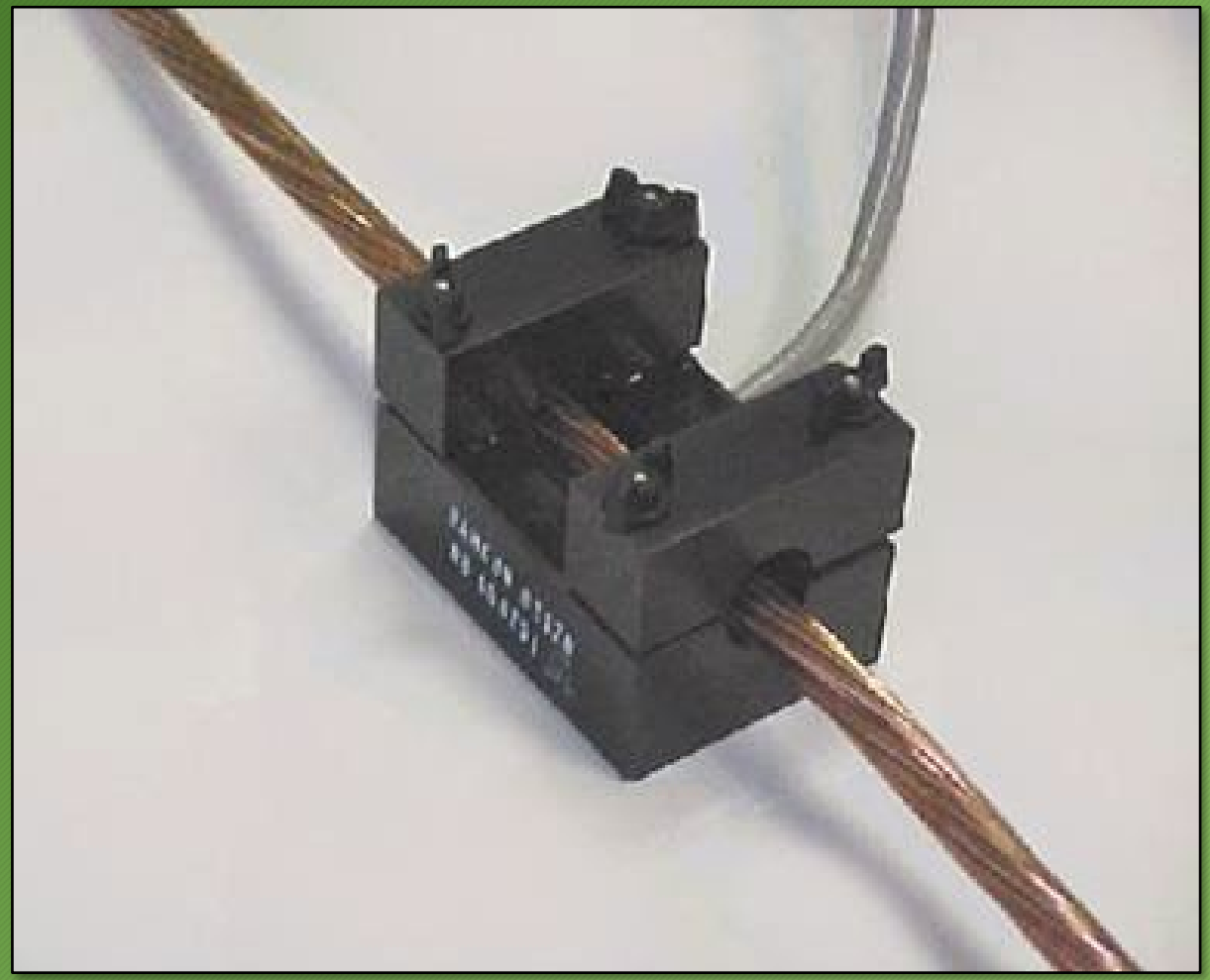
Grounding electrode system resistance monitoring equipment measures the grounding system performance on an ongoing basis and provides an early warning of ground system degradation or loss of integrity so remedial action can be taken



Copyright © IAEI 2020

Concept courtesy of Lyncole XIT

Ground Resistance Monitor System





Common Grounding Electrode

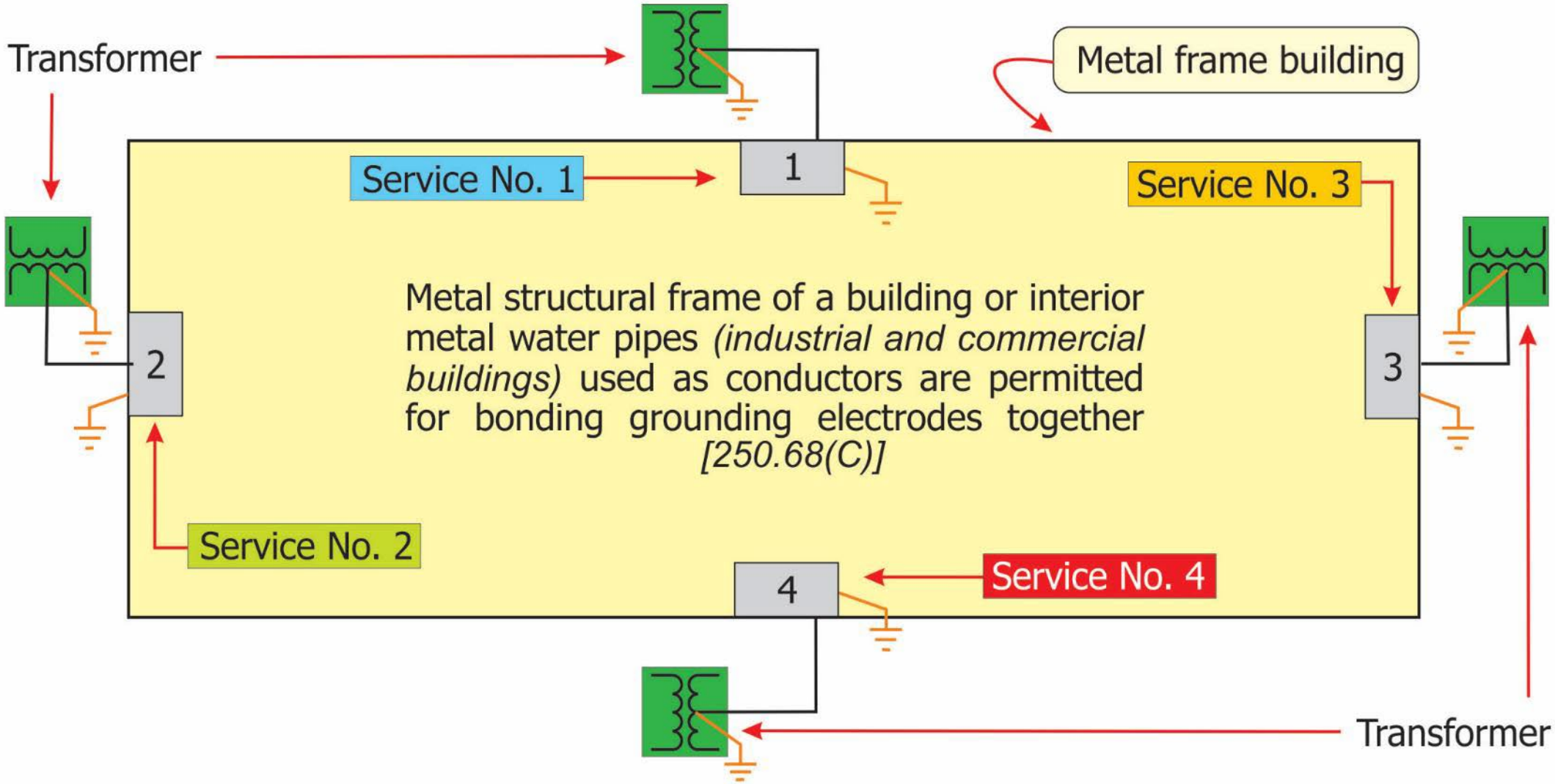
- Where more than one service supplies a building or structure, often there are more than one utility transformer or source *(which can have differences of potential between them)*
- Where more than one service are installed in the same building or structure, they must use the same grounding electrode system
- **Common grounding electrode** required to be used for all ac system grounding in or at a building or structure
- Where two or more grounding electrodes are bonded together, considered to be a **single grounding electrode system**
- See 250.58 and 250.50

Common Grounding Electrode *(cont.)*

- The *Code* does not specify a maximum distance between electrodes beyond which the electrodes do not have to be bonded together
- Buildings or structures of large area permitted to have more than one service *[230.2(B)(2)] (Code does not define dimensions of a large building or structure)*
- This bonding is important to keep all the equipment at the same earth potential
- Permitted to use the structural metal frame of a building as a bonding conductor
- Concrete-encased electrode (rebar) not permitted to interconnect other electrodes *[250.68(C)(3)(c)]*

250.58 Common Grounding Electrode

The same grounding electrode(s) must be used for all services, feeders, and branch circuits



Two or more electrodes bonded together are considered one grounding electrode system

Copyright © IAEI 2020

Earth Prohibited as Return Path

- In discussing grounding electrodes, notice that no mention is made for providing a low-resistance, low-impedance common grounding electrode path for clearing ground faults
- The high impedance of the earth makes it an **ineffective path** for the levels of current common to power systems
- The earth should never be used as a ground fault current path, as it is a very poor conductor
- See 250.4(A)(5)

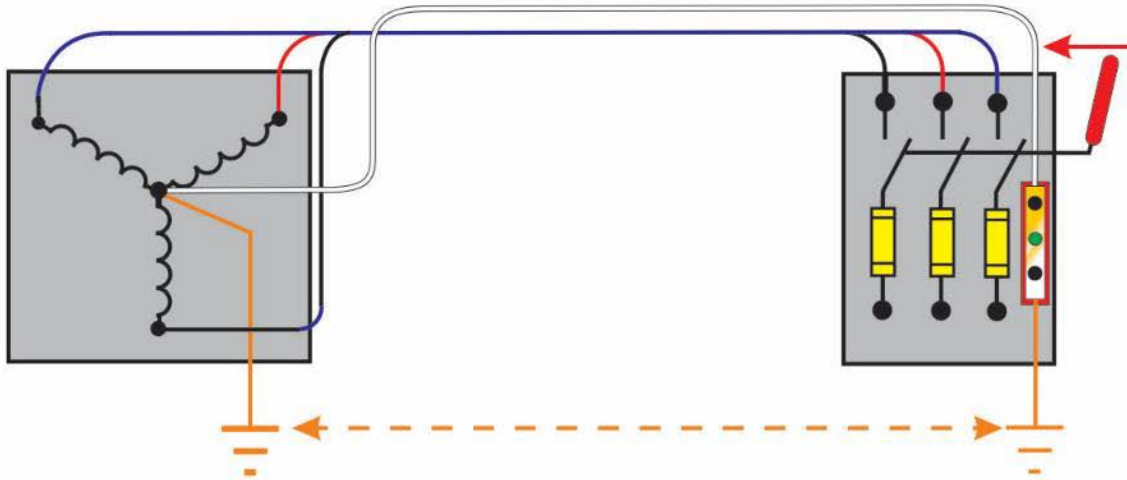
250.4(A)(5) Earth Return Prohibited



Ground fault at service attempts to return to source *(transformer)* through the **high-impedance path** through the earth *(ineffective and not permitted)*

High-impedance path

Low-impedance path



A **low-impedance path** for clearing ground faults is provided through the grounded service conductor

Copyright © IAEI 2020

Resistance of Grounding Electrodes

- No requirement in the *Code* that all grounding electrodes meet any maximum resistance to ground
- It is expected that the grounding electrode system will have a resistance to ground of **25 ohms or less**
- The *Code* specifies a resistance of 25 ohms or less *only* for single rod, pipe, or plate electrode(s)
- Where the resistance of a single rod, pipe, or plate electrode exceeds 25 ohms, required to be **supplemented** by an additional electrode *(other than a metallic water pipe electrode)*

Resistance of Grounding Electrodes *(cont.)*

- Rod, pipe and plate electrodes must be **supplemented** by additional electrode *[250.53(A)(2)]*
- Exception provides that where a single rod, pipe, or plate electrode has a resistance to ground of **25 ohms or less** then no supplemental electrode is required
- Where driven ground rods are installed, two ground rods would be the maximum required under any condition
- No requirement that additional electrodes *(such as ground rods or plates)* be installed until the 25 ohms-to-ground resistance is obtained

250.53(A)(2) Rod, Pipe, and Plate Electrodes

A single rod, pipe or plate electrode required to be supplemented by an additional electrode as specified in 250.52(A)(2) through (A)(8)

The supplemental electrode permitted to be bonded to one of the following:

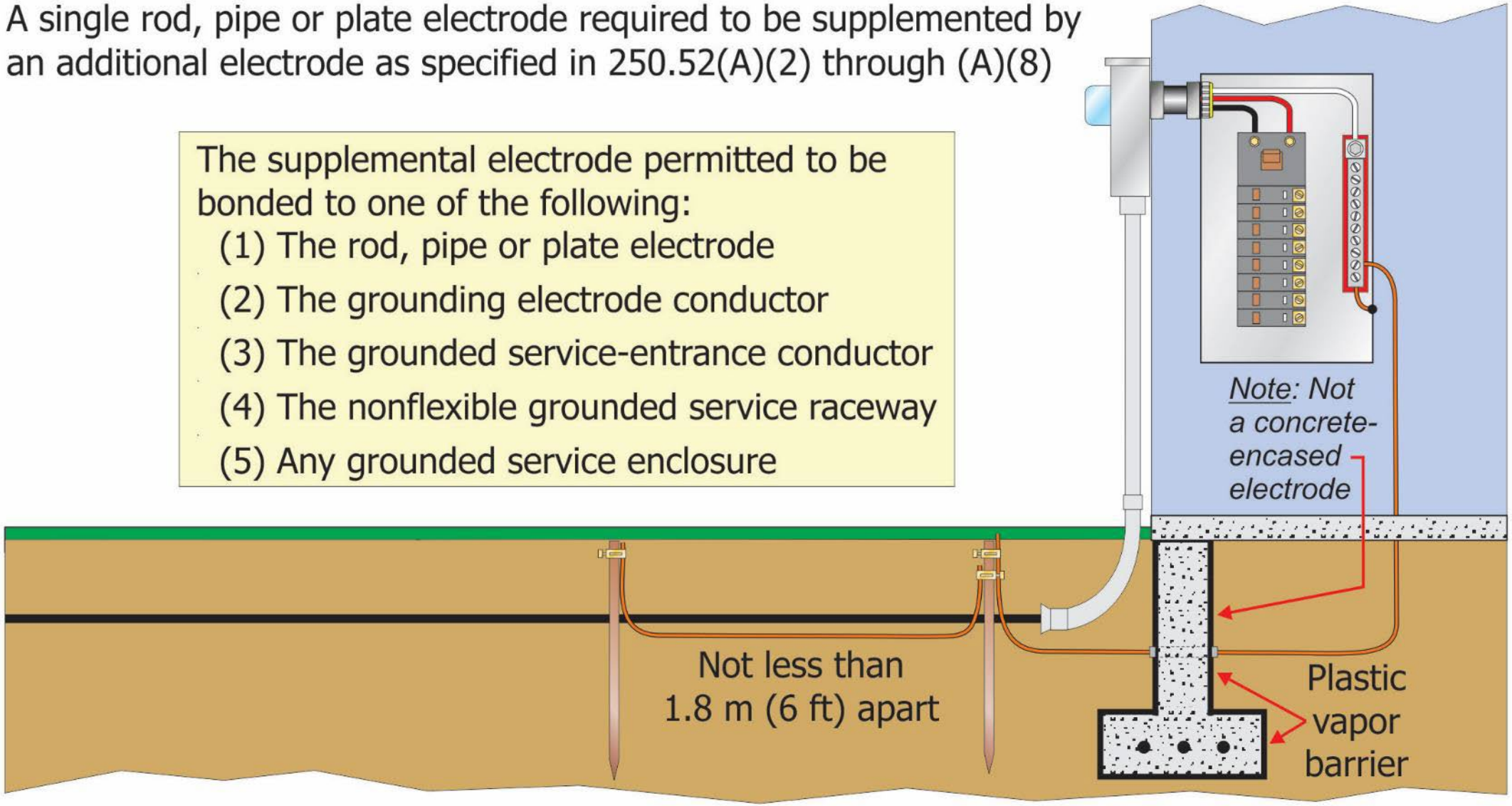
(1) The rod, pipe or plate electrode

(2) The grounding electrode conductor

(3) The grounded service-entrance conductor

(4) The nonflexible grounded service raceway

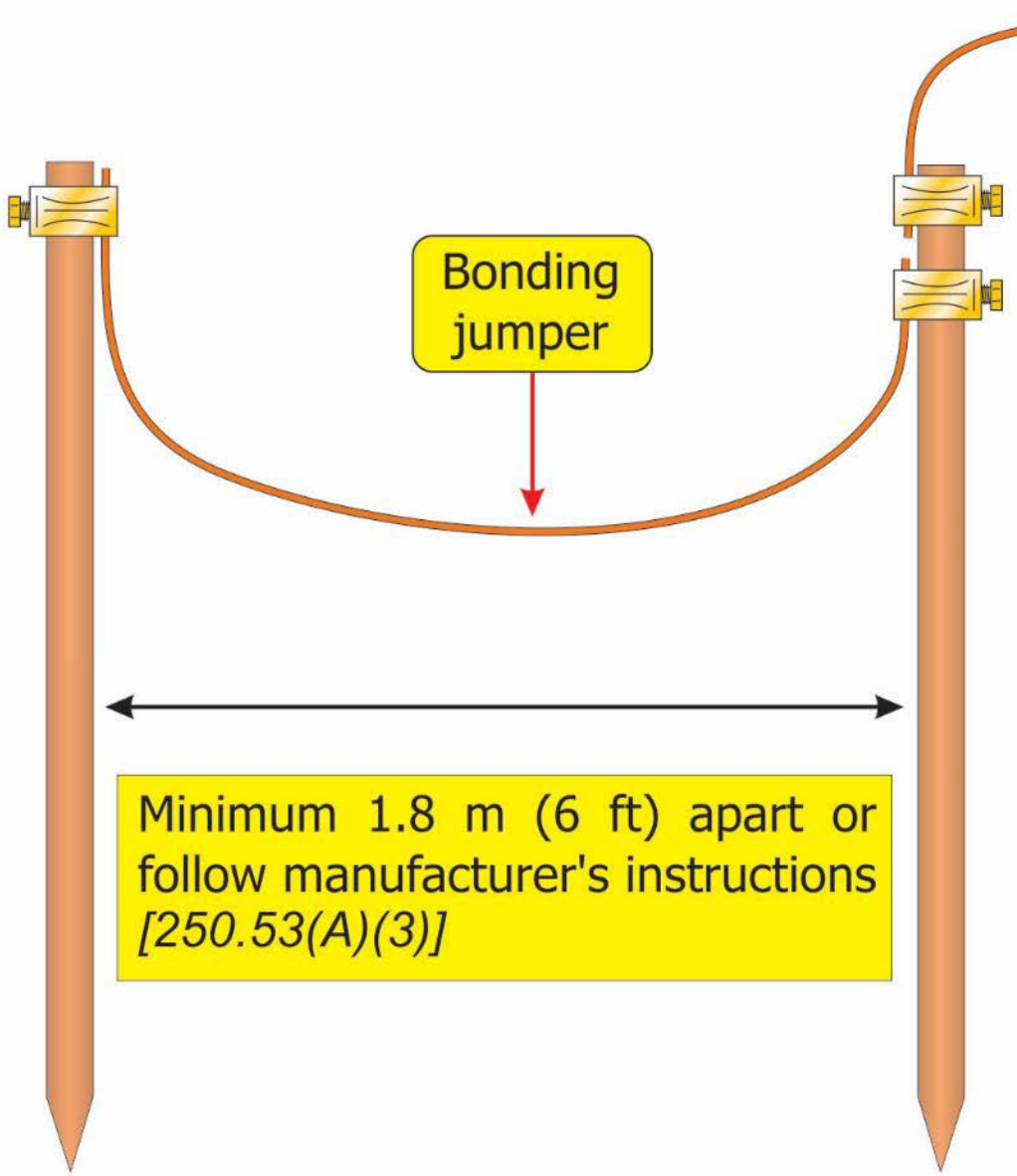
(5) Any grounded service enclosure



Exception: *If a single rod, pipe, or plate grounding electrode has a resistance to earth of* ***25 ohms or less****, the supplemental electrode shall not be required*

Copyright © IAEI 2020

250.53(A) Resistance of Rod, Pipe, and Plate Electrodes



A single rod, pipe or plate electrode required to be supplemented by an additional electrode as specified in 250.52(A)(2) through (A)(8)

No resistance measurement required for rod, pipe, and plate electrodes after these electrodes have been supplemented

Copyright © IAEI 2020

Ground Electrode Resistance

- Grounding electrodes maintain a reference potential for:
  - Instrument safety
  - Protect against static electricity,
  - Limit the system-to-frame voltage for operator safety
- Ground resistance should be zero ohms *(ideally)*
- Low ground resistance is essential to meet *NEC*, OSHA, and other electrical safety standards

Ground Electrode Resistance *(cont.)*

- Resistance of the electrode has the following components:
  - Resistance of the metal and that of the connection to it
  - Contact resistance of the surrounding earth to the electrode
  - Resistance in the surrounding earth to current *(earth resistivity)*, which is often the most significant factor

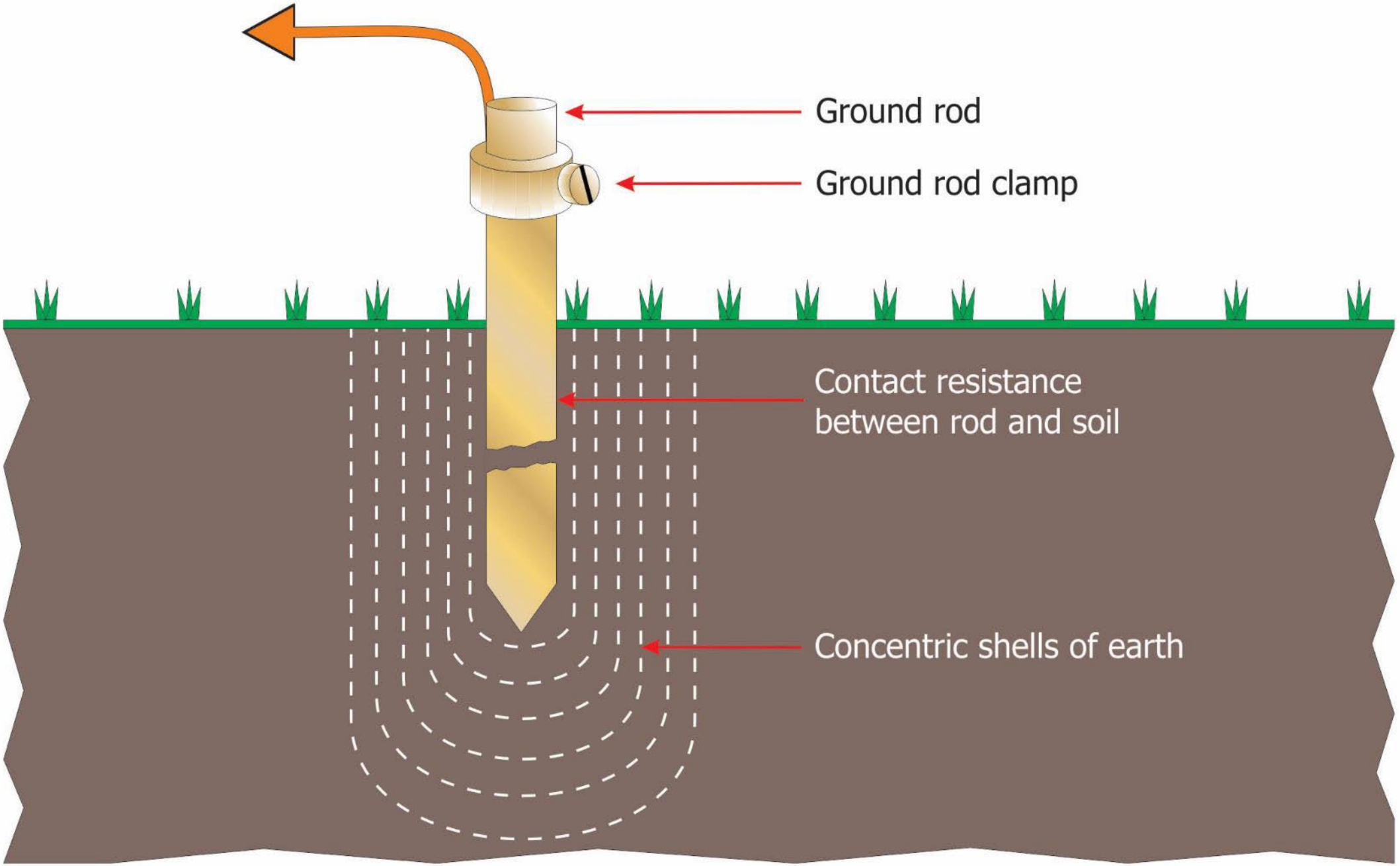
Ground Electrode Resistance *(cont.)*

- Grounding electrodes are usually made of very conductive material with adequate cross sections so overall resistance is negligible
  - Copper, copper clad, or zinc plated *(galvanized)*
- NIST *(National Institute of Standards and Technology)* has demonstrated that resistance between the surrounding earth and the electrode is negligible if electrode is:
  - Free of paint, grease or other coating and…
  - Earth is firmly packed

Ground Electrode Resistance *(cont.)*

- The electrode can be thought of as being surrounded by **concentric shells of earth** or soil, all of the same thickness
- Closer the shell is to the electrode, the smaller its surface ***(greater its resistance)***
- Farther away the shells are from the electrode, the greater the surface of the shell ***(lower the resistance)***

Ground Rod Resistance

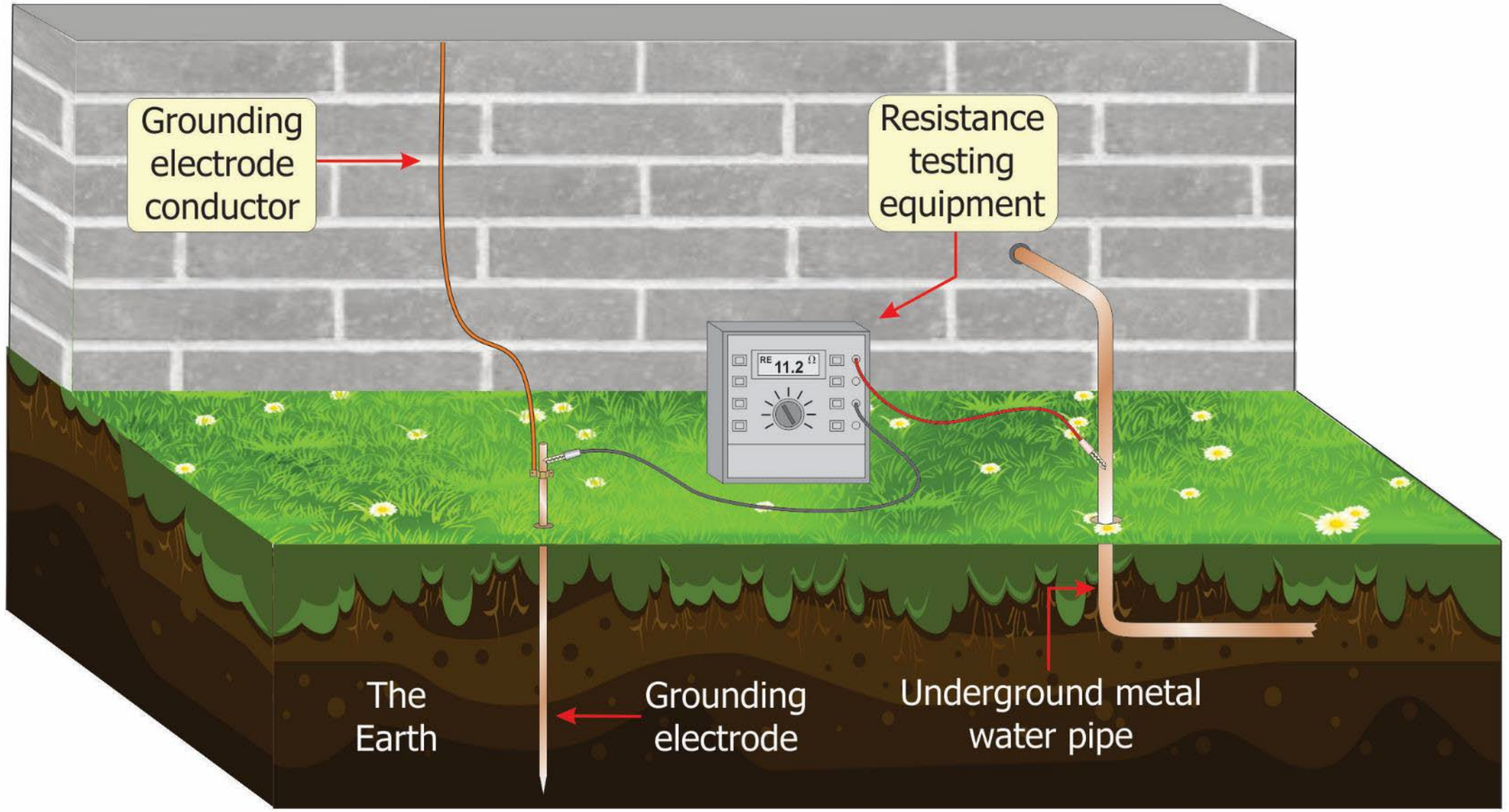


Copyright © IAEI 2020

Grounding Electrode Resistance Testing

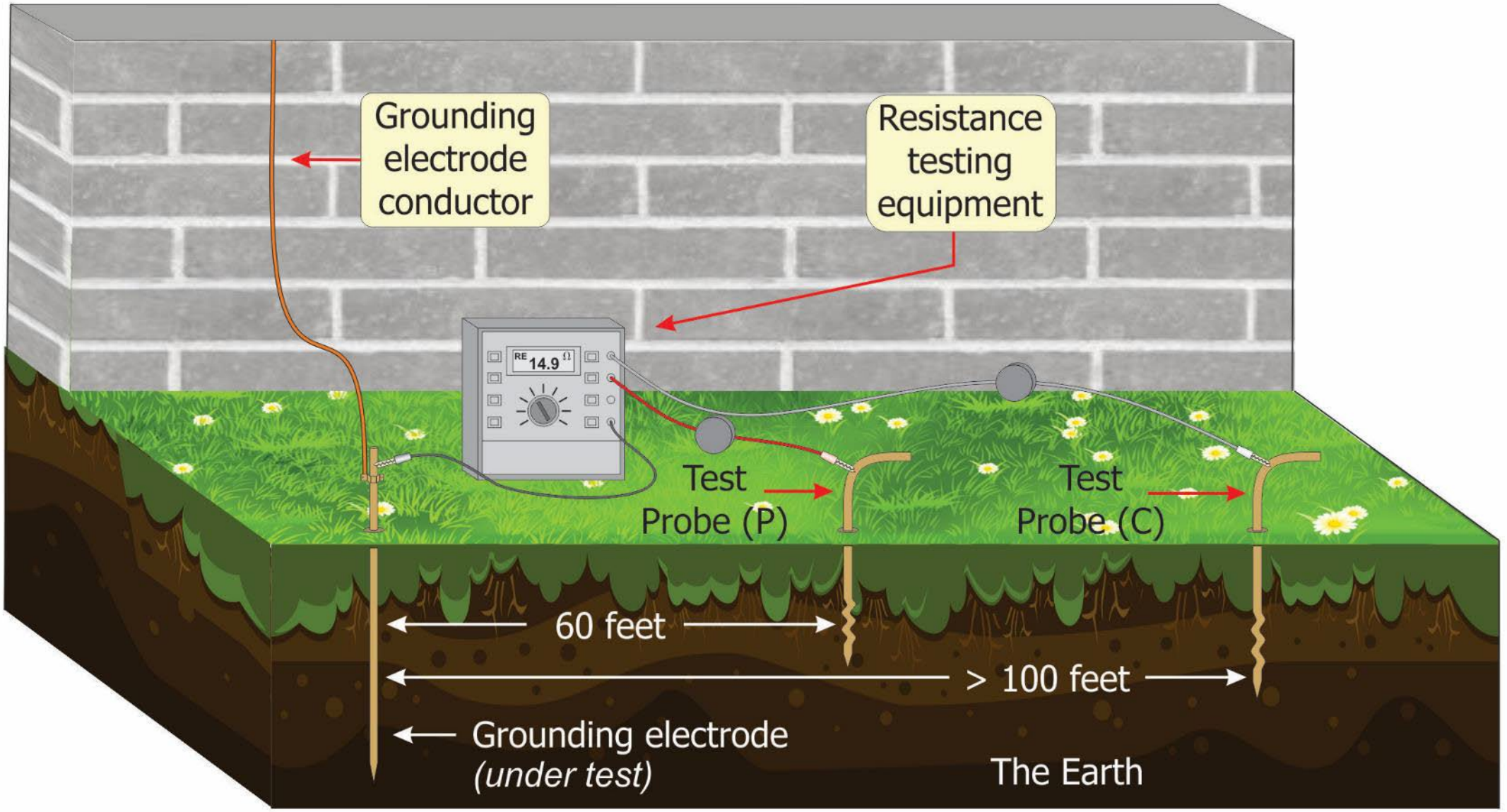
- Measurement of ground resistances can only be accomplished with specially designed test equipment
- Most ground resistances instruments use the **fall-of-potential principle** of alternating current (ac) circulating between an auxiliary electrode and the grounding electrode under test
- Reading will be given in ohms
- Ohms represent the resistance of the ground electrode to the surrounding earth
- Some manufacturers of earth resistance testing instruments have introduced **clamp-on ground resistance testers**

Two-Point Resistance Measurement Method



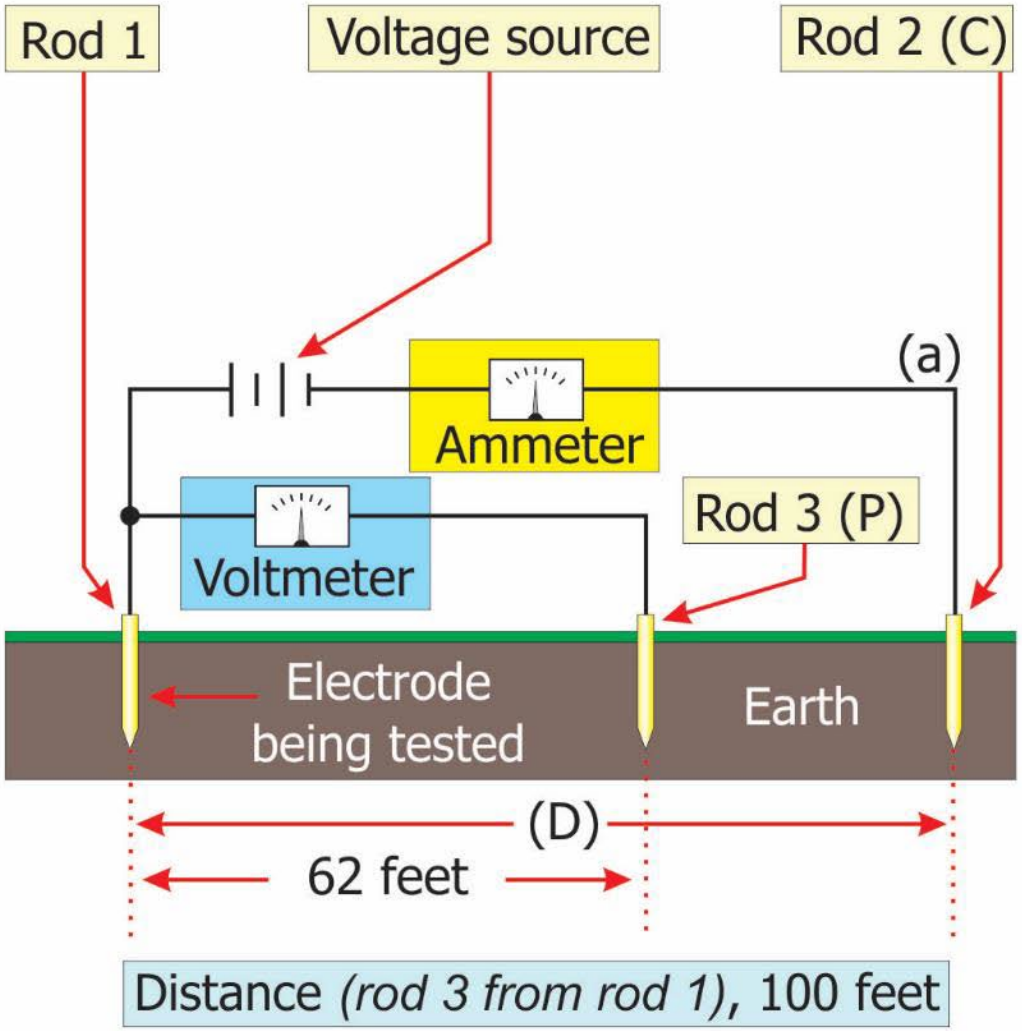
Copyright © IAEI 2020

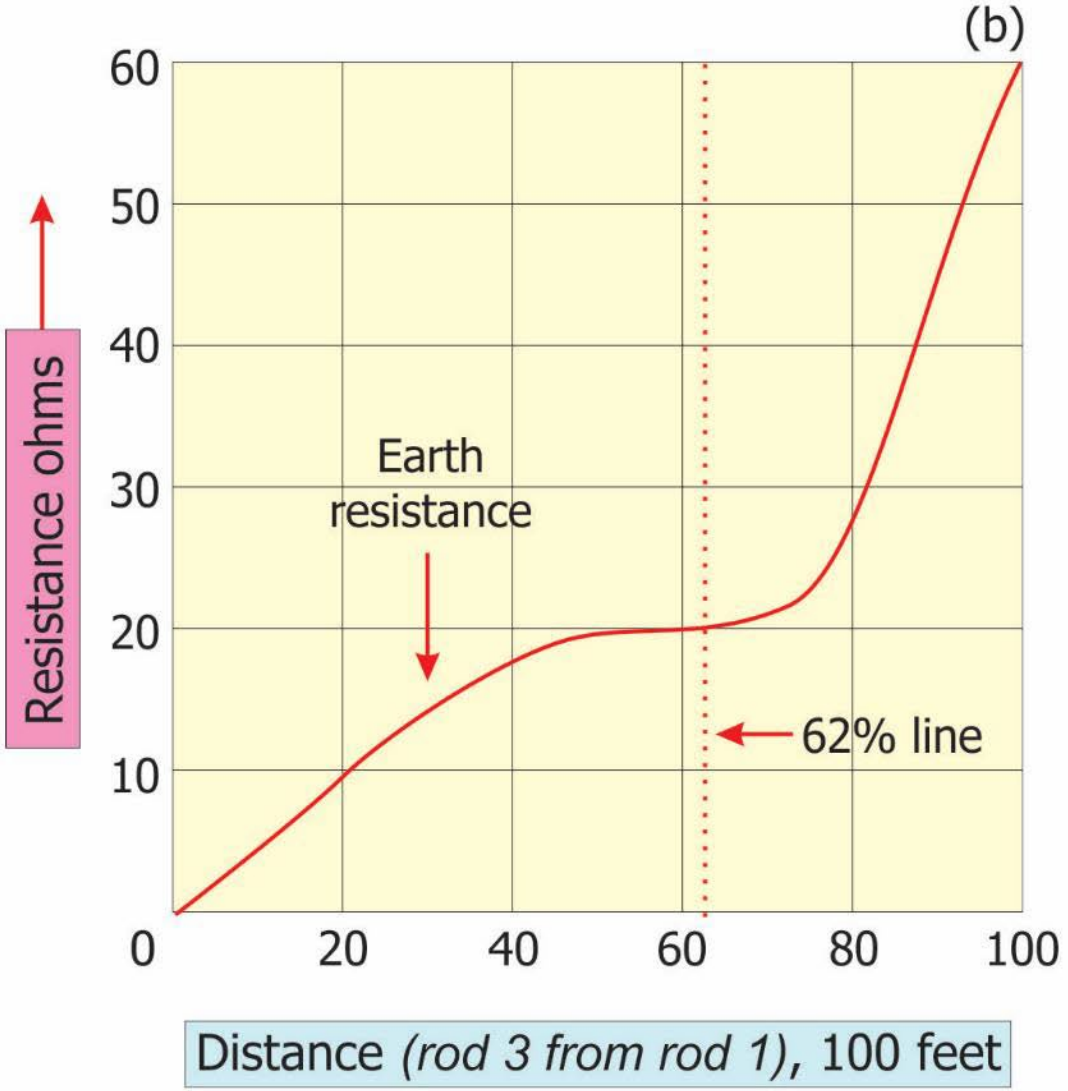
Three-Point Fall-of-Potential Test Method



Copyright © IAEI 2020

Principles of Earth Testing





Copyright © IAEI 2020

Ground Resistance Clamp-on Tester



Courtesy of Megger



Objectionable Currents

- The term ***objectionable current*** is not defined
- Objectionable current created due to the installation, equipment and operating conditions
- Certain installation conditions can exist which can cause **objectionable current** through the grounding electrode conductor or equipment grounding conductor
- The *Code* points out that temporary currents resulting from **accidental conditions** *(such as ground-fault currents)* that occur only while the grounding electrode or equipment grounding conductors are performing their **intended protective functions** are **not considered objectionable currents**

Objectionable Currents *(cont.)*

- Steps permitted to correct ***objectionable currents***:
  - If due to multiple grounds, one or more, but not all, of such grounds may be discontinued
  - Change location of grounding connection
  - Interrupt continuity of grounding conductor or conductive path causing the objectionable current
  - Other means acceptable to the authority having jurisdiction (AHJ)
- See 250.6

Lightning Protection System

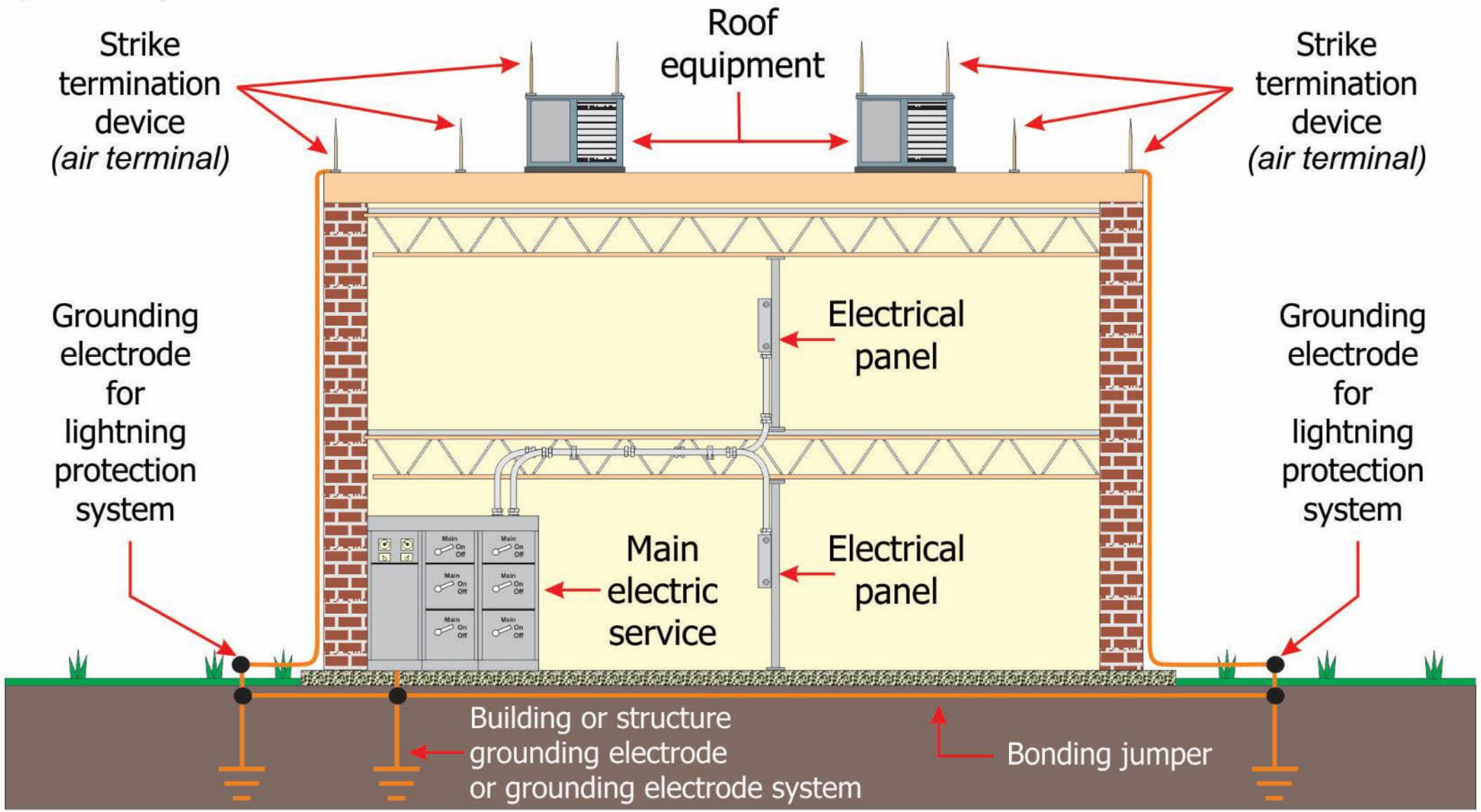
- Lightning protection systems should be installed in accordance with **NFPA-780, *Standard for the Installation of Lightning Protection Systems***
- The *Code* does not provide information on the **design or installation requirements** for lighting protection systems *(other than the required interconnection of the different grounding electrode systems for both the lightning and building systems)*
- The *Code* prohibits the use of conductors, driven pipes, rods, or plates, or other electrodes installed for connection of the lightning protection strike termination devices in place of the grounding electrodes required for a wiring system and for equipment
- See 250.60

Lightning Protection System *(cont.)*

- Two grounding electrode systems required:
  - One for the lightning protection system *(NFPA 780)*
  - One for the building electrical system *(NFPA 70 – NEC)*
- Note that where these two grounding electrode systems are installed, they are required to be **bonded together**
- Lightning protection grounding electrode system *required* be bonded to the building or structure power grounding electrode system
- See 250.106

250.106 Bonding of Grounding Systems Together

Bonding of building grounding electrode system to strike termination device of lightning protection system required



Copyright © IAEI 2020

CHAPTER EIGHT

GROUNDING ELECTRODE CONDUCTORS (GEC)



Grounding Electrode Conductors

- ***Grounding electrode conductors*** used to connect the following to a grounding electrode or a point on grounding electrode system:
  - Electrical system grounded conductor
  - Equipment grounding conductor
  - or both,
- Required to be sized per Table 250.66 based on size of the service-entrance conductors or largest derived ungrounded conductors of a separately derived system
- Not required to exceed **3/0 AWG copper** or **250-kcmil aluminum or copper-clad aluminum**

Grounding Electrode Conductors *(cont.)*

- ***Grounding Electrode Conductor:*** A conductor used to connect the system grounded conductor or the equipment to a grounding electrode or to a point on the grounding electrode system. *(NEC Article 100)*
- Specific requirements for ***grounding electrode conductors*** given regarding:
  - Conductor material
  - Installation procedures
  - Protection from physical damage
  - Connection procedures

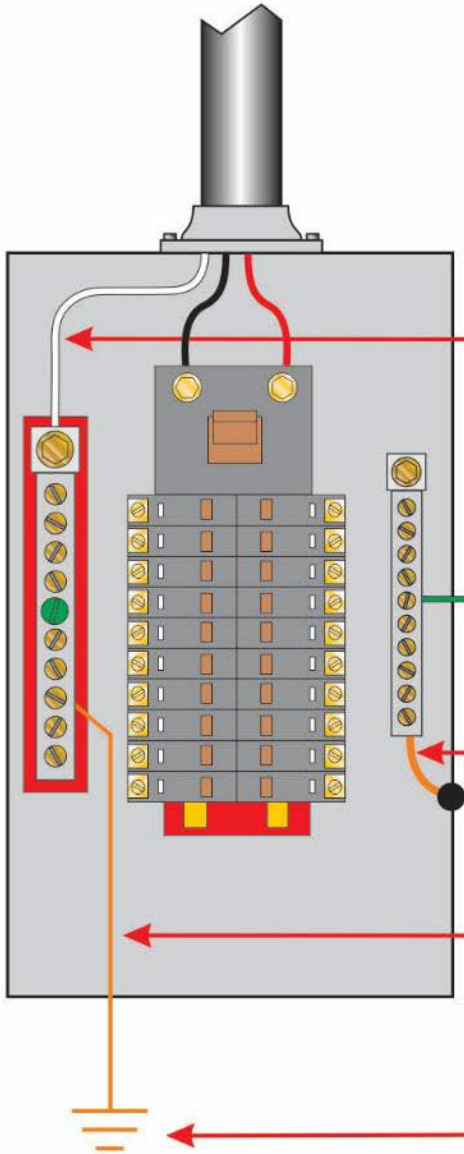
Function of the Grounding Electrode Conductor(s)

- In a **grounded system**, GEC is the sole connection from the grounding electrode to the grounded system conductor *(may be a neutral)* and the equipment grounding conductor(s)
- For an **ungrounded system**, sole connection from the grounding electrode to the service equipment or building disconnect enclosure and to the equipment grounding conductor(s)
- See 250.24(A), (D), and (E)

Function of the Grounding Electrode Conductor(s) *(cont.)*

- A **single grounding electrode conductor** is required to connect both the system grounded conductor and the equipment grounding conductor
- Example: One grounding electrode conductor cannot be used to ground the system grounded conductor and a second grounding electrode conductor be used to ground the equipment grounding conductor *(even though both grounding electrode conductors are connected to the same grounding electrode)*

Grounding Electrode Conductor *(Grounded System)*



System grounded conductor routed to the service disconnect

Equipment grounding conductor

Equipment

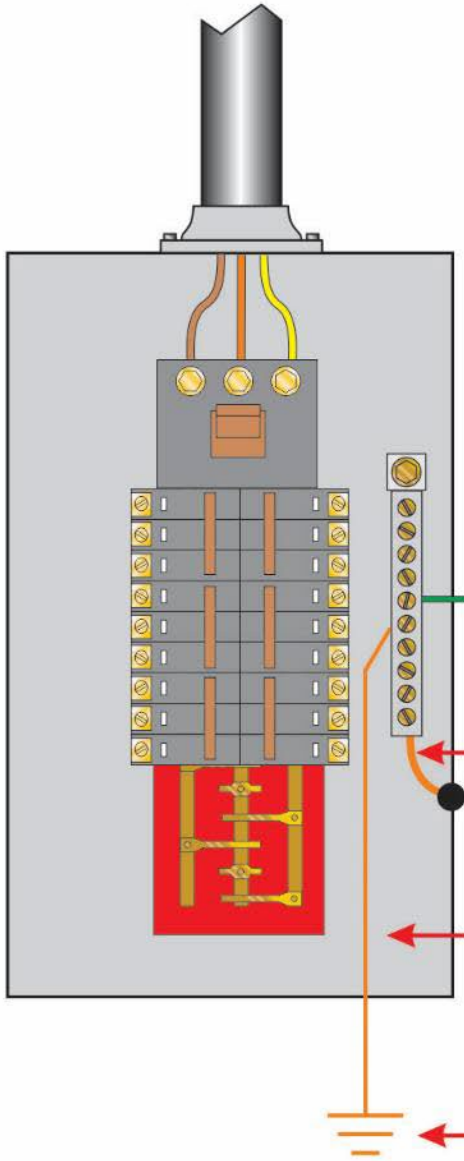
Main bonding jumper

Grounding electrode conductor connects system grounded conductor and equipment to the grounding electrode

Grounding electrode(s)

Copyright © IAEI 2020

Grounding Electrode Conductor *(Ungrounded System)*



No system grounded conductor in an ungrounded system

Equipment grounding conductor

Equipment

Main bonding jumper

Grounding electrode conductor connects the equipment non-current carrying metal parts to the grounding electrode

Grounding electrode(s)

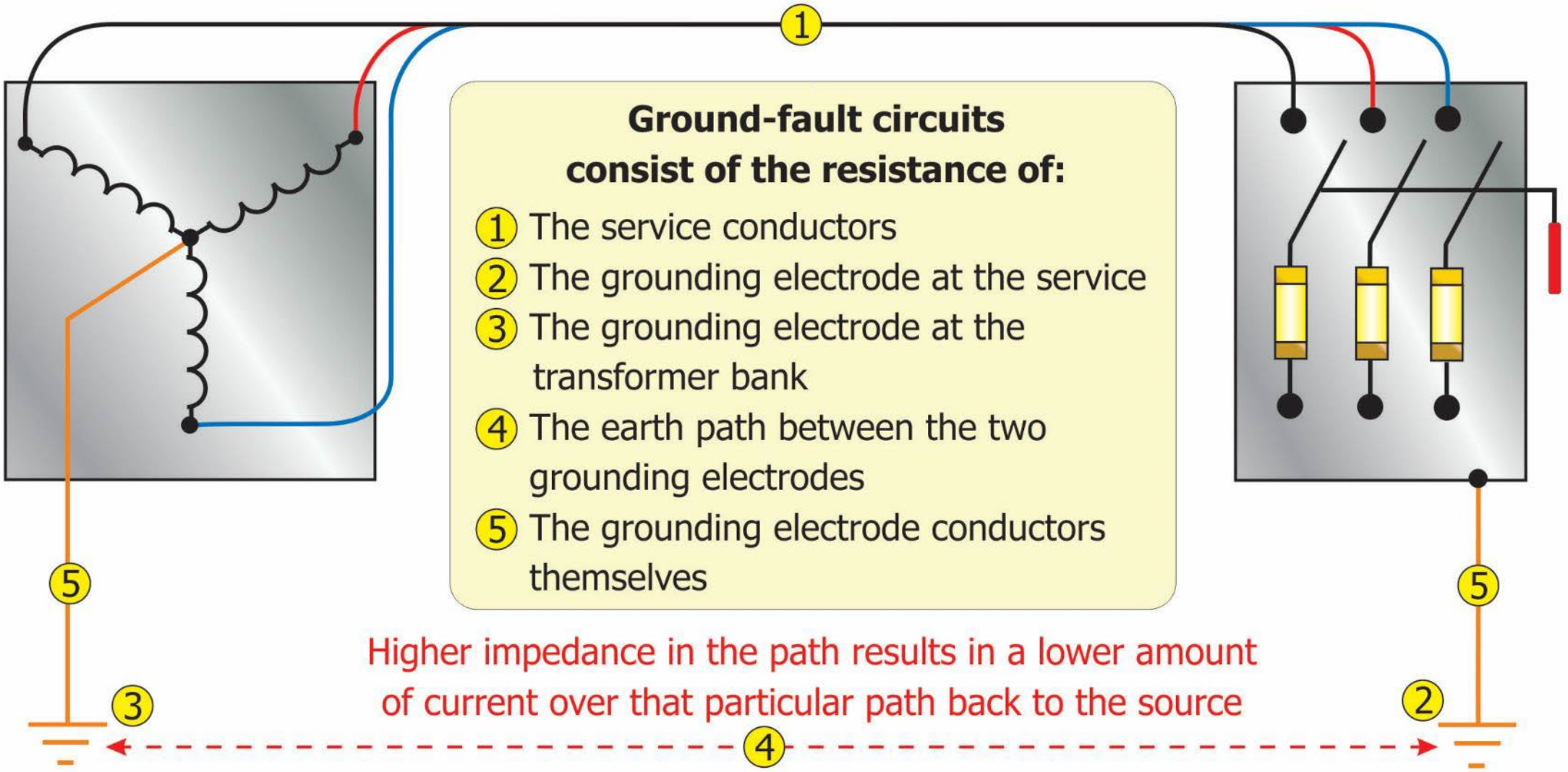
Copyright © IAEI 2020

Current on the Grounding Electrode Conductor(s)

- The maximum amount of current on a grounding electrode conductor is directly related to the **impedance** in the ground return path to the source
- Ground-fault circuit and the **impedance path** consists of the:
  - Service conductor
  - Grounding electrode at the service
  - Grounding electrode at the transformer bank
  - Grounding electrode conductors themselves
  - Earth path between the grounding electrodes
- GEC has little or no effect in clearing ground faults

High Impedance Earth Return

Maximum current of ground fault is limited by the high-impedance series circuit through grounding electrodes and the earth



Ground-fault circuits consist of the resistance of:

1. The service conductors
2. The grounding electrode at the service
3. The grounding electrode at the transformer bank
4. The earth path between the two grounding electrodes
5. The grounding electrode conductors themselves

Higher impedance in the path results in a lower amount of current over that particular path back to the source

Copyright © IAEI 2020

Sizing Grounding Electrode Conductors

- The minimum size of the grounding electrode conductor is based on the **largest ungrounded service-entrance conductor** or derived phase conductor from a separately derived system
- Refer to 250.66 and Table 250.66
- Scan down left column and find the size of the service-entrance conductor being installed
- Scan across the row to find the size of copper, aluminum, or copper-clad aluminum grounding electrode conductor

Table 250.66 Grounding Electrode Conductor for Alternating-Current Systems

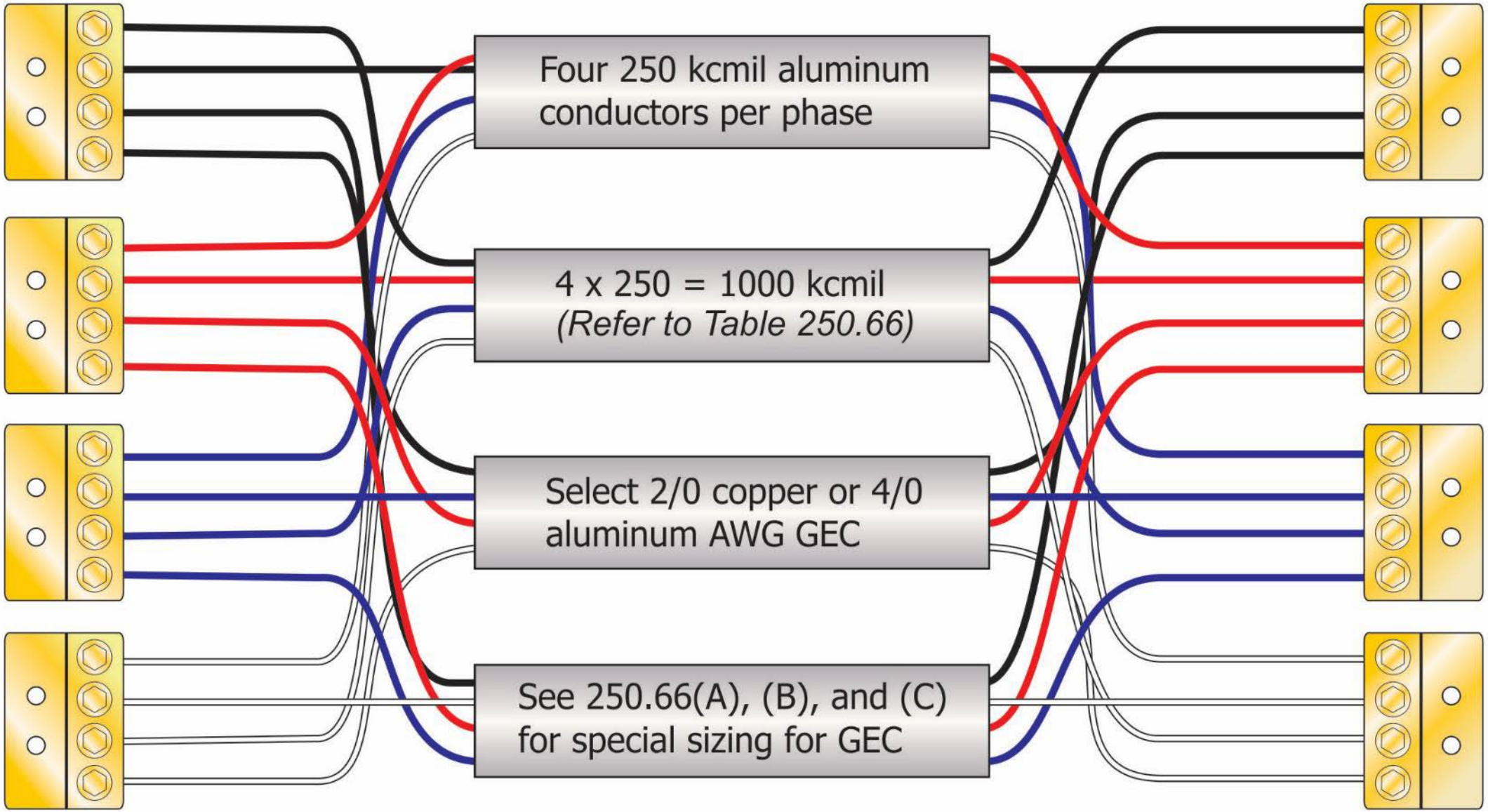
Size of Largest Ungrounded Service-Entrance Conductor or Equivalent Area for Parallel Conductors *(AWG/kcmil)*		Size of Grounding Electrode Conductor *(AWG/kcmil)*	
Copper	Aluminum or Copper-Clad Aluminum	Copper	Aluminum or Copper-Clad Aluminum
2 or smaller	1/0 or smaller	8	6
1 or 1/0	2/0 or 3/0	6	4
2/0 or 3/0	4/0 or 250	4	2
Over 3/0 through 350	Over 250 through 500	2	1/0
Over 350 through 600	Over 500 through 900	1/0	3/0
Over 600 through 1100	Over 900 through 1750	2/0	4/0
Over 1100	Over 1750	3/0	250

Copyright © IAEI 2020

Sizing Grounding Electrode Conductors

- Where service-entrance conductors are **installed in parallel** as allowed by 310.10(H), the circular mil area of one set of parallel conductors is added together and treated as a single conductor for purposes of sizing GEC
- **Example:** Four 250-kcmil aluminum service-entrance conductors installed in parallel are considered to be a single 1000-kcmil aluminum conductor
- Reference Table 250.66 for sizing of GEC for this set of service-entrance conductors

Grounding Electrode Conductor for Parallel Service-Entrance Conductors



Copyright © IAEI 2020

Sizing Grounding Electrode Conductors

- Grounding electrode conductors are generally required to be not smaller than the values in Table 250.66
- Grounding electrode conductor or bonding jumper may be sized as follows where not extended on to other types of electrodes that require a larger size conductor:
  - Not required to be larger than 6 AWG copper or 4 AWG aluminum to **rod, pipe, or plate** type grounding electrodes *[250.66(A)]*
  - Not required to be larger than 4 AWG copper to **concrete-encased electrode** *[250.66(B)]*
  - Not larger than the **ground ring** conductor *[250.66(C)]*

Sizing Grounding Electrode Conductors *(cont.)*

- Bare aluminum conductors are not permitted where installed in direct contact with masonry or earth, or where subject to corrosive conditions *[250.64(A)]*
- Aluminum grounding electrode conductor terminations are not allowed within 450 mm (18 in.) of the earth *[250.64(A)]*

Sizing at Multiple Service Disconnects

- Services are permitted to be installed in up to six separate enclosures installed at one location or under certain conditions at separate locations
- Method of sizing grounding electrode conductors is a matter of choice for the designer or installer
- Basic rules must be followed:
  - Size the grounding electrode conductor for either the circular mil area of service-entrance conductor(s) at the point of connection for each service disconnect, or…
  - Size it as a common grounding electrode conductor based on the size of the main service-entrance conductor(s)

GEC Connections at Multiple Service Disconnects

- If a building or structure is supplied by a service or feeder with two or more disconnecting means in separate enclosures, the grounding electrode connections required to be made using one of (4) four options available to make this installation:
  - Single wire type common grounding electrode conductor
  - Busbar as the common grounding electrode conductor
  - Grounding electrode conductor from the individual service disconnects to the grounding electrode(s)
  - Single grounding electrode conductor to the wireway or other common location
- See 250.64(D)(1), (D)(2), and (D)(3)

Sizing at Multiple Service Disconnects

- Three methods permitted by the *NEC* for connections of grounding electrode conductor taps to a **common grounding electrode conductor** where multiple service disconnects are installed
  - Taps to common grounding electrode conductor 250.64(D)(1)
    - Single wire type
    - Busbar type
  - Individual conductors to grounding electrode(s) 250.64(D)(2)
  - Connection at common location 250.64(D)(3)

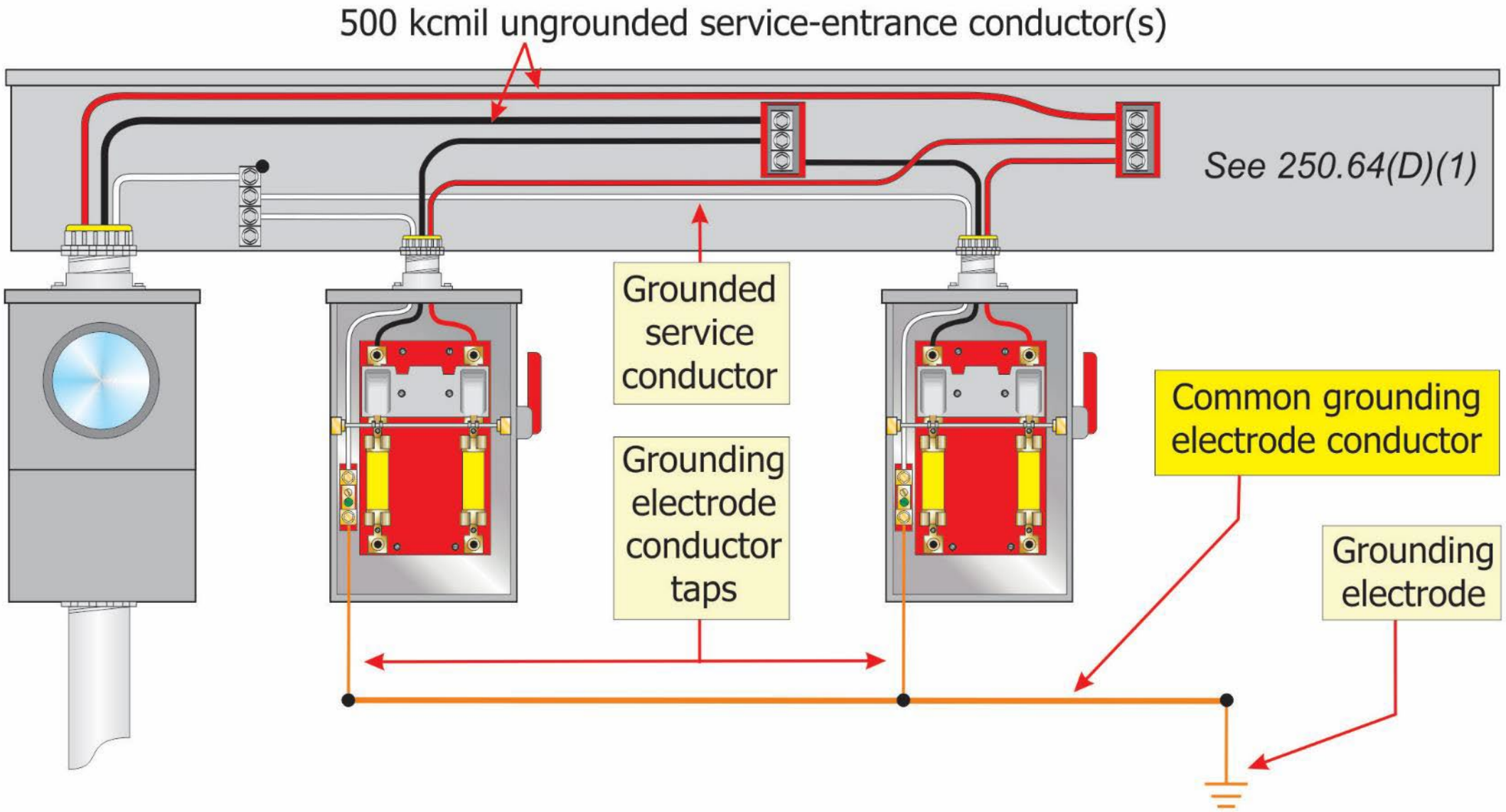
Sizing Common Grounding Electrode Conductor and Taps

- Single GEC permitted to serve separate enclosures
- Common GEC sized based on main service-entrance conductors
- Tap conductors sized based on individual service-entrance conductors supplying each service disconnect *(connected from each service disconnect to the common grounding electrode)*
- See 250.64(D)(1)

Sizing Common Grounding Electrode Conductor and Taps *(cont.)*

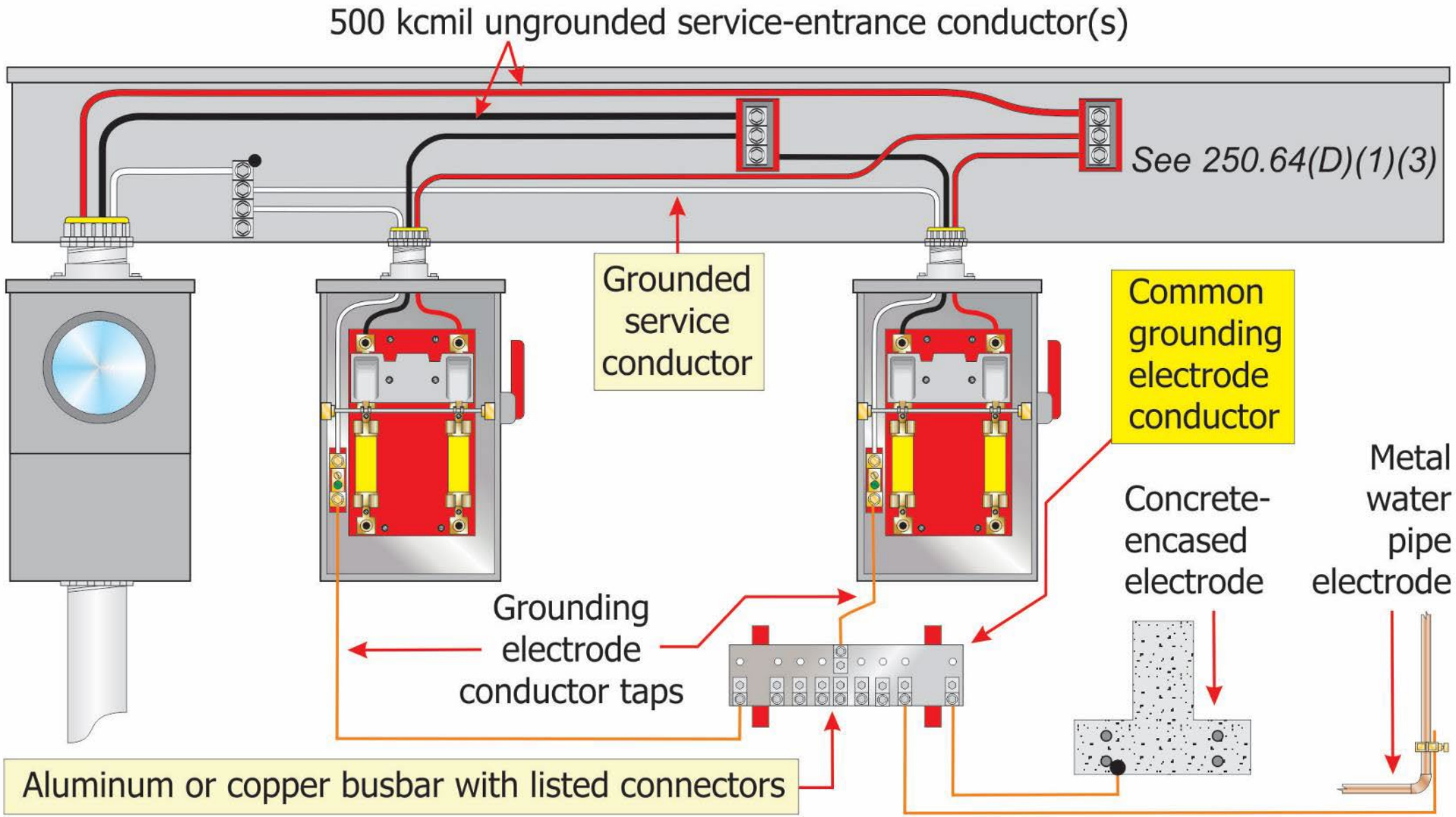
- Important to understand alternative provided at 250.64(D)(1) addresses two conductors;
  - **Common grounding electrode conductor**
    - Required to be installed without a splice or joint *(generally)*
  - **Grounding electrode conductor tap(s)**
    - Permitted to be connected to the common grounding electrode conductor

Taps to Common Grounding Electrode Conductor



Copyright © IAEI 2020

Taps to Common Grounding Electrode Conductor

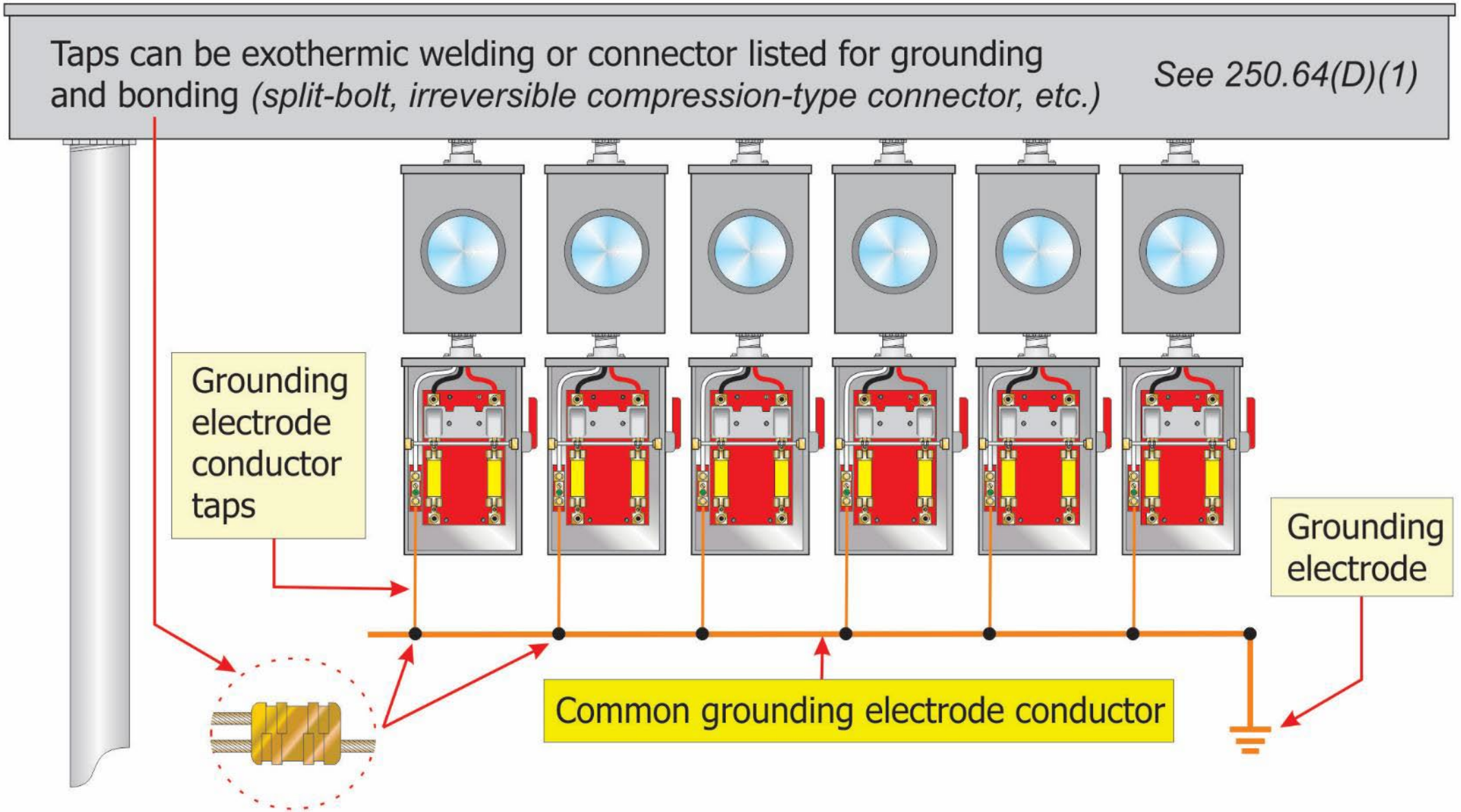


Copyright © IAEI 2020



2145

Taps to Common Grounding Electrode Conductor

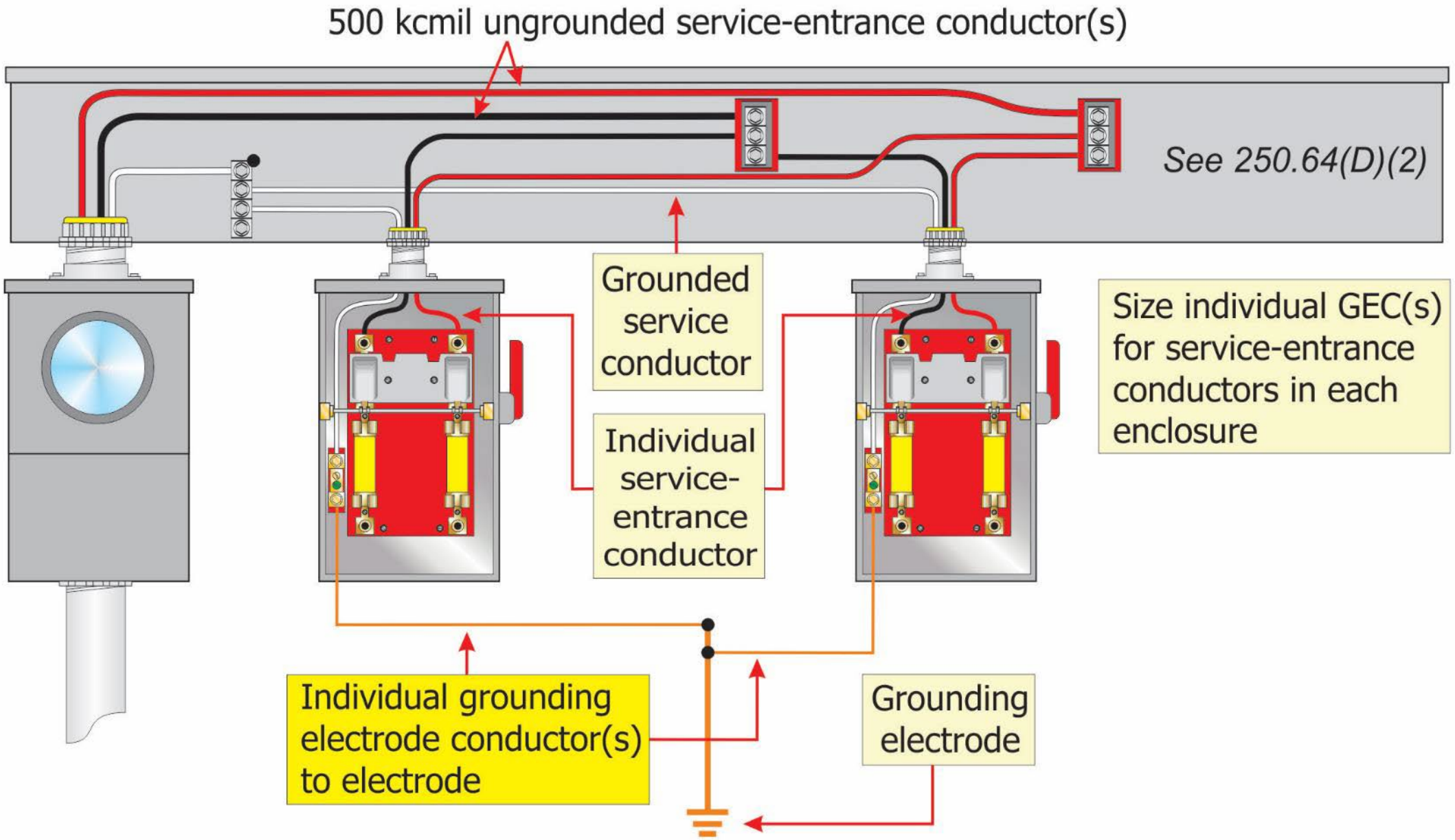


Copyright © IAEI 2020

Sizing Individual Grounding Electrode Conductors

- Permitted to install grounding electrode conductor from **individual service disconnects** to grounding electrode *(rather than being tapped to the common grounding electrode conductor)*
- Grounding electrode conductor sized for the service-entrance conductor serving each individual enclosure
- See 250.64(D)(2)

Individual GEC Connection to Electrode

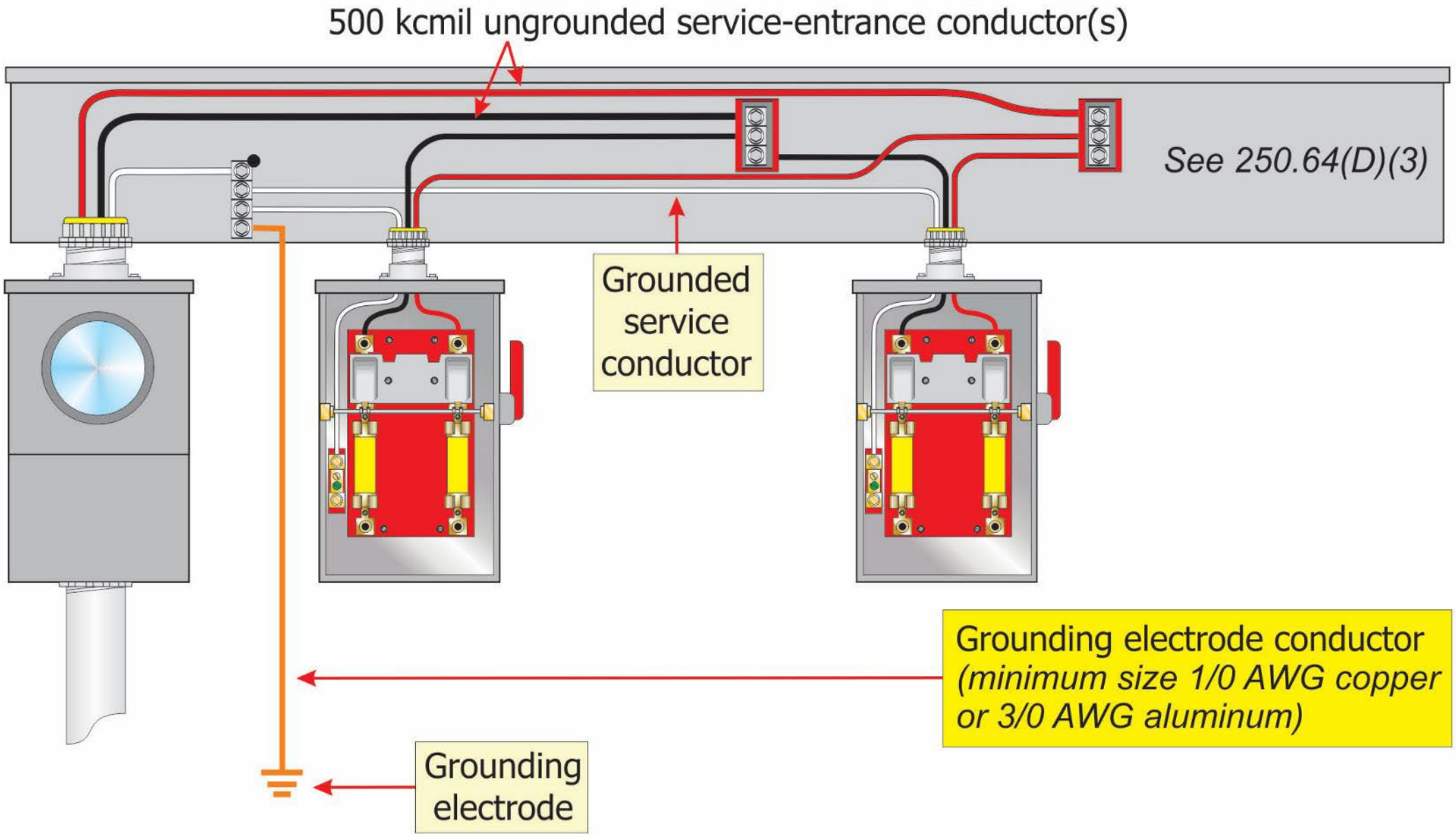


Copyright © IAEI 2020

Sizing at Common Location

- Permitted to install a **single grounding electrode conductor** to wireway or other **common location** to all connected individual service entrance conductors
- Example:
  - 500-kcmil copper service-entrance conductors with grounded conductor grounded inside the wireway
  - GEC to a water pipe or metal in-ground building steel electrode required to be 1/0 AWG copper or 3/0 AWG aluminum *(Table 250.66)*
- See 250.64(D)(3)

GEC Connection in Common Location *(Wireway)*



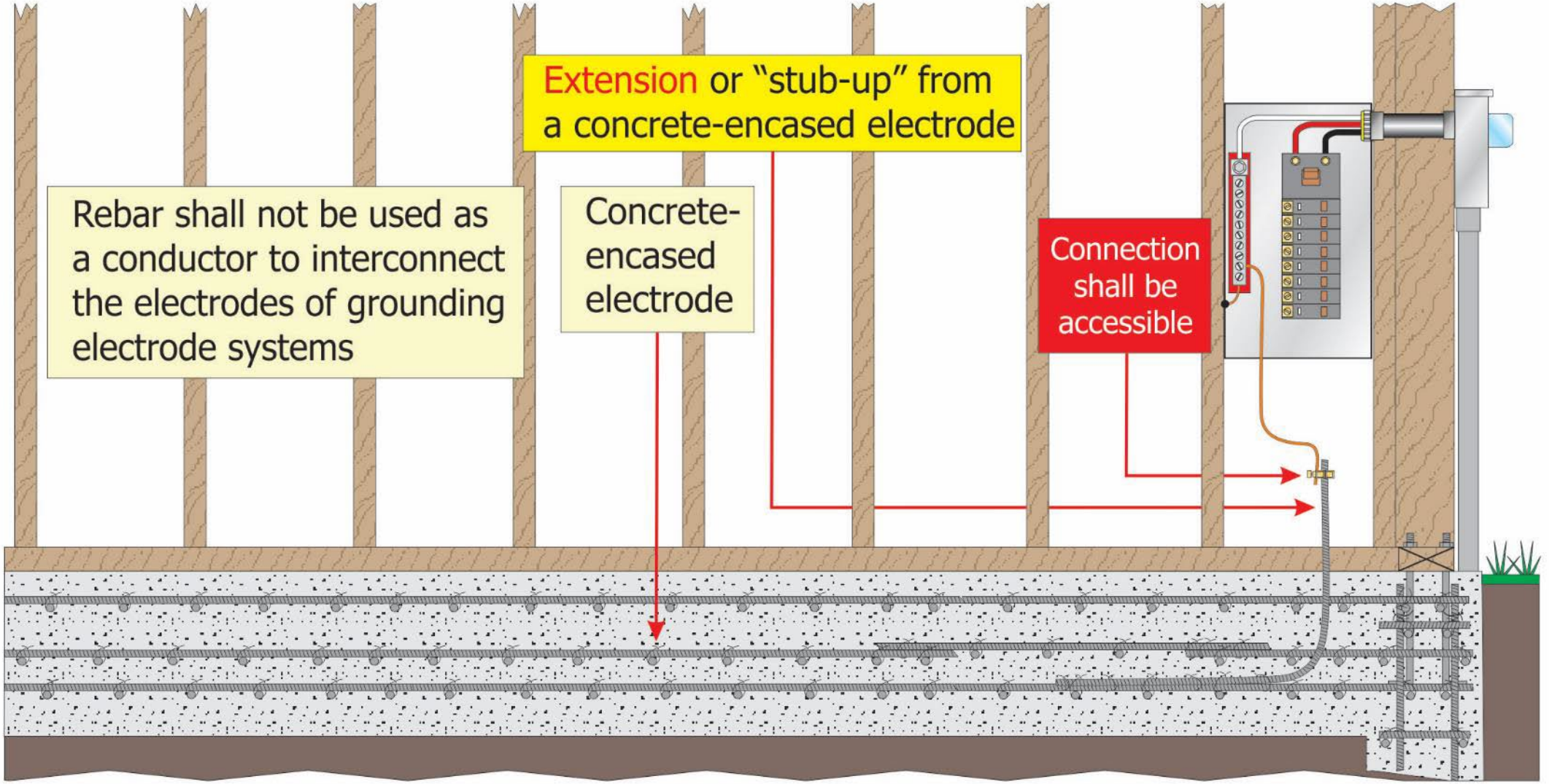
Copyright © IAEI 2020

GEC Connections from Extension at Concrete-Encased Electrode

- Common practice to extend a rebar-type concrete-encased electrode out of the footing or foundation before the slab or foundation is poured
- Typically accomplished by using another piece of rebar connected to the concrete-encased electrode and **"stubbed-up"** out of the poured concrete to provide an accessible connection point above the slab
- GEC connection can be made after the foundation has been poured and cured
- Extension or "stub-up" is not part of the concrete-encased electrode
- Concrete encased electrode is not permitted to interconnect other electrodes
- See 250.68(C)(3)

250.68(C)(3) Concrete-Encased Electrode Extension

A rebar extension from a concrete-encased electrode is recognized for connection to the grounding electrode conductor from the grounding electrode



Copyright © IAEI 2020


Ground clamp identified
to be used with rebar

Grounding Electrode Conductor Connections

- Grounding electrode conductors and bonding jumpers permitted to be connected at the following locations and used to extend the connection to an electrode(s):
  - **Interior metal water piping** located **not more than 1.52 m (5 ft)** from the point of entrance to the building
    - *See 250.68(C)(1)*
  - ***Exception*** *for industrial, commercial, and institutional buildings or structures beyond the first 1.52 m (5 ft) from the point of entrance to the building*
    - *See complete exception for details*

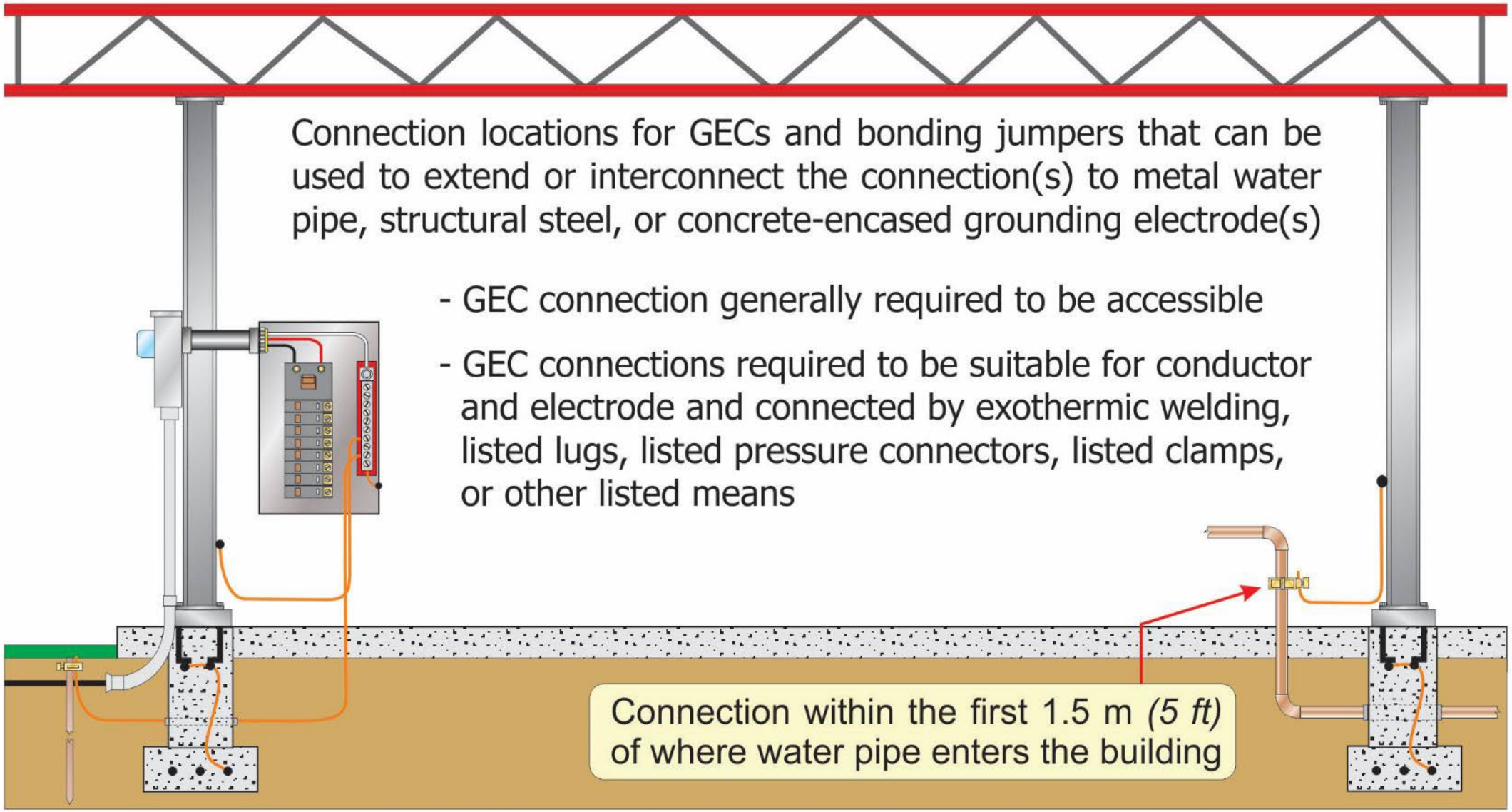
Grounding Electrode Conductor Connections *(cont.)*

- Grounding electrode conductors and bonding jumpers permitted to be connected at the following locations and used to extend the connection to an electrode(s): *(cont.)*
  - The **metal structural frame of a building**
    - *See 250.68(C)(2)*
  - A **concrete-encased electrode** of the rebar-type **extended from its location** within the concrete to an accessible location above the concrete
    - *See 250.68(C)(3)*

Grounding Electrode Conductor Connections *(cont.)*

- The *Code* generally requires that the point of connection of grounding electrode conductors and bonding jumpers to grounding electrodes be made **accessible** *[see 250.68(A)]*
  - **Two exceptions** to this accessibility rule
- GEC connection must be made in a manner that will ensure a permanent and effective grounding path
- An **encased or buried connection** to a concrete-encased, driven, or buried grounding electrode is **not required to be accessible** by 250.68(A) Ex. No. 1

250.68 GEC and Bonding Jumpers Connections

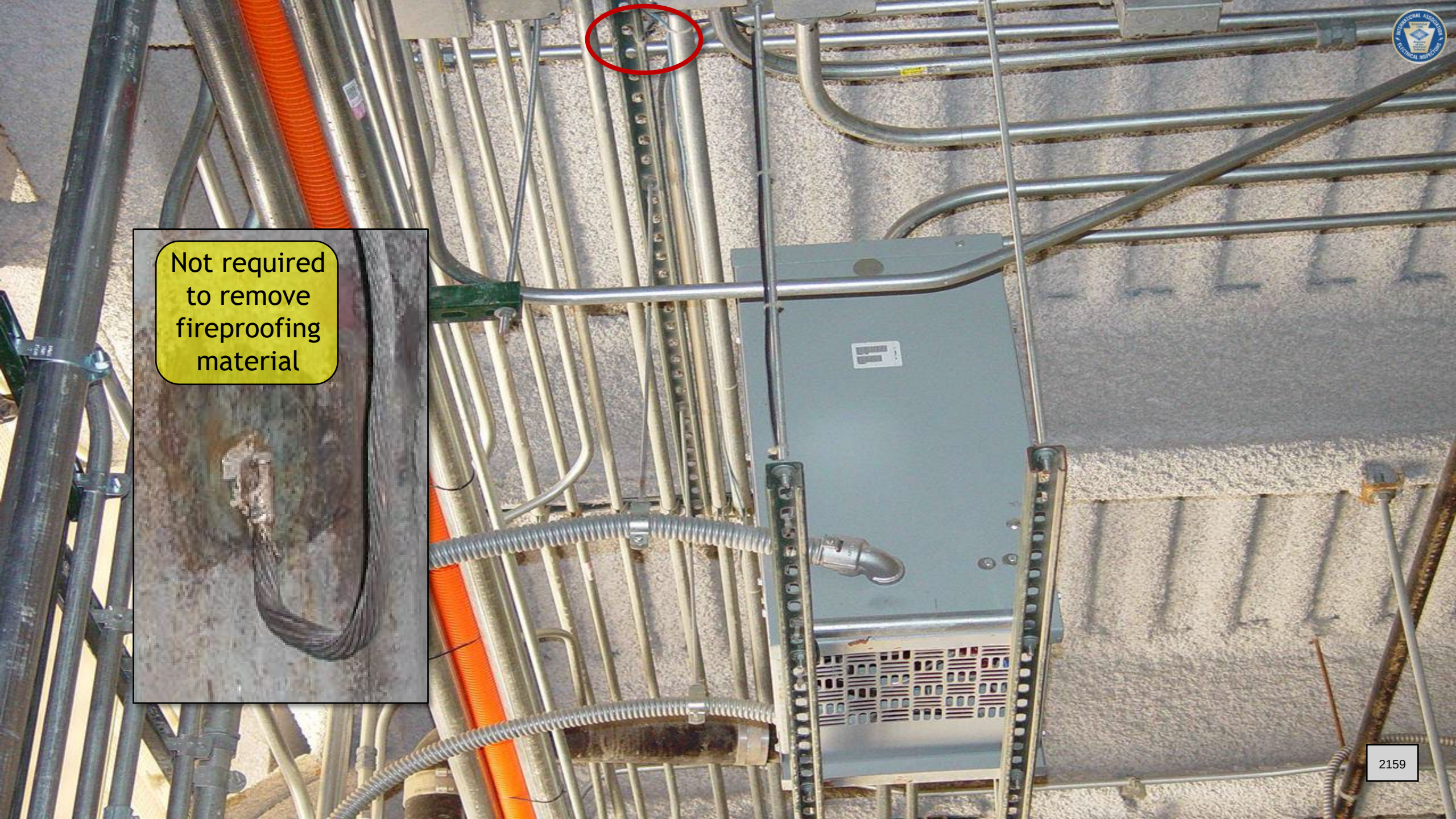


Structural metal frame of a building permitted as a bonding conductor to interconnect electrodes or as a grounding electrode conductor (GEC)

Copyright © IAEI 2020

Grounding Electrode Conductor Connections *(cont.)*

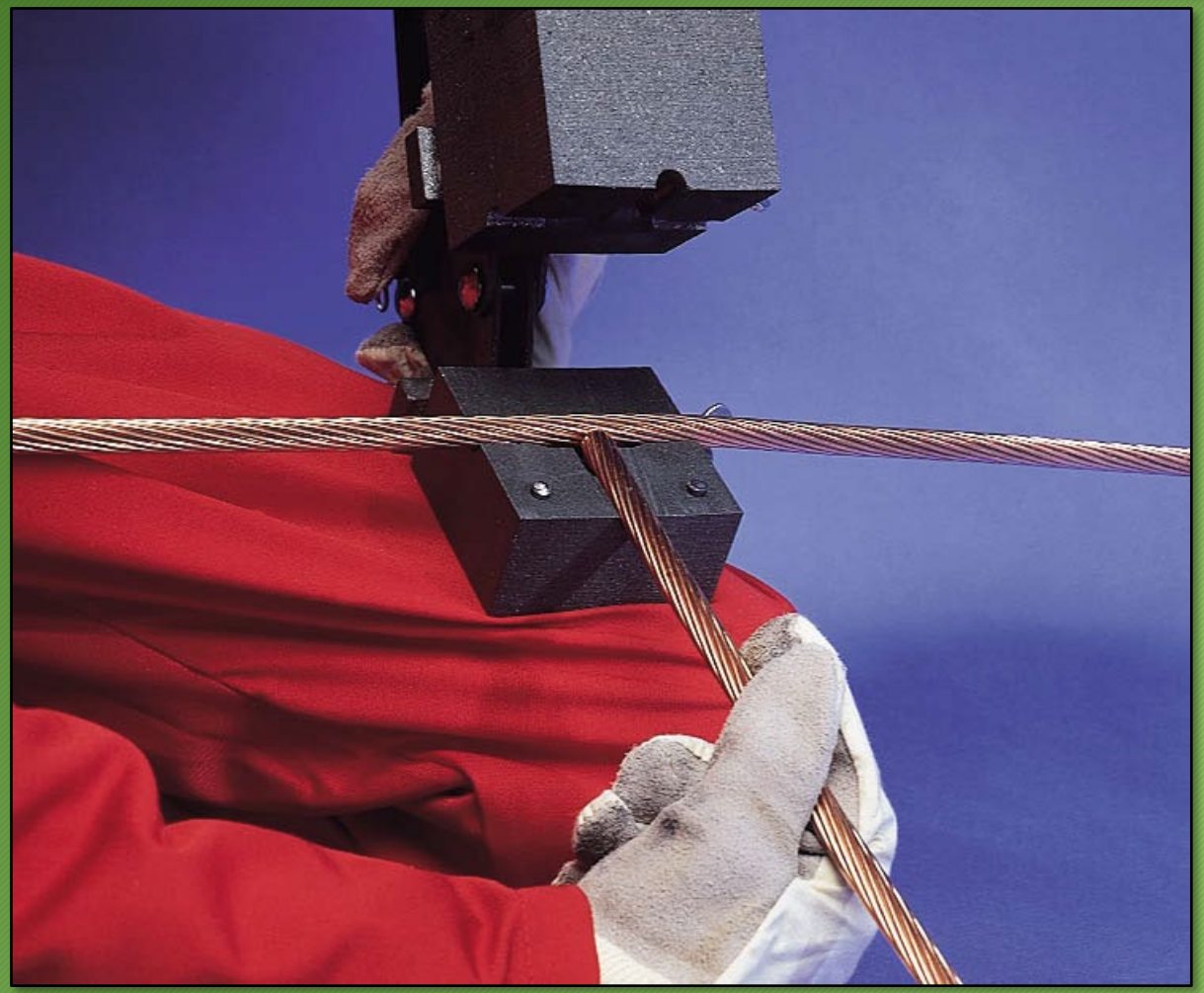
- All mechanical elements used to terminate a grounding electrode conductor or bonding jumper to a grounding electrode are generally required to be accessible
- **Exothermic or irreversible compression connections** used at terminations, together with the mechanical means used to attach such terminations to **fireproofed structural metal** whether or not the mechanical means is reversible, is **not required to be accessible** by 250.68(A) Ex. No. 2


Not required to remove fireproofing material

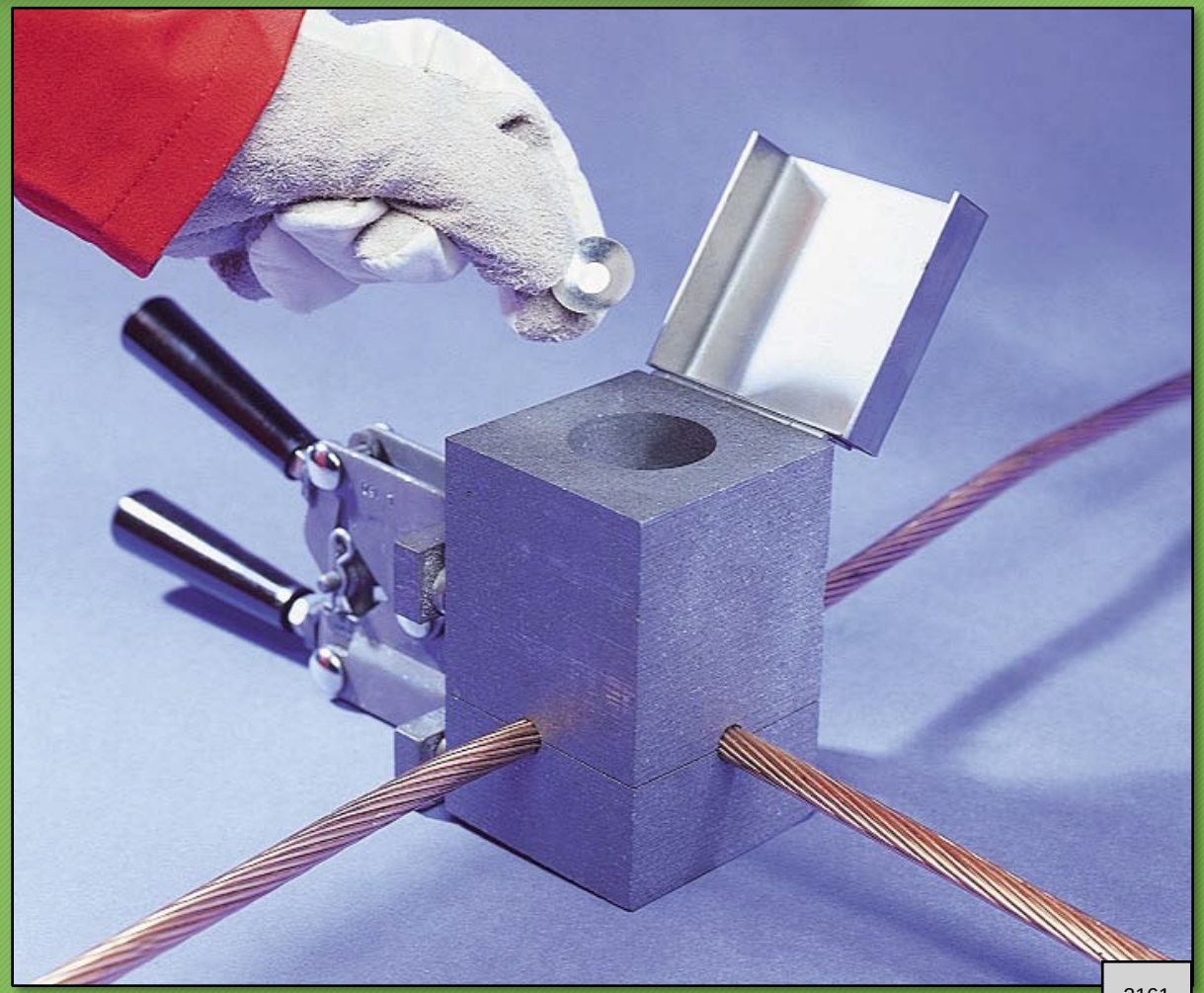
GEC Connections Using Exothermic Weld

- Specific rules for connections of GEC and bonding conductor to grounding electrodes are found at **250.70**
- Connections required to be made by:
  - Exothermic welding
  - Listed lugs
  - Listed pressure connectors
  - Listed clamps
  - Other listed means
- Only connection means not required to be listed are those made by **exothermic welding** *(listed exothermic weld connections are available)*

GEC Connections Using Exothermic Weld

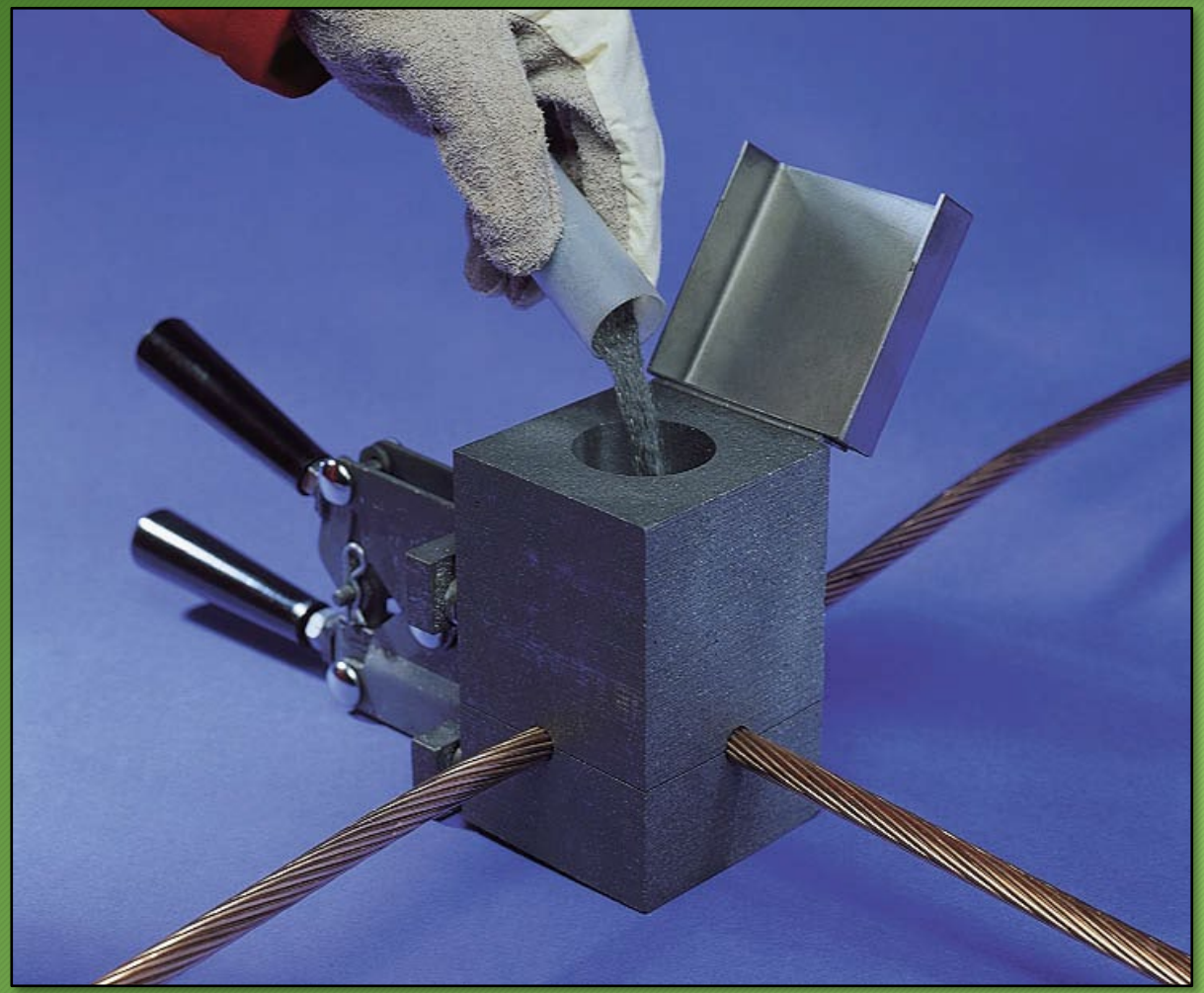


(1) Wires placed in mold



(2) Weld disc placed in mold

GEC Connections Using Exothermic Weld



(3) Weld metallic powder added to mold



(4) Preparing to strike an arc at mold

GEC Connections Using Exothermic Weld

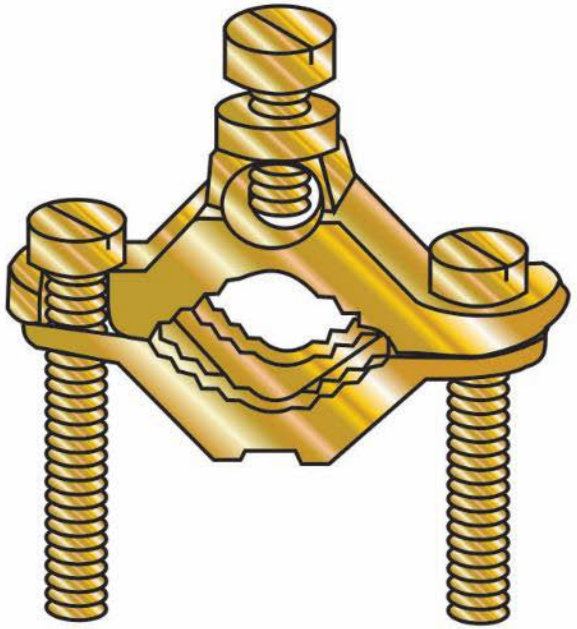


(5) Ignition of metallic weld powder



(6) Completed weld

Ground Clamps Listed for Application





- Grounding electrode conductor connected to grounding electrode by exothermic welding, listed lugs, listed pressure connectors, listed clamps or other listed means
- Connection devices shall be listed for materials of the grounding electrode and grounding electrode conductor
- Shall be listed for direct burial where used on pipe, rod or other buried or concrete encased electrodes
- See 250.70

Copyright © IAEI 2020

Ground Clamps for Rods and Pipes



Photos Courtesy of ABB Thomas and Betts

Ground clamp for water pipe

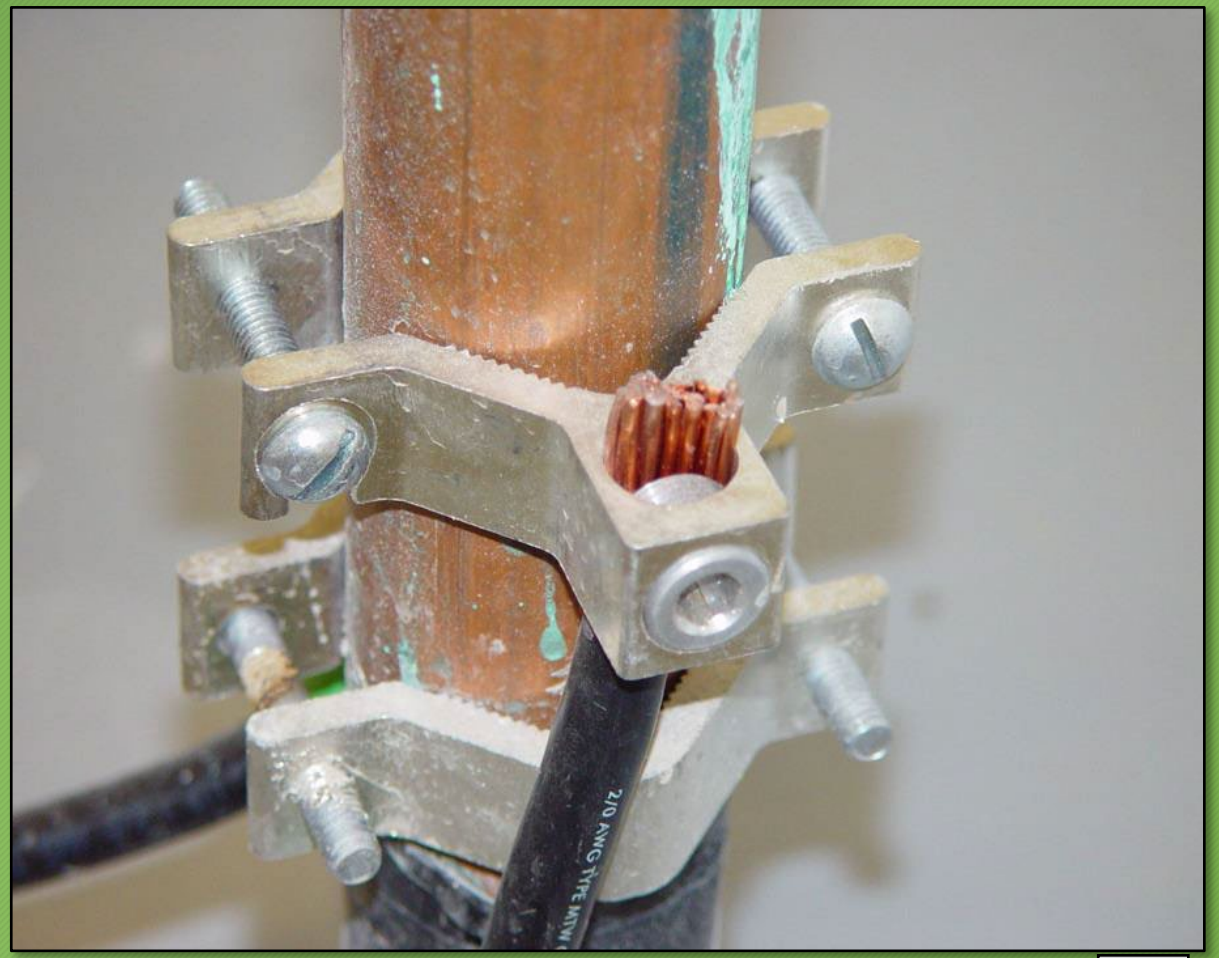


Grounding clamp for ground rod

Ground Clamps for Rods and Pipes

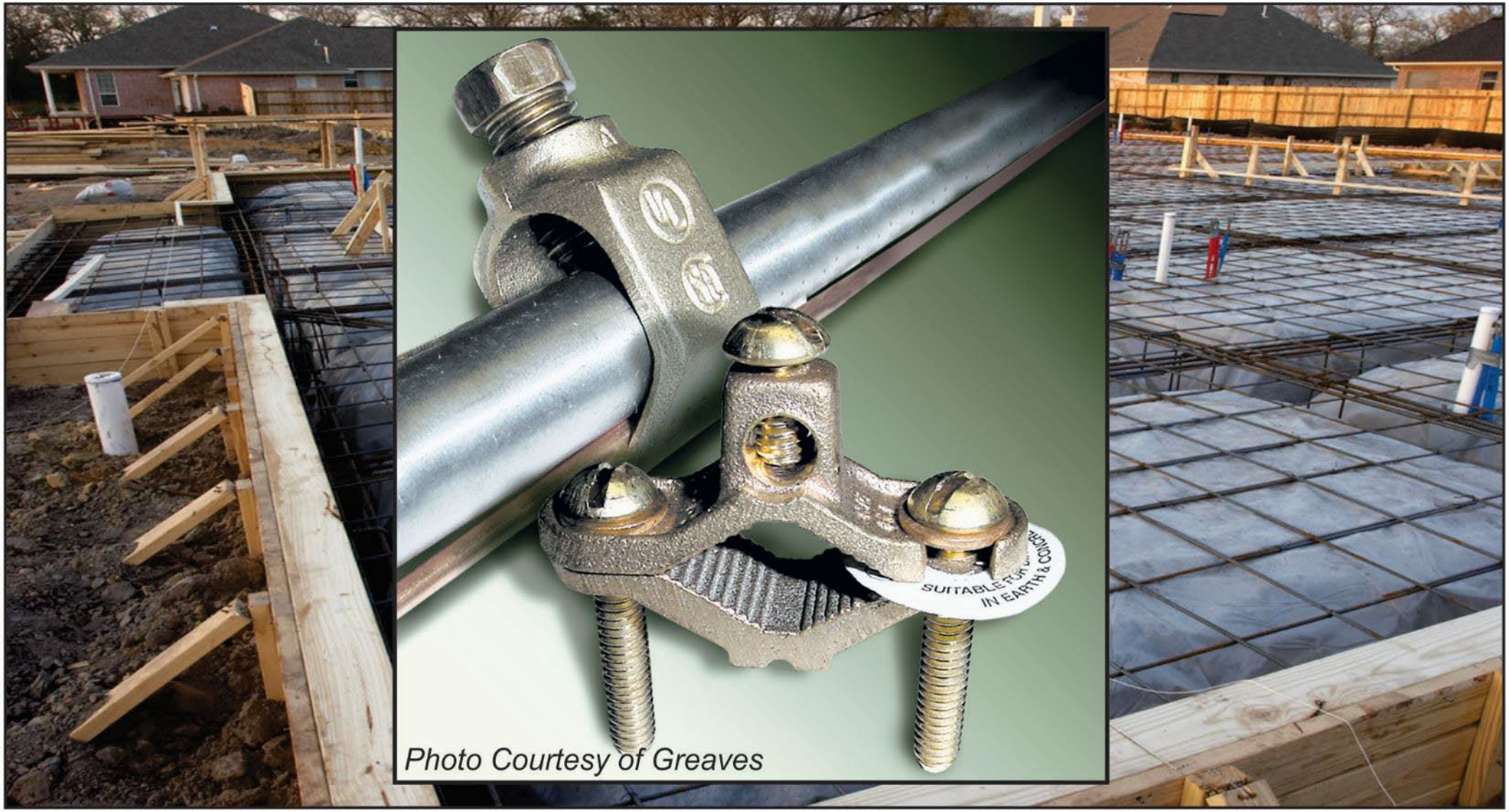


Ground clamp for rebar with lay-in feature



Grounding clamp for water pipe

Grounding Electrode Conductor Connections



Insert photo shows two different ground clamps that are permitted to be buried or concrete-encased *(not accessible)* as allowed by 250.68(A) Ex. No. 1

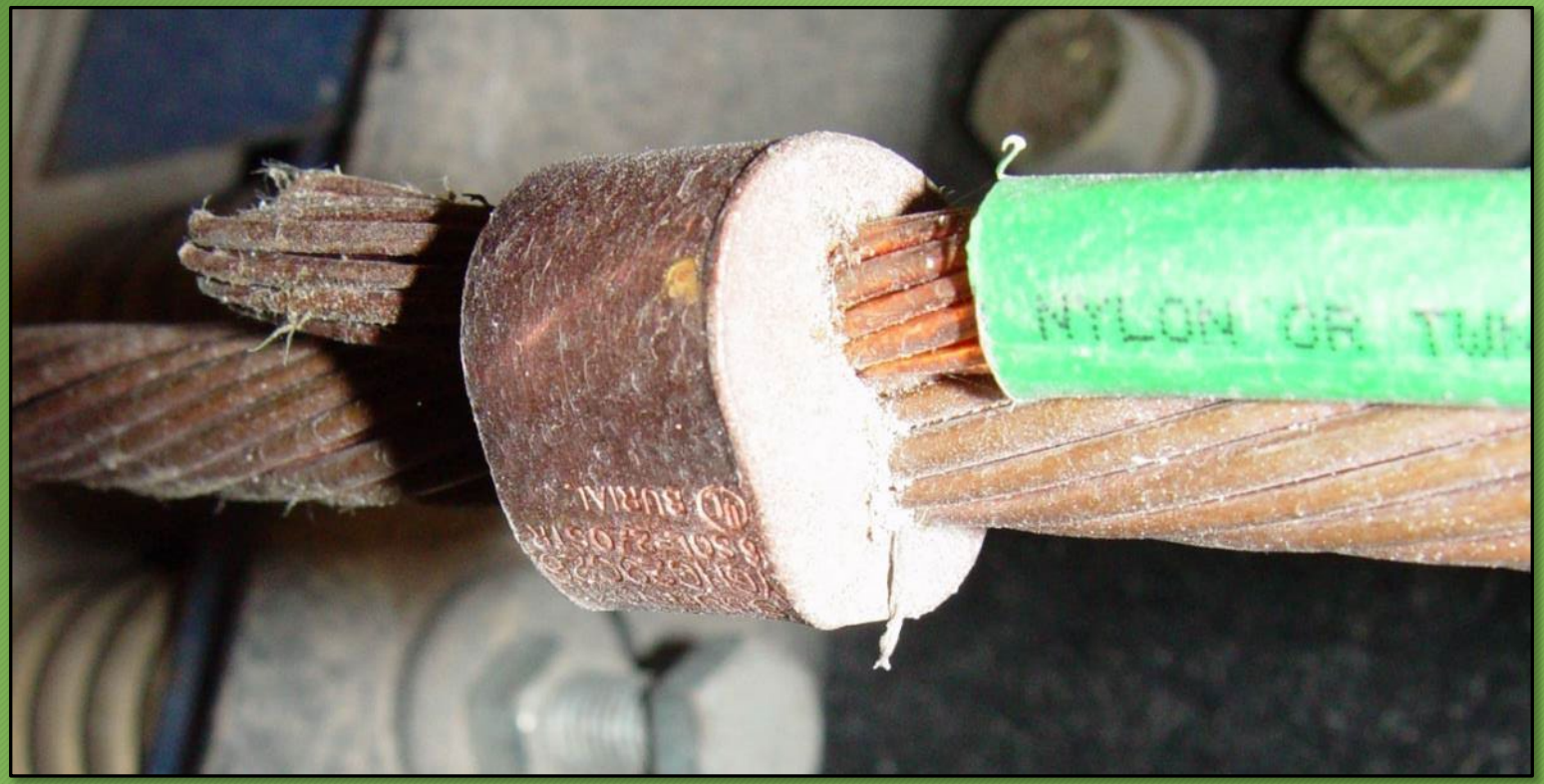
Copyright © IAEI 2020

Grounding Electrode Conductor Material

- Copper, aluminum, or copper-clad aluminum *[or the items as permitted in 250.68(C)]*
- Conductors of the wire type shall be:
  - Solid or stranded
  - Insulated, covered, or bare
- Aluminum and copper-clad aluminum grounding electrode conductors:
  - Installed external to buildings are **not permitted** to be terminated within 450 mm (18 in.) of the earth
  - Terminations made within outdoor enclosures that are listed and identified for the environment shall be **permitted** within 450 mm (18 in.) of the bottom of the enclosure
- See 250.62 and 250.64(A)

Grounding Electrode Conductor Material *(cont.)*

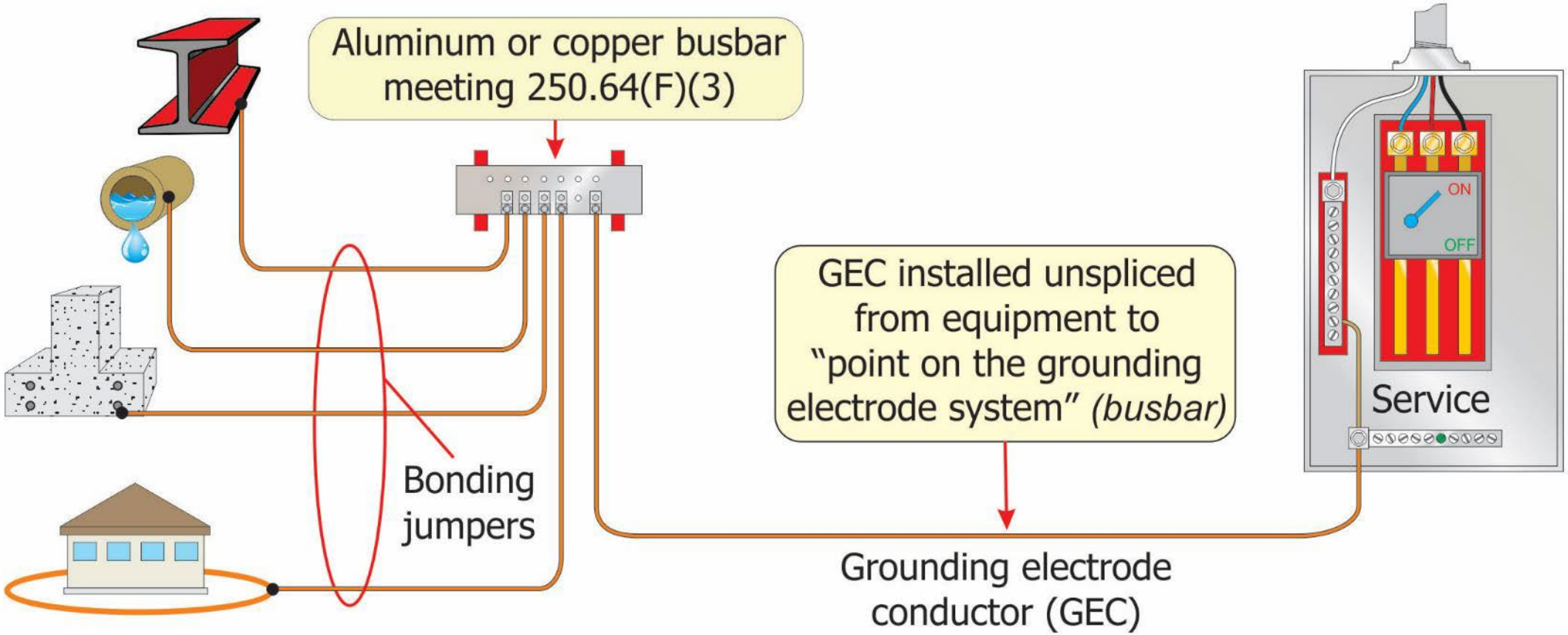
- **No specific color identification** for grounding electrode conductors but 250.119 permits the color green to be used for grounding and bonding conductors



Grounding Electrode Conductor Installation

- Where grounding of systems, equipment or both are required, grounding electrode conductors are installed and connected to the grounding electrode system
- *Code* provides **installation requirements** for grounding electrode conductors where installed for services, separately derived systems, or for buildings or structures supplied by a feeder(s) or branch circuit(s)
- See 250.64

250.64(F) Installation to Electrode(s)



Bonding jumper(s) from grounding electrodes and grounding electrode conductors are permitted to be connected to copper or aluminum busbars to form the grounding electrode system

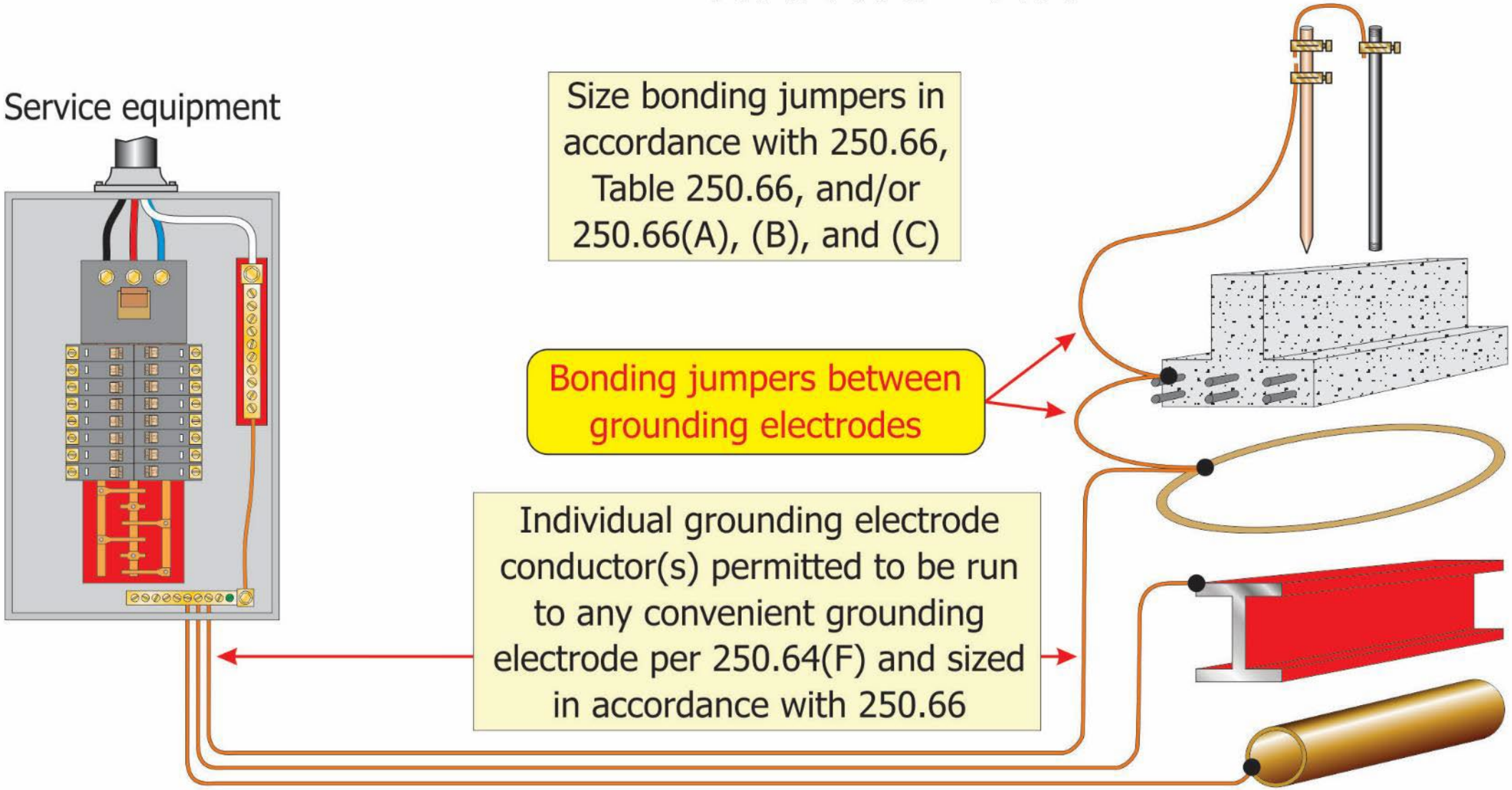
Connection to be made by a listed connector or by the exothermic welding process

Copyright © IAEI 2020


HAFFNER

250.64(F) Individual Grounding Electrode

Grounding electrode conductor(s) and bonding jumpers interconnecting grounding electrodes shall be installed in accordance with 250.64(F)(1), (F)(2), or (F)(3)



Copyright © IAEI 2020

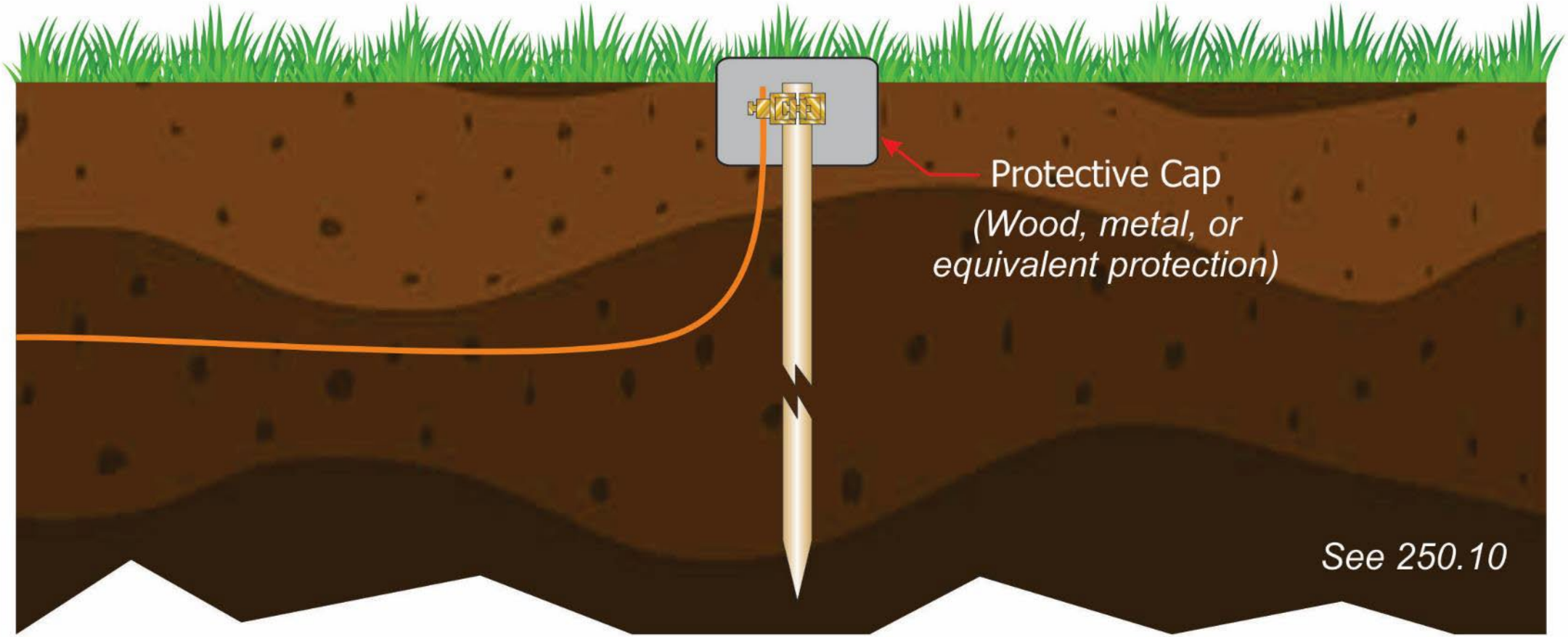
GEC - Securing and Protection from Physical Damage

- When exposed, grounding electrode conductor(s) or enclosure(s) are required to be **securely fastened to surface**
- Grounding electrode conductors are permitted to be installed on or through framing members
- Where **not exposed to physical damage**, 6 AWG or larger permitted to run along the surface of the building without protection or metal covering
- Where **exposed to physical damage**, 6 AWG or larger required to be protected by installation in cable armor or raceway *(RMC, IMC, PVC, etc.)*
- Sizes **smaller than 6 AWG** required to be protected from physical damage by installation in cable armor or raceway

GEC - Securing and Protection from Physical Damage *(cont.)*

- Grounding electrode conductors and grounding electrode bonding jumpers in contact with the earth are **not required to comply with *300.5*** *(minimum burial depth requirements) [250.64(B)(4)]*
- Must be buried or otherwise protected if subject to physical damage
- See 250.64(B) for securing and protection against physical damage requirements for grounding electrode conductors

Protection of Ground Clamp Attachment



Ground clamp to be approved for general use without protection or be protected from physical damage as follows:

(1) installed where they are not likely to be damaged or

(2) enclosed in metal, wood, or equivalent protective covering

Copyright © IAEI 2020

Splicing Grounding Electrode Conductors

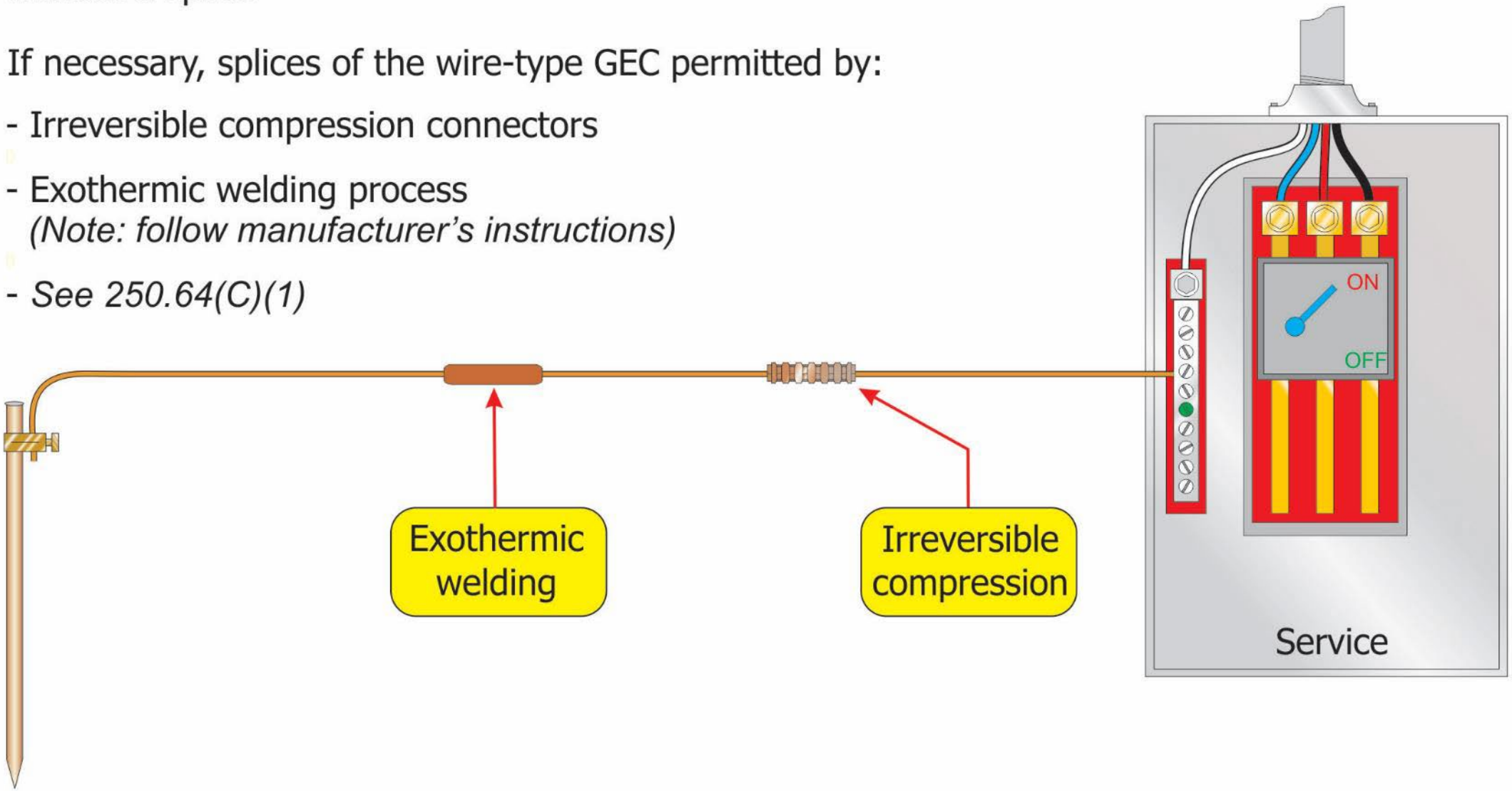
- Grounding electrode conductors generally required to be installed in **one continuous length without a splice** or joint
- If necessary, splices or connections shall be made as permitted as follows:
  - (1) Splicing of the wire-type GEC permitted only by **irreversible compression-type connectors** listed as grounding and bonding equipment or by the **exothermic welding process**
  - (2) Sections of **busbars** shall be permitted to be connected together to form a grounding electrode conductor
  - (3) Bolted, riveted, or welded connections of **structural metal frames of buildings** or structures
  - (4) Threaded, welded, brazed, soldered or bolted-flange connections of **metal water piping**

Splicing Grounding Electrode Conductor

Grounding electrode conductors are generally required to be installed in one continuous length without a splice

If necessary, splices of the wire-type GEC permitted by:

- Irreversible compression connectors
- Exothermic welding process
  (Note: follow manufacturer's instructions)
- *See 250.64(C)(1)*



Copyright © IAEI 2020

Protection from Magnetic Field

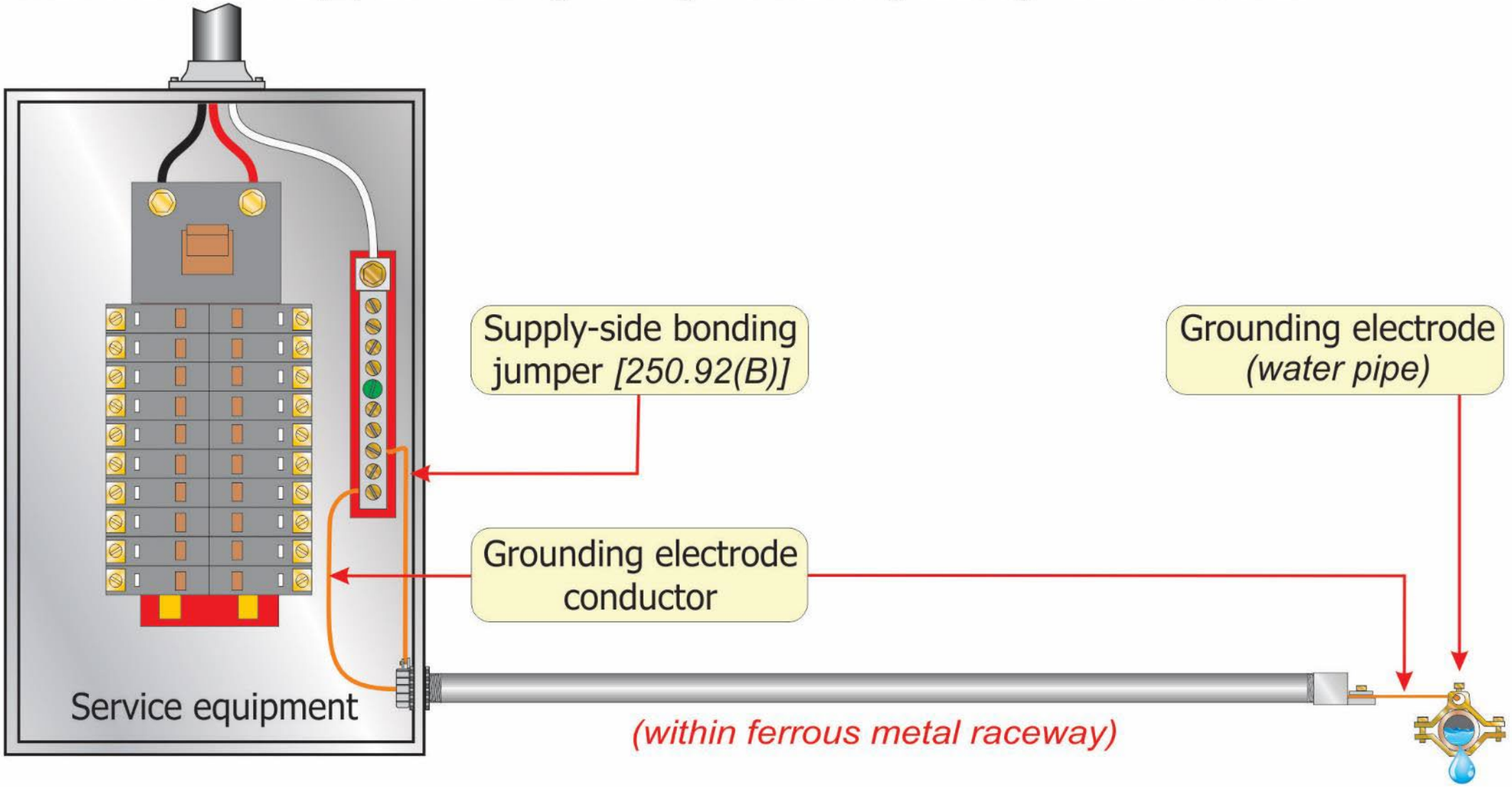
- Where **ferrous metal raceways** or enclosures are provided for **protection of the grounding electrode conductor**, special procedures must be followed
- Ferrous metal conduits must be **bonded at both ends** of the grounding electrode conductor to form a **parallel circuit** with the grounding electrode conductor
- Lack of observation, results in **doubling the impedance** of the grounding electrode conductor
- Where the impedance increased, the effectiveness of the grounding electrode conductor is reduced
- Ferrous metal conduit must be **electrically continuous** from the point of attachment at the cabinet or equipment to the grounding electrode

Protection from Magnetic Field *(cont.)*

- Ferrous metal conduit required to be **securely fastened** to clamp or fitting
- Nonferrous metal enclosures *(PVC)* are not required to be electrically continuous
- Ferrous metal conduit not physically continuous from the cabinet or equipment to the grounding electrode is required to be made electrically continuous by **bonding each end of the conduit** to the grounding electrode conductor
- This bonding is required at each end and to all intervening ferrous metal raceways, boxes, and enclosures between the service equipment and the grounding electrode
- See 250.64(E)

250.64(E) Protection from Magnetic Field

Ferrous metal raceways, enclosures, and cable armor are generally required to be electrically continuous from the cabinet or equipment to the grounding electrode or grounding electrode conductor



Copyright © IAEI 2020



2182

Grounding Electrode Conductor Connections



Grounding electrode conductor enclosed in armor cable and bonded to clamp and grounding electrode

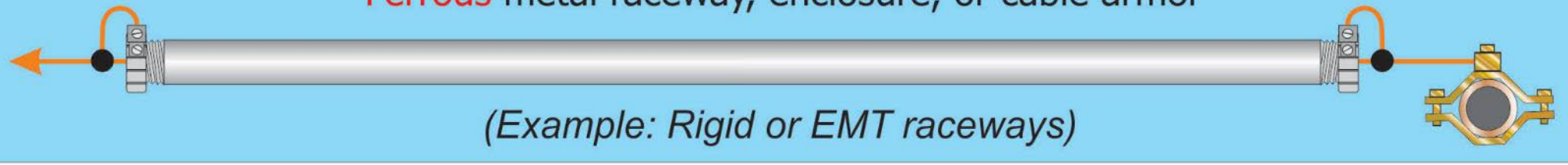
Copyright © IAEI 2020

250.64(E) Protection from Magnetic Field

Bonding required at grounding electrode conductor to both ends of ferrous metal raceways, enclosures, and cable armor that are not electrically continuous from cabinet or enclosure to grounding electrode or grounding electrode conductor

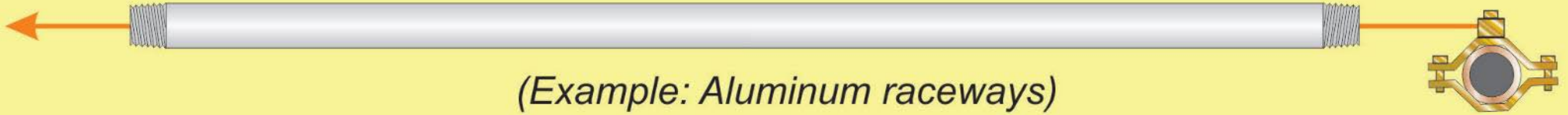
Note: Bonding jumper is required to be the same size as the grounding electrode conductor

Ferrous metal raceway, enclosure, or cable armor



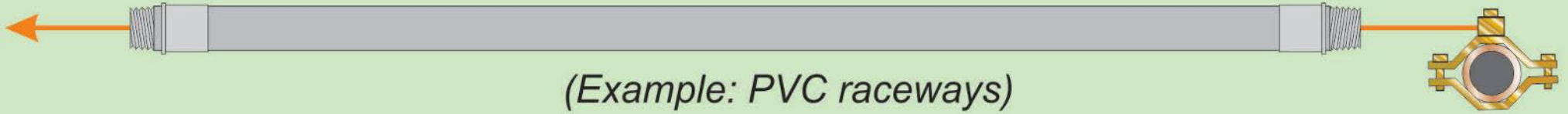
(Example: Rigid or EMT raceways)

Nonferrous metal raceway, enclosure, or cable armor



(Example: Aluminum raceways)

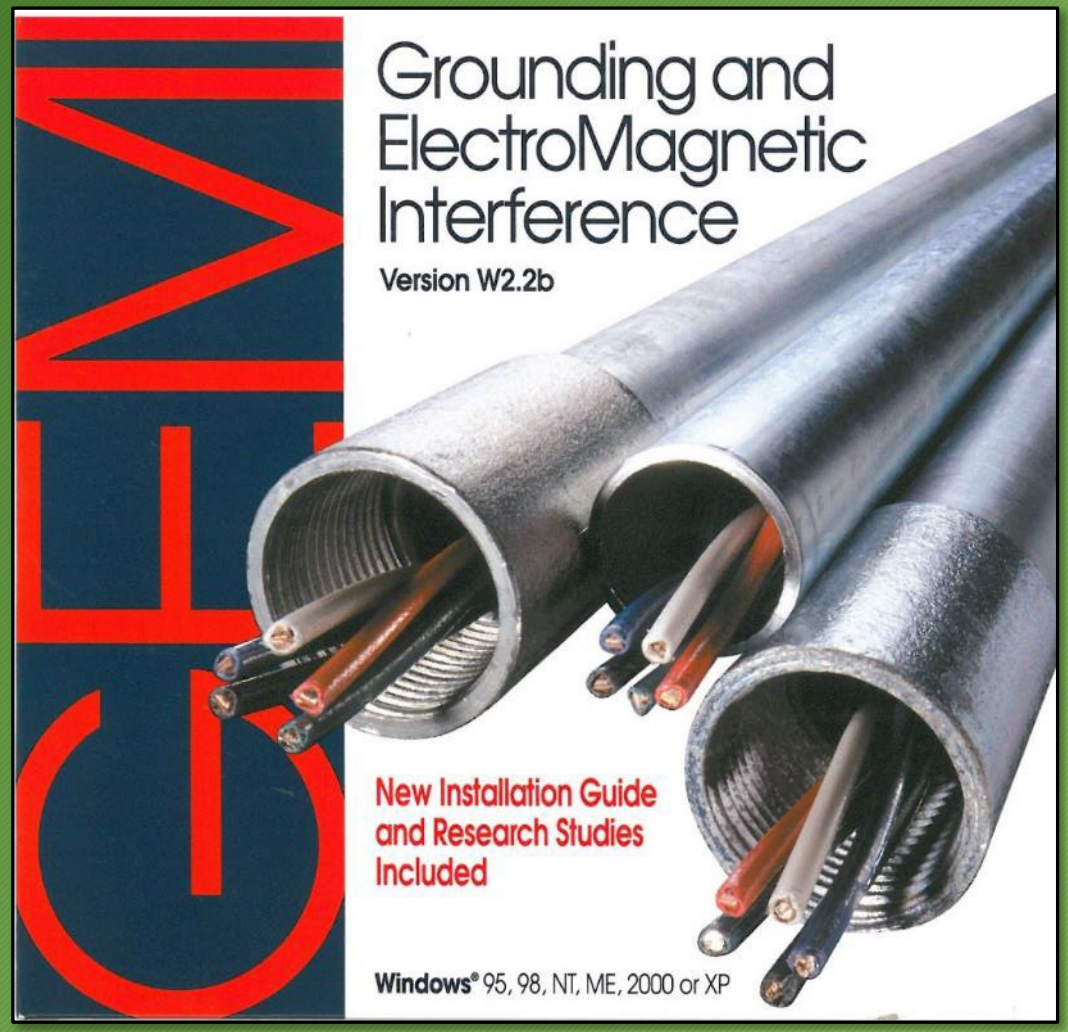
Nonmetallic raceway, enclosure, or cable armor



(Example: PVC raceways)

Copyright © IAEI 2020

Grounding and ElectroMagnetic Interference (GEMI) Research



Steel Tube Institute
OF NORTH AMERICA

www.steeltubeinstitute.org

Division of Current in Both Paths *(Conductor vs Raceway)*

Conductor	Conduit Size	Total Amperes	Current in Conductor	Current in Conduit
6	½	100	3	97
6	½	300	5	295
2	¾	90	7	83
2	¾	350	10	340
2/0	1	150	15	135
2/0	1	590	5	585
4/0	1¼	225	15	210
4/0	1¼	885	15	870

The above test data confirms that, for all practical purposes, the impedance of a conductor enclosed in steel conduit *(when the conduit is bonded at both ends)* is approximately equal to the impedance of the conduit

**Data from Grounding ElectroMagnetic Interference (GEMI) analysis software*

Copyright © IAEI 2020

Design Considerations for Grounding Electrode Conductor Length

- Short-time rating of copper grounding electrode conductor related to I^2t rating *(current x current x time)*
- Five-second rating is approximately 1 ampere for every 42.25 circular mil conductor area
- Voltage drop for grounding electrode conductors over 30 m (100 ft) should not exceed 40 volts
- The *NEC* does not currently limit the length or require larger grounding electrode conductors for long runs, but it should be a design consideration

Design Considerations for Grounding Electrode Conductor Length

- **Example:** 1/0 AWG copper service-entrance conductors, GEC is 6 AWG copper *(Table 250.66)*, length is 45 m (150 ft)
- 6 AWG has 26,240 circular mils, resulting in a short-time rating of 621 amperes, and a dc resistance of 0.0737 ohms for 45 m (150 ft.) (0.491 ohms/k ft.)
- Voltage drop would be 621 x 0.0737 or 46 volts
- Voltage drop for GECs over 30 m (100 ft) should not exceed 40 volts
- Next larger-sized GEC (4 AWG) has resistance of 0.0462 ohms for 45 m (150 ft) (0.308 ohms/k ft.)
- Voltage drop would be 621 x 0.0462 or 28.7 volts
- **4 AWG copper GEC** is the proper size

Grounding Electrode Conductors for Direct-Current Circuits

- For direct-current **(dc) circuits**, size of the grounding electrode conductor is specified in **250.166**
- Size can be larger than would be required for the same size alternating-current (ac) circuit
- **Resistance** only factor in determining current in a dc circuit
- Grounding electrode conductor for dc systems does not have to be larger than **3/0 copper** or **250 kcmil aluminum**

CHAPTER NINE

GROUNDING ELECTRICAL SERVICES



Grounding Electrical Services

- Electrical services are furnished to the premises by the serving utility as either **grounded** or **ungrounded**
- At the service disconnecting means, system is one of the following:
  - Solidly grounded
  - Ungrounded
  - Resistance or reactance grounded
- How the services are grounded depends on:
  - Type of system installed
  - Design criteria
  - *Code* requirements
  - How the utility grounded the supply system

Article 100 Definitions

- ***Grounded Conductor:*** A system or circuit conductor that is intentionally grounded.
- ***Service:*** The conductors and equipment connecting the serving utility to the wiring system of the premises served.

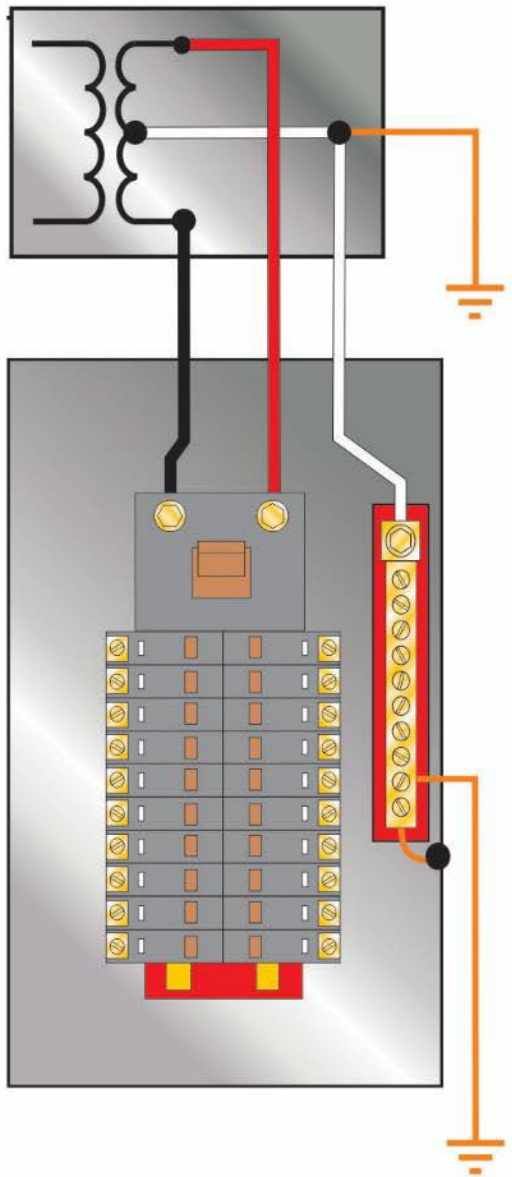
Grounded Electrical Services

- Where an ac system operating at **1000 volts or less** is grounded at any point, the **grounded conductor** *(usually a neutral conductor)* required to be run to each service disconnecting means
- Grounding point reference is not at the service but at the transformer providing power to the service equipment
- If the transformer is grounded, the **grounded (neutral) conductor is required to be installed** to the service without regard to if there are phase to neutral loads to serve or not
- See 250.24(C)

Grounded Conductor Size and Routing

- Shall be routed with service-entrance phase conductors
- Shall be connected to the grounded conductor terminal and bonded to service disconnecting means enclosure through the main bonding jumper
- Shall be sized to carry the load per 220.61
- Grounded conductor is not required to be larger than the largest ungrounded service-entrance phase conductor
- For high-impedance grounded neutral systems, see 250.36 for grounded conductor installation and sizing requirements
- Grounded conductor of a 3-phase, 3-wire delta service to have an ampacity not less than ungrounded conductors
- See 250.24(C)

250.24(C) Grounded Conductor Brought to Service



Grounded service conductor of 1000 volts or less must be:

1. Routed with phase conductors
2. Run to each service disconnecting means
3. Connected to the grounded conductor terminal and bonded to service disconnecting means enclosure through the main bonding jumper
4. Sized no smaller than specified in Table 250.102(C)(1)
5. Sized at least 12½ percent of area of conductors where larger than given in Table 250.102(C)(1)
6. Based on equivalent area of ungrounded parallel service-entrance conductors
7. Installed in parallel where service is installed in parallel in two or more raceways
8. Must not have an ampacity rating less than the ungrounded conductor of a 3-phase, 3-wire delta service
9. Sized in accordance with minimum service neutral load requirements of 220.61

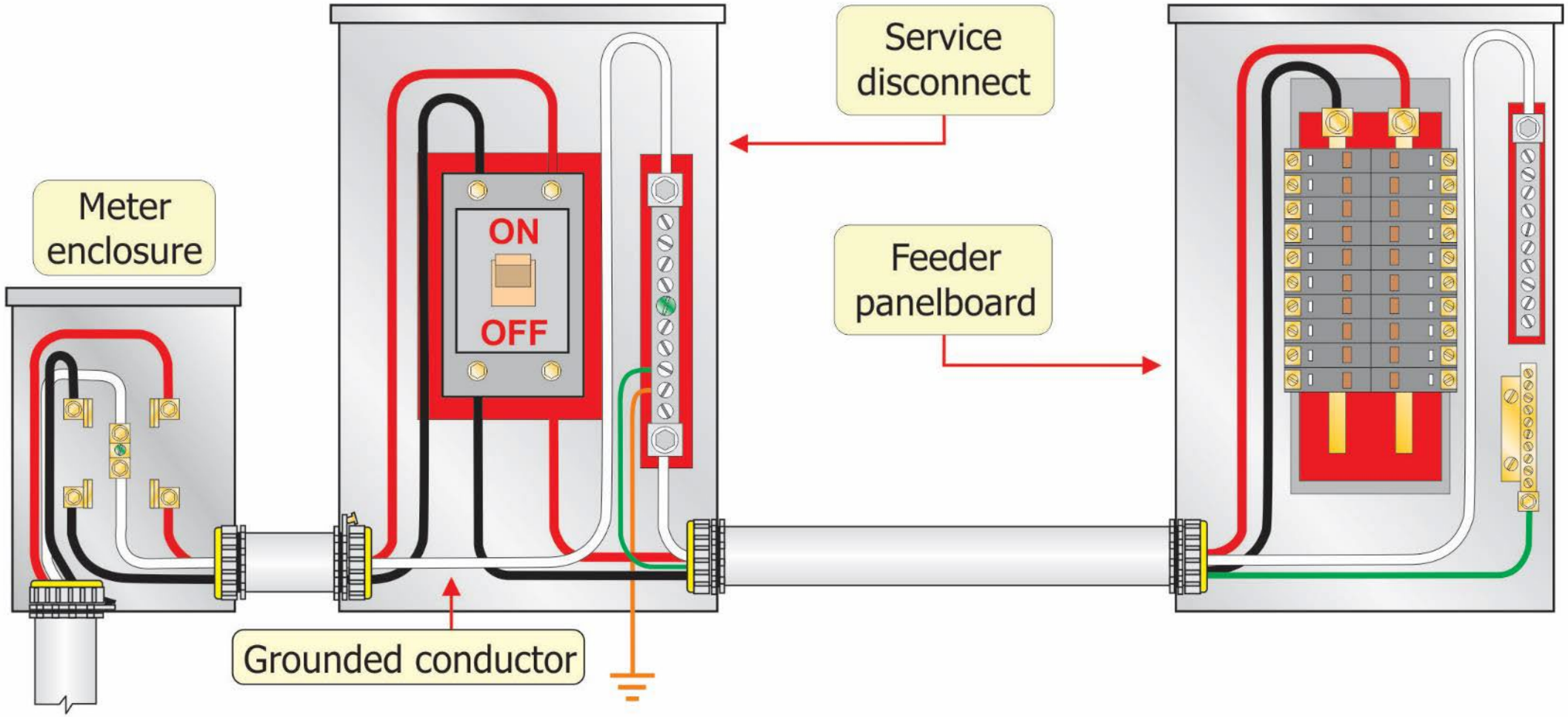
Copyright © IAEI 2020

Grounded Conductor Brought to Each Service Disconnecting Enclosure

- In addition to providing the return portion of the circuit for unbalanced loads, the **grounded service conductor** provides a key part of the vital **low-impedance path** for ground-fault current to return to the source
- System grounded conductor must be **run to each service disconnecting means enclosure**, connected to the grounded (neutral) conductor terminal bar, and be bonded to the enclosure through a **main bonding jumper**, regardless of whether or not it is needed for the service or is used to supply a load
- Must not be smaller than the specified size in Table 250.102(C)(1)
- See 250.24(C)

Grounded Conductor Run to Each Service Disconnect

The grounded conductor(s) is required to be brought to the grounded conductor terminal bus at each service disconnecting means and bonded to each service disconnecting means enclosure using a main bonding jumper [250.24(C)]



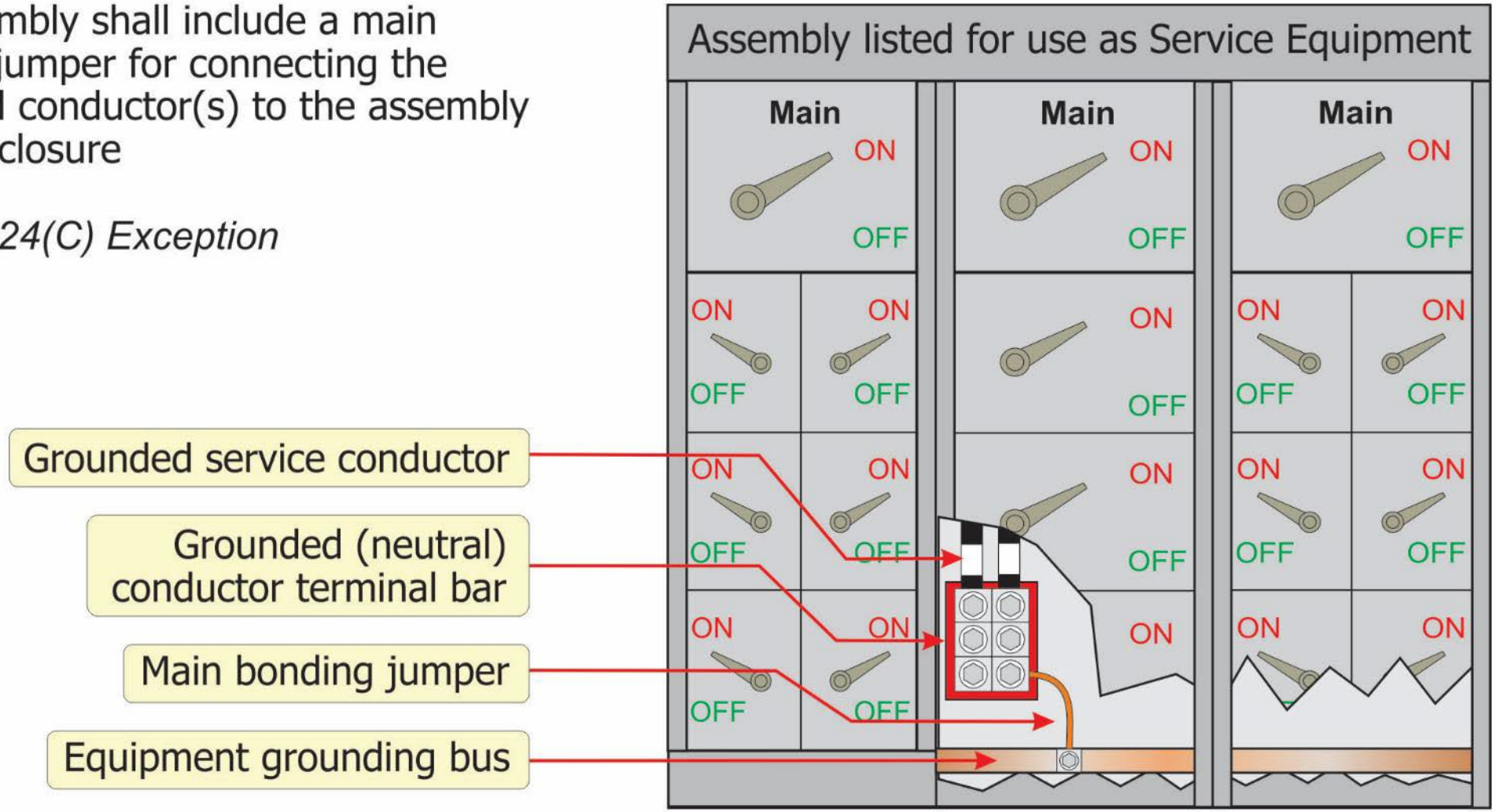
Copyright © IAEI 2020

Grounded Conductor to Service Equipment

Where two or more service disconnecting means are located in a single assembly *(with seperate sections)* listed for use as service equipment, it shall be permitted to connect the grounded conductor(s) to the assembly common grounded conductor(s) terminal or bus

The assembly shall include a main bonding jumper for connecting the grounded conductor(s) to the assembly of the enclosure

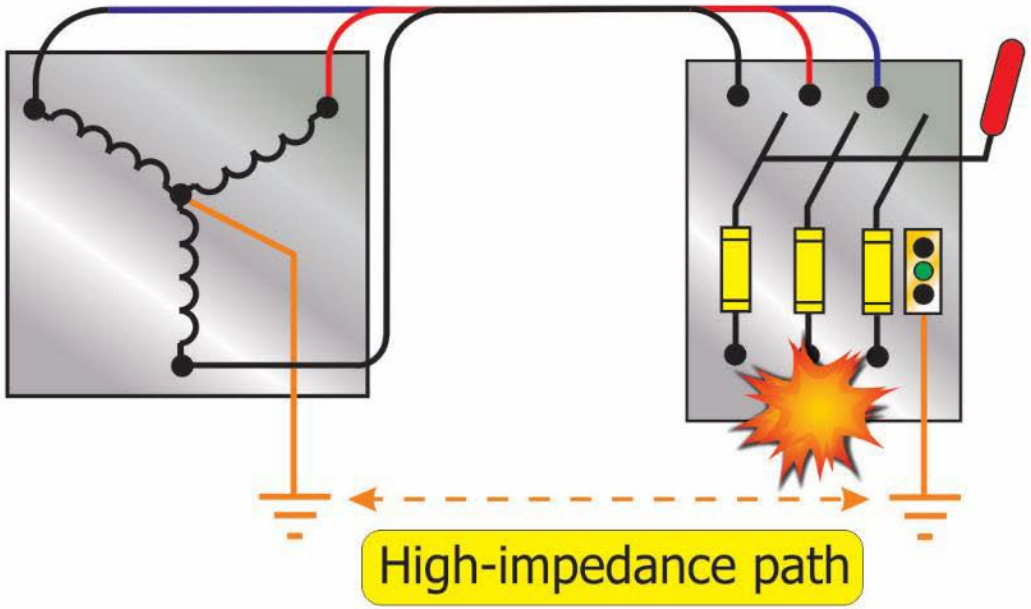
See 250.24(C) Exception



Copyright © IAEI 2020

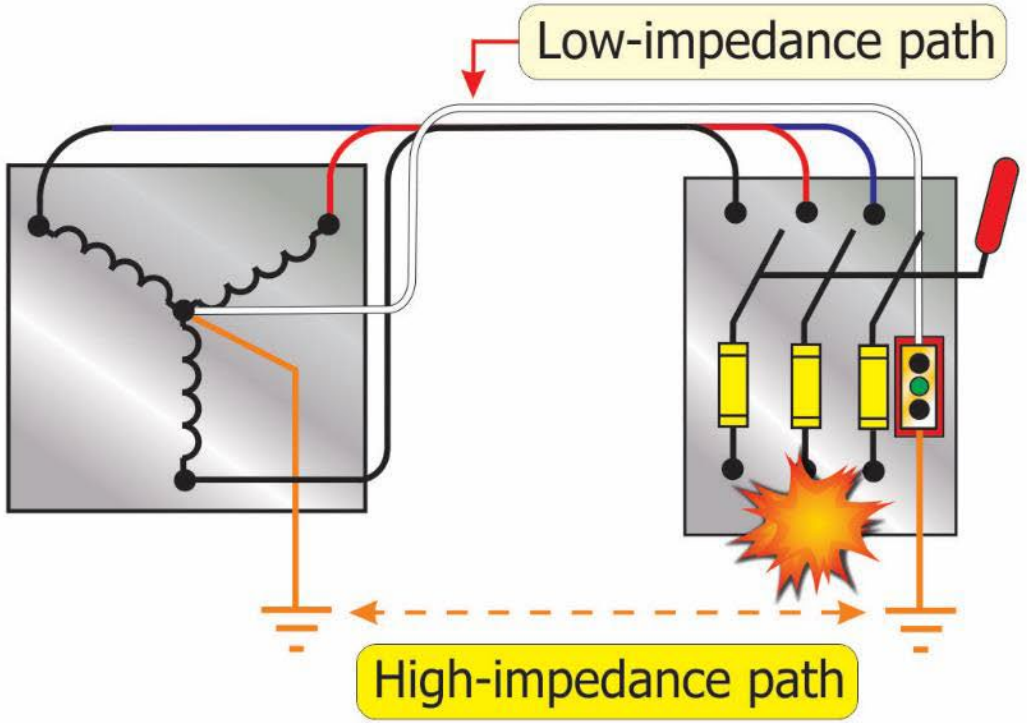
Low- and High-Impedance Paths

Grounded conductor not installed from source to service disconnect



Only path for return of ground-fault current from service disconnect to grounded source is a high-impedance path *(earth)*

Grounded conductor installed from source to service disconnect



Both high- and low-impedance paths for return of ground-fault current from source to service disconnect to source

Copyright © IAEI 2020

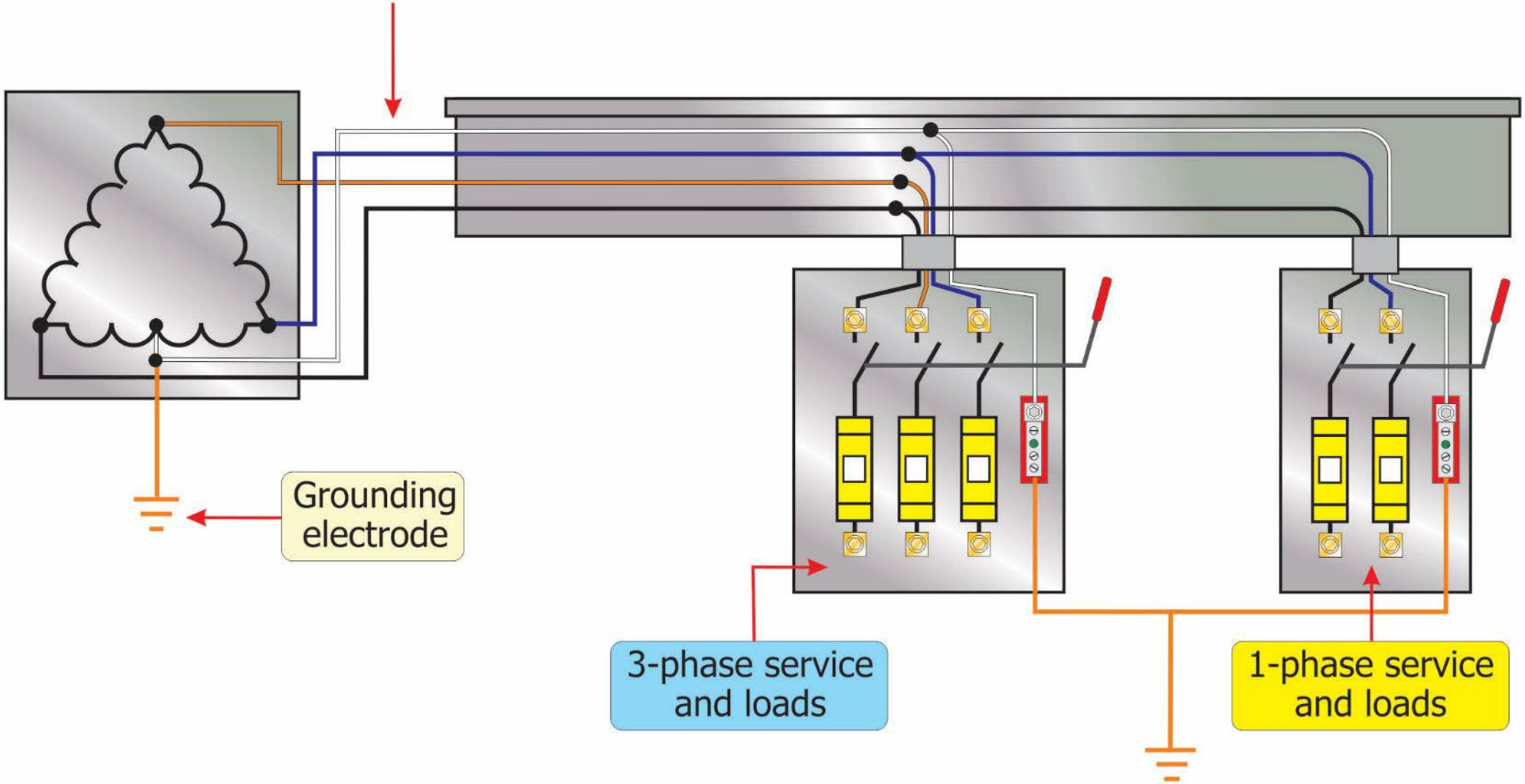
Grounded Conductor Brought to Enclosure



- Service disconnecting means showing the grounded conductor(s) brought to the enclosure and bonded to the enclosure
- Grounding electrode conductor is also connected to the neutral bus
- Main bonding jumper is in the form of a strap bonding the grounded conductor(s) to the enclosure

Power and Lighting Service for 3-Phase System

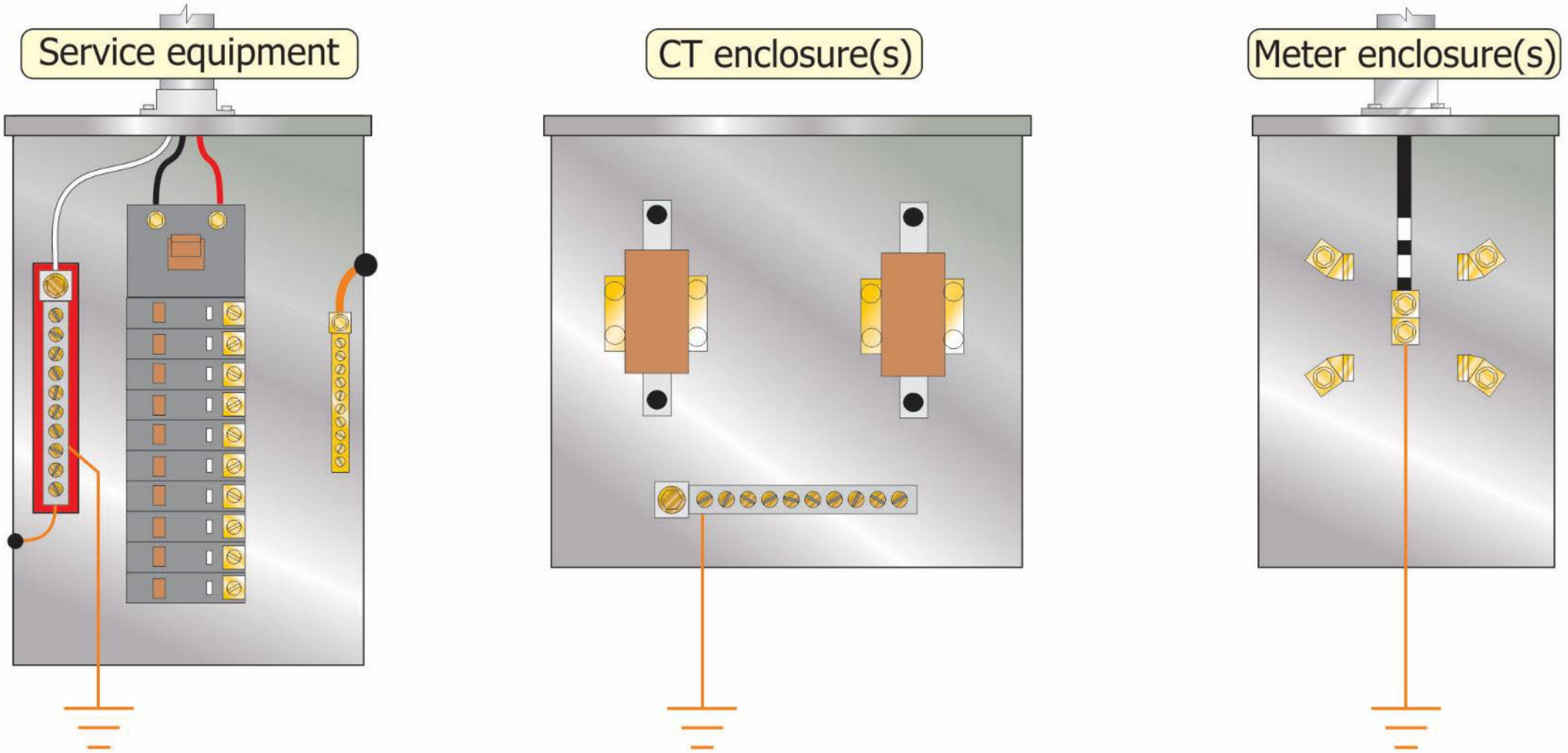
Grounded service conductor is run to both service disconnects and bonded to each enclosure



Copyright © IAEI 2020

250.24(A)(1) Service Grounding Connection to be Accessible

Location of grounding electrode conductor connection to grounded service conductor must be accessible and at load end of overhead service conductors, service drop, underground service conductors, or service lateral

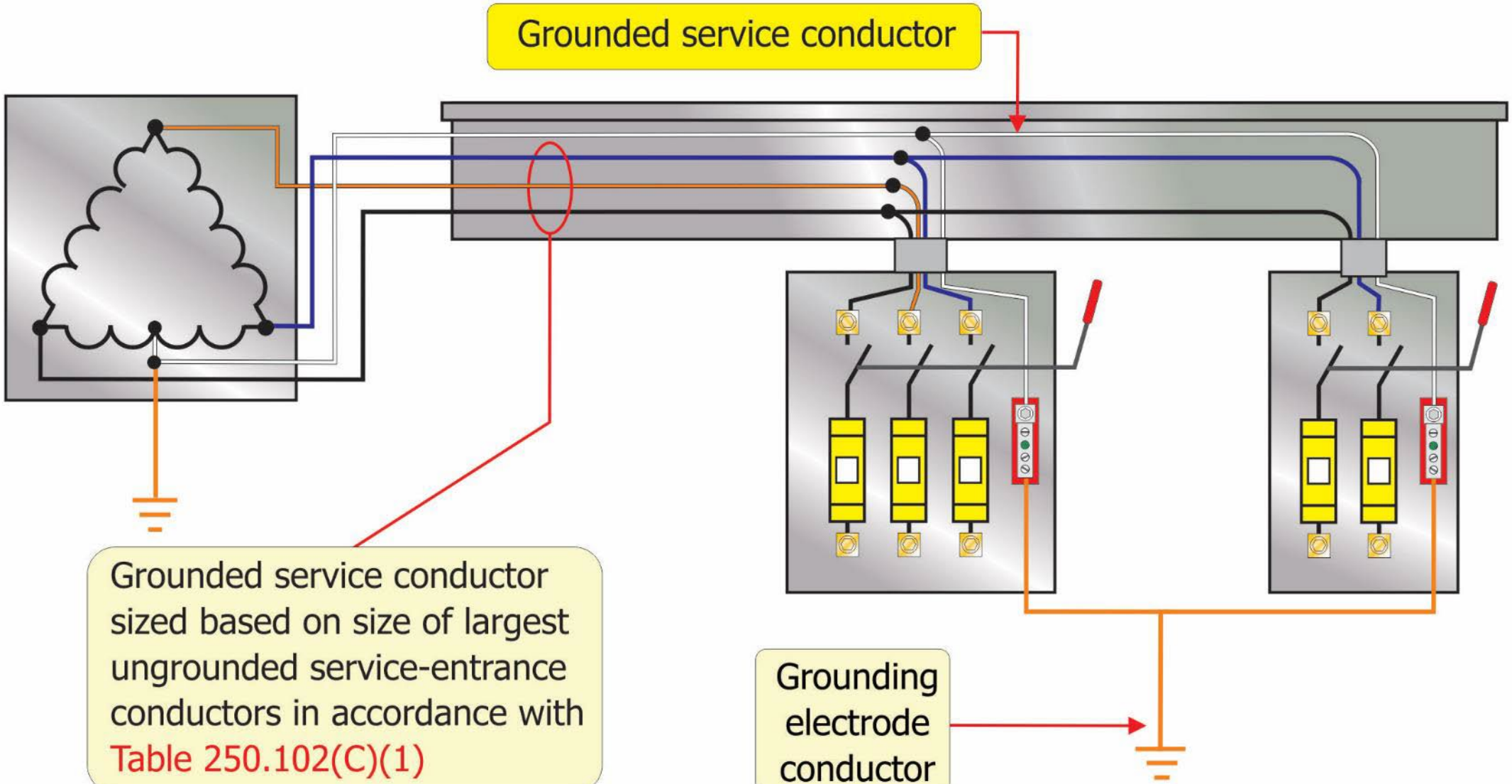


Copyright © IAEI 2020

Minimum Size of Grounded Service Conductor

- Calculate load on grounded conductor according to 220.61
- Compare calculated size with **Table 250.102(C)(1)**
- Use larger of two conductor sizes determined
- Grounded conductor shall not be smaller than specified in Table 250.102(C)(1)
- Use **12½ percent rule** for service-entrance conductors that exceed the kcmil values given in Table 250.102(C)(1) *(see Note 1 to table)*
- Grounded conductor based on size of ungrounded service conductors, not on overcurrent device rating

Minimum Size of Grounded Service Conductor



Copyright © IAEI 2020

Table 250.102(C)(1) Grounded Conductor, Main Bonding Jumper, System Bonding Jumper, and Supply- Side Bonding Jumper for Alternating-Current Systems

Size of Largest Ungrounded Conductor or Equivalent Area for Parallel Conductors (AWG/kcmil)		Size of Grounded Conductor or Bonding Jumper* (AWG/kcmil)	
Copper	Aluminum or Copper-Clad Aluminum	Copper	Aluminum or Copper-Clad Aluminum
2 or smaller	1/0 or smaller	8	6
1 or 1/0	2/0 or 3/0	6	4
2/0 or 3/0	4/0 or 250	4	2
Over 3/0 through 350	Over 250 through 500	2	1/0
Over 350 through 600	Over 500 through 900	1/0	3/0
Over 600 through 1100	Over 900 through 1750	2/0	4/0
Over 1100	Over 1750	See Notes 1 and 2	

Notes:
[See NEC for complete text of notes to Table 250.102(C)(1)]

*For the purposes of applying this table and its notes, the term *bonding jumper* refers to main bonding jumpers, system bonding jumpers, and supply-side bonding jumpers.

Copyright © IAEI 2020

Dwelling Unit Services and Feeders

- Special requirements for dwelling unit services and the main power feeder at 310.12
- Applies only for single-family dwellings, and individual units of two-family and multifamily dwellings
- Applies not only to **120/240-volt, single-phase, 3-wire**, dwelling services and the main power feeder, but can be applied to 208Y/120 volt single-phase feeders from a **208Y/120 volt system** as well
- Grounded conductor is permitted to be smaller than ungrounded conductors

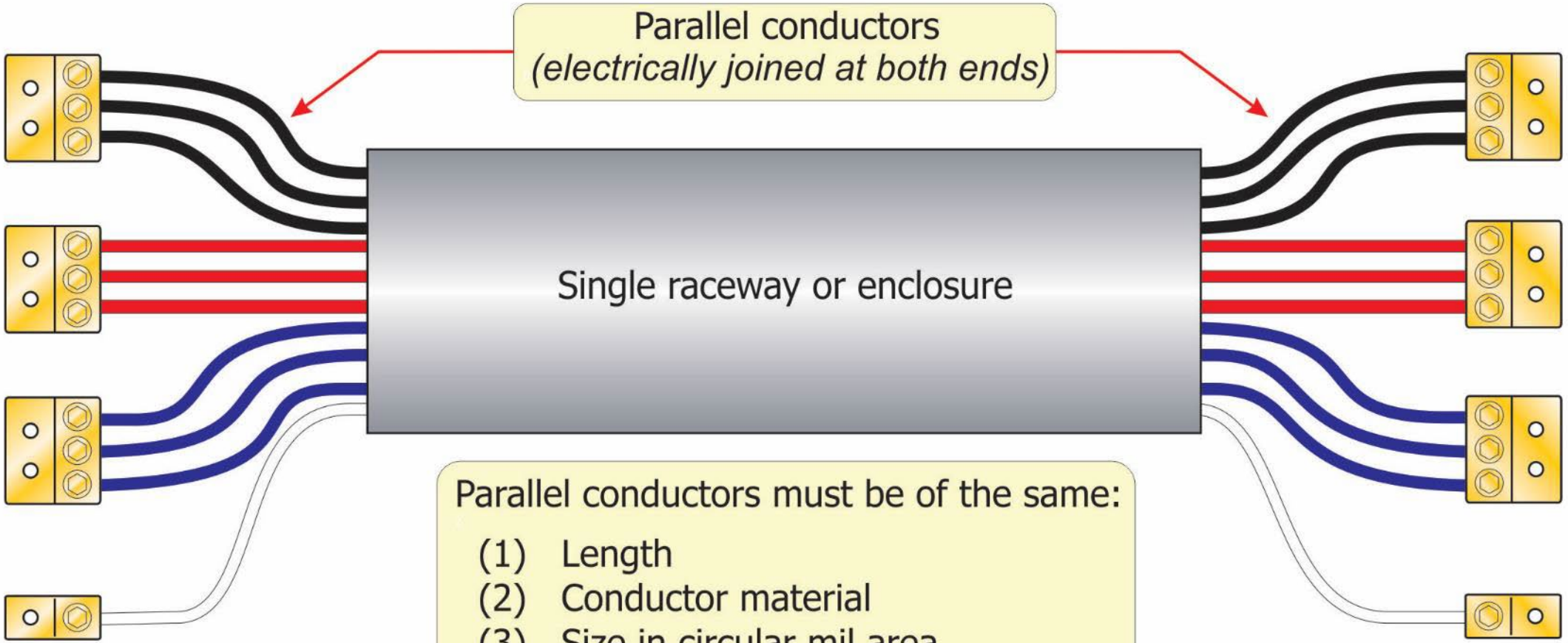
Dwelling Unit Services and Feeders *(cont.)*

- Section 215.2 - feeder to be adequate for load, of minimum sizes, and not larger than the service-entrance conductors
- 220.61 - calculation of feeder neutral load; carry maximum unbalanced load
- 230.42 - sufficient to carry the load, not smaller than required by 250.24(C)(1)
- 250.24(C)(2) is required for parallel service-entrance conductors *(not smaller than 1/0)*
- *Note: Previous permission to size the grounded conductor not more than two sizes smaller than the ungrounded conductors no longer part of the Code*

Sizing Parallel Grounded Conductors

- Where the service-entrance conductors are **run in parallel**, the size of the grounded (neutral) conductor shall be based on the total cm area of the parallel conductors in the same enclosure
- Where the service-entrance conductors are installed in **two or more raceways**, the size of the grounded (neutral) conductor shall be based on the size of the ungrounded service-entrance conductor in the raceway but not smaller than 1/0 AWG
- See 250.24(C)(2)

310.10(G) Parallel Service Conductors



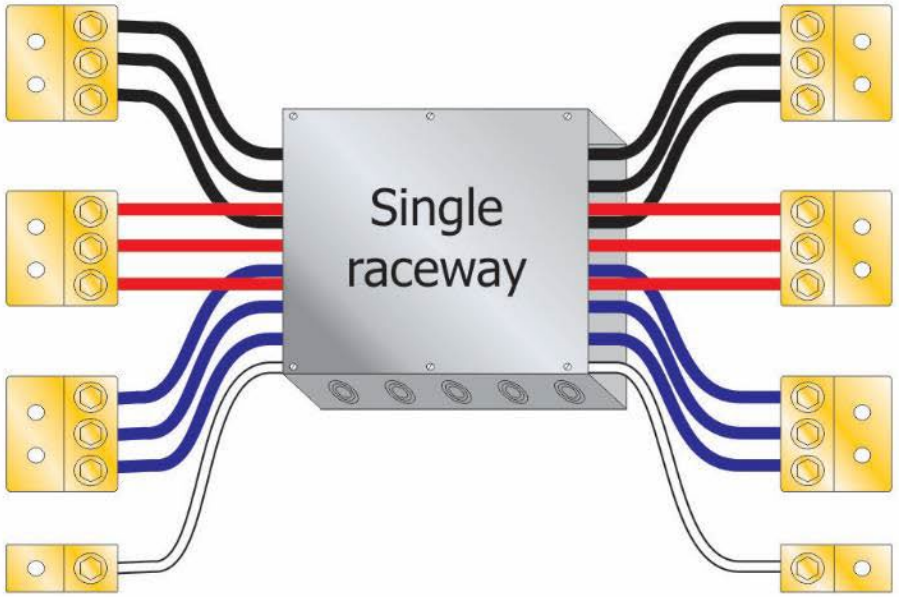
Parallel conductors must be of the same:

(1) Length
(2) Conductor material
(3) Size in circular mil area
(4) Insulation type
(5) Manner of termination

[Parallel conductors are generally required to be 1/0 AWG and larger in size (See 310.10(G)(1) and 310.10(G)(1) Ex. No. 1 and Ex. No. 2)]

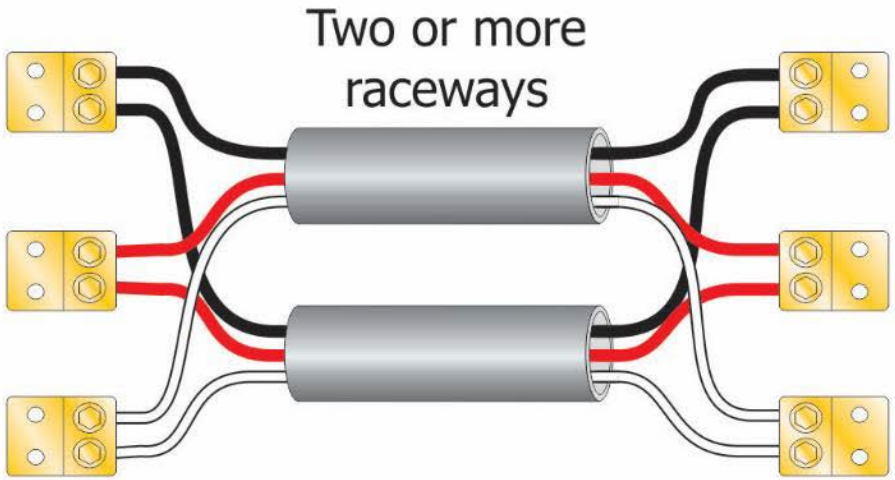
Copyright © IAEI 2020

Sizing Parallel Service Grounded Conductors



Where all service-entrance conductors are in the same raceway, the grounded conductor is to be sized at not less than given in Table 250.102(C)(1) *[see 250.24(C)(1)]*

For ungrounded conductors larger than Table 250.102(C)(1), sizing of grounded conductors to be not less than 12½ percent of total area of largest set of ungrounded conductors per Table 250.102(C)(1), Note 1



Where installed in two or more raceways, the grounded conductor size is based on the size of the ungrounded conductors in each raceway based on Table 250.102(C)(1), but not smaller than 1/0 AWG *[see 250.24(C)(2)]*

Copyright © IAEI 2020

Parallel Service-Entrance Conductors

Example Number 1:

3 - 4/0 AWG copper conductors per phase

Chapter 9, Table 8

4/0 AWG = 211,600 circular mils

3 X 211,600 = 634,800 cm

Refer to Table 250.102(C)(1)

Minimum size grounded service conductor is **2/0 AWG copper** or **4/0 AWG aluminum**

Parallel Service-Entrance Conductors

Example Number 2:

6 - 4/0 AWG copper conductors per phase

Chapter 9, Table 8

4/0 AWG = 211,600 circular mils

6 X 211,600 = 1,269,600 cm

Exceeds 1100 kcmils of T. 250.102(C)(1), use **12.5% rule**

1,269,600 cm x .125 = 158,700 cm

Chapter 9, Table 8, next larger size = **3/0 AWG copper**

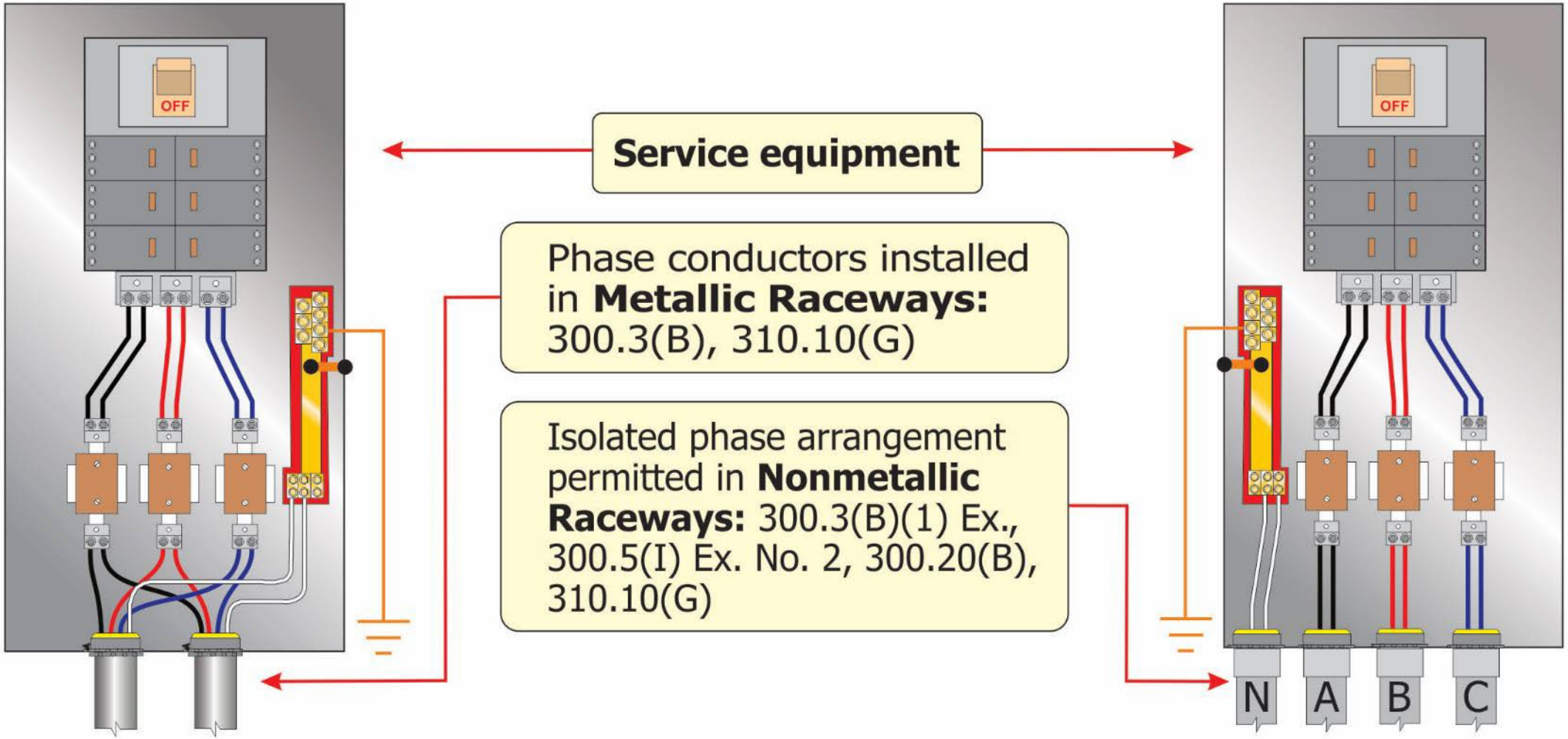
Underground Parallel Service Conductors

- All conductors of each phase permitted to be installed in the **same raceway** for **underground installations** in **nonmetallic raceways** *[300.3(B)(1) Exception]*
- Also permitted by 300.5(I) Exception No. 2
- All the ungrounded conductors of phase A are permitted to be installed in one raceway, phase B in another, phase C in the third, and the grounded service conductors in another
- Allows phase conductors to readily line up with bus terminations in bottom-fed switchboards
- Reduces the “rat’s nest” in the bottom of enclosures caused by many conductors crossing each other for termination

Underground Parallel Conductors

All conductors of the same circuit *(including the grounded conductor)* are generally required to be contained within the same raceway

Per exception, isolated phase arrangement permitted in nonmetallic raceways



Copyright © IAEI 2020

Multiple Services to One Building

- Multiple services permitted to be supplied to one building under one of several conditions allowed by 230.2
- Each service supplied from a grounded system must be provided with a **grounded service-entrance conductor**
- Size of ungrounded service-entrance conductor *(for each service)* determines the minimum size grounded service conductor for that service
- Each service is considered individually for sizing the grounded service conductor

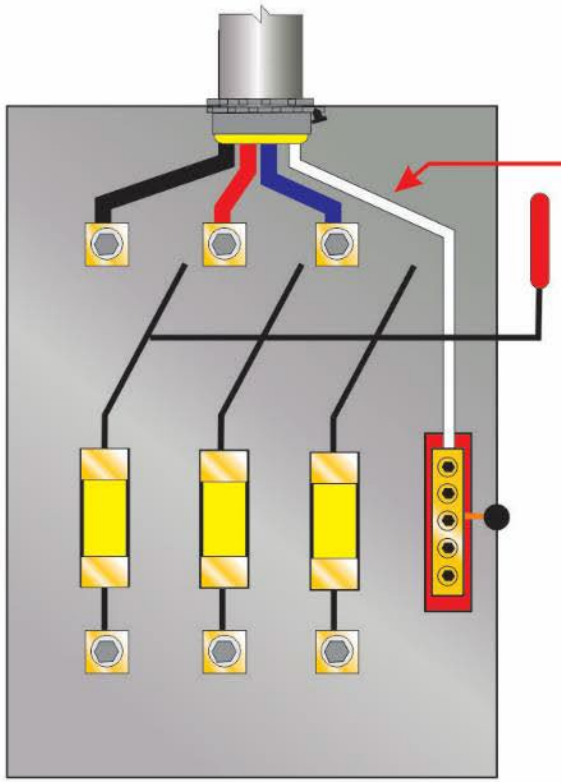
Multiple Services to One Building *(cont.)*

- **Example:**
- Building has a 400-ampere, 480-volt 3-phase, 4-wire service and a 100-ampere, 120/240-volt, single phase, 3-wire service
- Minimum size of grounded service conductor is determined as follows:
  - 400-ampere service
  - 750 kcmil THW aluminum ungrounded service conductors
  - Table 250.102(C)(1) = **1/0 AWG copper** or **3/0 AWG aluminum** grounded service conductor

Multiple Services to One Building *(cont.)*

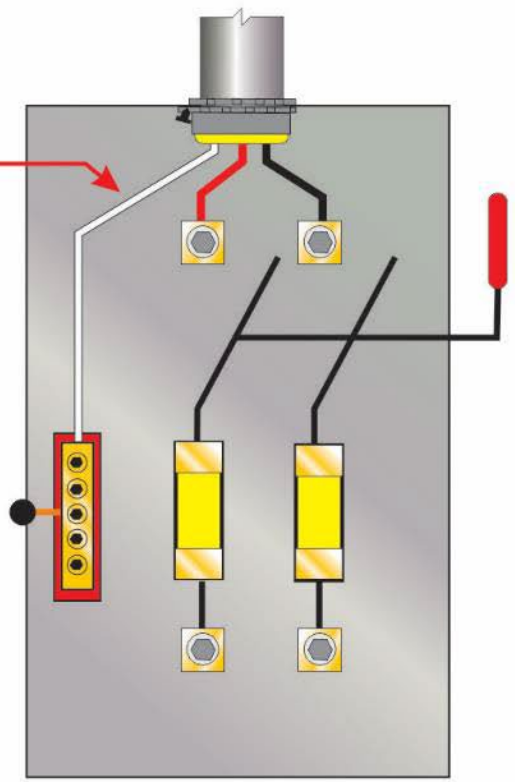
- **Example: *(cont.)***
- Building has a 400-ampere, 480-volt 3-phase, 4-wire service and a 100-ampere, 120/240-volt, single phase, 3-wire service
- Minimum size of grounded service conductor is determined as follows:
  - 100-ampere service
  - 2 AWG copper ungrounded service conductors
  - Table 250.102(C)(1) = **8 AWG copper** or **6 AWG aluminum** grounded service conductor

Two Services to One Building from Grounded System



1/0 AWG copper or 3/0 AWG aluminum grounded service conductor

8 AWG copper or 6 AWG aluminum grounded service conductor



See 250.102(C)(1) and Table 250.102(C)(1)

400-ampere service with 750 kcmil THW aluminum ungrounded service conductors

100-ampere service with 2 AWG copper ungrounded service conductors

Minimum size of grounded service conductor to each service is based upon the size of ungrounded service conductor to each individual service

Copyright © IAEI 2020

Multiple Services to One Building *(cont.)*

- This method determines minimum size of grounded service conductor to comply with **250.24(C)**
- Larger conductor may be required to carry the maximum unbalanced load on the neutral conductor as determined by **220.61**

High-Impedance Grounded Neutral Systems

- Continuous industrial process facilities and other continuous operations such as data centers often need **uninterrupted electrical power and systems**
- Common to see these facilities located near a power company substation with more than one high-voltage service supply to improve system reliability
- At the utilization voltage levels, ground fault protection for equipment is required by 230.95, 215.10 and 240.13 *(which can lead to **widespread outages** during a single ground fault event)*
- An alternative design that is commonly taken to improve system reliability is to install **high-impedance grounded neutral systems** *(rather than solidly grounded systems)*

High-Impedance Grounded Neutral Systems *(cont.)*

- Advantages to high-impedance grounded neutral systems include:
  - Improved reliability
  - Ability to have ground-fault relaying that alarms rather than trips
  - Fewer problems to the system from transient overvoltages
- High-impedance grounded systems can be applied to both services and separately derived systems to premises wiring

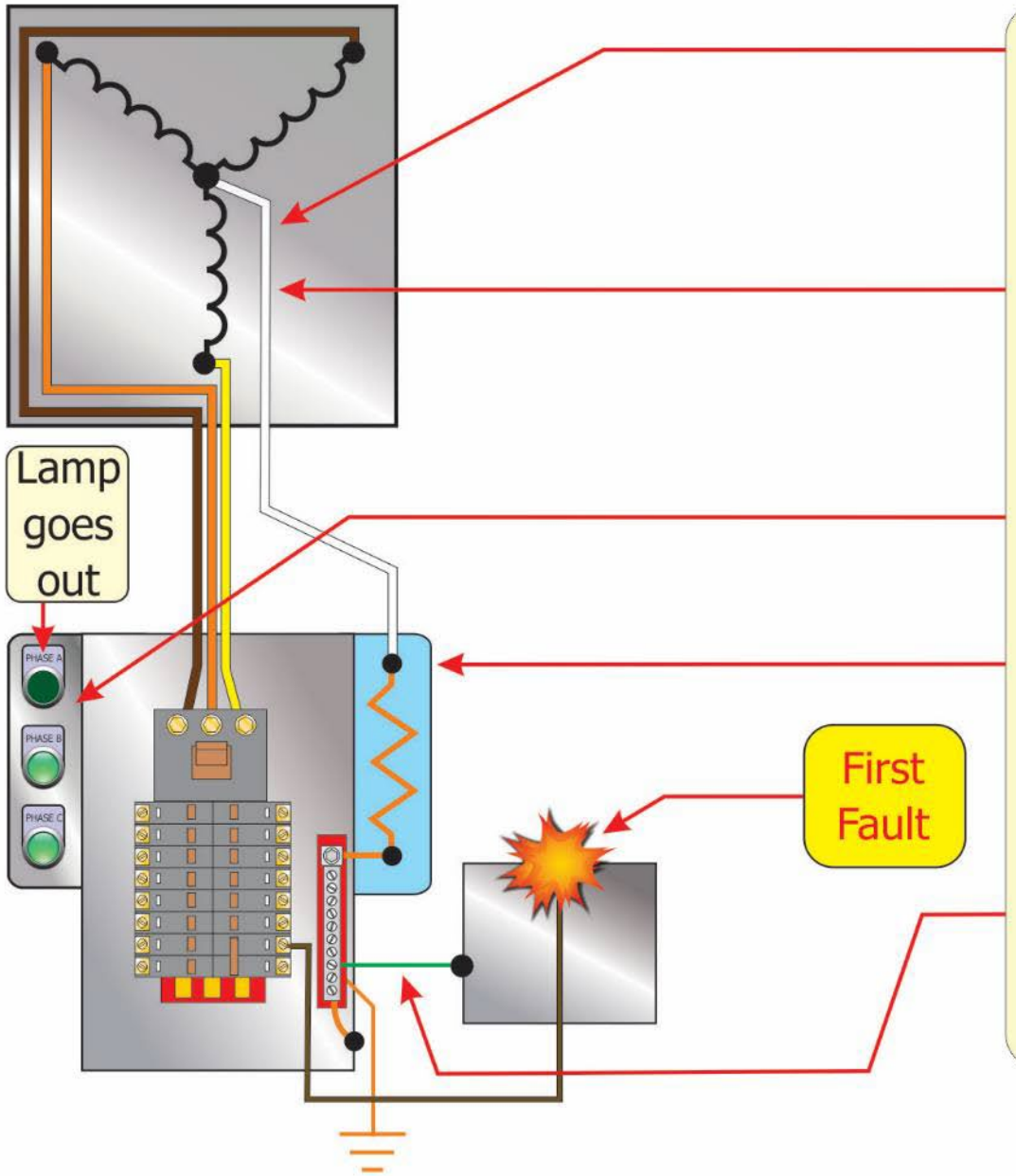
High-Impedance Grounded Neutral Systems *(cont.)*

- Three conditions must be met before the *Code* will permit high-resistance grounded neutral systems to be installed:
  - Qualified person(s) must be available to service the system
  - Ground detectors *(a ground fault alarm rather than trip system)* must be installed to indicate an insulation failure
  - Line to neutral loads are not served
- See 250.36 *(systems where the voltage is less than 1000 volts)*

High-Impedance Grounded Neutral Systems *(cont.)*

- Systems in which a grounding impedance *(usually a resistor)* limits the ground-fault current to a low value by installing the resistor between the transformer supplied grounded service-entrance conductor or derived neutral conductor and the grounding electrode
- Permitted for 3-phase ac systems of 480 volts to 1000 volts
- Impedance device is typically sized to a value greater than the capacitive charging current of the system *(for 480-volt systems, this is usually about 10 amperes)*
- Provides enough separation so that a fault will still be detected at minimal damage levels while normal charging or capacitive leakage current would not be detected causing false alarms

250.36 High Impedance Grounded Neutral Systems



Grounded system conductor must be fully insulated

Grounded system conductor not smaller than current rating of impedance device, minimum 8 AWG copper or 6 AWG aluminum

Ground detectors installed on the system

Grounded system conductor connects to the impedance device

Equipment grounding conductor(s) connected below impedance device

See 250.36(A) through (G)

Copyright © IAEI 2020

Equipment for High-Impedance Grounded Neutral Systems



High resistance grounded system cabinets complete with tapped resistor and controls

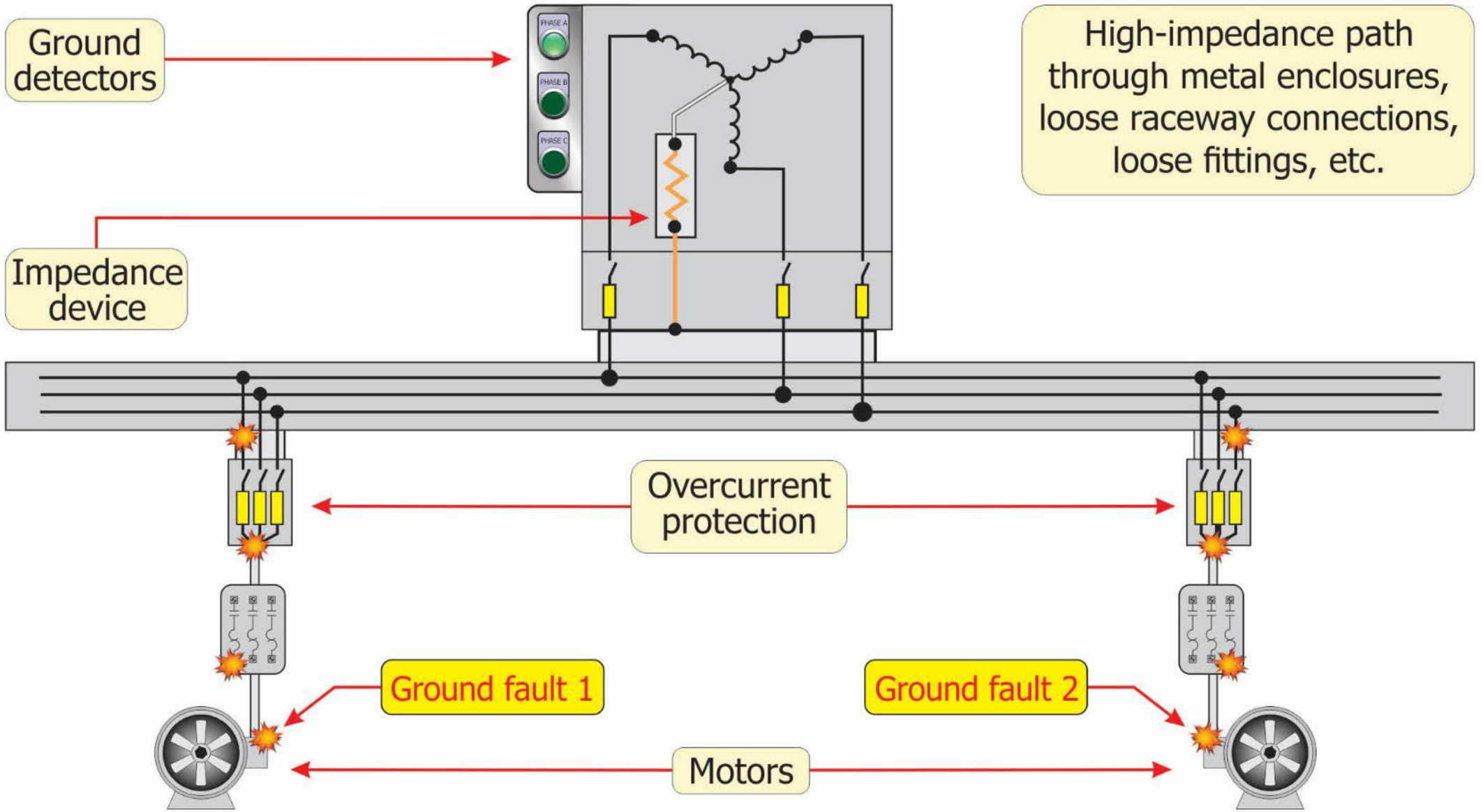
Resistor for high-impedance grounded neutral system with single phase grounding transformer *(provides low current grounding at voltages 2.4 kV and higher)*



Photos Courtesy of Post Glover

Copyright © IAEI 2020

Second Ground Fault on High-Impedance Grounded Neutral System



Copyright © IAEI 2020

Grounding of Ungrounded Systems

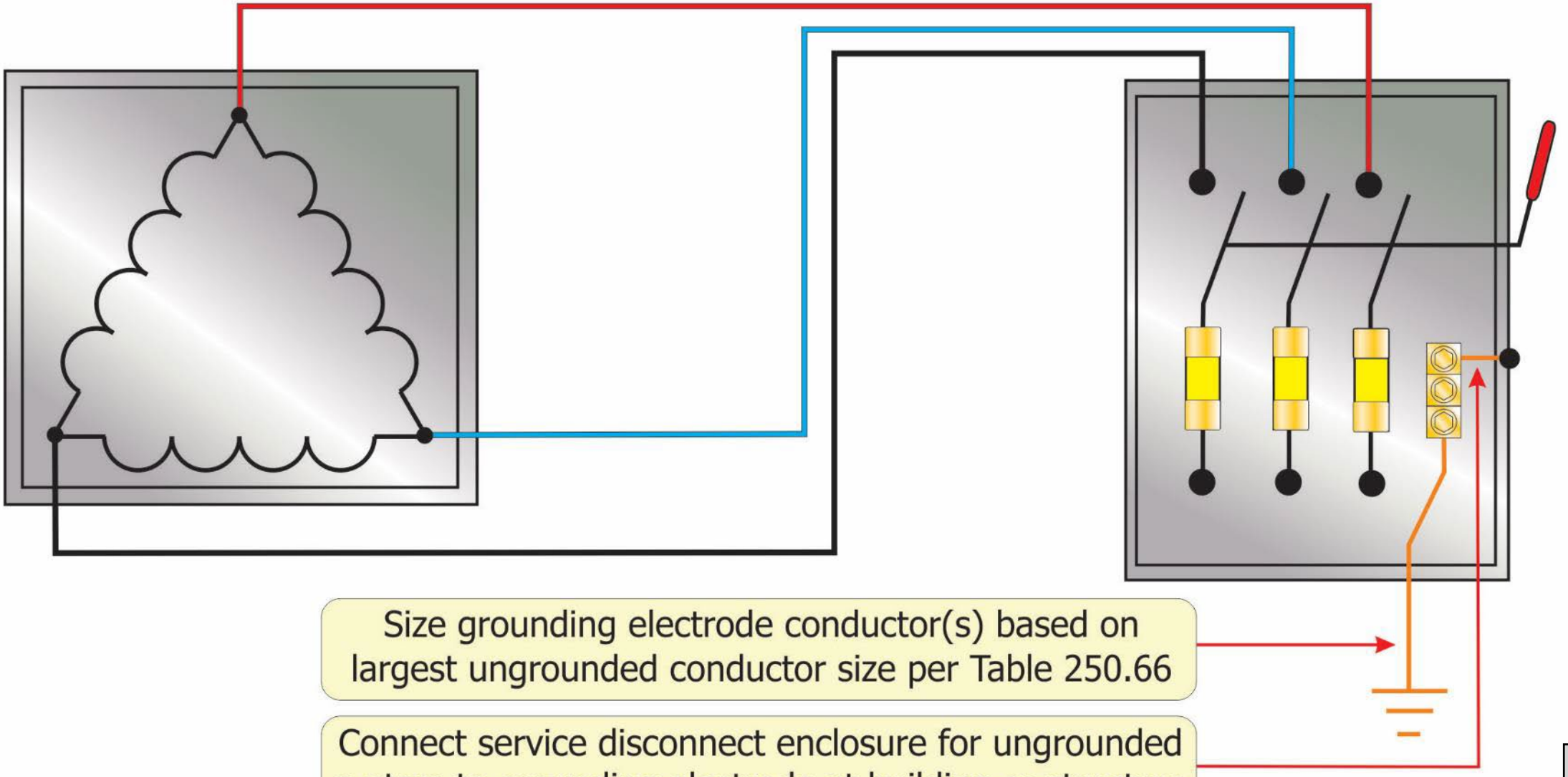
- Ungrounded systems that experience a ground fault *(particularly an arcing type ground fault)* are subject to relatively severe transient over-voltages that can reach several times normal voltage to ground
- Such abnormal voltages become potential hazards and often cause insulation failure and equipment breakdowns in other parts of the system
- Grounded systems *(with one conductor purposely grounded)* greatly reduces the value of such transient over-voltages as they develop
- Ungrounded system must have its conductor and equipment enclosures connected to a grounding electrode system at the building or structure served
- This keeps such enclosures as near to ground potential as possible and reduces shock hazards to a minimum

Grounding of Ungrounded Systems *(cont.)*

- Service equipment enclosures are grounded by connecting them to a grounding electrode system
- Enclosures, raceways, etc. of an ungrounded system are required to be grounded
- Grounding electrode system and equipment grounding conductors are required
- An ungrounded system has **no system grounded conductor present**
- Grounding electrode conductor sizing based on 250.66 using the largest ungrounded phase conductor(s)
- Equipment grounding conductors in ungrounded systems are sized based on the rating of the overcurrent device using Table 250.122
- See 250.24(E)

250.24(E) Grounding Requirements for Ungrounded Systems

Enclosures, raceways, etc. of an ungrounded system are required to be grounded



Size grounding electrode conductor(s) based on largest ungrounded conductor size per Table 250.66

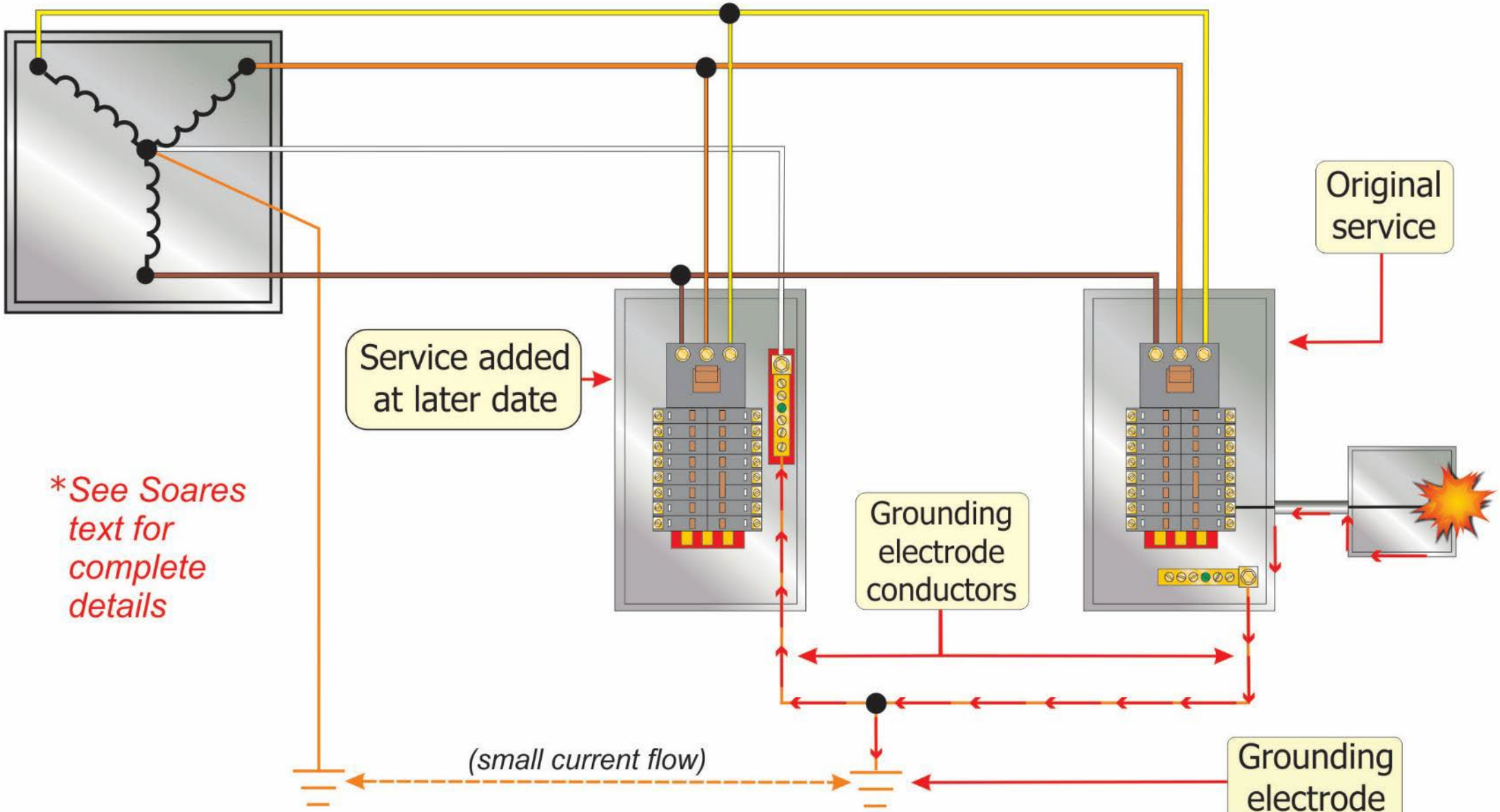
Connect service disconnect enclosure for ungrounded system to grounding electrode at building or structure

Copyright © IAEI 2020

Hazard of Services Without a Grounded Conductor Supplied from a Grounded System

- The illustration on the next slide illustrates the hazard of operating a service from a grounded system without installing a grounded service conductor
- Original ungrounded service *(on right)* in the illustration existed before the newer service *(on left)* was installed
- First and original service was supplied by an ungrounded utility system with the service and feeder shown supplying equipment protected by large overcurrent devices
- Sometime later, the service on the left, which included a grounded service conductor, was installed
- ***See Soares textbook (last section of Chapter 9) for complete details***

Hazard of Ungrounded Service from Grounded System Without a Grounded Conductor



Copyright © IAEI 2020

CHAPTER TEN

MAIN BONDING JUMPERS AND BONDING AT SERVICES

Main Bonding Jumpers and Bonding at Services

- Main bonding jumper is one of the most critical elements in the safety grounding and bonding system
- Main bonding jumper serves as the link between:
  - Grounded service conductor
  - Equipment grounding conductor(s)
  - Grounding electrode conductor

Main Bonding Jumpers and Bonding at Services *(cont.)*

- Primary purpose of the main bonding jumper is to **carry the ground-fault current** from the service enclosure and from the equipment grounding conductor system that is returning to the source during ground-fault conditions
- Ensures equipment grounding bus is at the **same potential as the earth** where the grounding electrode conductor is connected directly to the grounded service conductor *(neutral)* bus
- Main bonding jumper **completes the earth connection** to the grounded (neutral) conductor where the grounding electrode conductor is connected to the equipment grounding bus as permitted in 250.24(A)(4)

Article 100 Definitions

- ***Bonded (Bonding):*** "Connected to establish electrical continuity and conductivity"
- ***Bonding Jumper, Main:*** "The connection between the grounded circuit conductor and the equipment grounding conductor, or the supply-side bonding jumper, or both, at the service"
- ***Bonding Jumper, Supply-Side:*** "A conductor installed on the supply side of a service or within a service equipment enclosure(s), or for a separately derived system, that ensures the required electrical conductivity between metal parts required to be electrically connected"

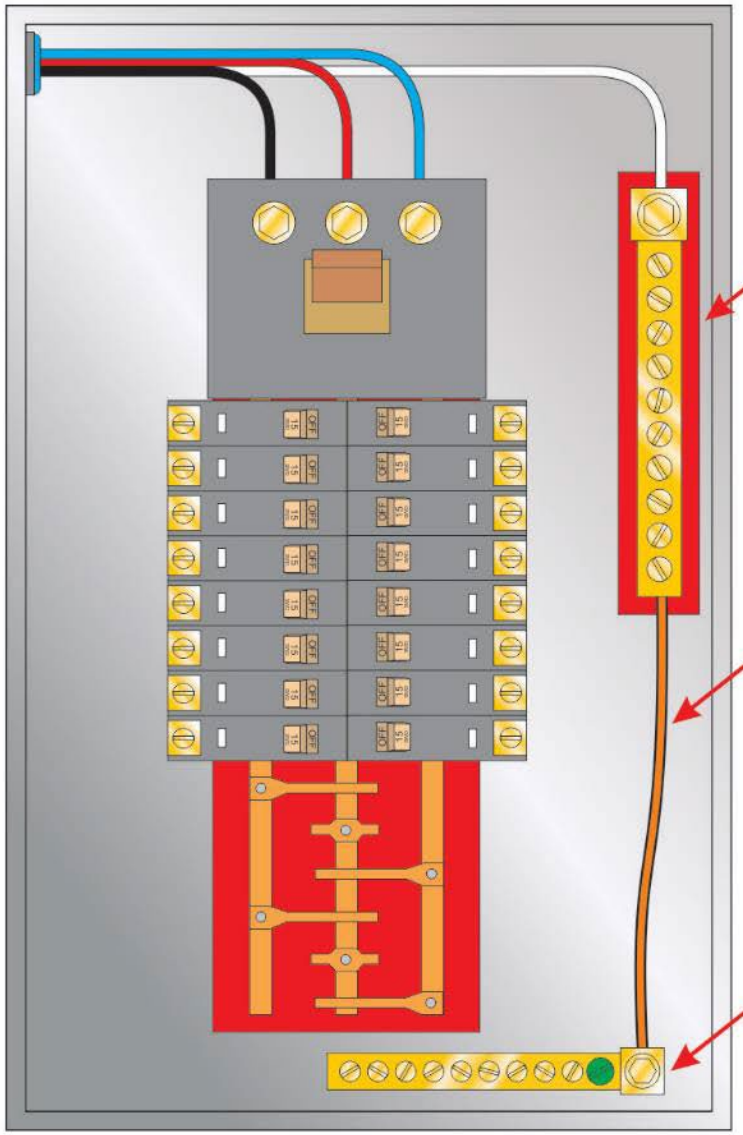
Main Bonding Jumper in Listed Equipment

- Busbar, strap, conductor, or screw type **main bonding jumper** that is furnished by the manufacturer as part of the **listed equipment** may be used without calculating its adequacy
- Sized in accordance with sizing requirements of the applicable product safety standard
- Example:
  - Dead-Front Switchboards, UL-891
  - Motor Control Centers, UL-845
  - Panelboards, UL-67
  - Power Outlets, UL-231

Main Bonding Jumper

- For a grounded system, 250.24(B) requires an unspliced main bonding jumper to be used to connect:
  - **Equipment grounding conductor(s)** and the **service disconnect enclosure** to the **grounded conductor** of the electrical system
- Connection must be made within the enclosure for **each service disconnect** *(see 250.28)*

250.28 Main Bonding Jumper



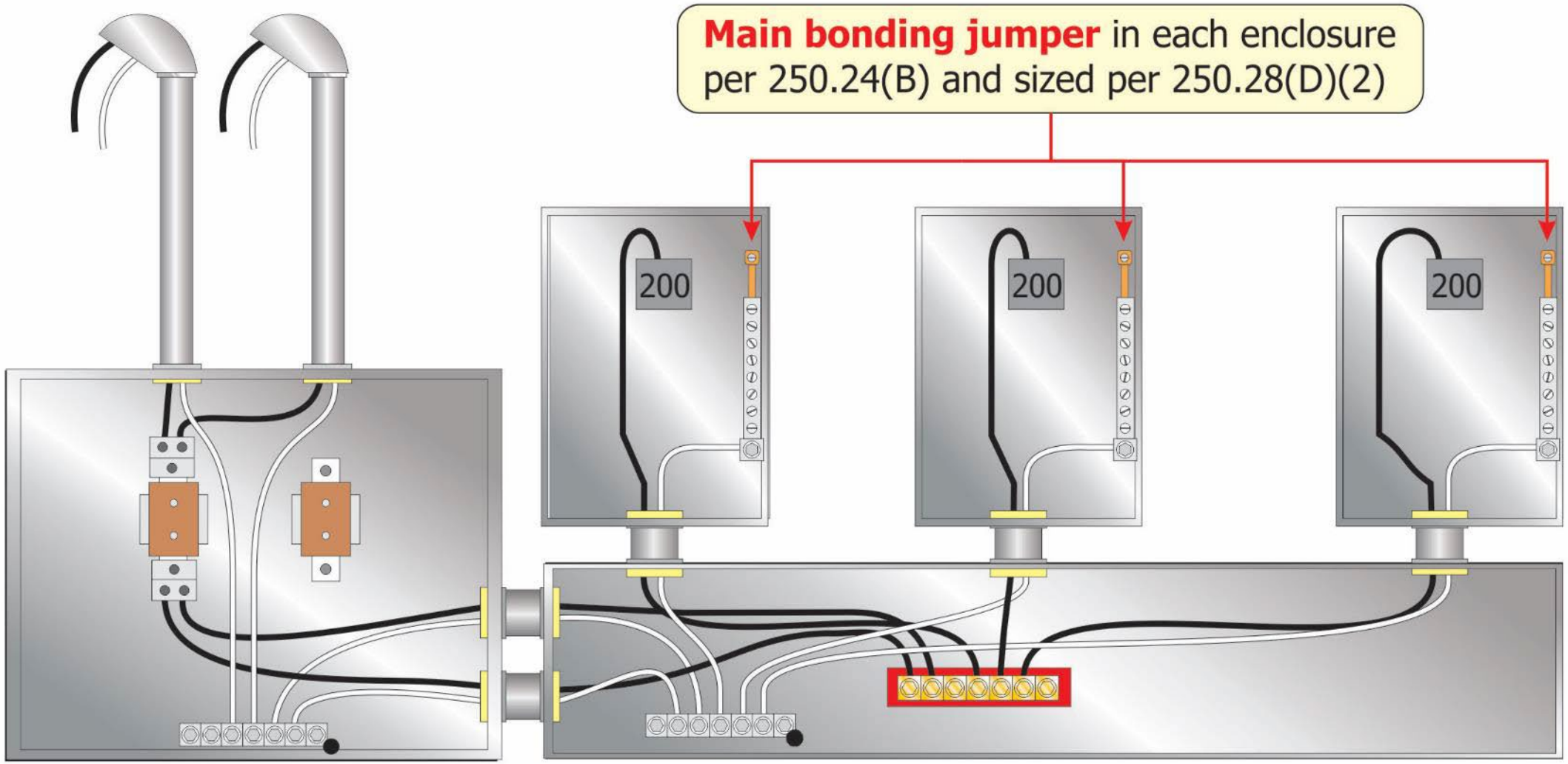
Bus for neutral or grounded conductor

Main bonding jumper may be wire, bus or screw *(green finish if it is a screw)*

Equipment grounding bus bonded to enclosure *(by green screw)*

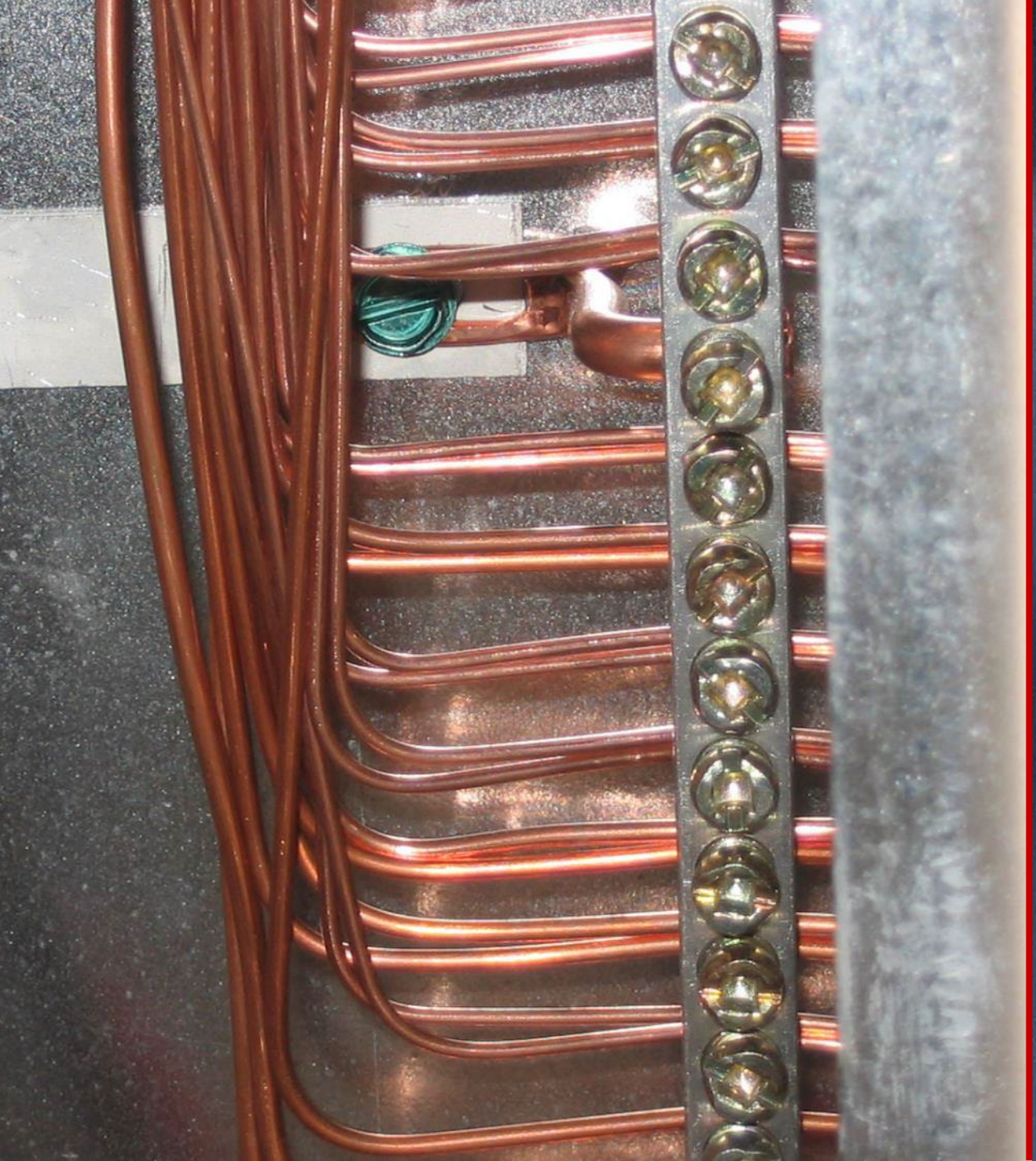
Copyright © IAEI 2020

Main Bonding Jumper- Multiple Enclosures



(All conductors not shown)

Copyright © IAEI 2020



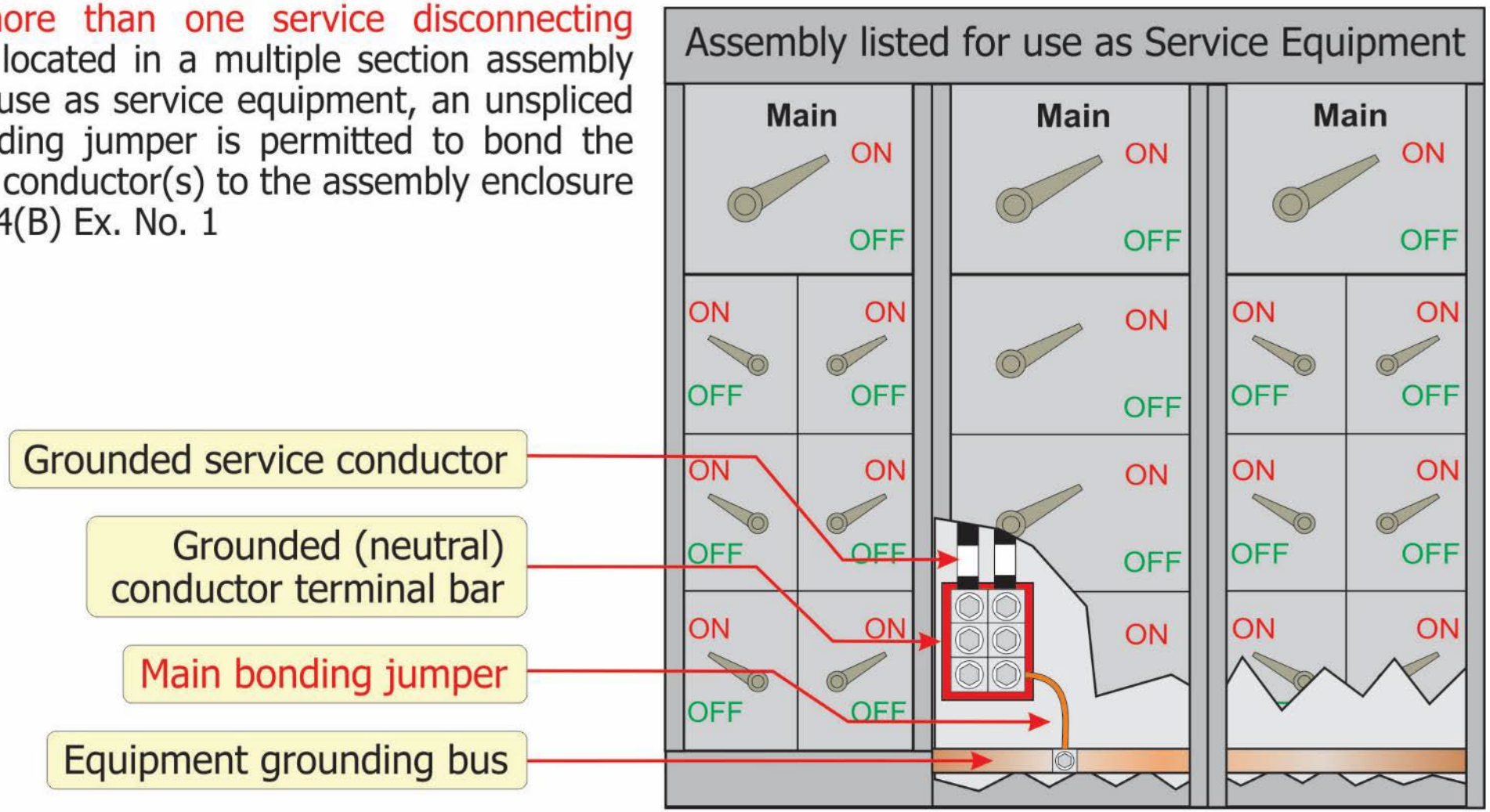

TIME
DELAY
60200R


NEUTRAL LINK
DISCONNECT
BONDING
JUMPER

Main Bonding Jumper in Multiple Disconnect Service Equipment

For a grounded system, an unspliced main bonding jumper is required to connect the equipment grounding conductor(s) and the service-disconnect enclosure to the grounded conductor within the enclosure for each service disconnect

Where more than one service disconnecting means is located in a multiple section assembly listed for use as service equipment, an unspliced main bonding jumper is permitted to bond the grounded conductor(s) to the assembly enclosure per 250.24(B) Ex. No. 1



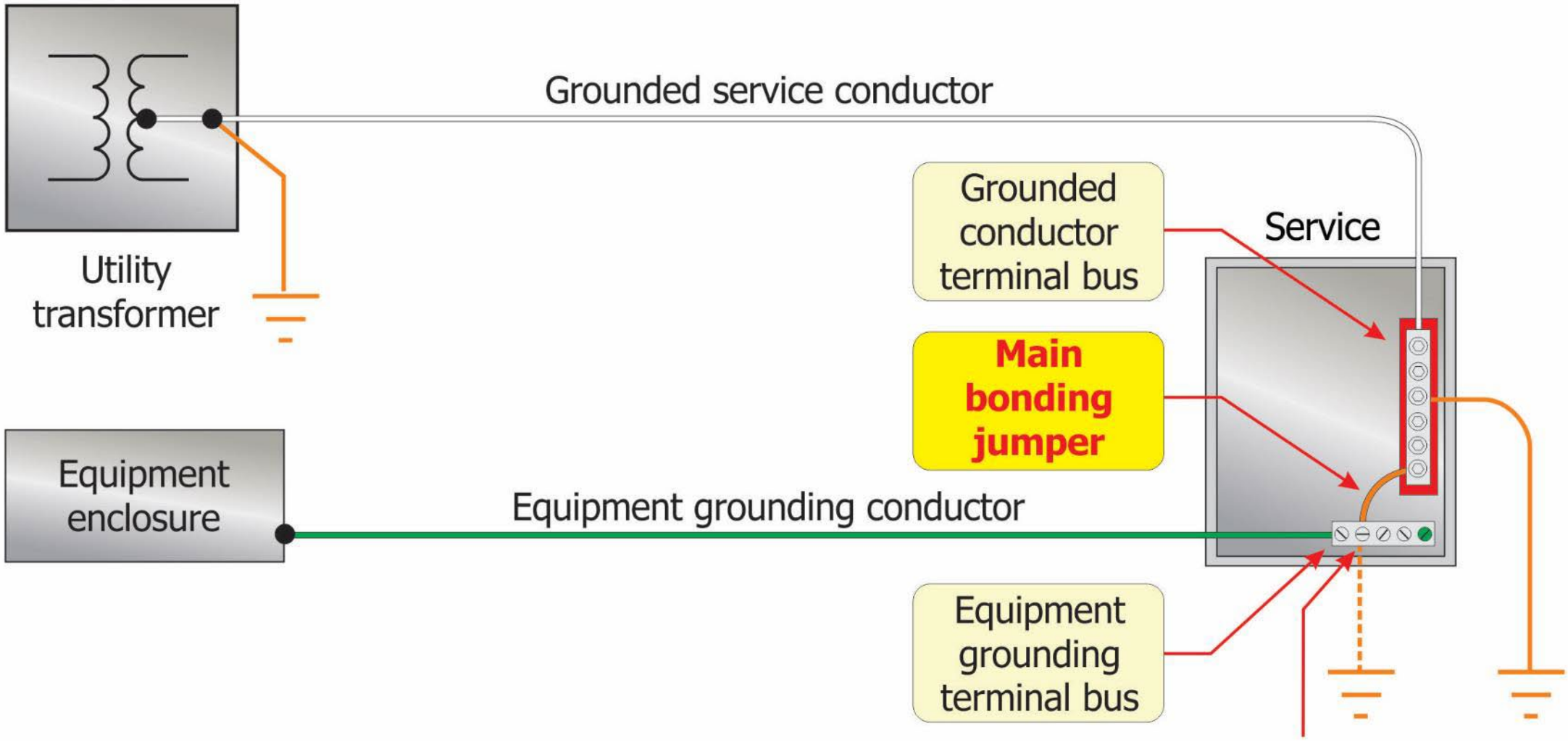
Copyright © IAEI 2020

Functions of Main Bonding Jumper

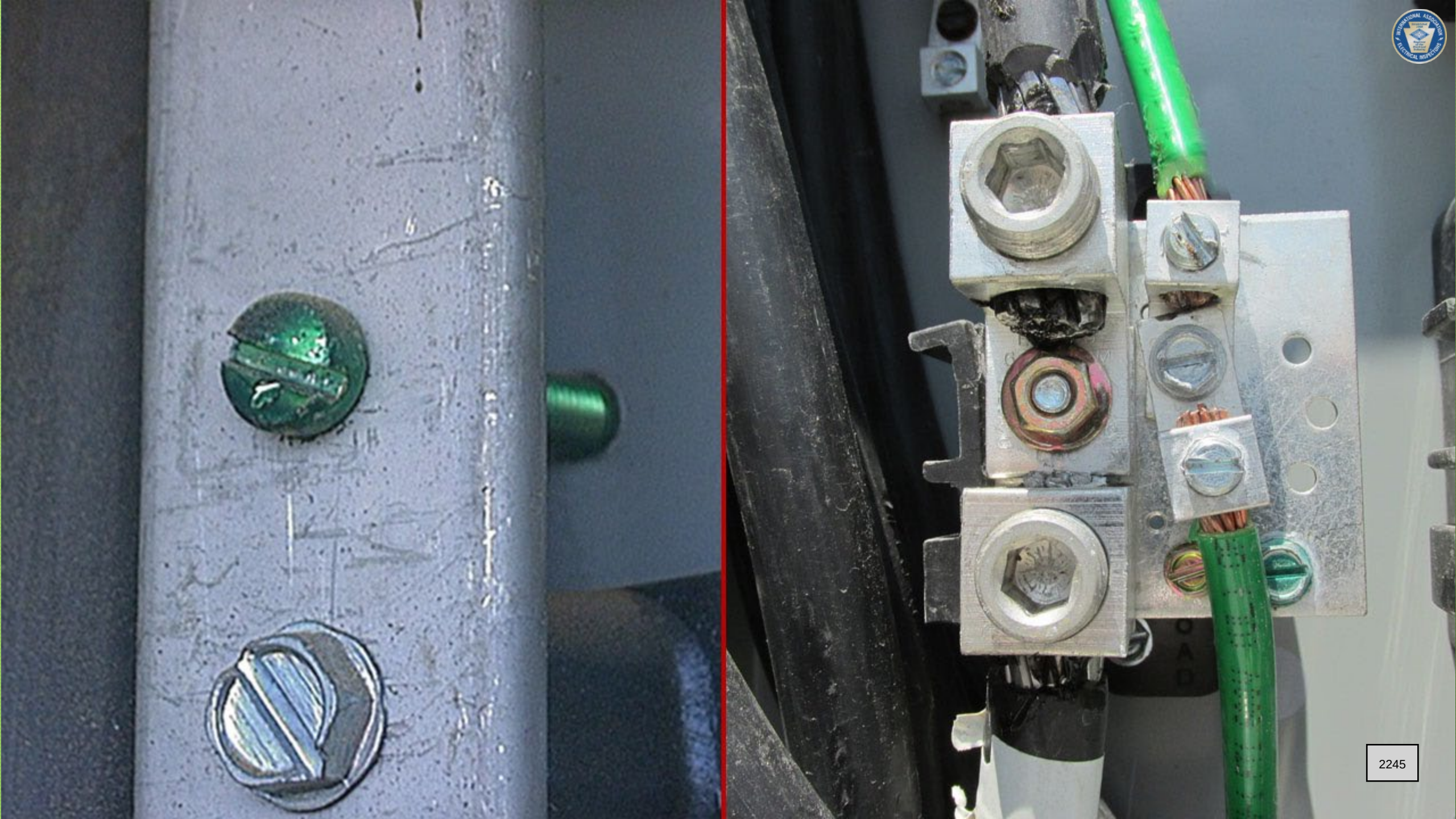
- The main bonding jumper performs **three major functions**:
  - Connects grounded service conductor to the equipment grounding bus or conductor and the service enclosure
  - Provides **low-impedance path** for return of ground-fault currents to the source by completing the ground-fault return circuit from the equipment grounding conductors and enclosure to the source via the service grounded (neutral) conductor
  - Connects the grounded service conductor to the grounding electrode conductor where the grounding electrode conductor is terminated on the equipment grounding bus or bar

Major Functions of Main Bonding Jumper

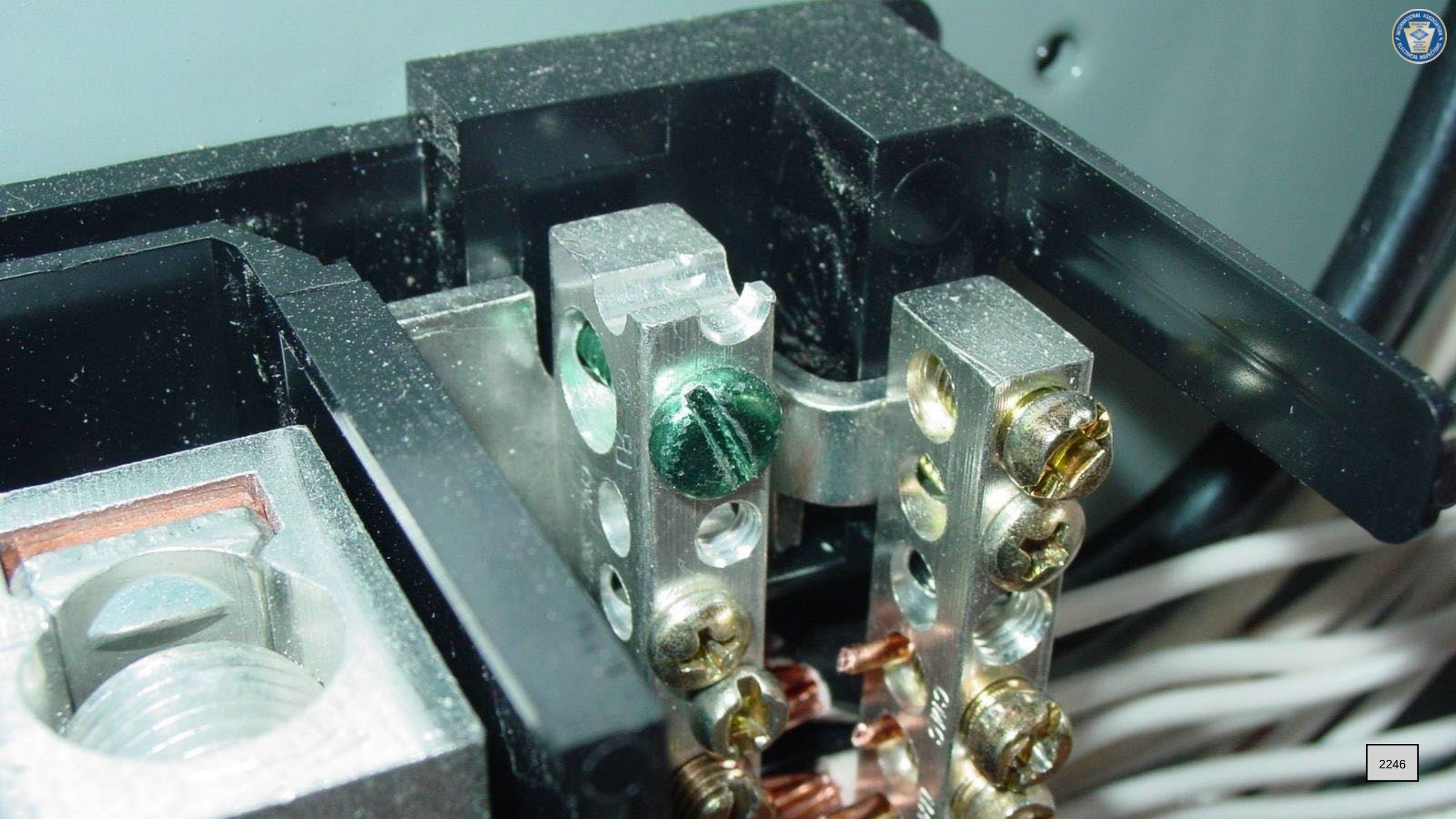
Main Bonding Jumper. The connection between the grounded circuit conductor and the equipment grounding conductor, or the supply-side bonding jumper, or both, at the service.

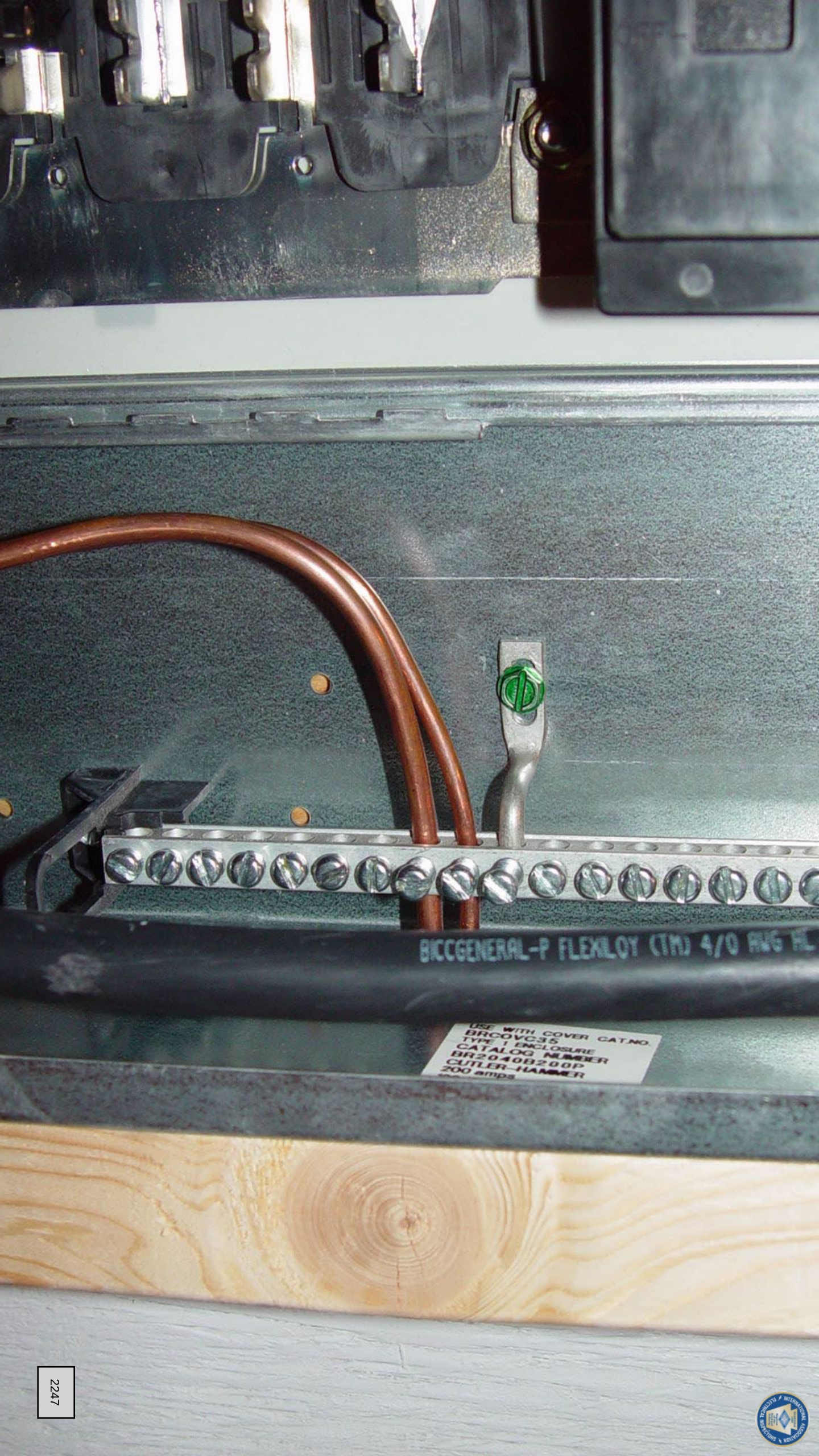


Copyright © IAEI 2020



2245

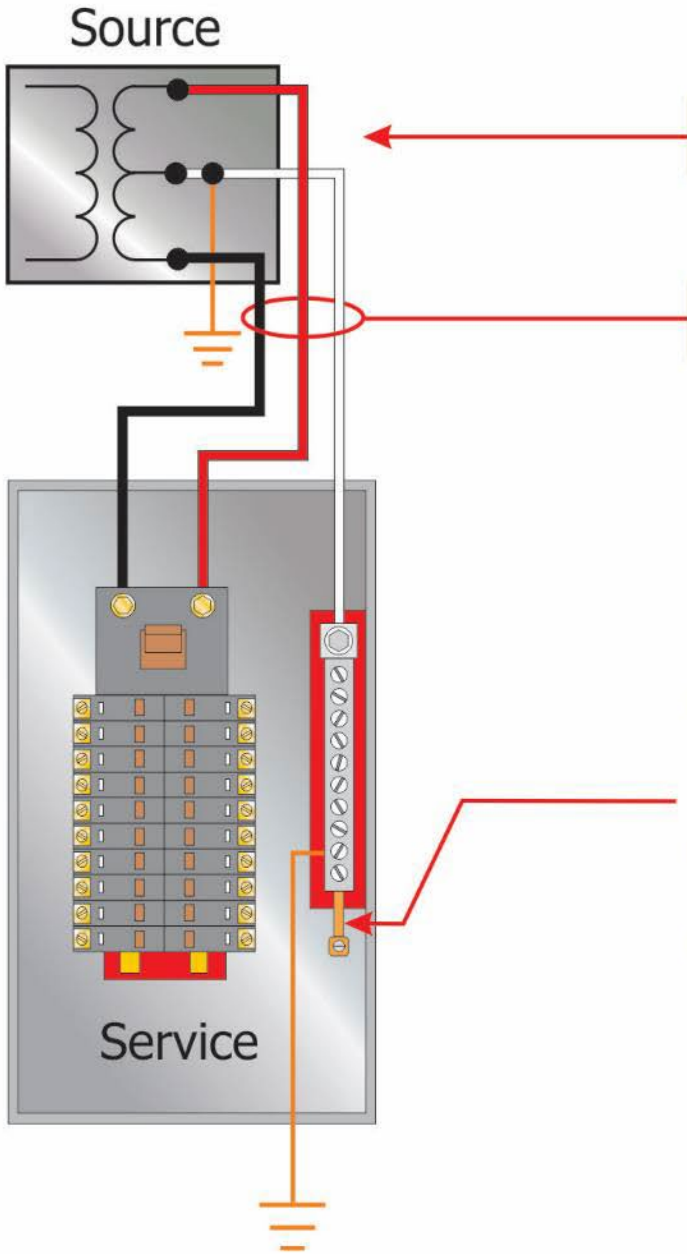



BICCGENERAL-P FLEXILOY (TM) 4/0 AWG
USE WITH COVER CAT.NO.
BRCOVC35
TYPE 1 ENCLOSURE
CATALOG NUMBER
BR2040B200P
CUTLER-HAMMER
200 amps

Sizing of Main Bonding Jumper

- Main bonding jumper must carry the full ground-fault current of the system back to the grounded service conductor *(which may be a neutral)*
- Size must relate to the rating of the service conductors which supply the service
- Minimum size of the main bonding jumper is determined from the requirements of 250.28(D)
- For services with service-entrance conductors **up to 1100 kcmil copper or 1750 kcmil aluminum**, use Table 250.102(C)(1)
- Where the service-entrance conductors are larger than table values, main bonding jumper to be sized a minimum of **12½ percent** of the cross-sectional area of the largest service-entrance conductor

Main Bonding Jumper at Single Disconnect



Grounded electrical system

Service-entrance conductors

Size of **main bonding jumper** in listed service equipment in accordance with the applicable standard *(done by manufacturer)*

Size of **main bonding jumper** *(if conductor)* based on size of largest ungrounded service entrance conductors

Size per Table 250.102(C)(1) and table notes

If larger than table values, 12½ percent of largest service-entrance conductor area *[see Note 1 to Table 250.102(C)(1)]*

Copyright © IAEI 2020

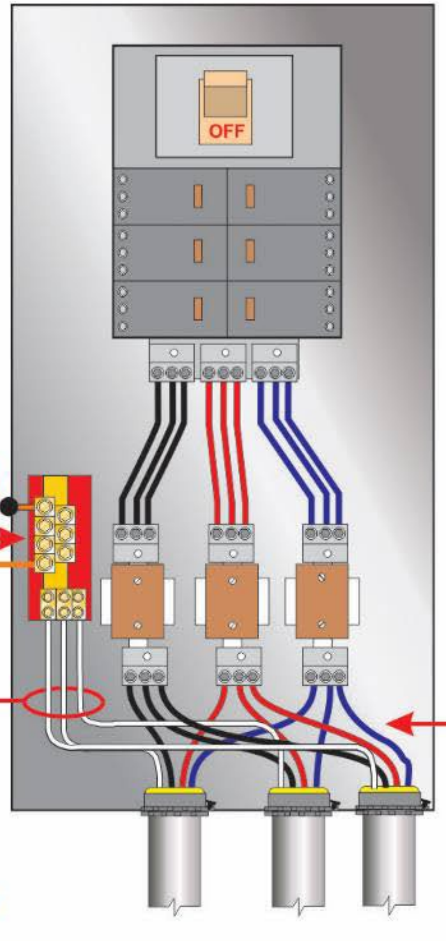
Sizing Main Bonding Jumper *(Conductor)*

- **Example 1:**
  - 250 kcmil aluminum service-entrance conductors
  - Table 250.102(C)(1)
  - Minimum **4 AWG copper** or **2 AWG aluminum** or copper-clad aluminum main bonding jumper required

Sizing Main Bonding Jumper *(Conductor)*

- **Example 2:**
  - (3) 500-kcmil copper conductors are installed in parallel as service-entrance conductors
  - Add circular mil area together and if larger than 1100 kcmil copper or 1750 kcmil aluminum, use **12½ % rule**
  - 3 x 500 kcmil = 1500 kcmil
  - 1500 x .125 = 187,500 circular mils
  - Refer to *NEC* Chapter 9, Table 8
  - Next conductor that would exceed 187,500 circular mils is a **4/0 AWG conductor** *(211,600 circular mils)*

Sizing Main Bonding Jumper for Parallel Service Conductors



Main bonding jumper

Equipment grounding bus

Grounded service conductors

Grounding electrode conductor

Service-entrance conductors
(3- 250 kcmil aluminum per phase)

Step 1- (3) 250 kcmil aluminum conductors per set *[3 x 250 = 750 kcmil]*

Step 2- Refer to Table 250.102(C)(1)

Step 3- Minimum size MBJ for 750 kcmil aluminum: 1/0 AWG copper or 3/0 AWG aluminum

Copyright © IAEI 2020

Functions of Supply-Side Bonding Jumper

- The service grounded (neutral) generally provides **electrical continuity** between the supply source *(such as the utility transformer enclosure)* and the various enclosures of the service equipment
- Where additional bonding is required in this equipment *(such as for bonding bushings on metal raceways)*, the **supply-side bonding jumper** provides the connection to the service grounded (neutral) conductor in the service equipment enclosure(s)
- The **supply-side bonding jumper** functions to:
  - Carry ground-fault current from ground faults that occur on the supply side of the main overcurrent protection
  - Provide a low impedance path for the ground-fault current to return to the source

Supply-Side Bonding Jumper

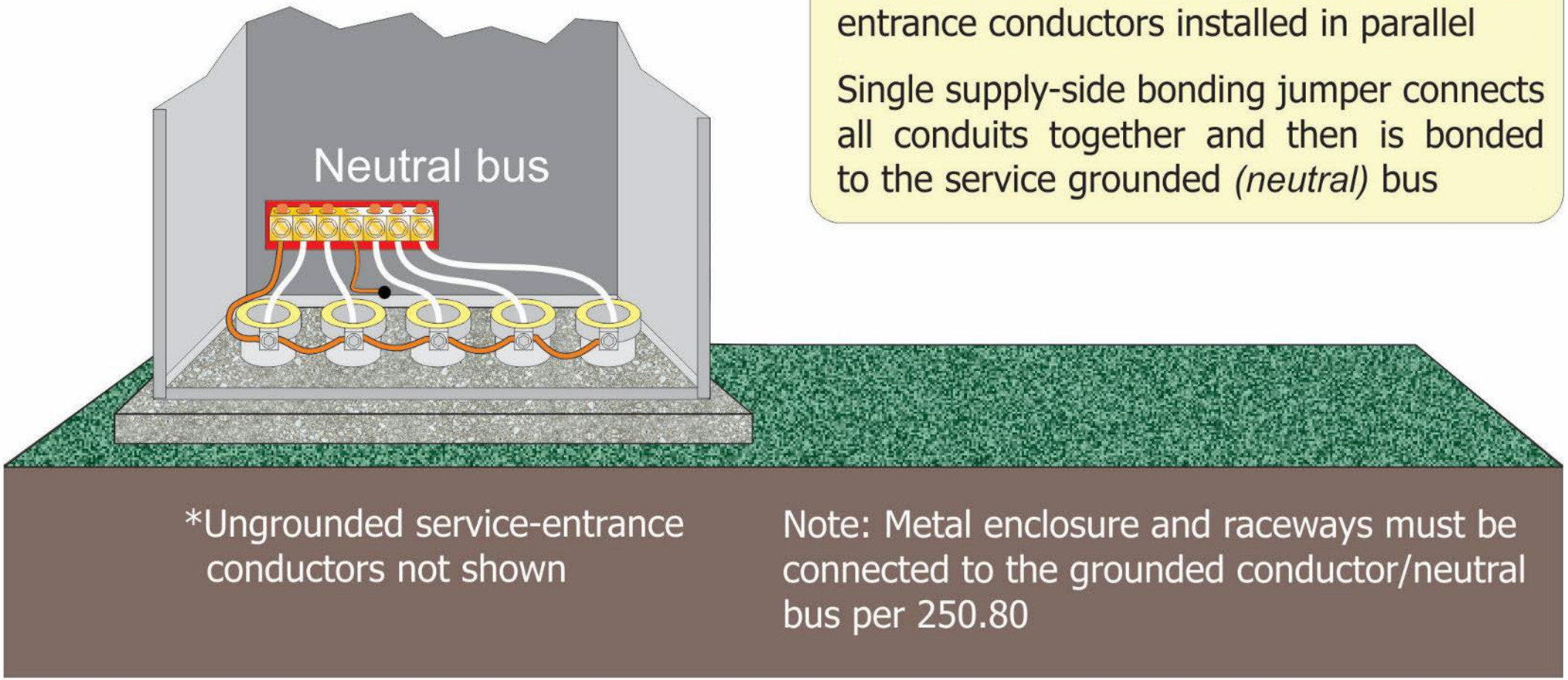
- Supply-side bonding jumper can be non-flexible metal raceway or a wire type conductor
- Where the service is ungrounded *[no grounded (neutral) conductor]*, a supply-side bonding jumper is required to provide bonding of all the metal enclosures and raceways together
- Review of the definition:
  - ***Bonding Jumper, Supply-Side:*** "A conductor installed on the supply side of a service or within a service equipment enclosure(s), or for a separately derived system, that ensures the required electrical conductivity between metal parts required to be electrically connected."

Sizing of Supply-Side Bonding Jumper on the Line (Supply) Side of Service

- Size per Table 250.102(C)(1)
- Based on size of ungrounded service-entrance conductor(s)
- Use rules in 250.102(C)
  - Parallel conductors in the ***same*** raceway or enclosure *[see 250.102(C)(1)]*
  - Parallel conductors in ***separate*** raceways or enclosures *[see 250.102(C)(2)]*

Size of Supply-Side Bonding Jumper on Line Side of Service

Open-bottom switchboard



Where installed in series, a supply-side bonding jumper is sized for the total circular mil area of ungrounded service-entrance conductors installed in parallel

Single supply-side bonding jumper connects all conduits together and then is bonded to the service grounded *(neutral)* bus

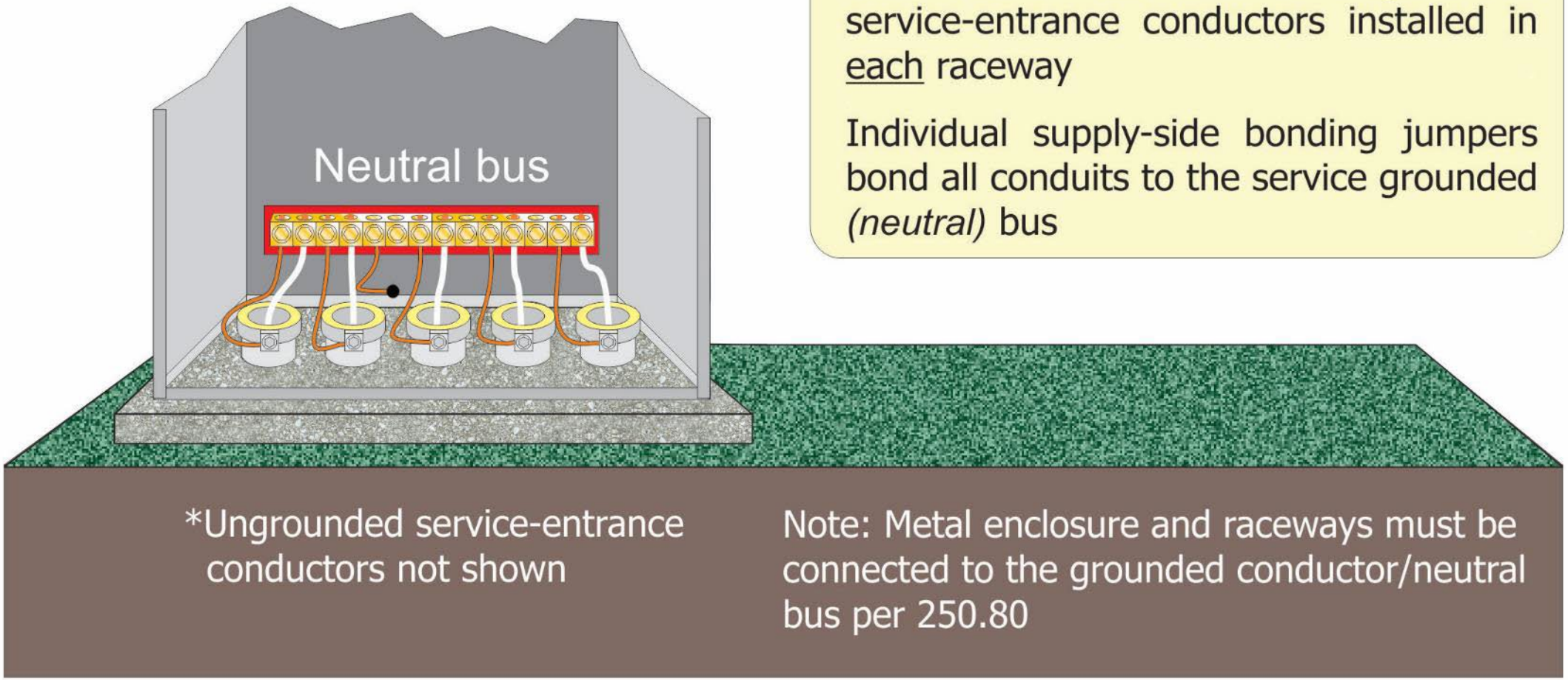
*Ungrounded service-entrance conductors not shown

Note: Metal enclosure and raceways must be connected to the grounded conductor/neutral bus per 250.80

Copyright © IAEI 2020

Size of Supply-Side Bonding Jumper on Line Side of Service

Open-bottom switchboard



Where installed individually, supply- side bonding jumpers are sized based on the total circular mil area of ungrounded service-entrance conductors installed in each raceway

Individual supply-side bonding jumpers bond all conduits to the service grounded *(neutral)* bus

*Ungrounded service-entrance conductors not shown

Note: Metal enclosure and raceways must be connected to the grounded conductor/neutral bus per 250.80

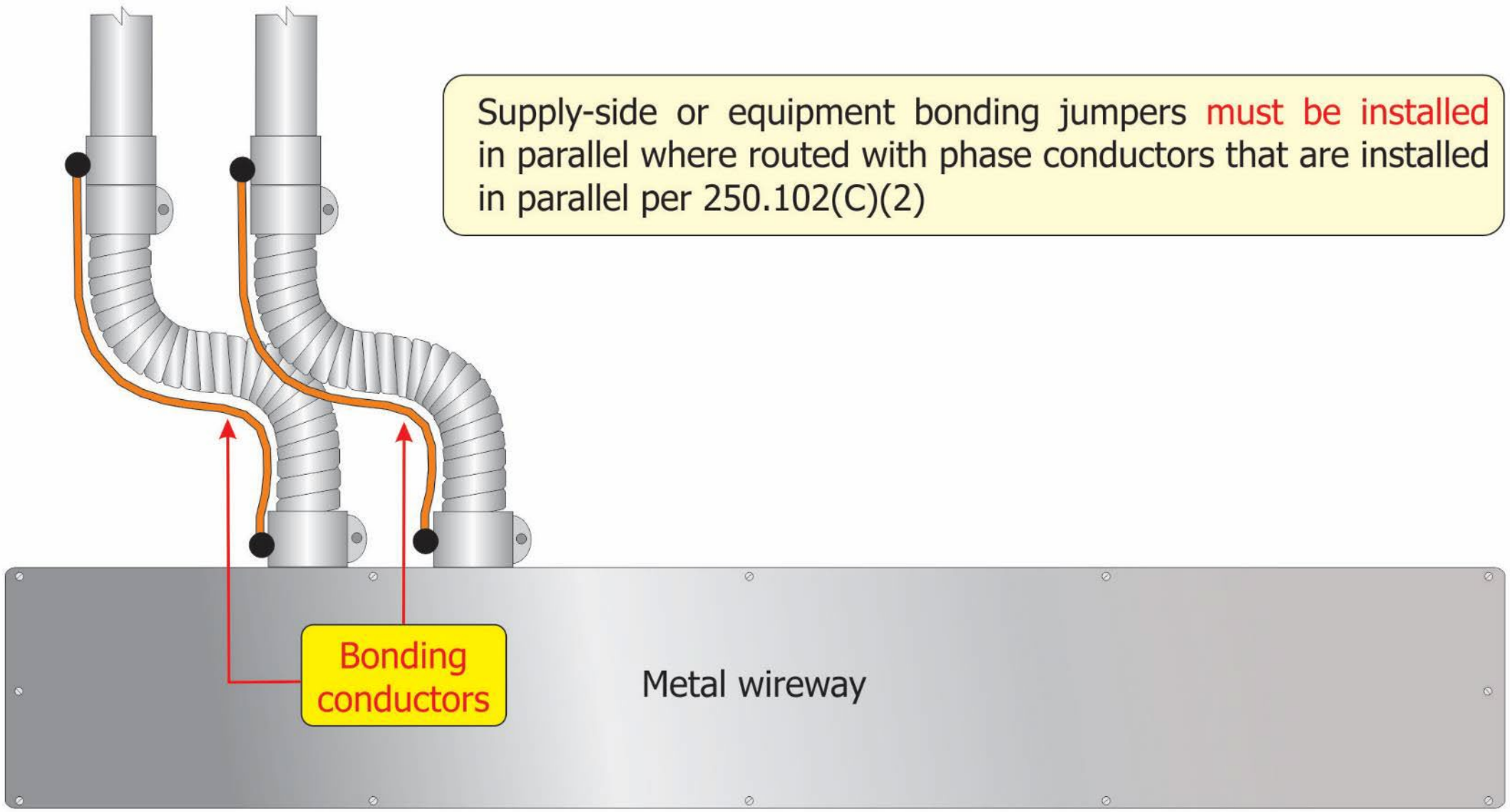
Copyright © IAEI 2020

Parallel Supply-Side Bonding Jumpers

- Where the paralleled service-entrance conductors are installed in **two or more raceways or cables** and the supply-side bonding jumper(s) is **routed along with but *outside* raceways or cables**, the require supply-side bonding jumper(s) is to be run in parallel as well *[see 250.102(C)(2)]*
- Size of the bonding jumper along each raceway is based upon size of the service-entrance conductor inside the raceway *[Table 250.102(C)(1) and 250.102(C)(2)]*
- Must make bonding jumper connections on both sides of the raceway with equipment or fittings that are suitable for that use

250.102(C)(2) Parallel Bonding Conductors

Supply-side or equipment bonding jumpers must be installed in parallel where routed with phase conductors that are installed in parallel per 250.102(C)(2)



Copyright © IAEI 2020



2260

Bonding Service Equipment Enclosures

- Special rules are provided for bonding enclosures on the line side of the service disconnecting means
- All metallic enclosures that contain service conductors must be bonded together
- This equipment typically does not have overcurrent protection on the line side *(like feeders and branch circuits)*
- See 250.92(A)

Bonding Service Equipment Enclosures *(cont.)*

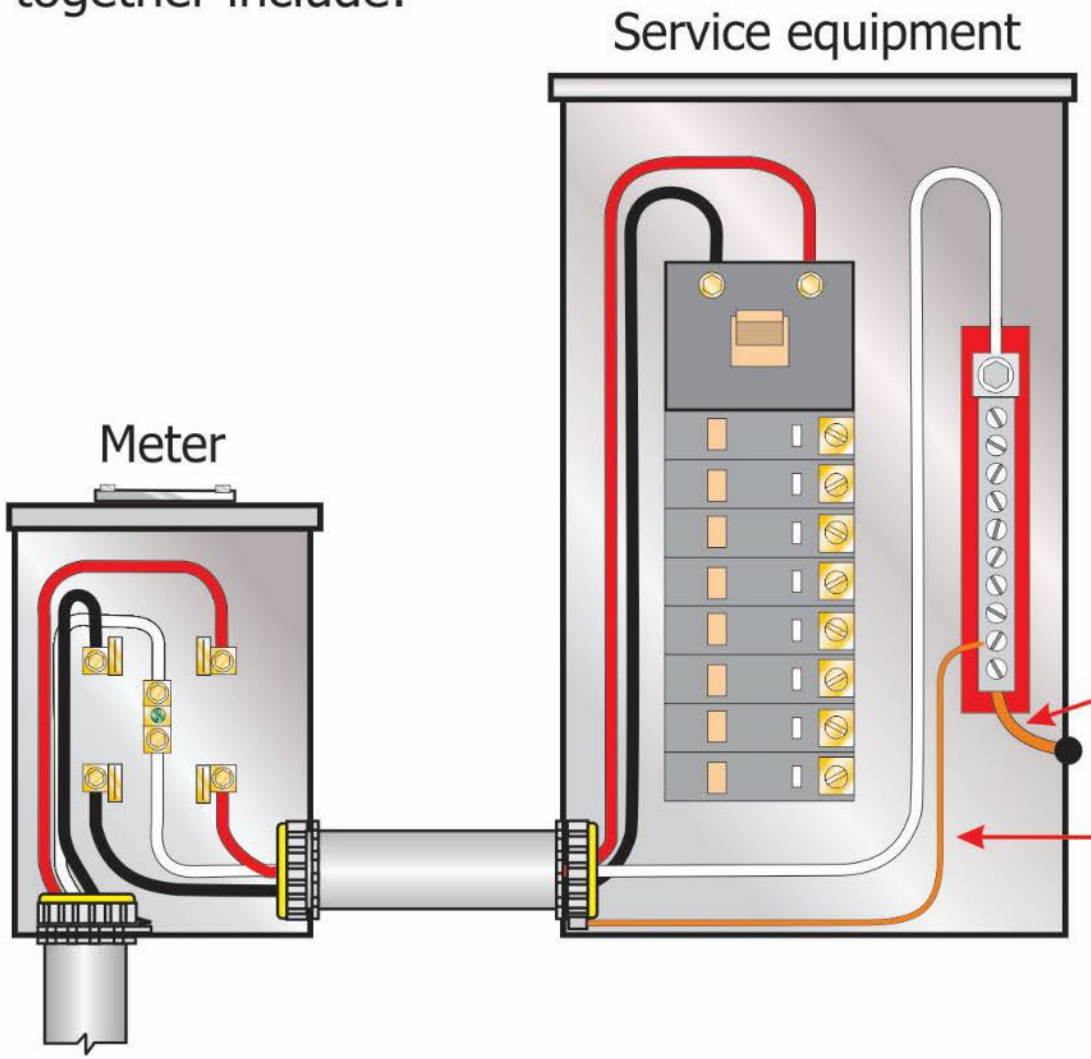
- Bonding at service equipment:
  - Ensures that none of the equipment enclosures can become **electrically isolated** and become a shock hazard should a line-to-ground fault occur in that enclosure or metal raceway
  - Provides a **low-impedance path** for fault current so the fuse or circuit breaker on the supply side of the electric utility transformer will open or operate
- See 250.92(A)(1) and (A)(2)

Bonding Service Equipment Enclosures *(cont.)*

- The normally non-current-carrying metal parts of service equipment required to be effectively bonded together include:
  - Service raceways, cable trays, cablebus framework, auxiliary gutters, or service cable armor or sheath that **enclose, contain, or support service conductors** *(except as permitted in 250.80)*
  - All enclosures **containing service conductors**, including meter fittings, boxes or the like, interposed in the service raceway or armor
- See 250.92(A)

250.92(A) Bonding Service Equipment Enclosures

The normally non–current-carrying metal parts of service equipment required to be bonded together include:



Service raceways and cable armor or sheath

Service equipment enclosures including meter enclosures

Note: Bonding required around impaired connections, such as reducing washers or oversized concentric or eccentric knockouts

Main bonding jumper

Supply-side bonding jumper

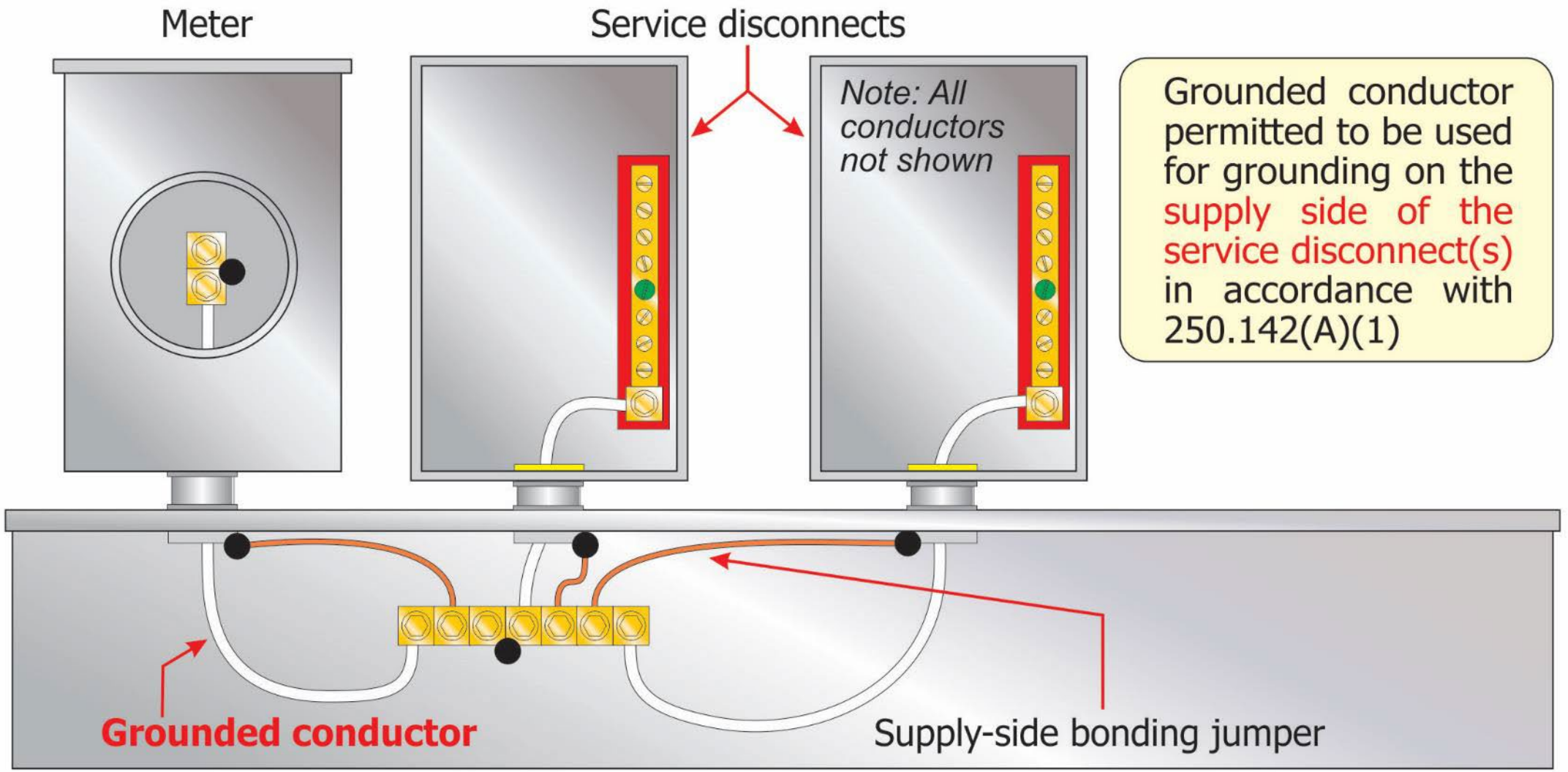
Bond together in a method specified by 250.92(B) and size bonding jumpers in compliance with Table 250.102(C)(1)

Copyright © IAEI 2020

Neutral Conductor for Bonding on Line Side of Service

- Section 250.92(B) establishes the use of the **grounded service conductor** *(may be the neutral)* as one means for grounding and bonding equipment on the **supply side of the service disconnecting means**
- Also permitted by 250.142(A)(1)
- Typically done with equipment such as:
  - Meter bases
  - Current transformer enclosures
  - Wireways
  - Auxiliary gutters
- Often, connecting the grounded service conductor to this type of equipment is the most practical method of bonding these enclosures and meeting the requirements in 250.80

Use of Grounded *(Neutral)* Conductor for Bonding *(Line Side of Service)*



Copyright © IAEI 2020

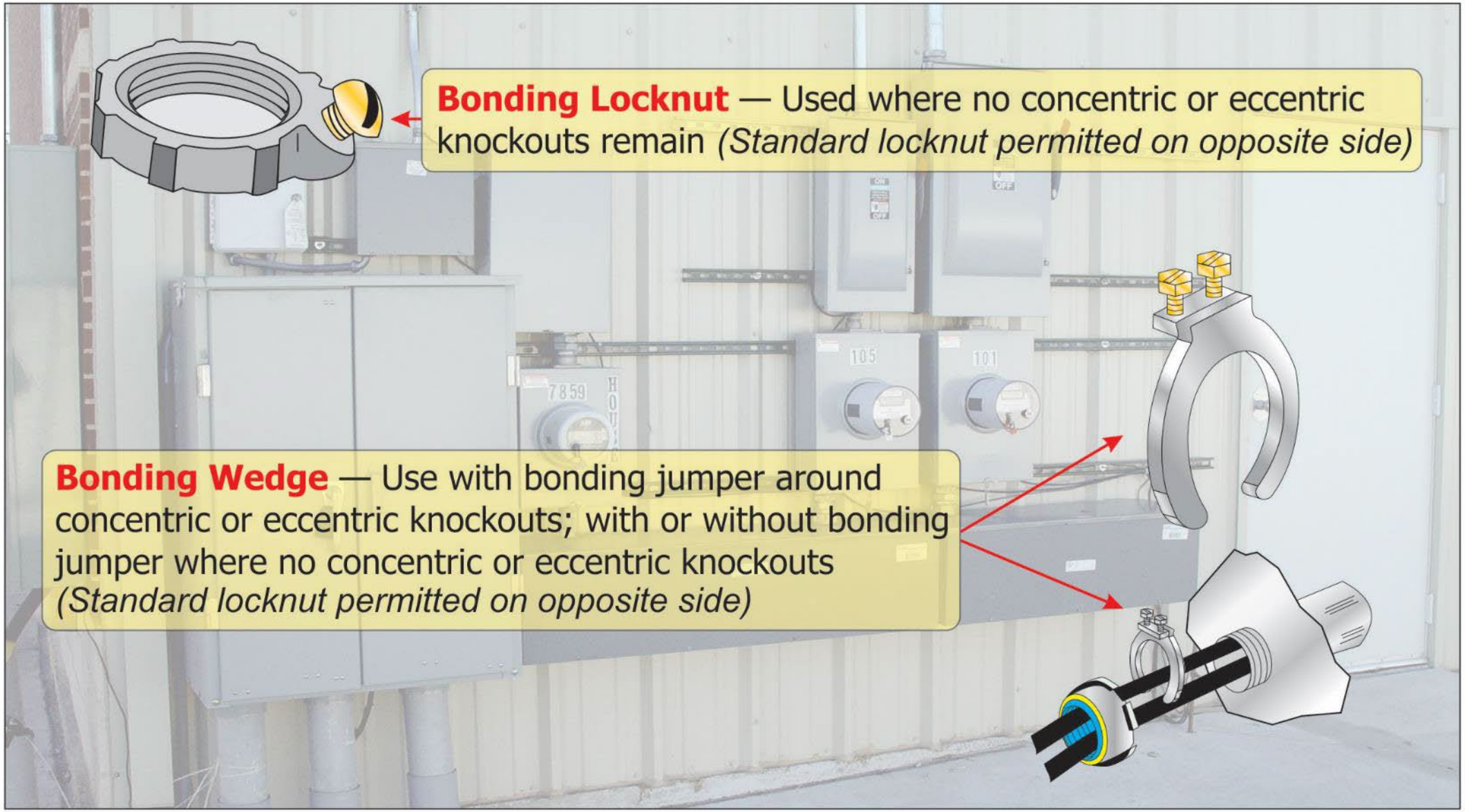
Methods of Bonding at Service Equipment Enclosures

- Various methods for bonding at the service are addressed by the *Code*
- Bonding requirements are more restrictive at services than downstream from the service disconnect
- Service equipment and enclosures can be subject to heavy fault currents in the event of a line-to-ground fault
- Overcurrent protection is controlled by the serving utility
- See 250.92(B)

Methods of Bonding at Service Equipment Enclosures *(cont.)*

- Service conductors only have **short-circuit protection** provided by the overcurrent device on the line side of the utility transformer
- Only **overload protection** is provided at the load end of the service conductors by the service main overcurrent device
- This is one reason the *Code* limits the length of service conductors inside a building by requiring the service disconnecting means to be **"nearest the point of entrance"** of the service conductors *[see 230.70]*
- Various methods for bonding at the service are featured on the next few slides

250.92(B) Bonding Fittings



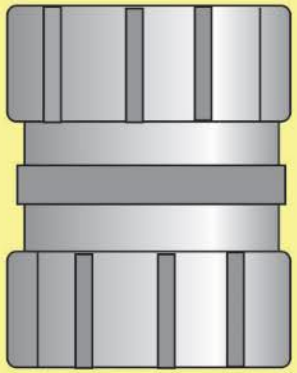
Copyright © IAEI 2020

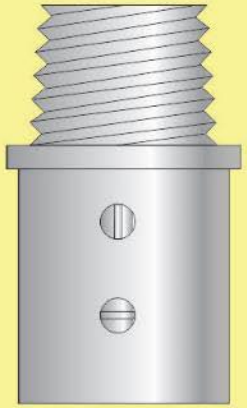

2270

Methods of Bonding at Service *[250.92(B)]*

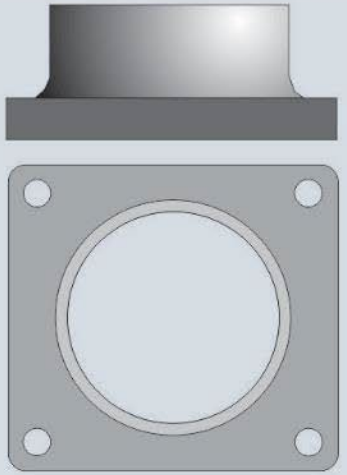
- Listed lugs, pressure connectors, other listed means *(250.8)*
- Threaded couplings and connectors or threaded hubs on enclosures where made up wrenchtight
- Threadless couplings and connectors if made up tight for metal raceways or metal-clad cables
- Other listed devices, such as bonding-type locknuts, bushings, or bushings with bonding jumpers
- Standard locknuts are not permitted for the bonding required by this section
- Bonding jumpers are required to be used around impaired concentric or eccentric knockouts
- Connections cannot depend solely upon solder *[250.8(B)]*

250.92(B) Methods of Bonding Service Equipment





Threadless couplings and connectors made up tight for rigid metal conduit, intermediate metal conduit, and electrical metallic tubing



Conduit hub furnished in many trade conduit sizes as accessory by equipment manufacturer *(Install according to manufacturer's instructions)*

Threaded couplings or bosses on enclosures made up wrenchtight



Copyright © IAEI 2020



2273



2274





2276

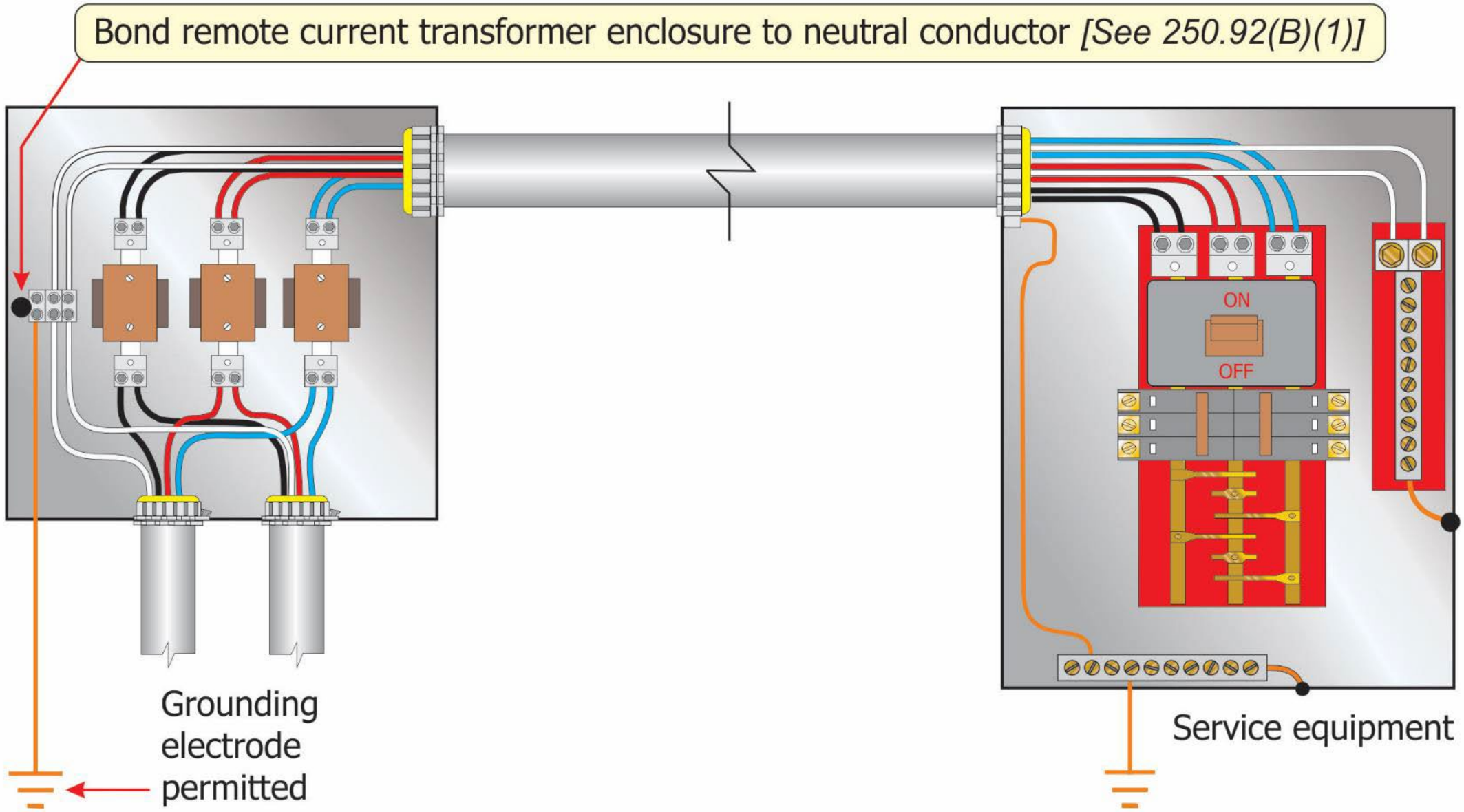
Grounding and Bonding of Remote Metering

- All metallic equipment containing service conductors required to be bonded together and to the **grounded service conductor** *[see 250.92(A)]*
- This includes remote *(from the service equipment)* meter cabinets and meter socket enclosures, current transformer cabinets, raceways, and auxiliary gutters
- Grounding and bonding of equipment to the **grounded service conductor** at locations on the line side of and remote from the service disconnecting means increases safety

Grounding and Bonding of Remote Metering *(cont.)*

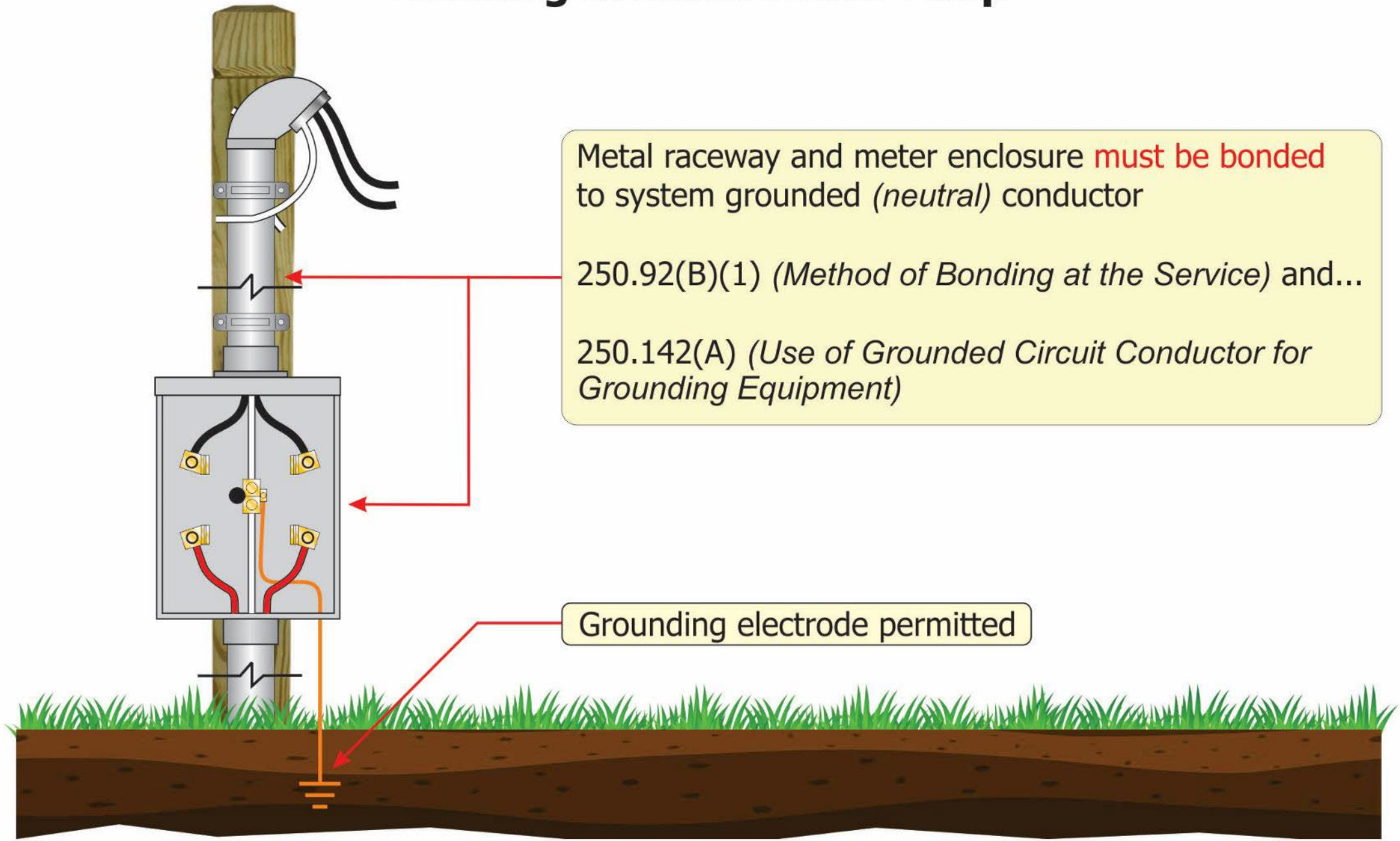
- Remote equipment should never be grounded only to a grounding electrode *(such as a ground rod)*
- If a ground fault occurred on the line-side of remote equipment *(and not bonded as required)*, only means for clearing ground fault would be through the grounding electrodes and earth *(high impedance path)*
- No overcurrent device will open or operate, leaving the equipment enclosure(s) at a dangerous voltage-to-ground potential
- Any person or animal that contacts the enclosure can be shocked or electrocuted

Grounding and Bonding of Remote Metering



Copyright © IAEI 2020

Bonding Remote Meter Loop



Metal raceway and meter enclosure must be bonded to system grounded *(neutral)* conductor

250.92(B)(1) *(Method of Bonding at the Service)* and...

250.142(A) *(Use of Grounded Circuit Conductor for Grounding Equipment)*

Grounding electrode permitted

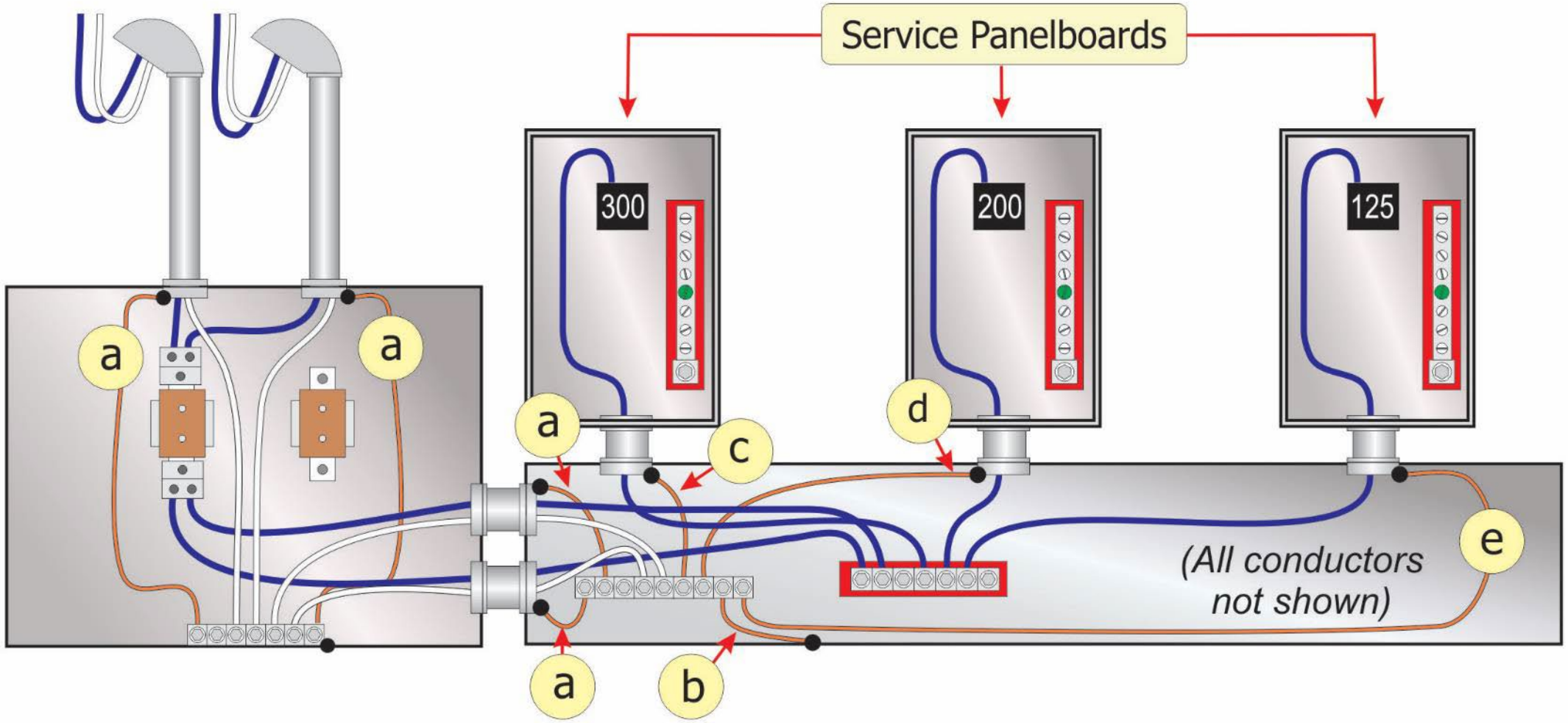
Copyright © IAEI 2020

Bonding of Multiple Service Disconnecting Means

- Installation of multiple services permitted by 230.2(A) through (D)
- Installations of services that have multiple disconnecting means can take several forms *(additional services are permitted by 230.2)*
- Basic rule for sizing the supply-side bonding jumper for bonding these various configurations is found at 250.102(C)
- Supply-side bonding jumpers on the line side of each service and the main bonding jumper sized from Table 250.102(C)(1)
- Size of supply-side bonding jumper for each raceway based on the size of service-entrance conductors in that raceway

Bonding of Multiple Service Disconnecting Means

Size supply-side bonding jumpers in accordance with 250.102(C)



Note: See next slide for legend

Copyright © IAEI 2020

Sizing Supply-Side Bonding Jumpers

- The appropriate size of **supply-side bonding jumpers *(SSBJ)*** for the installation in Figure 10.16 *(previous slide)* with the assumed size of conductors is as follows: *(all sizes copper)*
  - **(a)** 500 kcmil in service mast and nipple has a SSBJ of **1/0 AWG**
  - **(b)** 1000 kcmil in wireway has a SSBJ of **2/0 AWG**
  - **(c)** 300 kcmil to 300-ampere service has a SSBJ of **2 AWG**
  - **(d)** 3/0 AWG to 200-ampere service has a SSBJ of **4 AWG**
  - **(e)** 2 AWG to 125-ampere service has a SSBJ of **8 AWG**

CHAPTER ELEVEN

GROUNDING
SEPARATELY DERIVED SYSTEMS

Grounding of Separately Derived Systems

- Virtually every building or structure has a **separately derived system**
- In a dwelling this most often will be the doorbell transformer
- Many distribution systems for commercial, institutional, or industrial occupancies have **separately derived systems** to provide another voltage level lower or higher than the electrical system supplied by the service
- Many possible on-site sources of energy *(such as generators, solar photovoltaic systems, fuel cells, and energy storage)* that may be, or potentially operate, as a separately derived system
- Several *Code* requirements must be met when installing a separately derived system

Grounding of Separately Derived Systems *(cont.)*

- If there is a separately derived system, there will be a **new "source" established** producing a voltage and providing a capacity from which current will be drawn
- This capacity is usually referred to as the **kVA** or **kW rating** of the system
- System must have a capacity to supply the load served
- Overcurrent protection sizing and the protection of conductors connected to the point of supply of the separately derived system are also required
- Very important element is determining which **grounding and bonding rules** must be applied to satisfy the requirements

Separately Derived Systems



Separately Derived System: An electrical source, other than a service, having no direct connection(s) to circuit conductors of any other electrical source other than those established by grounding and bonding connections.







Article 100 Definition

- The first step in applying grounding and bonding requirements is establishing whether or not a system is separately derived
- This step requires a clear understanding of the definition and all its parts

- ***Separately Derived System:*** An electrical source, other than a service, having no direct connection(s) to circuit conductors of any other electrical source other than those established by grounding and bonding connections.

Examples of Separately Derived Systems

- An example of a system or transformer that is not separately derived:
  - Autotransformer
  - AC side of an alternate energy source *(photovoltaic, fuel cell, or energy storage)* that has a grid interactive inverter
- Example that is clearly a separately derived systems:
  - Generator that provides power as a stand-alone system

Grounding of Separately Derived Systems

- Separately derived system requiring grounding *[per 250.30(A)]* is established in 250.20
- These systems can be **required to be grounded** or **permitted to be grounded**
- There are times when separately derived systems are **not permitted to be grounded** *(see 250.22)*
- If the system can be grounded so that the voltage to ground from any of the system conductors does not exceed 150 volts, then generally it must be grounded
- For an ungrounded system the provisions of 250.30(B) and requirements found in 250.21 for ungrounded systems apply

Grounding of Separately Derived Systems *(cont.)*

- Where there are multiple sources of the same type that are installed in parallel to serve premises wiring, the paralleled sources are to be considered as a **single separately derived system**
- Examples of this condition include:
  - Two or more engine-generators with paralleling switchgear
  - Photovoltaic (PV) systems that have multiple inverters which are paralleled together before interconnecting with a single feeder to the premises power system
- See 250.30 and 250.30(A)(1)(b), Exception

Grounding of Separately Derived Systems *(cont.)*

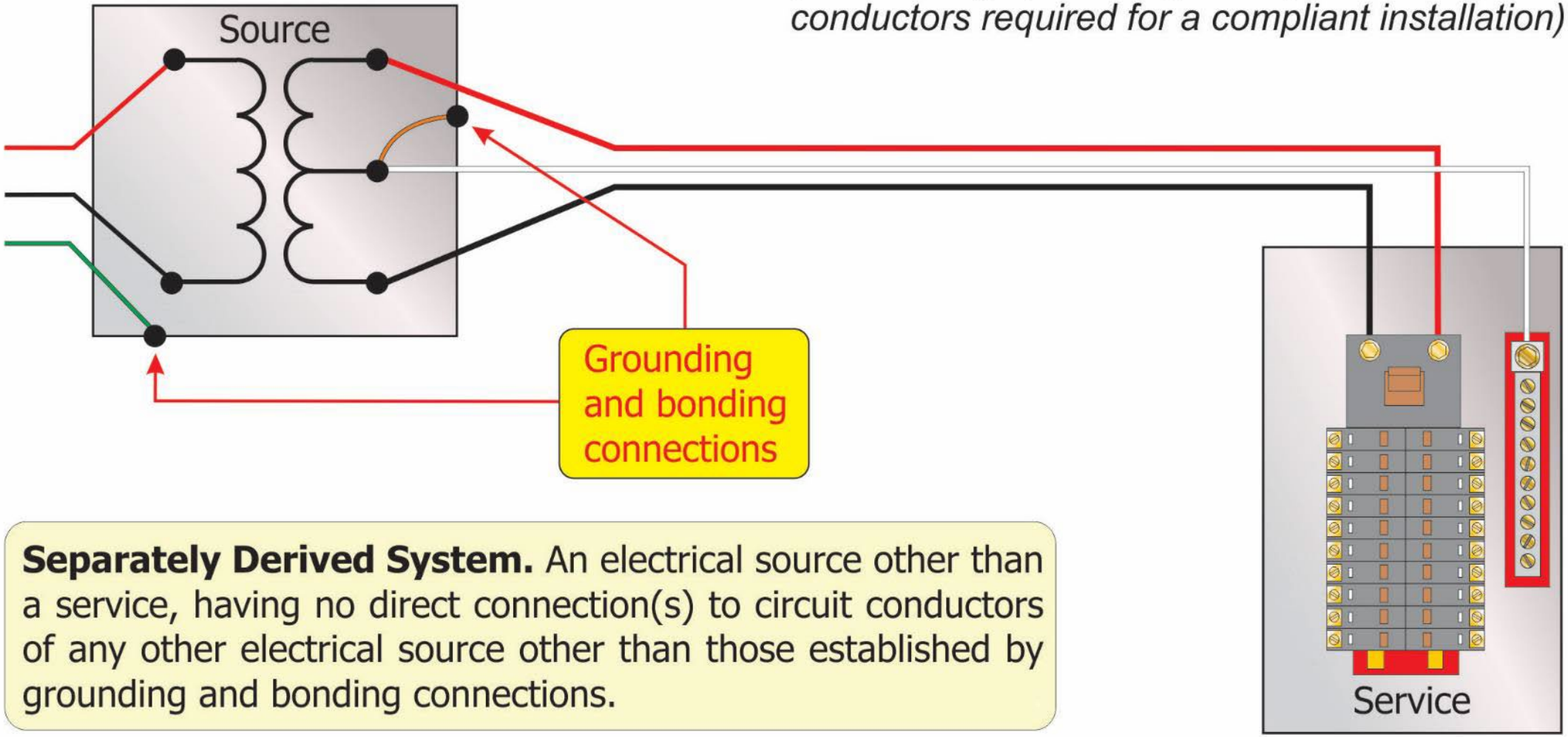
- 250.20(B)(1), (2), and (3) determine when the system produced is required to be grounded
- Ground these systems in accordance with 250.30
- Each new derived voltage level must be grounded in accordance with 250.30(A)
  - Can be grounded at source or first disconnecting means [250.30(A)(1)]
  - May be required to be grounded at source if outside the building [250.30(C)]

Transformer-Type Separately Derived Systems

- Supply or **primary** of the transformer is at one voltage level, and the **secondary** is typically at another voltage level *(either lower or higher)*
- As shown in the next slide, there is **no direct electrical connection between the transformer primary and secondary circuit conductors**, so the installation meets the definition of a separately derived system
- Only connection between the primary and the secondary is through magnetic coupling and grounding and bonding conductors which are excluded in the definition
- Where 3-phase systems are installed, the primary is usually delta connected so a neutral conductor is not needed
- Secondary may be connected delta or wye as desired
- Some installations are now using wye-wye transformers, and the system design will need to determine the need for a neutral on one or both sides

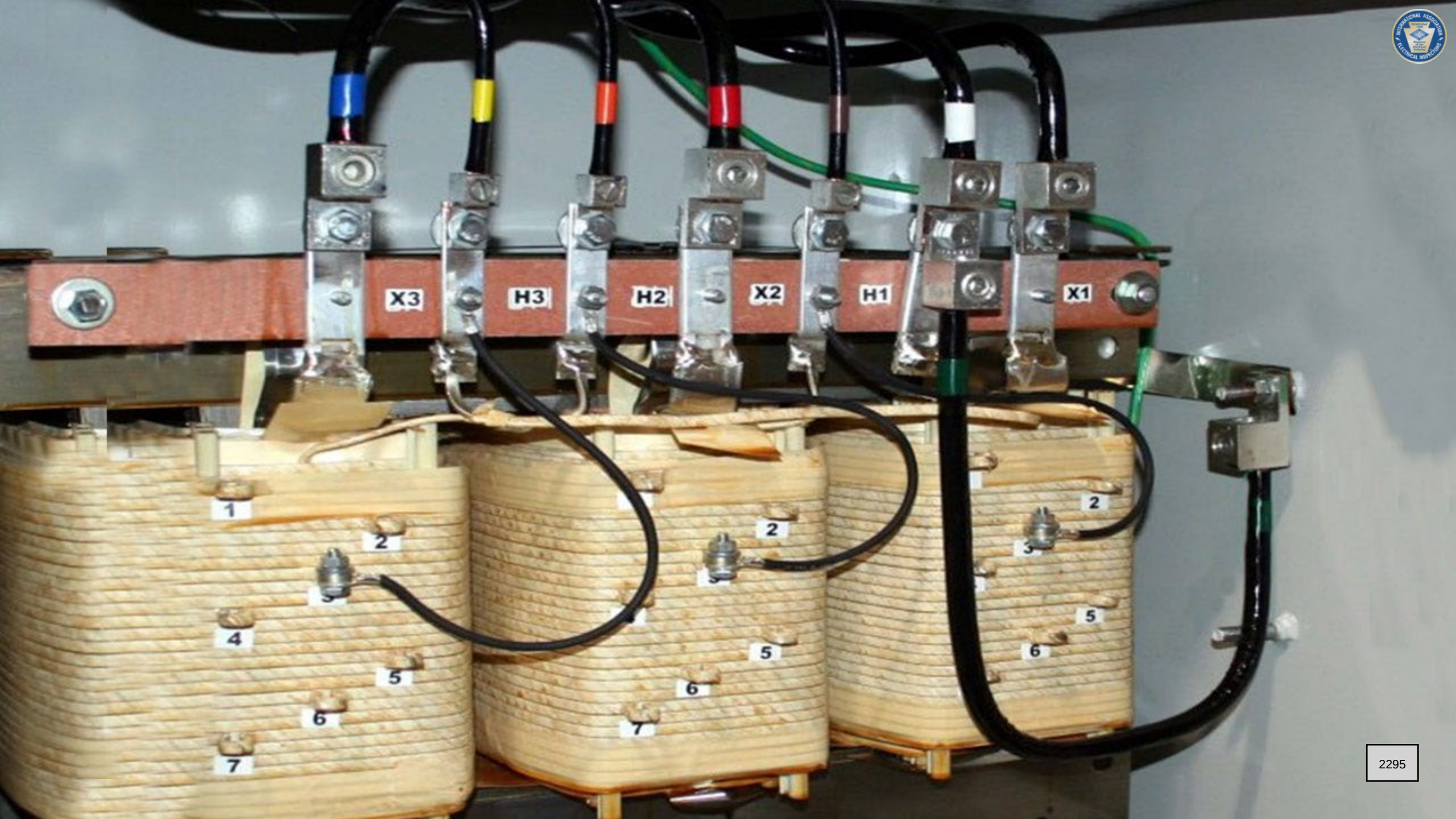
Separately Derived System - Transformer Type

(Note: the graphic images may not show all conductors required for a compliant installation)



Separately Derived System. An electrical source other than a service, having no direct connection(s) to circuit conductors of any other electrical source other than those established by grounding and bonding connections.

Copyright © IAEI 2020


X3
H3
H2
X2
H1
X1
1
2
3
4
5
6
7
2
5
6
7
2
3
5
6

Steps to Grounding and Bonding of a Separately Derived System

- Install the **system bonding jumper** *[250.30(A)(1)]*
- Install the **supply side bonding jumper** *[and possibly the grounded (neutral) conductor] [250.30(A)(2) and (A)(3)]*
- Determine what is to be used for the **grounding electrode** *[250.30(A)(4)]*
- Install the **grounding electrode conductor** using one option or the other *[250.30(A)(5), (A)(6), and (A)(7)]*, and…
- Complete the **bonding** to the local metallic piping systems and the local structural metal building frame members *[250.30(A)(8)]*

Impedance Grounding of Separately Derived Systems

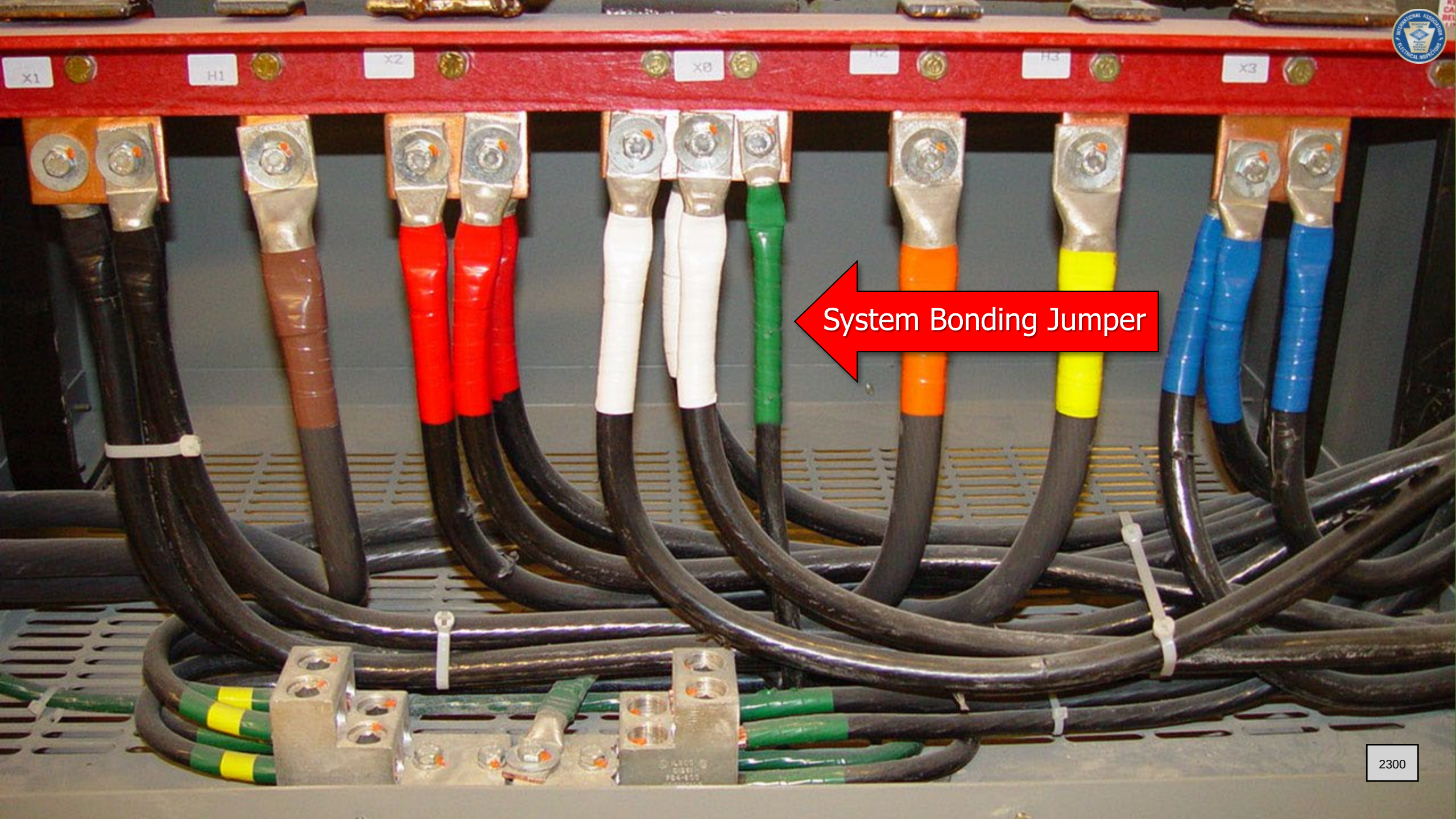
- Alternate provisions for grounding and bonding separately derived systems are addressed when an **impedance grounding design** is installed *[250.30(A) Exception] [Also see 250.36 and 250.187]*
- These systems are grounded only through an **impedance device** *(often a resistor)* usually located at the switchboard, panelboard, or motor control center
- Designed to limit the fault current of the first ground fault to a predetermined value and often incorporate a ground detection indicator or alarm system

System Bonding Jumper

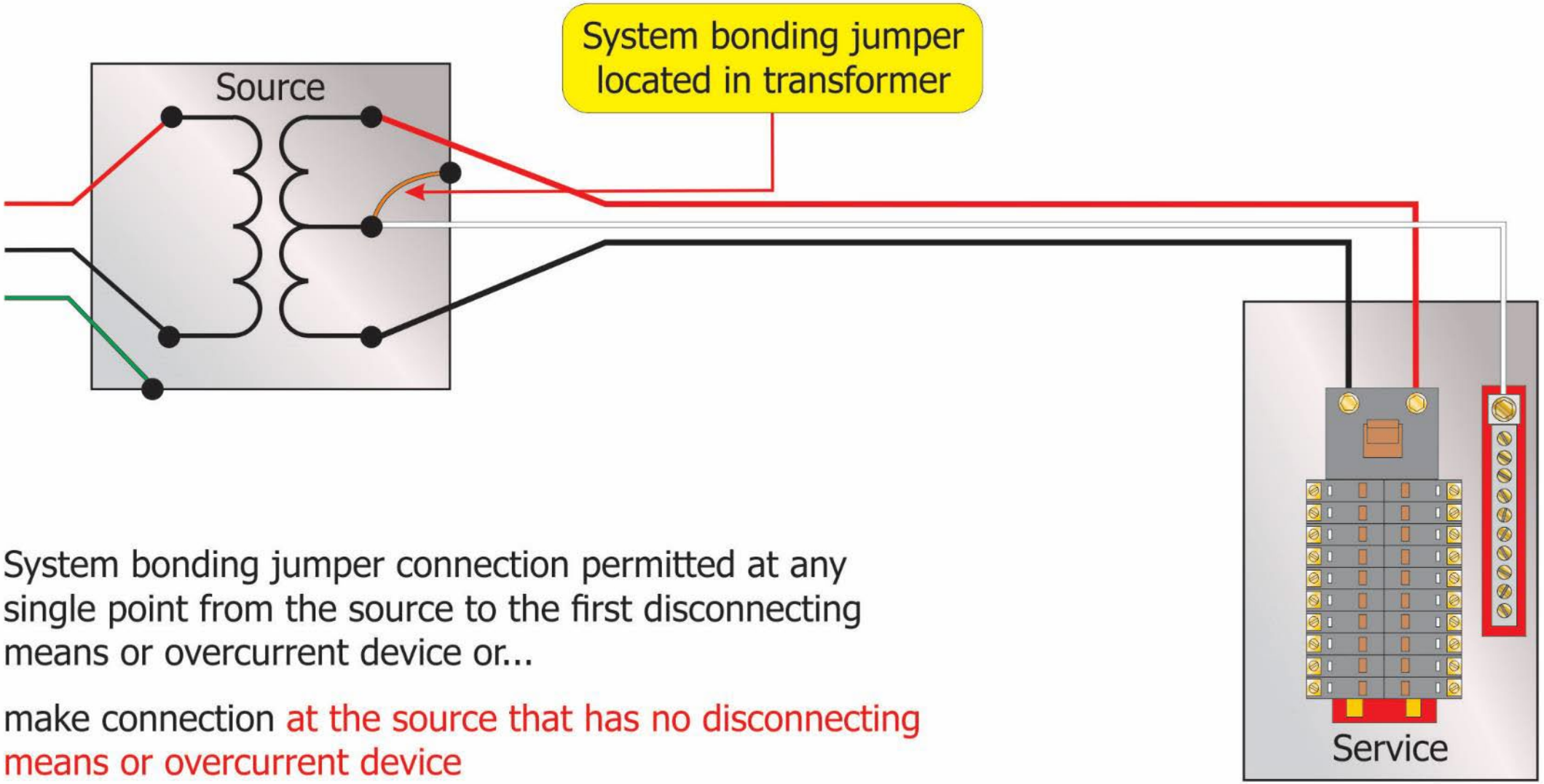
- Connects the supply side bonding jumper of the derived system to the grounded conductor at the source
- Connects the equipment grounding conductors and the grounded (neutral) conductor at the equipment containing the first overcurrent protective device
- The system bonding jumper is sized in accordance with 250.28(D) based on the size of the derived phase conductors
- Sized per **Table 250.102(C)(1)** or 12½% rule if derived phase conductors exceed the values in Table 250.102(C)(1)
- Function of a “system bonding jumper” is essentially the same as the “main bonding jumper” of a service but a is installed at separately derived systems *(which are not “services”)*

System Bonding Jumper *(cont.)*

- Locate system bonding jumper inside source enclosure or at any point to and including the first disconnecting means or overcurrent device of the system
- System bonding jumper to remain within the enclosure where it originates
- The point of connection shall be made at the same point as the grounding electrode conductor connection to the system
- System bonding jumper should not be confused with a supply side bonding jumper
- See 250.30(A)(1)


X1
H1
X2
X0
H2
H3
X3
System Bonding Jumper

System Bonding Jumper Locations

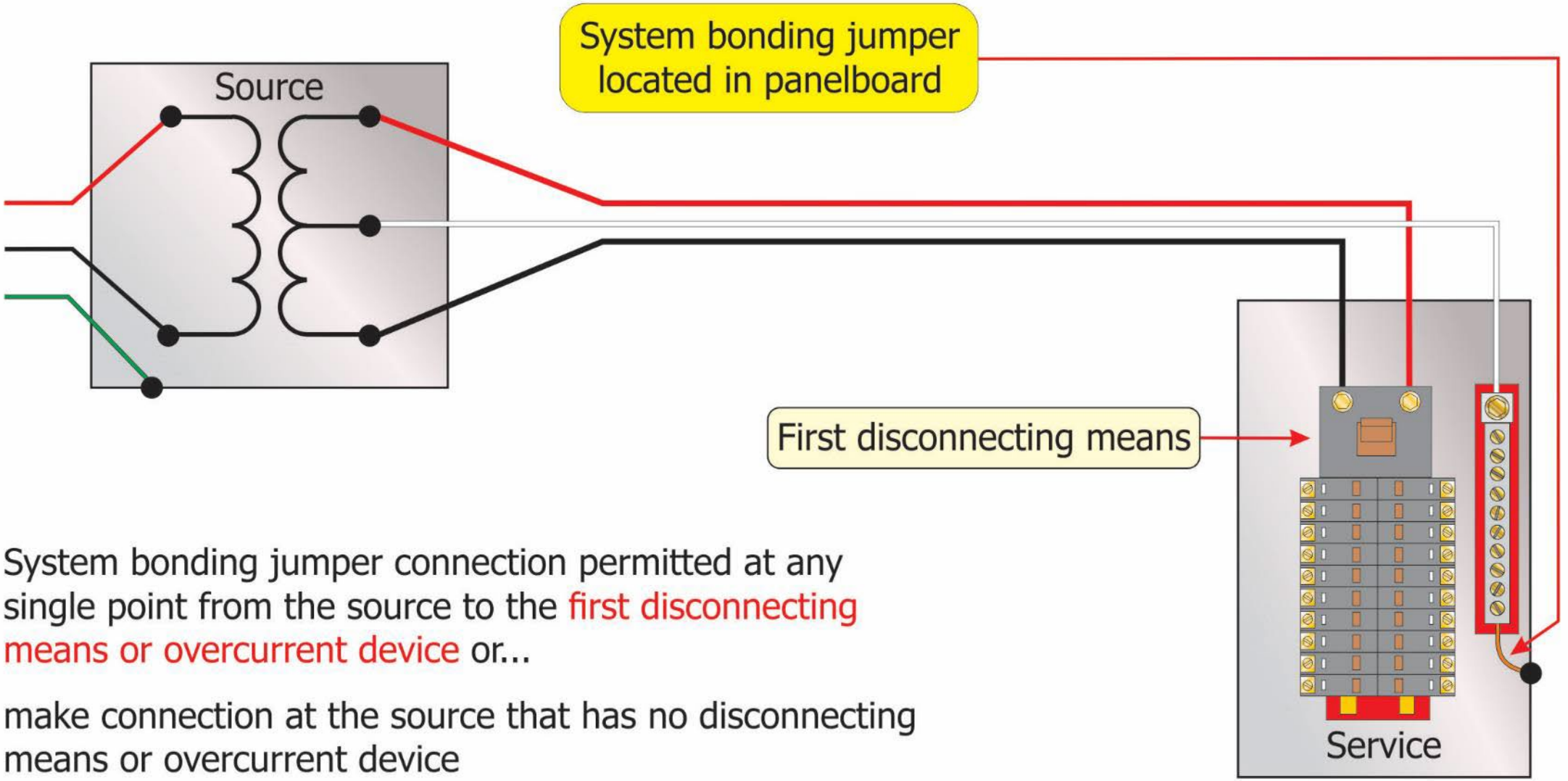


System bonding jumper connection permitted at any single point from the source to the first disconnecting means or overcurrent device or...

make connection at the source that has no disconnecting means or overcurrent device

Copyright © IAEI 2020

System Bonding Jumper Locations



System bonding jumper connection permitted at any single point from the source to the first disconnecting means or overcurrent device or...

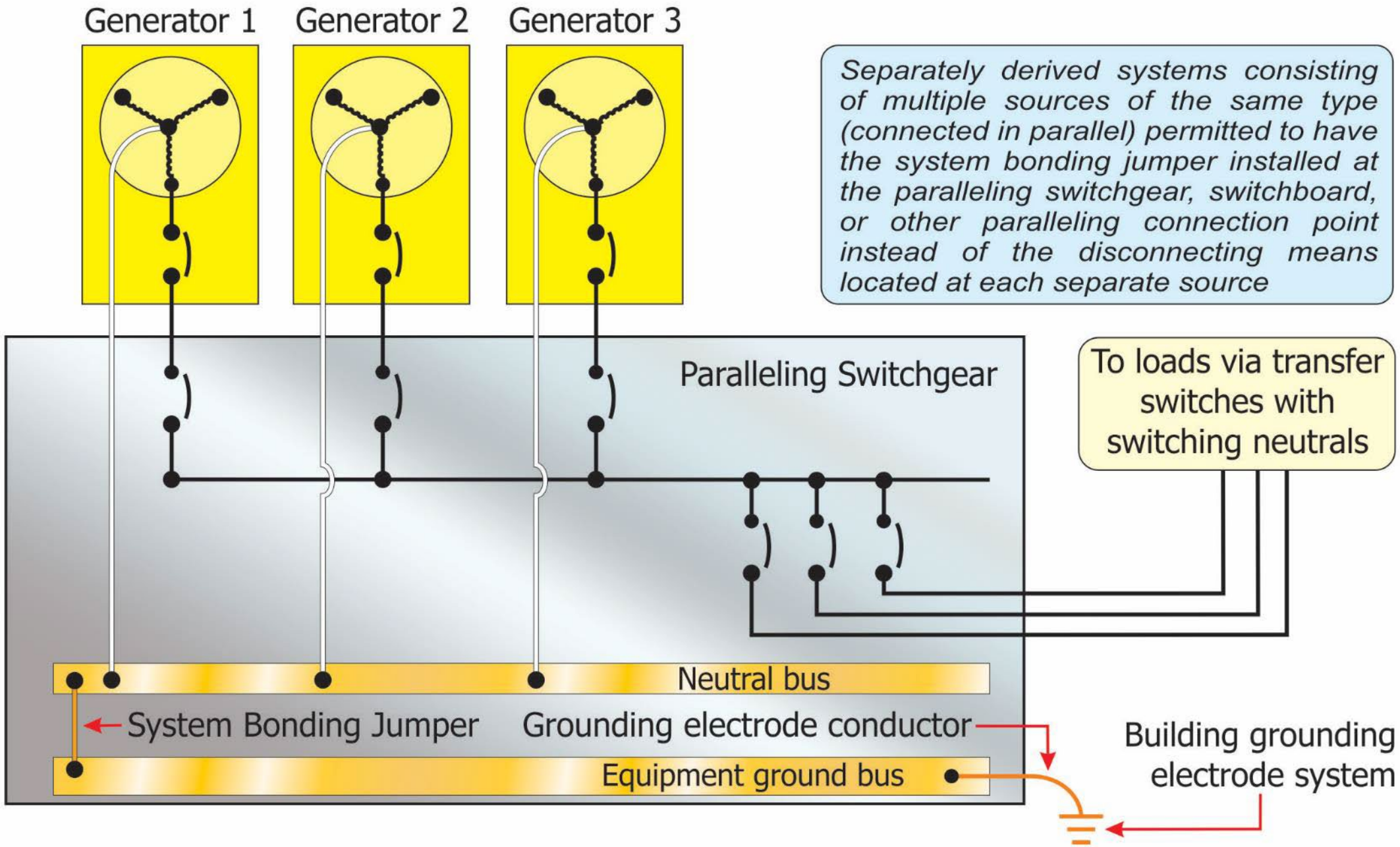
make connection at the source that has no disconnecting means or overcurrent device

Copyright © IAEI 2020

System Bonding Jumper Location Exceptions

- Several exceptions to 250.30(A)(1)
- **Exception No. 1** allows for a single system bonding jumper where transformers are installed in accordance with 450.6 *(known as a "double-ended" system)*
- **Exception No. 2** applies in concert with 250.30(C) and 250.30(A)(2) Ex.
  - Under these provisions, transformer is located outside the building and transformer secondary conductors or feeder enter the building for distribution
- New **Exception No. 3** provides for multiple separately derived systems that are paralleled together and then connected to the premises power system
  - Permits system bonding jumper to be located in the paralleling switchgear or AC combiner panelboard rather than at the individual source first disconnecting means

250.30(A)(1)(b), Exception - System Bonding Jumper



Copyright © IAEI 2020

System Bonding Jumper Location Exceptions *(cont.)*

- Exception No. 1 to 250.30(A)(5) and (A)(6) permits the grounding electrode connection to be made to an equipment grounding terminal bus *(rather than to the neutral bar)* where the system bonding jumper is a wire or busbar connecting the equipment ground terminal or bus to the neutral bar or bus
- Examples:
  - Neutral ground strap type ground-fault protection systems where a ground-fault current sensor is located in or on the system bonding jumper *(measures ground-fault currents back to the source)*
  - Larger capacity switchboards or switchgear where the main or system bonding jumper is a wire or busbar *(better access to the equipment grounding bus)*

250.30(A)(5), Ex. No. 1 - System Bonding Jumper

If the system bonding jumper is a wire or busbar, permitted to connect the grounding electrode conductor to the equipment grounding terminal bar if the equipment grounding terminal bar is of sufficient size for the separately derived system

Separately derived system

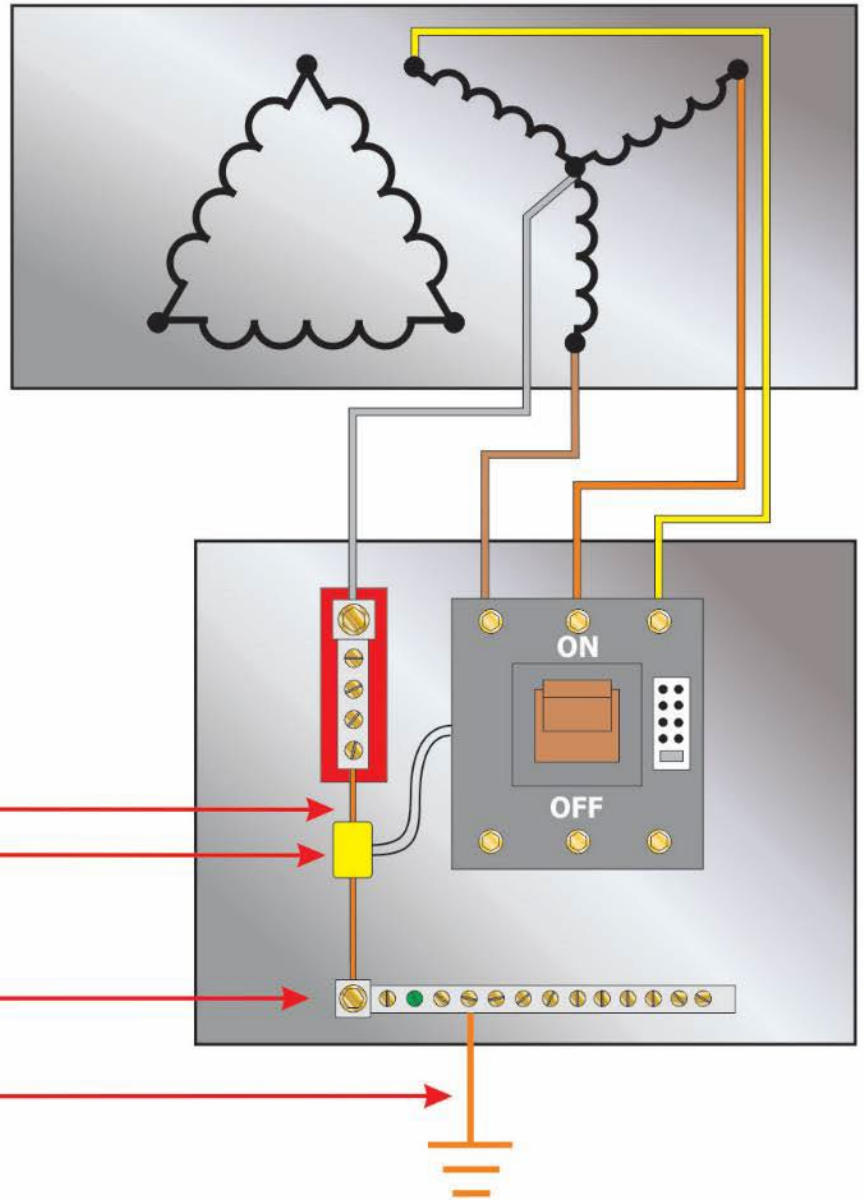
This application typically used for neutral ground strap style equipment ground-fault protection systems

System bonding jumper

Ground fault sensor typically installed on the system bonding jumper

Equipment grounding terminal bar

Grounding electrode conductor



Copyright © IAEI 2020

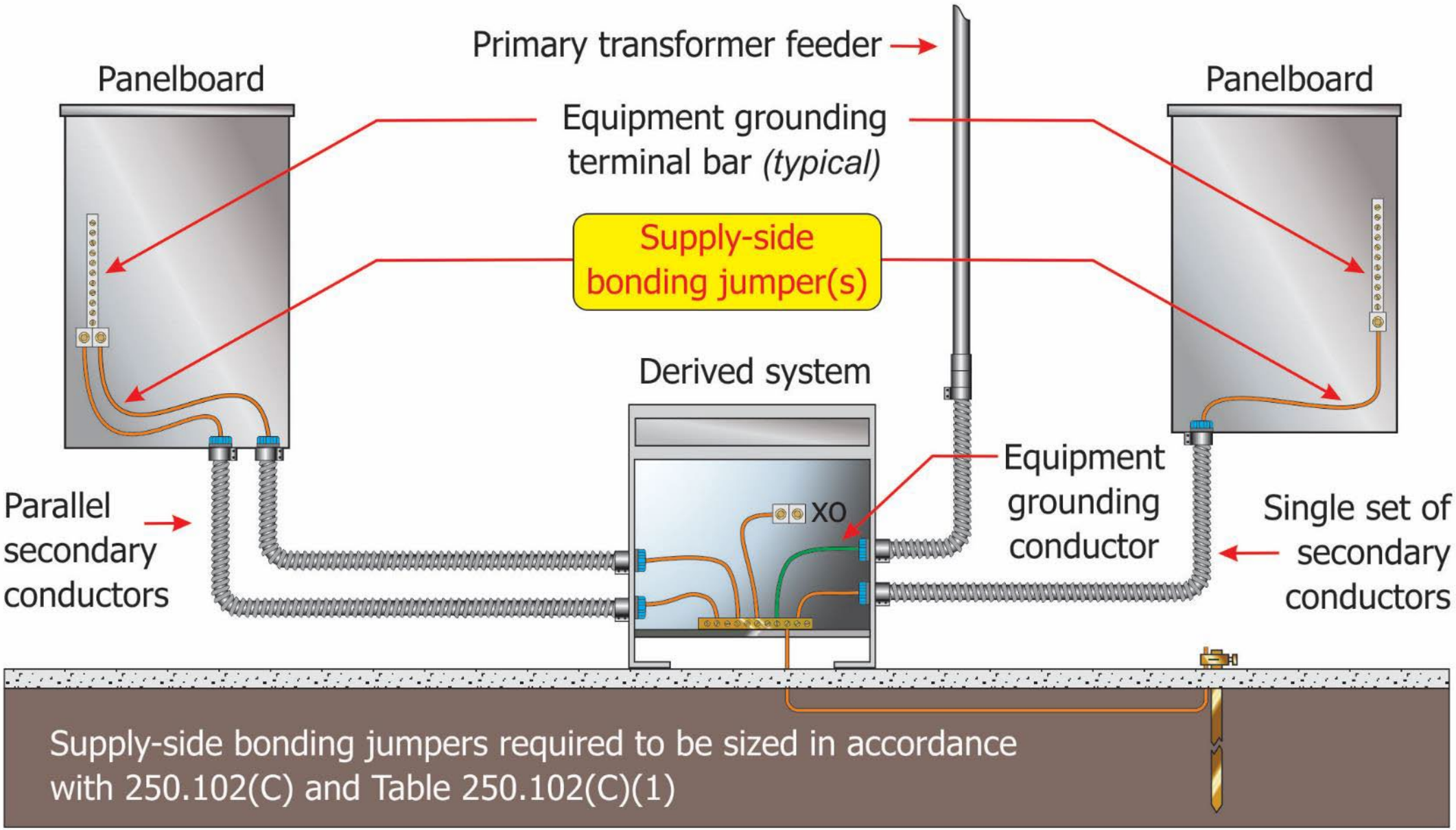
Supply-Side Bonding Jumper

- One key function of the **supply side bonding jumper** is to **bond the enclosures** of the derived system source and the disconnecting and/or overcurrent device if they are not in the same enclosure or already connected
- Where the grounding electrode conductor and system bonding jumper connections are made at a separate source enclosure, most installations include the installation of the derived phase conductors, the grounded (neutral) conductor, and a means *(supply-side bonding jumper)* to connect the enclosures together
- 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 enclosure

Supply-Side Bonding Jumper *(cont.)*

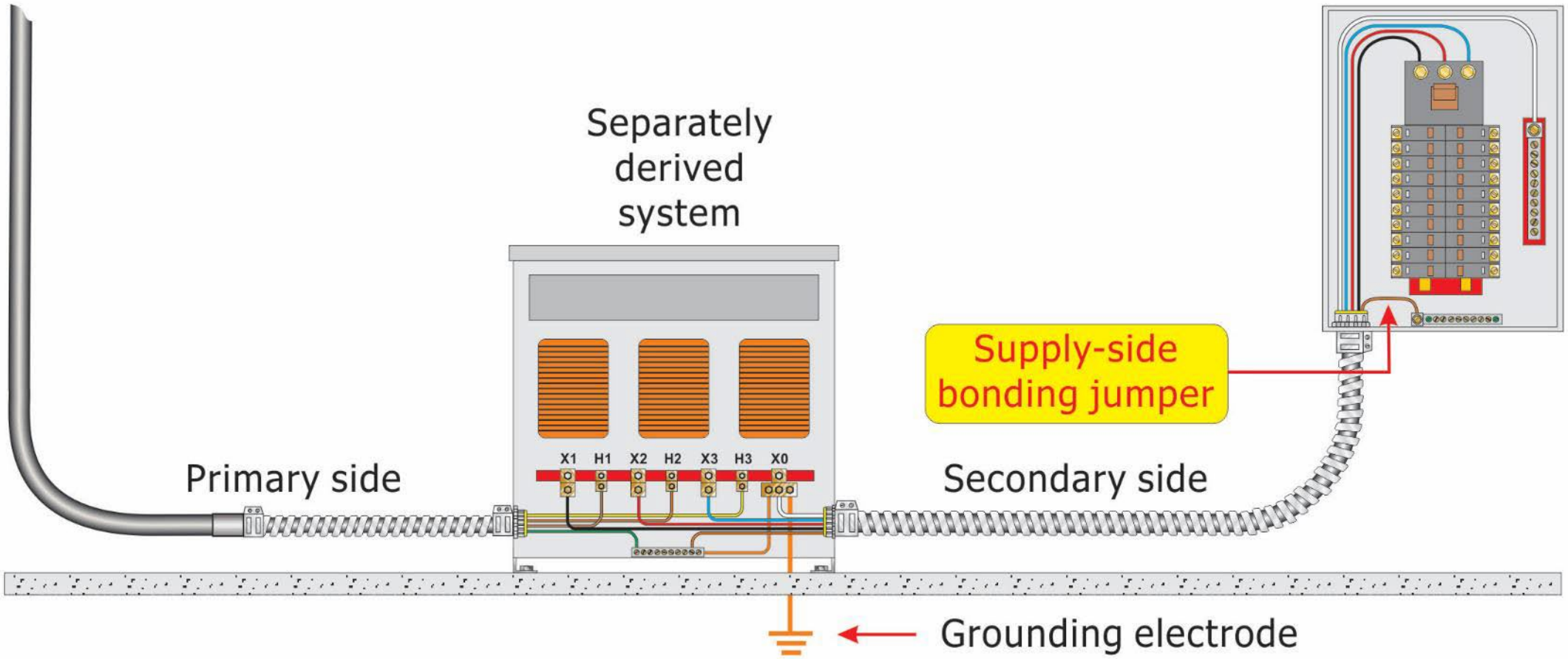
- Supply-side bonding jumper not required to be larger than the derived ungrounded conductors
- Supply-side bonding jumper permitted to be of nonflexible metal raceway type or of the wire or bus type as follows:
  - A supply-side bonding jumper of the **wire type** is sized per 250.102(C), based on the size of the derived ungrounded conductors
  - A supply-side bonding jumper of the **bus type** shall have a cross-sectional area not smaller than a supply-side bonding jumper of the wire type as determined in 250.102(C)
- See 250.30(A)(2)

250.30(A)(2) Sizing of Supply-Side Bonding Jumpers



Copyright © IAEI 2020

Sizing (Wire-Type) Supply-Side Bonding Jumpers



Where supply-side bonding jumpers *(wire-type)* are run with the derived phase conductors, size supply-side bonding jumpers in accordance with 250.102(C) *[not smaller than the sizes provided in Table 250.102(C)(1)]* *[See 250.30(A)(2)(1)]*

Use the 12.5% rule where the derived phase conductors exceed 1100 kcmil copper or 250 kcmil aluminum or copper-clad aluminum

Copyright © IAEI 2020

Grounded Conductor

- If a grounded conductor is installed and the system bonding jumper connection is not located at the source of the separately derived system and installed in a **single raceway**, it must comply with all of the following:
  - Routed with the derived phase conductors [300.3(B)]
  - Not smaller than specified in Table 250.102(C)(1)
  - Sized using 12.5% rule where the derived phase conductors are larger than 1100 kcmil copper or 1750 kcmil aluminum
  - Not required to be larger than the largest ungrounded conductor(s)

Grounded Conductor *(cont.)*

- Where a grounded conductor is installed and the system bonding jumper connection is not located at the source of the separately derived system and is installed in parallel in **two or more raceways**, it must comply with all of the following:
  - If the ungrounded conductors are installed in parallel in two or more raceways, the grounded conductor shall also be installed in parallel
  - Grounded conductor in each raceway must be sized based on the size of largest derived phase conductor in each raceway, but not **smaller than 1/0 AWG**
- This is different than permitted for supply side bonding jumpers sized to 250.102(C)(2) where the minimum size of 1/0 AWG is not imposed

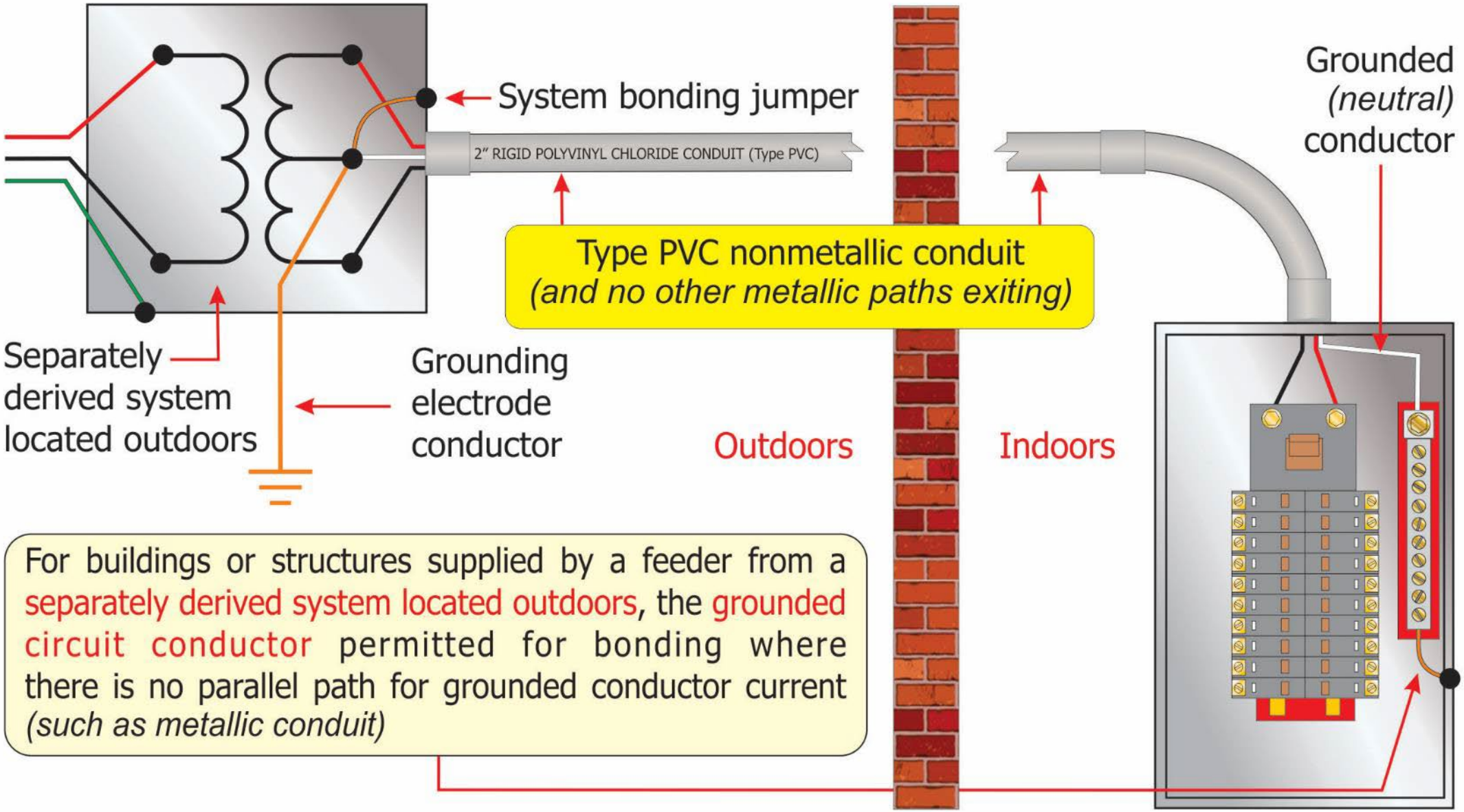
Grounded Conductor *(cont.)*

- Where a grounded conductor is installed and the system bonding jumper connection is not located at the source of the separately derived system, it must comply with all of the following:
  - The grounded conductor of a **3-phase, 3-wire delta system** shall have an ampacity not less than that of the ungrounded conductors
  - The grounded conductor of an **impedance grounded neutral system** shall be installed in accordance with 250.36 or 250.187
- See 250.30(A)(3)(c) and 250.30(A)(3)(d)

Use of Derived Grounded (Neutral) Conductor

- Alternative method of bonding permitted that utilizes the **grounded conductor** and allows it to be bonded to the source enclosure and also at the first system disconnect or overcurrent device enclosure
- Permitted where doing so does not create a parallel path for current that would be returning to the source over the grounded conductor
- In this case, the grounded (neutral) conductor permitted to be the ground fault current return path
- Limits on this option established that this applies only to separately derived systems that are **installed outside the building or structure** being served
- See 250.30(A)(1) Ex. No. 2, 250.30(A)(2) Exception, and 250.30(C)

Use of Grounded Conductor for Bonding



For buildings or structures supplied by a feeder from a separately derived system located outdoors, the grounded circuit conductor permitted for bonding where there is no parallel path for grounded conductor current *(such as metallic conduit)*

See 250.30(A)(1), Ex. No. 2 and 250.30(A)(2) Ex.

Copyright © IAEI 2020

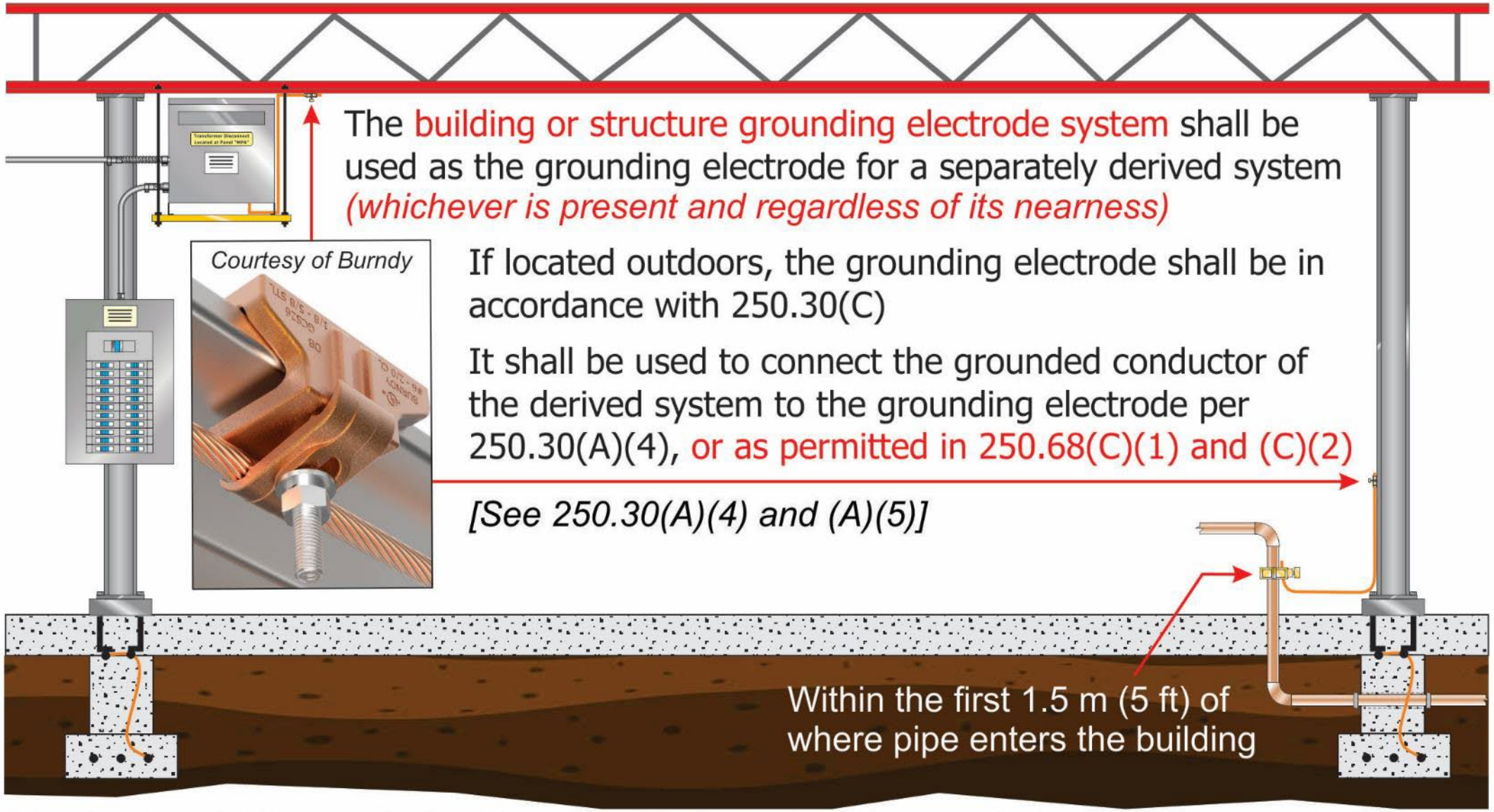
Grounding Electrode for Separately Derived Systems

- The use of metal water piping or building steel as the first options as a grounding electrode system for a separately derived system were eliminated last *Code* cycle
- Now, **any of the building or structure grounding electrode(s)** that are present can *(and must)* be used as the grounding electrode(s) for a separately derived system *(without looking to metal water piping or building steel as the first options)*
- Grounding electrode(s) used for separately derived systems do not have to be located near the grounding electrode conductor connection

Grounding Electrode for Separately Derived Systems *(cont.)*

- Metal water piping and the structural metal frame as covered in 250.68(C)(1) and (2) have been recognized as **conductors to extend the grounding electrode connection** at 250.30(A)(5)
- *Note: See exception that covers separately derived systems contained within listed* equipment such as unit substations
- *See 250.30(A)(4)*

250.30(A) Grounding Separately Derived Systems



Structural metal frame of a building permitted as a bonding conductor to interconnect electrodes or as GEC *[250.68(C)(2)]*

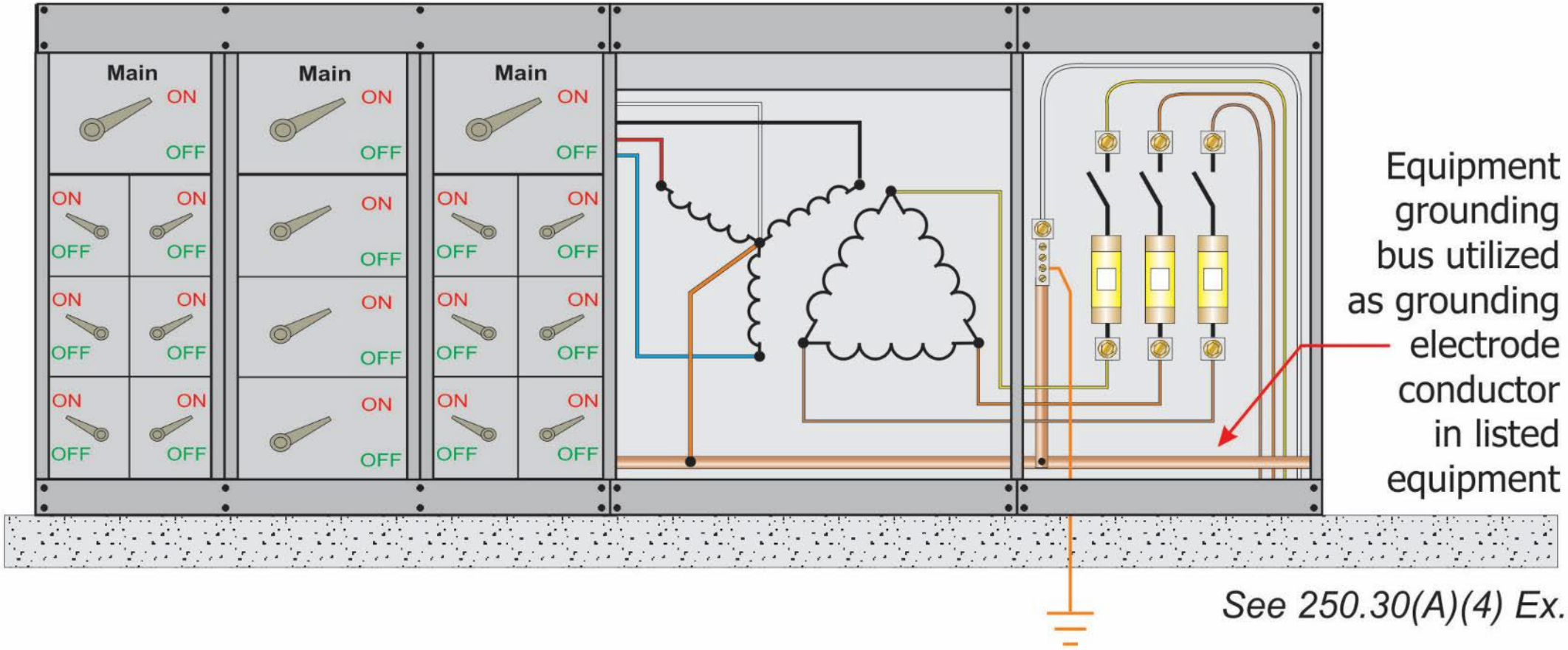
Copyright © IAEI 2020

Grounding Electrode for Separately Derived Systems *(cont.)*

- Where separately derived systems are an **integral part of listed equipment** *(such as in unit substations)*, the grounding electrode used for the service equipment, or equipment that is suitable for use as service equipment installed in accordance with the requirements of Article 225 for feeders, shall be **permitted to serve as the grounding electrode** for the separately derived system
- Internal equipment grounding bus permitted to serve as the grounding electrode conductor if it is large enough, and provided the grounding electrode conductor from the service or feeder to the grounding electrode is also large enough for the separately derived system
- See 250.30(A)(4), Exception

Separately Derived Systems in Listed Equipment

Separately derived systems in listed equipment *(such as unit substation)*



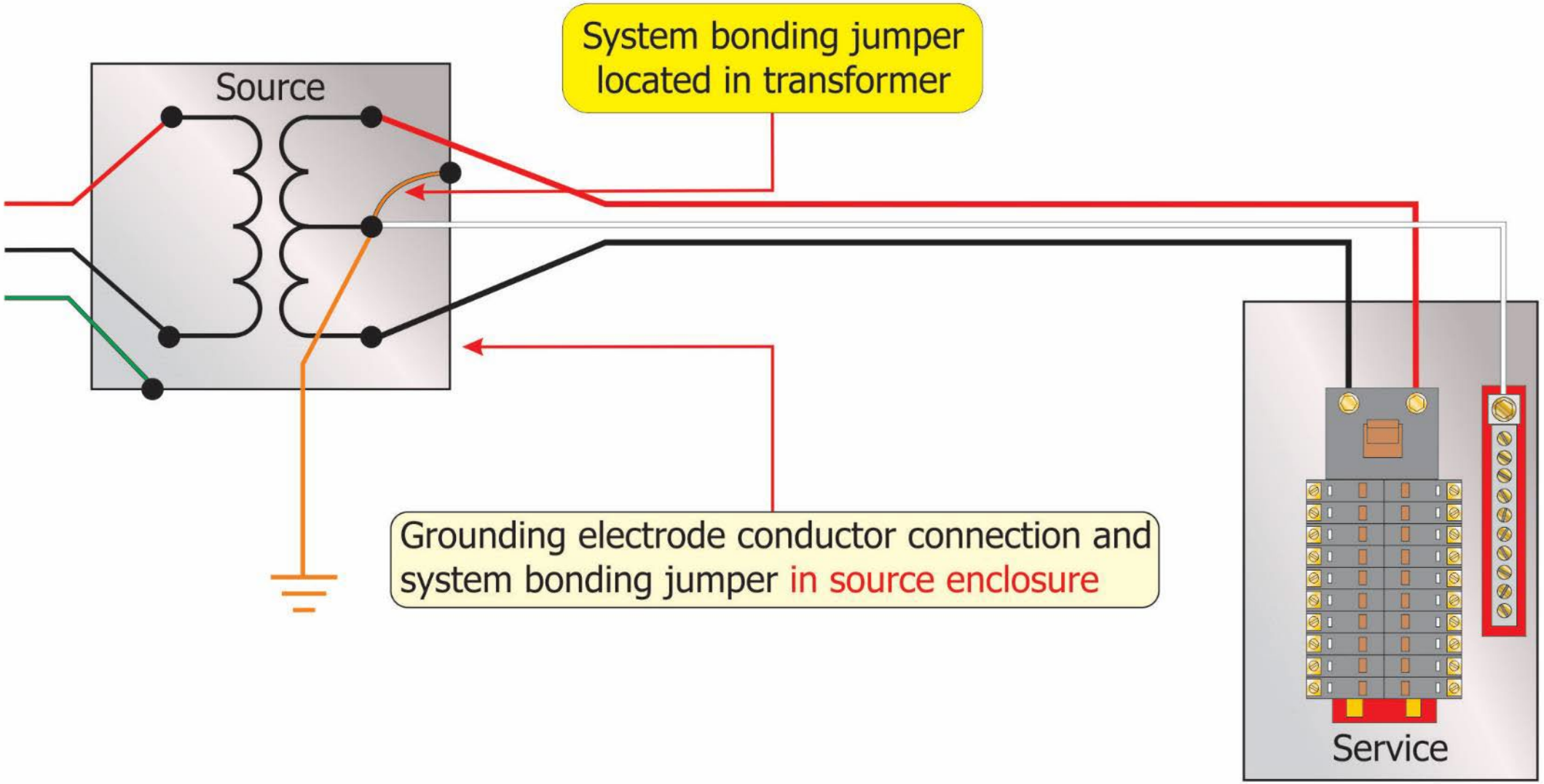
If a separately derived system originates in equipment that is listed and identified as suitable for use as service equipment, the grounding electrode used for the service or feeder equipment permitted to be used as the grounding electrode for the separately derived system

Copyright © IAEI 2020

GEC for Single Separately Derived System

- Size grounding electrode conductor per Table 250.66 based on the size of the derived ungrounded conductors
- Used to connect **SDS grounded conductor** to the **grounding electrode** in source enclosure or to any point to and including the first disconnecting means or overcurrent device
- Connection generally required to be made at the **same point** on the separately derived system where the **system bonding jumper** is installed
  - See exceptions to 250.30(A)(4) and 250.30(A)(5) *(Dual-Fed Services)* or 250.30(A)(5) *(System Bonding Jumper as Wire or Busbar)*
- See 250.30(A)(5)

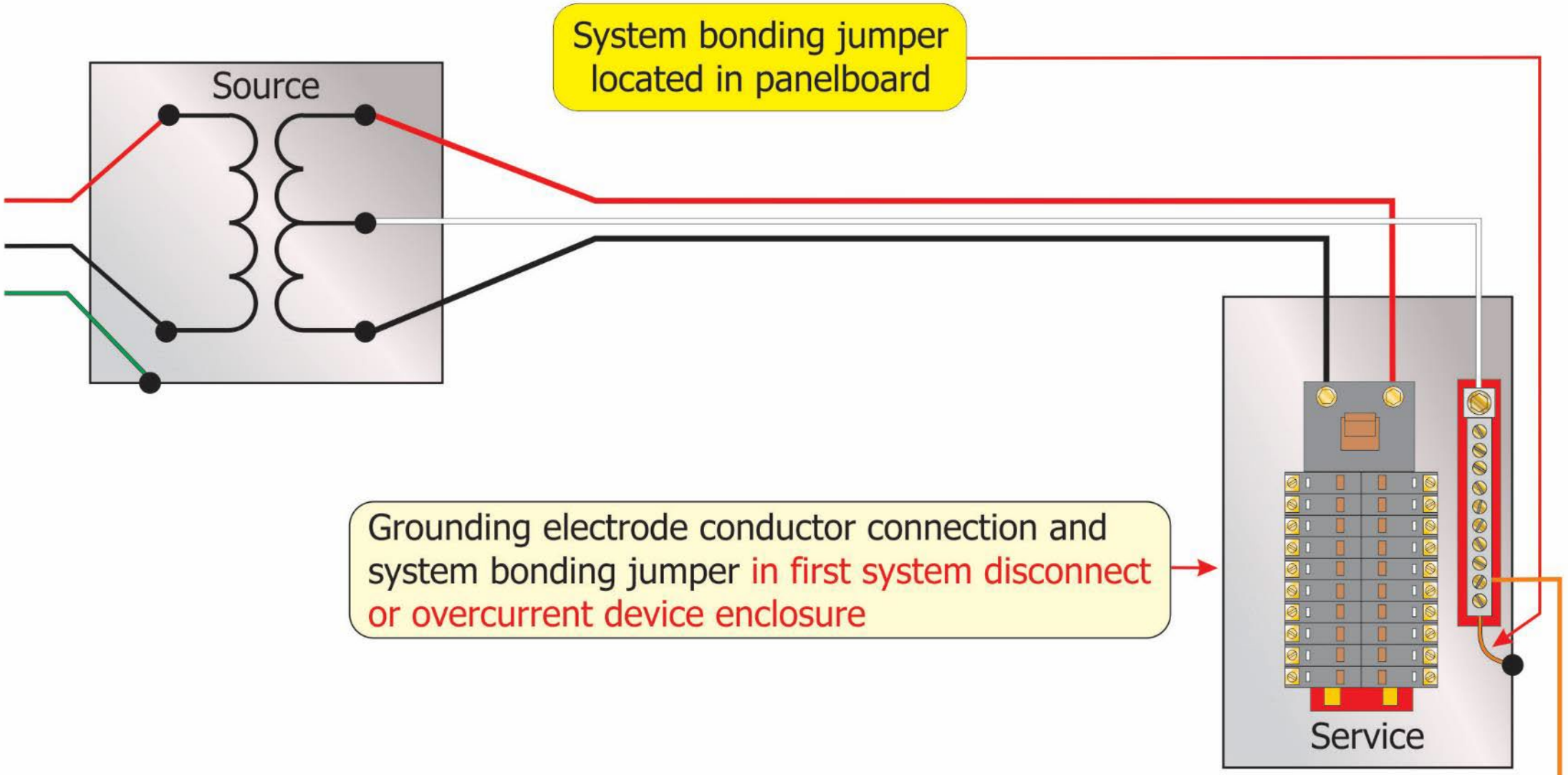
GEC Connection Location for Separately Derived System



Grounding electrode conductor connection shall be made at the same point on the separately derived system where the system bonding jumper is connected *[See 250.30(A)(5)]*

Copyright © IAEI 2020

GEC Connection Location for Separately Derived System



Grounding electrode conductor connection shall be made at the same point on the separately derived system where the system bonding jumper is connected *[See 250.30(A)(5)]*

Copyright © IAEI 2020

GEC for Multiple Separately Derived Systems

- Multiple separately derived systems are permitted to be connected to a **common grounding electrode conductor**
- Providing **individual grounding electrode conductor connections** when there two or more separately derived systems is acceptable as well
- Used to connect to grounded conductor to the grounding electrode in source enclosure or to any point to and including the first disconnecting means or overcurrent device
- This connection is generally required to be made at the **same point** on the separately derived system where the **system bonding jumper** is installed
  - See exceptions to 250.30(A)(4) and 250.30(A)(6) *(Dual-Fed Services)* or 250.30(A)(6) *(System Bonding Jumper as Wire or Busbar)*
- See 250.30(A)(6)

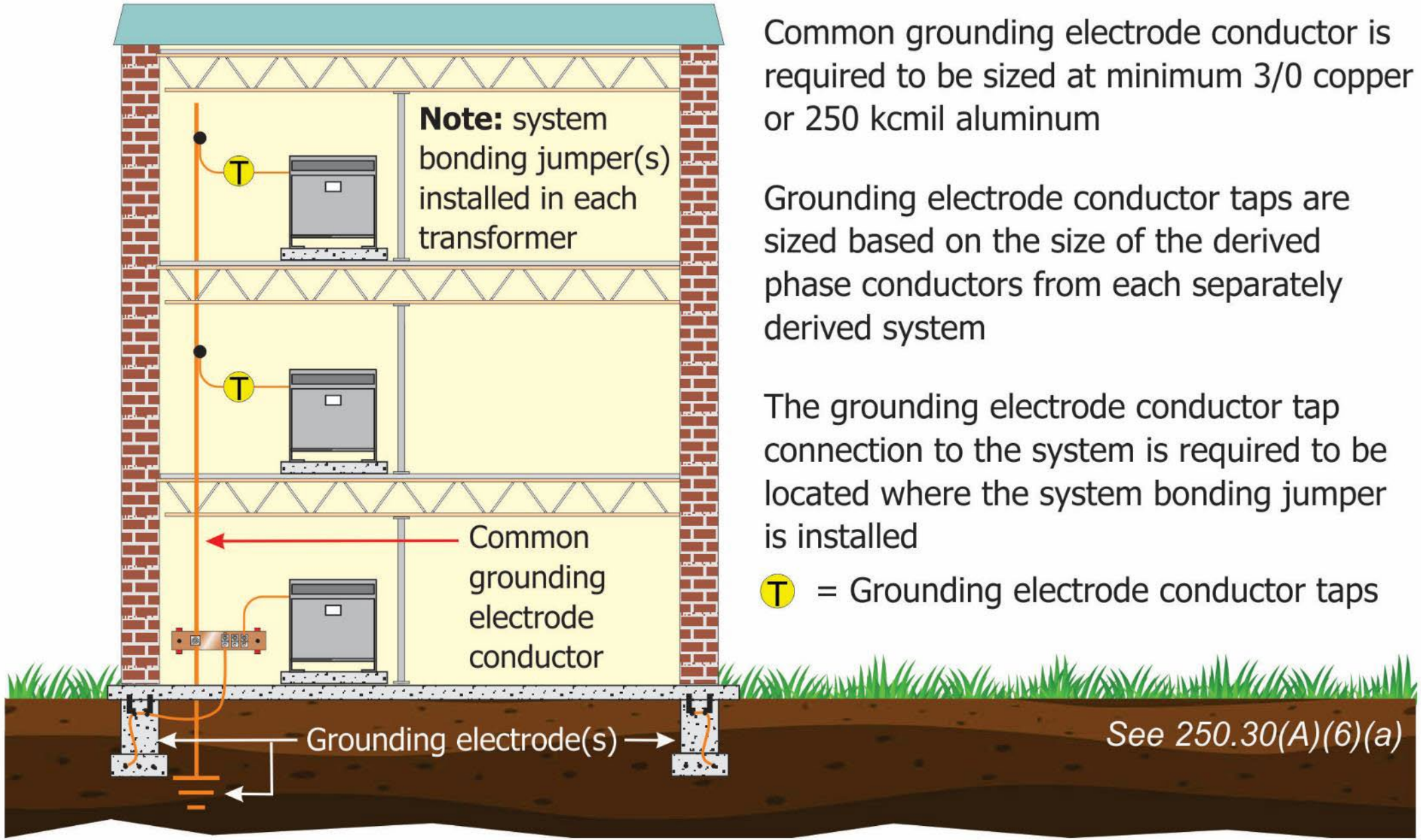
GEC for Multiple Separately Derived Systems *(cont.)*

- The common grounding electrode conductor shall be sized not less than 3/0 AWG copper or 250 kcmil aluminum or copper-clad aluminum if of the wire type [250.30(A)(6)(a)(1)]
- The common grounding electrode conductor can be a **wire type** as provided in 250.30(A)(6), **metallic water pipe** as provided in 250.68(C)(1) and exception, or **structural metal** as provided in 250.68(C)(2)
- A grounding electrode conductor taps shall be installed from each separately derived system to the common grounding electrode conductor
- This method is common in **high rise structures** where the nearest grounding electrode is in the basement of the structure *(not limited to high rise buildings)*

Grounding Electrode Conductor Taps

- Permitted to connect taps from multiple separately derived systems to a **common GEC**
- Each tap conductor shall connect the grounded conductor of the separately derived system to the common grounding electrode conductor
- This connection shall be made at the **same point** on the separately derived system where the **system bonding jumper** is installed
- Each tap conductor shall be sized in accordance with Table 250.66 based on the size of the derived ungrounded conductors of the individual separately derived system it serves
- See 250.30(A)(6)

Taps to a Common Grounding Electrode Conductor



Common grounding electrode conductor is required to be sized at minimum 3/0 copper or 250 kcmil aluminum

Grounding electrode conductor taps are sized based on the size of the derived phase conductors from each separately derived system

The grounding electrode conductor tap connection to the system is required to be located where the system bonding jumper is installed

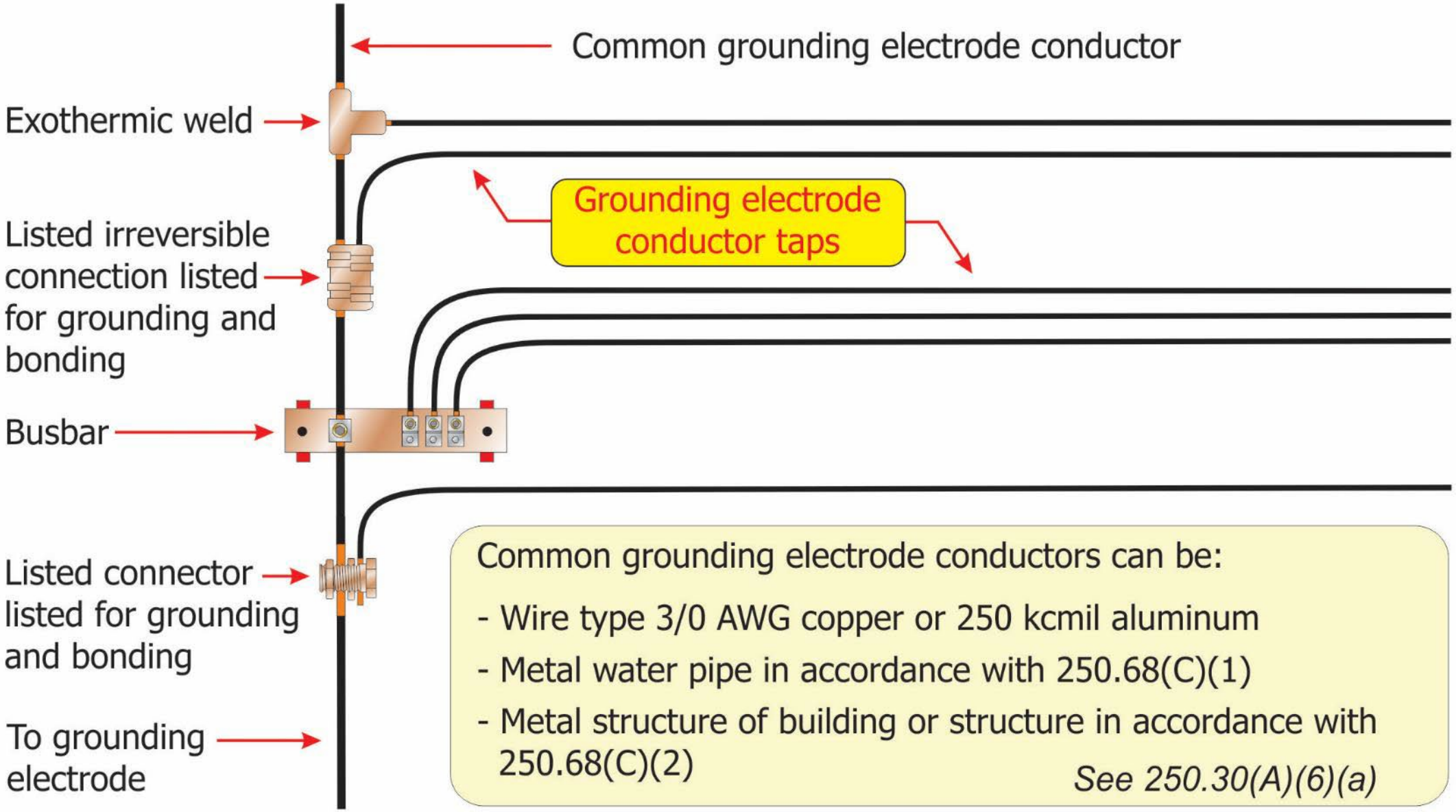
T = Grounding electrode conductor taps

Copyright © IAEI 2020

Grounding Electrode Conductor Taps *(cont.)*

- Connections shall be made by one of the following:
  - A connector listed as grounding and bonding equipment *(irreversible crimp, or mechanical connector such as a split bolt, etc.)*
  - Listed connections to aluminum or copper busbars not less than 6 mm thick x 50 mm wide *(¼ in. thick x 2 in. wide)*
  - Exothermic welding process
- Tap conductor connections are to be made to the common GEC so that common GEC remains **without a splice or joint**
- Common GEC and taps to be installed in accordance with 250.64(A), (B), (C), and (E) *(GEC installation requirements)*

Grounding Electrode Conductor Tap Connections



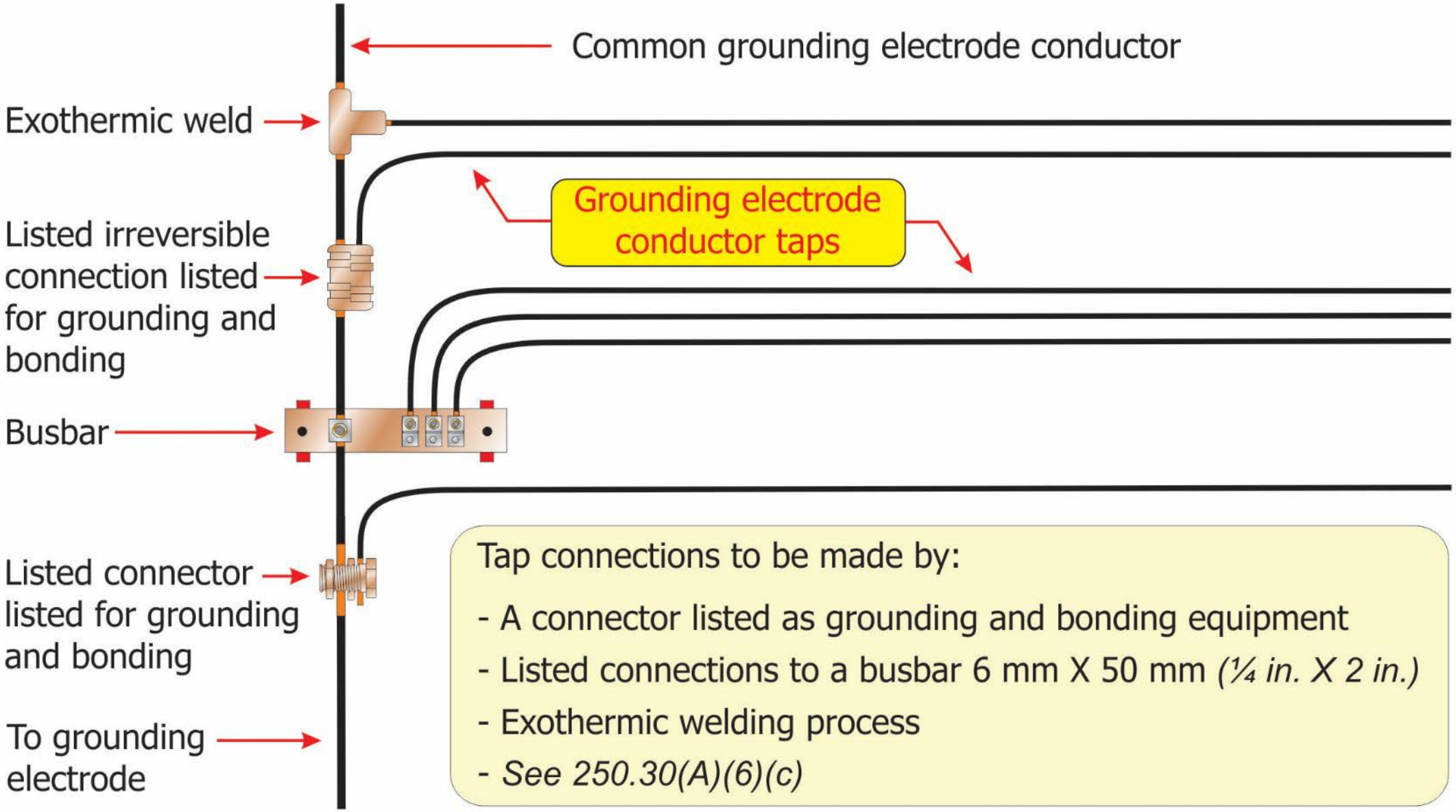
Common grounding electrode conductors can be:

- Wire type 3/0 AWG copper or 250 kcmil aluminum
- Metal water pipe in accordance with 250.68(C)(1)
- Metal structure of building or structure in accordance with 250.68(C)(2)

See 250.30(A)(6)(a)

Copyright © IAEI 2020

Grounding Electrode Conductor Tap Connections



Tap connections to be made by:

- A connector listed as grounding and bonding equipment
- Listed connections to a busbar 6 mm X 50 mm *(¼ in. X 2 in.)*
- Exothermic welding process
- *See 250.30(A)(6)(c)*

Copyright © IAEI 2020

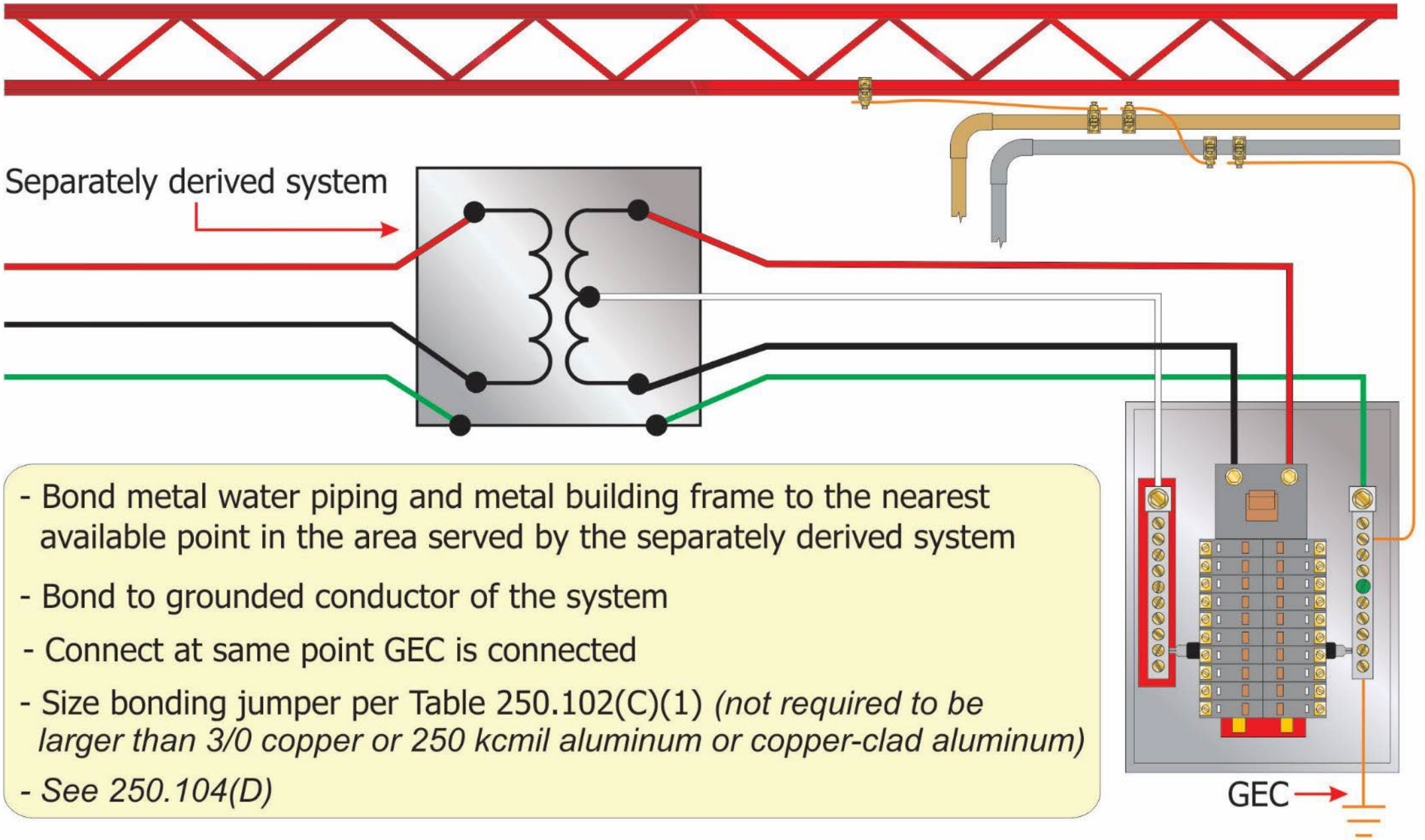
Bonding of Structural Steel and Metal Piping

- Where the following items exist in the area served by the separately derived system, it shall be bonded to the grounded conductor of each separately derived system
  - **Exposed structural steel** that is interconnected to form a building frame
  - **Interior metal piping system**
- Bonding to be in accordance with 250.104(D)
- See 250.30(A)(8)

Bonding of Structural Steel and Metal Piping *(cont.)*

- The grounded conductor of each separately derived system is required to be bonded to the nearest available point on the **metal water piping system(s)** and the **exposed structural metal building frame** in the area served by each separately derived system
- Connection to be made at the same point where the GEC is connected to the separately derived system
- The bonding jumper(s) shall be sized based on Table 250.102(C)(1) based on the cm area of the derived ungrounded conductors of the system(s) *(not required to be larger than 3/0 AWG copper or 250 kcmil aluminum or copper-clad aluminum)*
- See 250.104(D)

Bonding Structural Metal and Water Piping to Grounded Conductor



- Bond metal water piping and metal building frame to the nearest available point in the area served by the separately derived system
- Bond to grounded conductor of the system
- Connect at same point GEC is connected
- Size bonding jumper per Table 250.102(C)(1) *(not required to be larger than 3/0 copper or 250 kcmil aluminum or copper-clad aluminum)*
- *See 250.104(D)*

Copyright © IAEI 2020

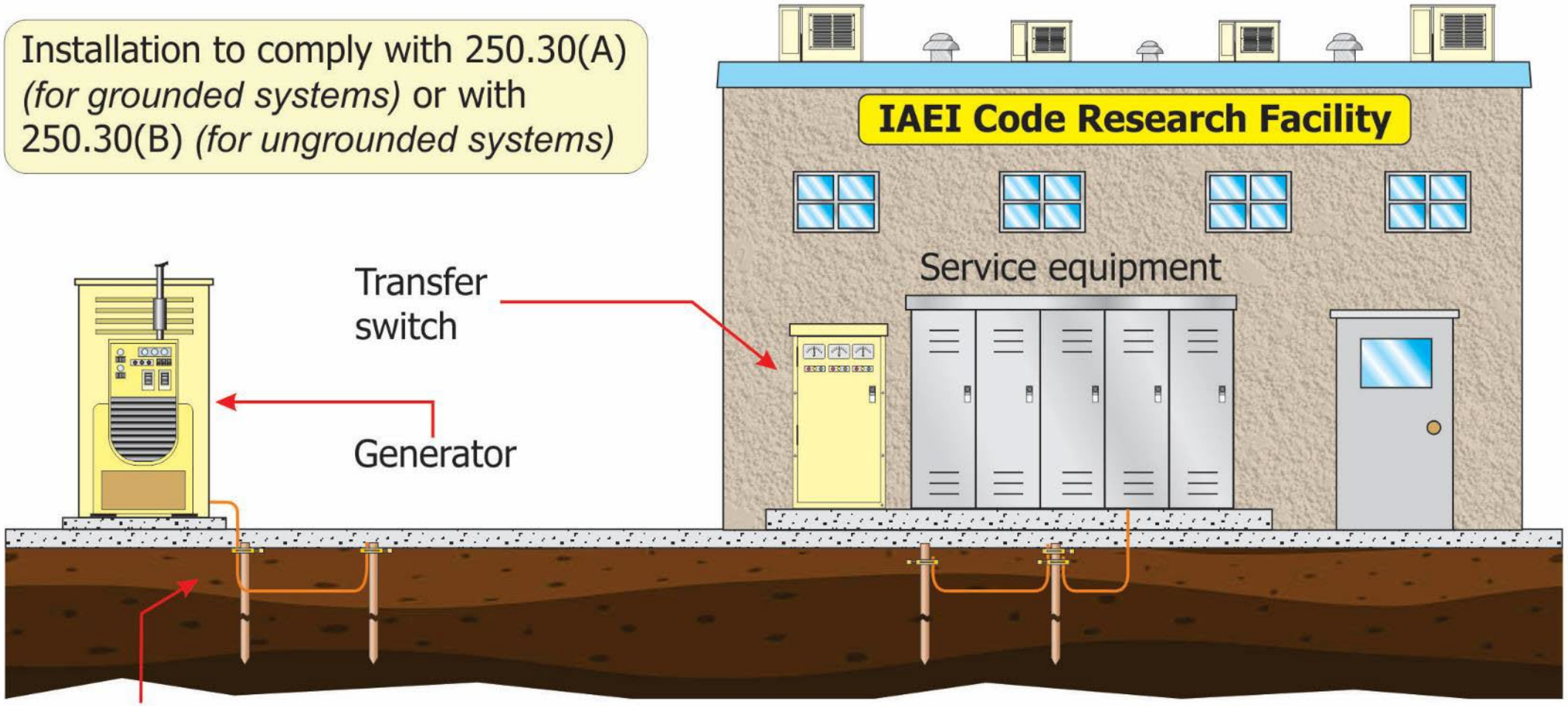
Separately Derived Systems Located Outside of Buildings or Structures Served

- If source of separately derived system is **located outside the building or structure** supplied, a grounding electrode connection shall be made **at the source location** to one or more grounding electrodes
- Installation shall comply with 250.30(A) for **grounded systems** or with 250.30(B) for **ungrounded systems**
- Provides protection due to lightning
- Ensures separately derived system enclosure is at **same voltage potential** as the area of the earth where installed
- See 250.30(C)

250.30(C) Outdoor Sources

Separately derived systems located outside the building or structure supplied require grounding electrode connection compliance with 250.30(C)

Installation to comply with 250.30(A) *(for grounded systems)* or with 250.30(B) *(for ungrounded systems)*



Grounding electrode connection must be made at the source location to one or more grounding electrodes in compliance with 250.50

Copyright © IAEI 2020

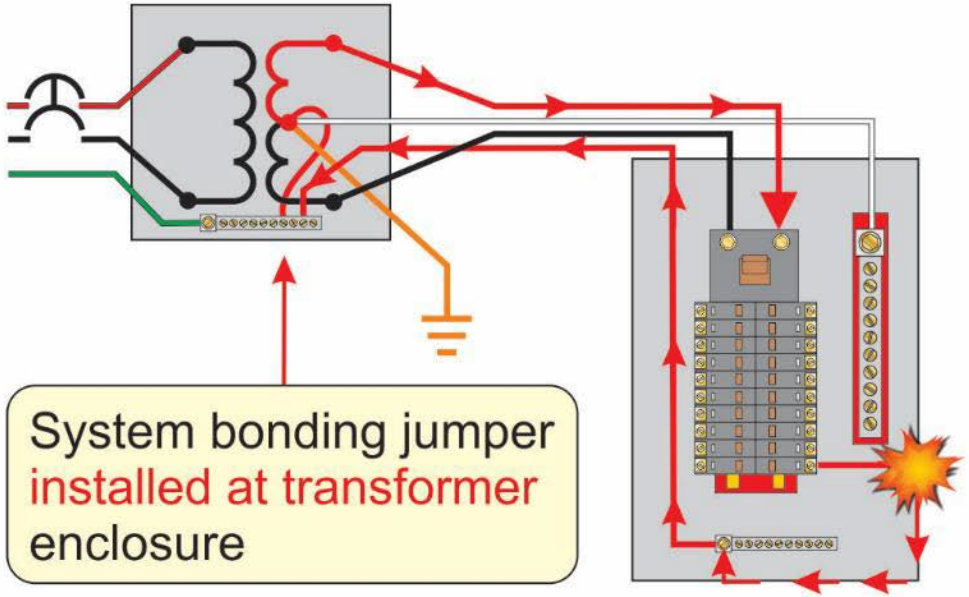
Effective Ground-Fault Return Path and Equipment Grounding Conductors

- As with all electrical systems, it is vital to be certain that an effective ground-fault return path exists from the furthermost point on the electrical system back to the source *(in this case, the source is the separately derived system)*
- Fault current downstream from the separately derived system follows the same laws of physics, as does the fault current on the line side *(seeks all possible paths to return to its source)*
- Fault current downstream from the separately derived system will return to the secondary windings of the transformer *(not to the primary or to the service)*
- Necessary to provide an effective path for ground-fault current be electrically continuous, of adequate capacity, and low impedance from the equipment supplied back to the separately derived system

Effective Ground-Fault Return Path and Equipment Grounding Conductors *(cont.)*

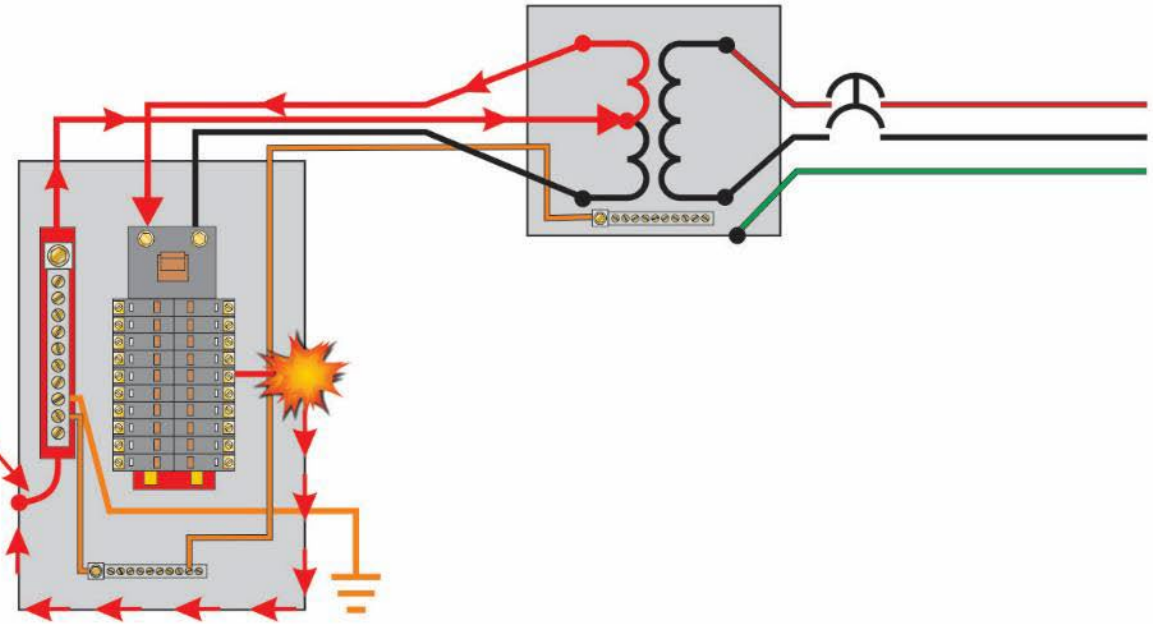
- Raceway may serve as equipment grounding conductor for both primary and derived systems
- Provides low impedance path for both systems
- Equipment grounding conductors of the primary and supply-side bonding jumpers of the secondary meet at some point
- Such connections do not make a “direct connection from circuit conductors of one system to circuit conductors of another system”

Effective Ground-Fault Current Path



System bonding jumper installed at transformer enclosure

- Fault path is electrically continuous
- Ample capacity for ground-fault current
- Lowest practicable impedance



System bonding jumper installed at panelboard enclosure

Ensure effective ground-fault current path complies with 250.4(A)(5)

Copyright © IAEI 2020

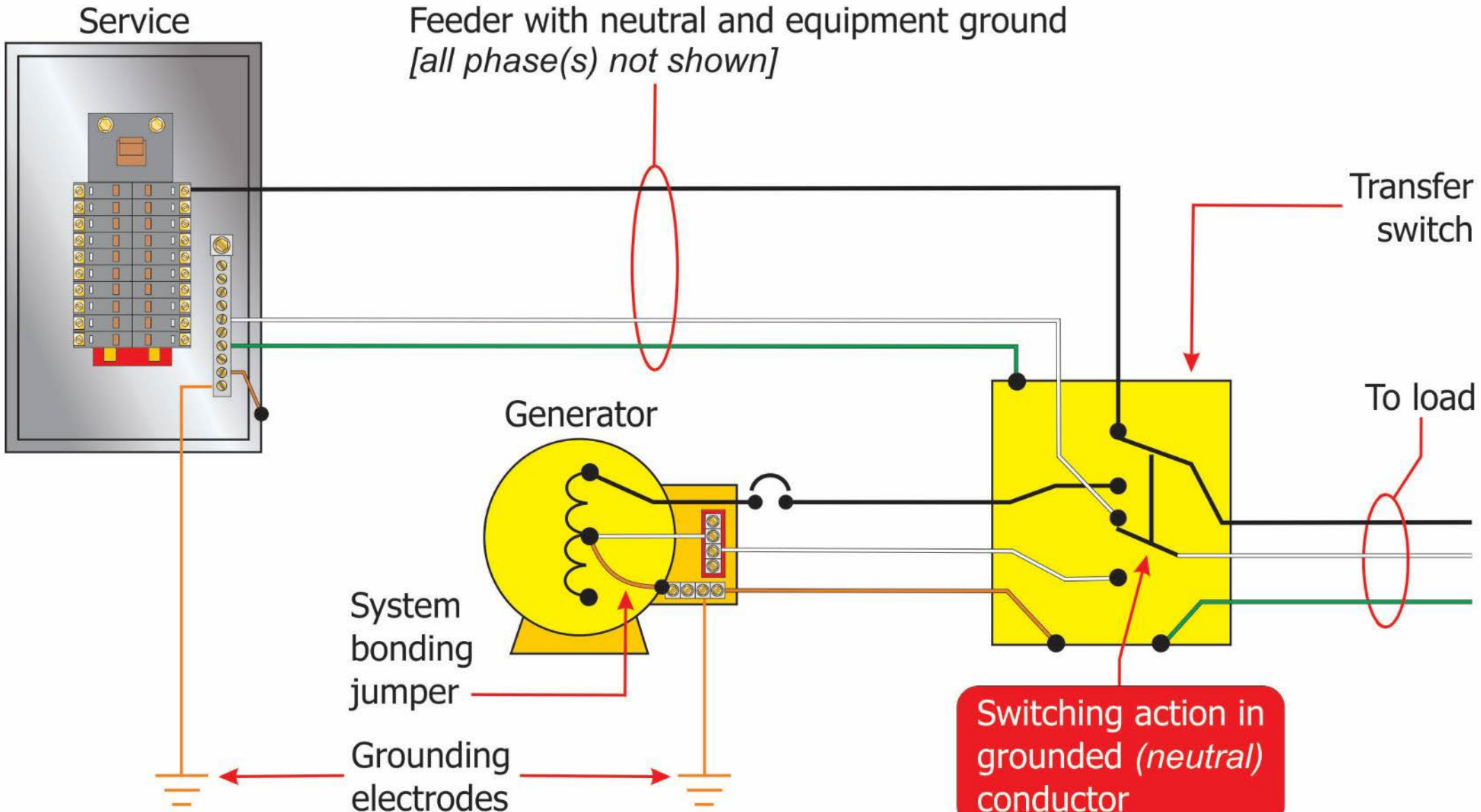
Generators-Type Separately Derived Systems

- A separately derived system supplied from a generator has no system connection *(including that of a solidly grounded neutral conductor)* between the two systems *(interconnection of equipment grounding conductors and bonding conductors is not considered as a direct electrical connection)*
- Generators are required to be grounded as a separately derived system in accordance with 250.30(A) when the transfer equipment includes a **switching action in the grounded conductor**
- Where a generator is a separately derived system, it is required to comply with all grounding and bonding rules in 250.30(A)
- See 250.20, 250.30(A), and 250.30 Informational Note No. 1

Generators-Type Separately Derived Systems *(cont.)*

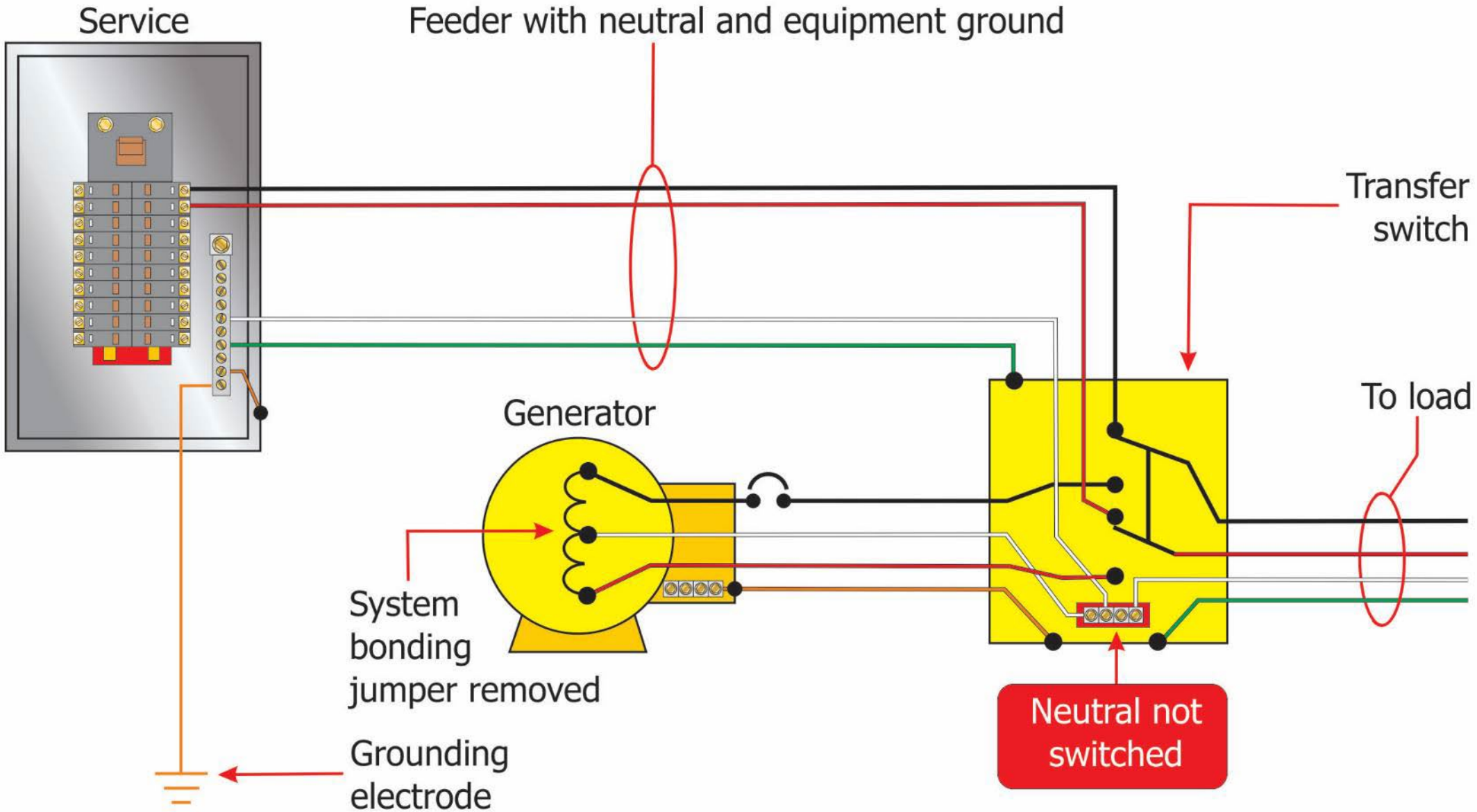
- Where the generator or source is to be grounded as a separately derived system, the **system bonding jumper** must be installed
- System bonding jumper is to be installed at:
  - The generator
  - First disconnecting means or overcurrent device
  - Any point between the generator and the first means of disconnect or overcurrent device
- A grounding electrode conductor must be installed from the system grounded *(neutral)* conductor to a grounding electrode
- The grounding electrode conductor connection to the system must be located at the **same point** where the system bonding jumper is installed

Generator - Separately Derived System



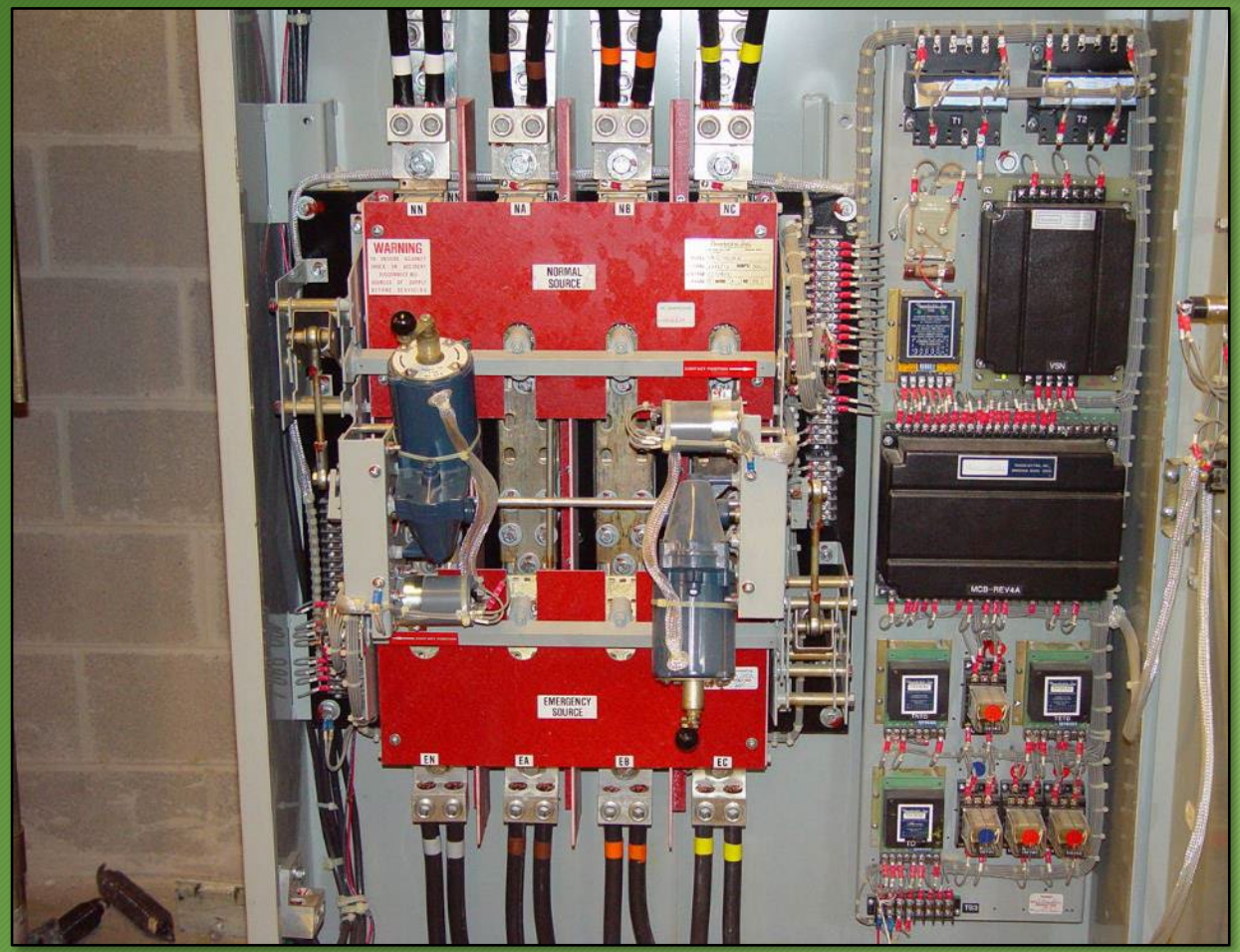
Copyright © IAEI 2020

Generator - Not Separately Derived System

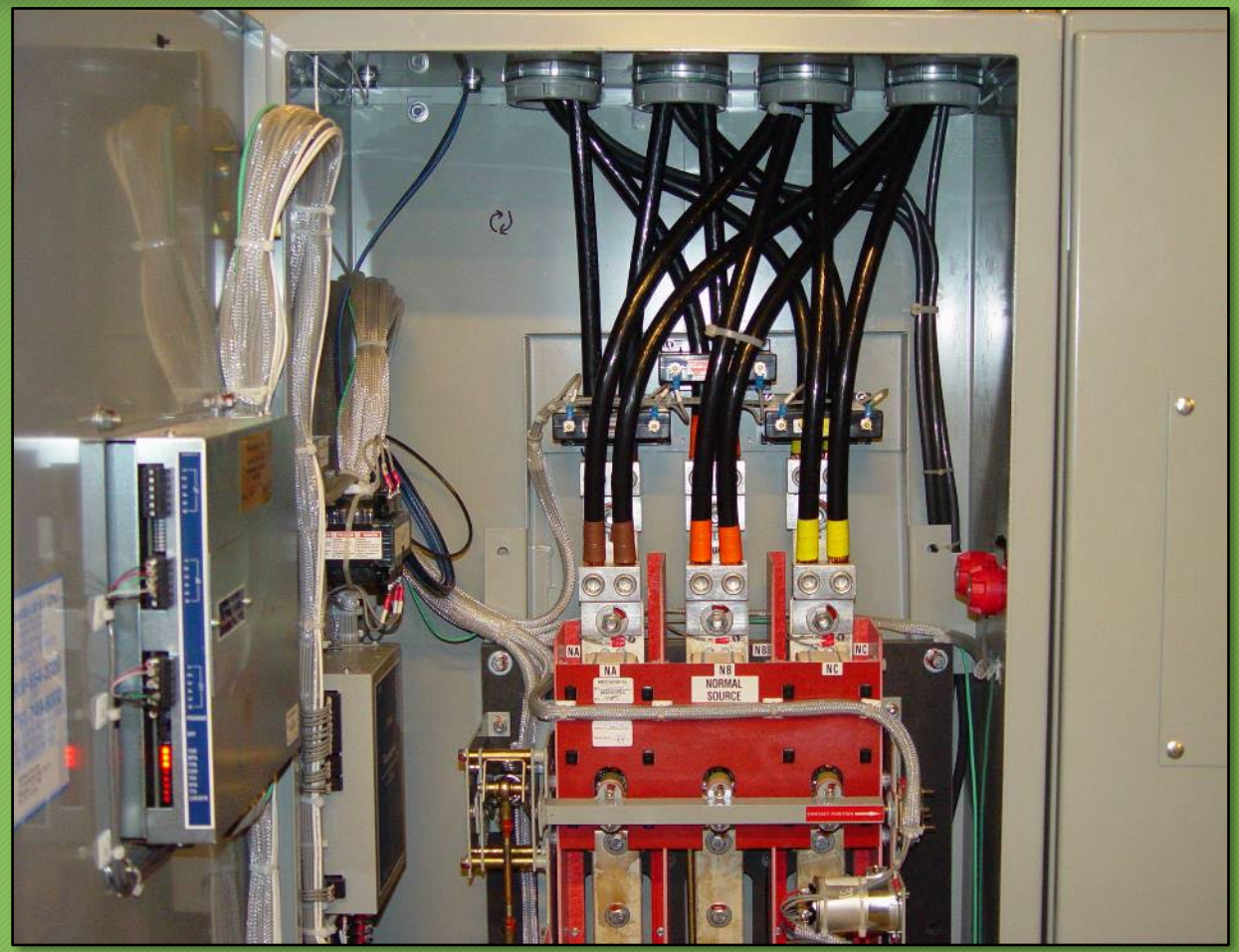


Copyright © IAEI 2020

Separately Derived System? Yes or No?



Transfer equipment that ***does*** switch the grounded (neutral) conductor

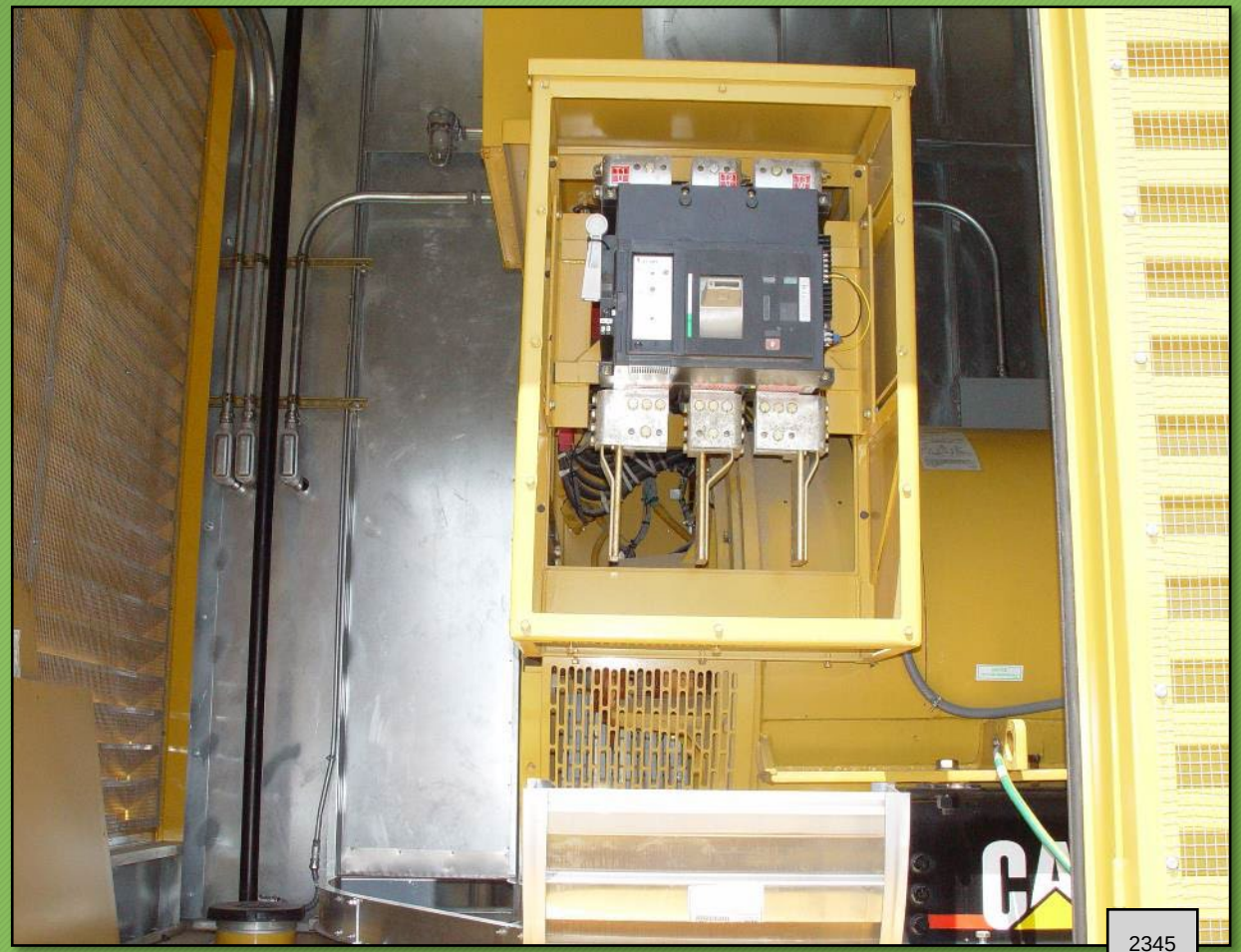


Transfer equipment that ***does not*** switch the grounded (neutral) conductor

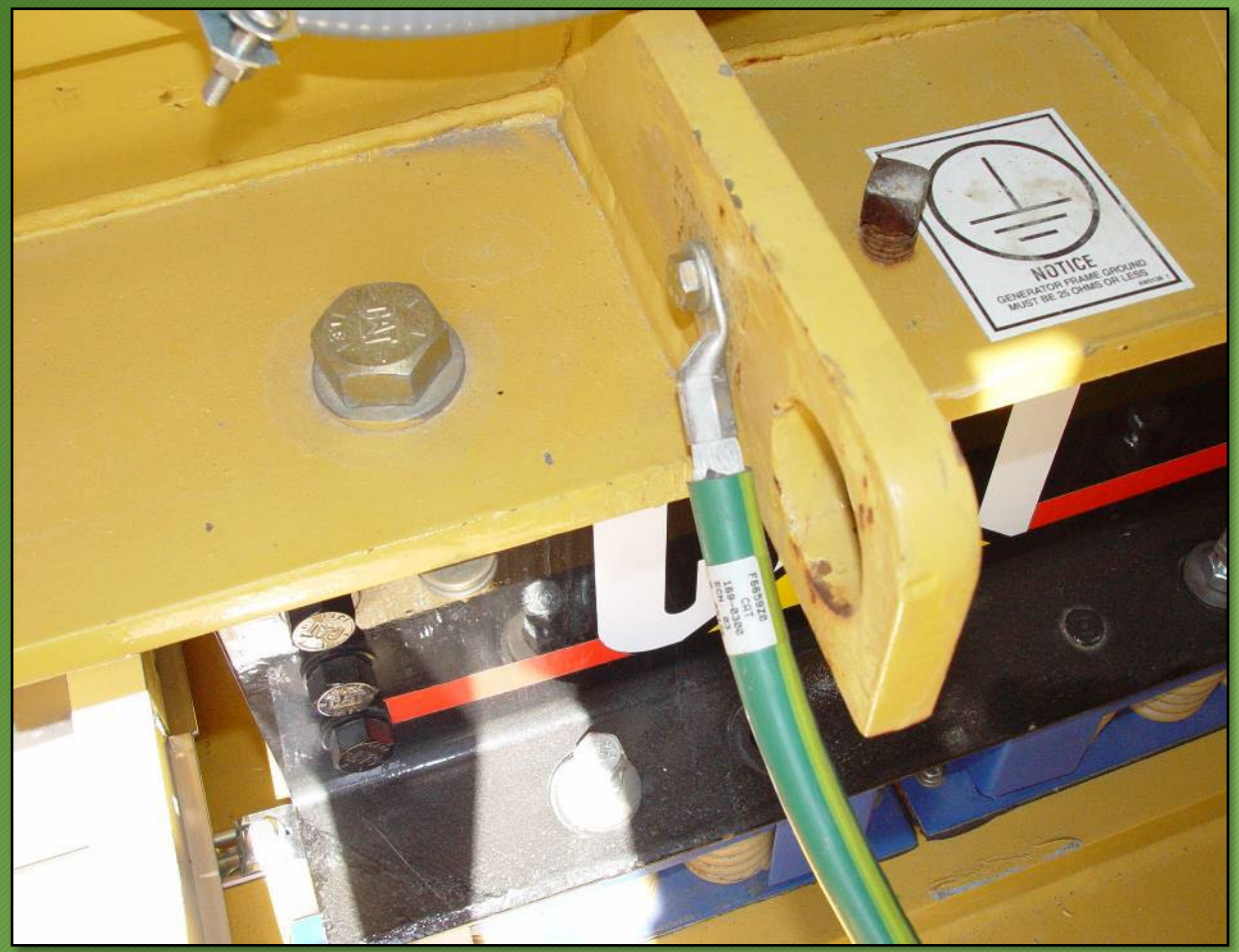


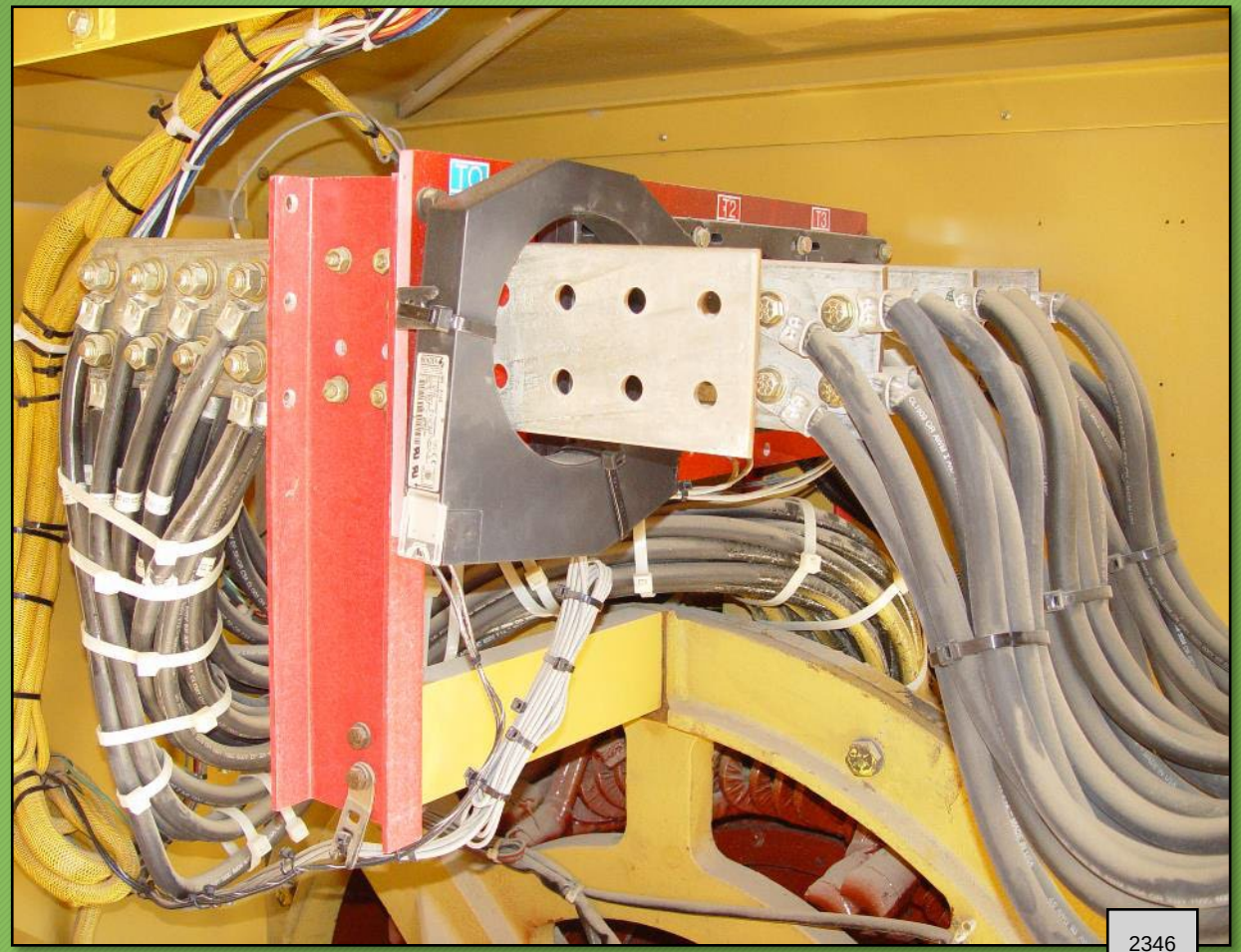
Generator Type Separately Derived System





Generator Type Separately Derived System





Generator Not Grounded as Separately Derived Systems

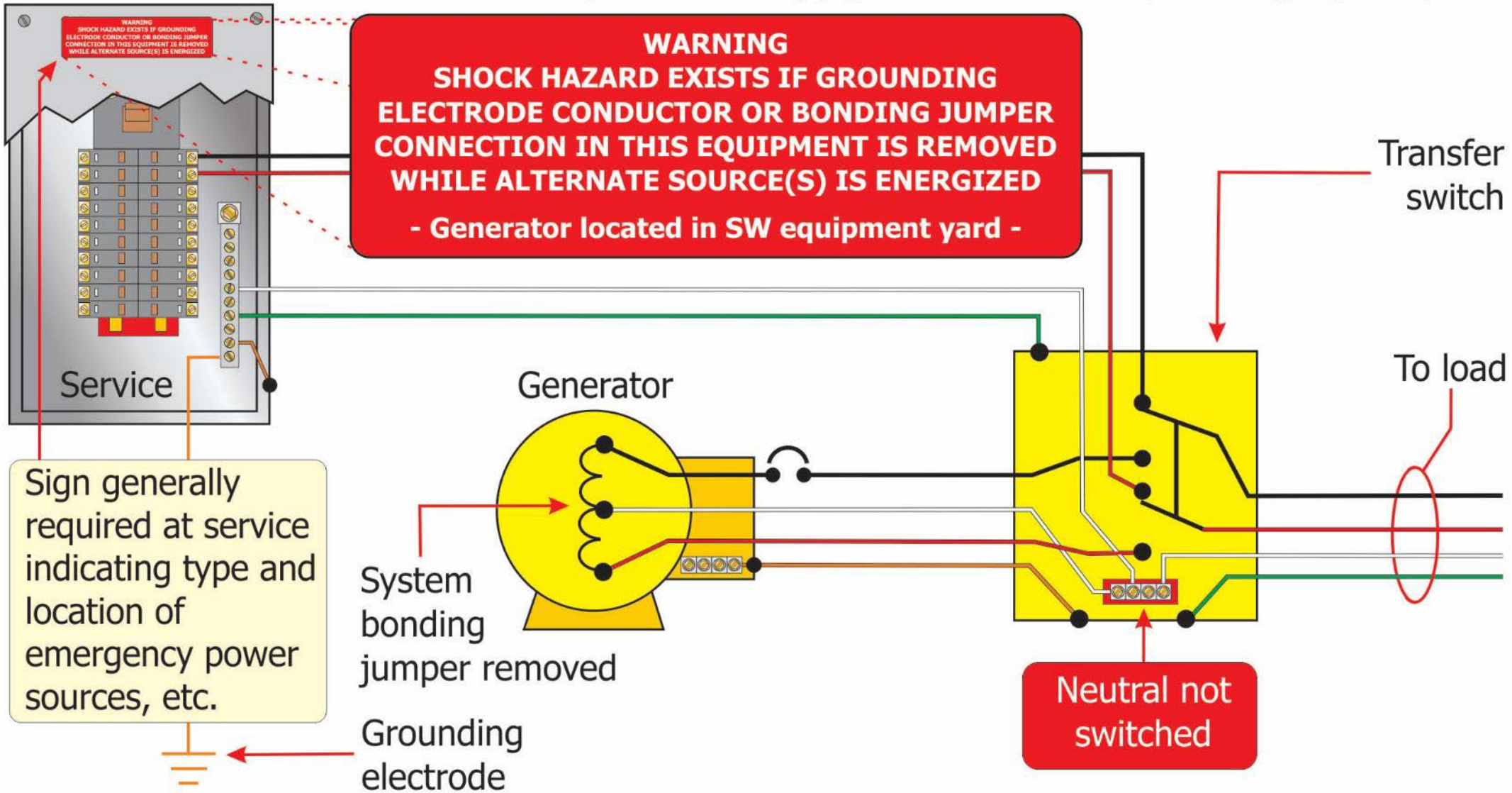
- Where the generator is **not a separately derived system**, the system bonding jumper must be **removed from the generator**, and the neutral must not be grounded at the generator or at any point between the generator up to the service
- System is grounded by its solid connection to the neutral of the premises wiring system which is connected to earth by the grounding electrode conductor
- Generator neutral is solidly connected from the generator to the terminal in the transfer switch completing the connection to earth
- Equipment grounding conductors are installed throughout the system with the circuit conductors and to the supply-side bonding jumper between the generator and the generator disconnect

Hazard Sign for Non-Separately Derived System

- Where removal of a grounding or bonding connection in normal power source equipment interrupts the grounding electrode conductor connection to the alternate power source(s) grounded conductor, a **warning sign** shall be installed at the normal power source equipment
- Identical requirements located at:
  - 700.7(B) for **Emergency Systems**
  - 701.7(B) for **Legally Required Standby Systems**
  - 702.7(B) for **Optional Standby Systems**

700.7(B) Identification Signs Required at Service

Where removal of a grounding or bonding connection in normal power source equipment interrupts the GEC connection to the alternate power source(s) grounded conductor, warning sign required

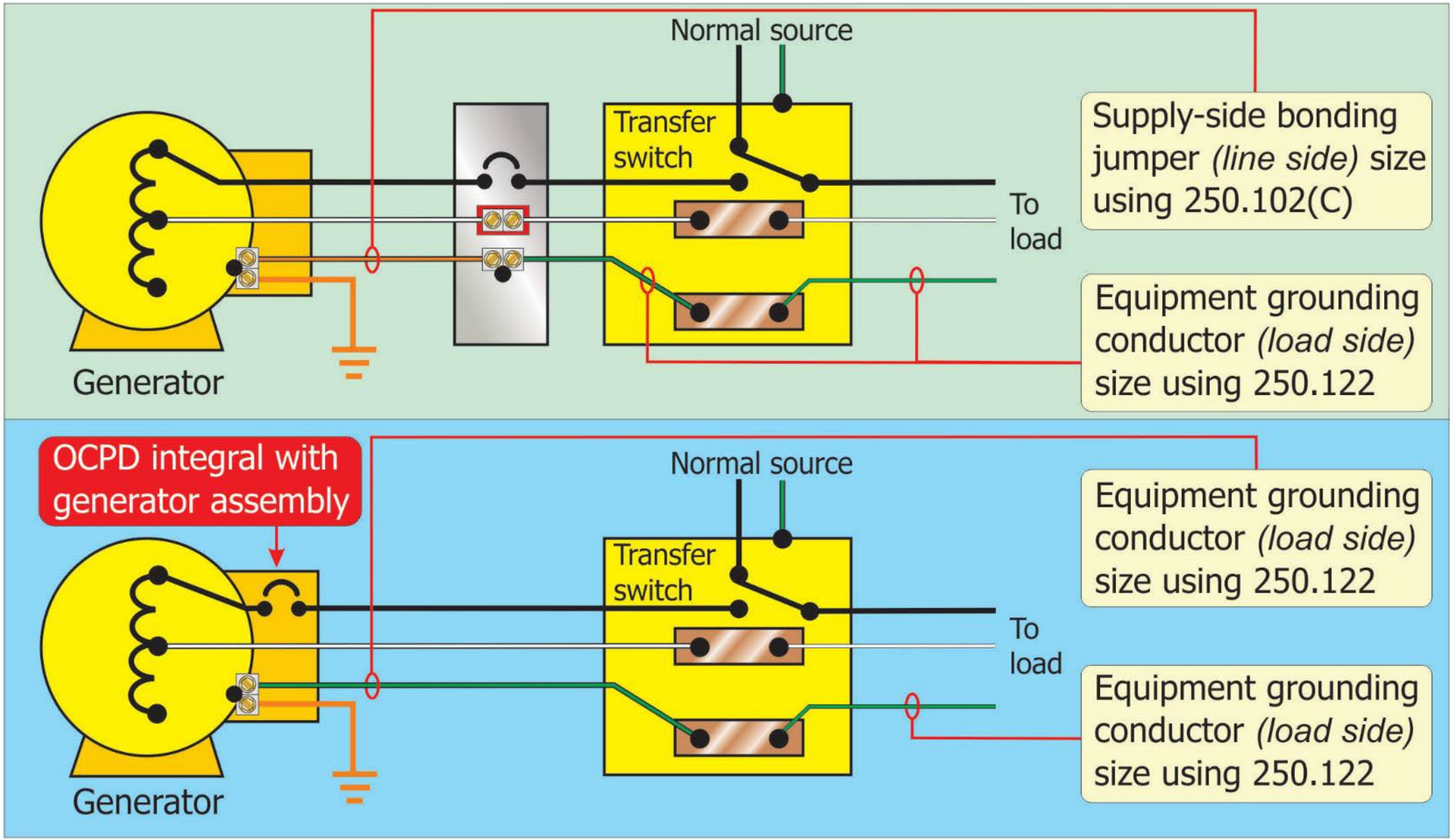


Copyright © IAEI 2020

Permanently Installed Generators

- An **effective ground-fault current path** is required to be provided between permanently installed generators and the first disconnecting means enclosure *(see 250.35)*
- 250.35 addresses both separately derived systems and non-separately derived systems
- Where the **generator is a separately derived system**, required to comply with all grounding and bonding rules in 250.30(A)
- Where the **generator is not separately derived**, the grounding and bonding connections are required to be in accordance with 250.35(B) *(depending on the location of the derived system overcurrent device)*
- Supply-side bonding jumpers on the supply side *(line side)* of each generator OCPD must be sized according to 250.102(C)

250.35 Permanently Installed Generators



Generator sources that are not grounded as separately derived systems

Copyright © IAEI 2020

CHAPTER TWELVE

GROUNDING AND BONDING AT BUILDINGS AND STRUCTURES SUPPLIED BY FEEDERS OR BRANCH CIRCUITS



2353

Grounding and Bonding at Buildings or Structures Supplied by Feeders or Branch Circuits

- *NEC* 250.32 provides requirements for grounding of electrical systems and equipment at buildings or structures that are supplied from feeders or branch circuits
- *NEC* now permits **more than one feeder or branch circuit** of the same characteristics to supply separate buildings or structures *[see 225.30(B)]*
- This change will add some complexity to the compliance with the grounding and bonding requirements from Article 250
- While 225.30 has several provisions allowing more than one feeder or branch circuit, those allowances for multiple branch circuits would not be permitted to exclude the grounding electrode required in 250.32(A)

Grounding and Bonding at Buildings or Structures Supplied by Feeders or Branch Circuits *(cont.)*

- Included in the provisions at 250.32 are requirements for:
  - Grounding electrodes
  - Grounding electrode conductors
  - Grounded systems
  - Ungrounded systems
  - Where supplied from separately derived systems
  - Equipment grounding conductors
  - Grounding at buildings where the main disconnecting means are permitted to be located in a separate building or structure on the same premises

Article 100 Definitions

- ***Grounding Electrode:*** A conducting object through which a direct connection to earth is established.
- ***Grounding Electrode Conductor:*** "A conductor used to connect the system grounded conductor or the equipment to a grounding electrode or to a point on the grounding electrode system."
  - Definition includes the grounding electrode conductors at services and separately derived systems *(discussed in Soares Chapters 8 and 11)*
  - Definition also applies to the GEC connecting the grounding electrode at a second or additional building or structure supplied by a feeder or branch circuit

Grounding Electrode Required

- For each building(s) or structure(s) served by one or more feeders or branch circuits, a **grounding electrode system** meeting the requirements of Part III of Article 250 must be used or installed
- The grounding electrode(s) must be connected in a manner specified in 250.32(B) or (C)
- Where no grounding electrode(s) are present from the construction of the building or structure, a grounding electrode system as specified in Part III of Article 250 *[specifically 250.50 and 250.52(A)]* **must be installed and used**
- See 250.32(A)

Grounding Electrode Required *(cont.)*

- One of the main reasons for a grounding electrode system to be required at the additional building or structure is so the conductive non-current-carrying parts of equipment and enclosures in the building or structure reference the earth where the building or structure is located
- **Minimizes the possible difference in voltage potential** that could exist for a person when standing on the ground in or at this building or structure and being in contact with the electrical equipment enclosures or other non-current-carrying parts that are referenced to earth somewhere else
- By ensuring all the electrical equipment enclosures and other non-current carrying parts are referenced to the earth at the building or structure also ensures that persons contacting these parts while standing on the ground are at or near the same potential

Grounding Electrode Required *(cont.)*

- An **exception** to 250.32(A) indicates that a grounding electrode at separate buildings or structures is not required where a **single branch circuit** supplies the building or structure and the single branch circuit *(including a multiwire branch circuit)* includes an equipment grounding conductor for grounding conductive non-current-carrying parts of equipment
- Single branch circuit could be a multiwire branch circuit
- See 250.32(A), Exception

Grounding Electrode Requirements

- Grounding electrodes at additional buildings or structures must be **bonded together** to form a grounding electrode system
- Where no grounding electrodes are present at the building or structure, one or more of the grounding electrodes specified in 250.52(A)(4) through (A)(8) **must be installed and used**
- Rod, pipe, and plate electrodes to comply with 250.53(A)(1) through (A)(3)
- See 250.50

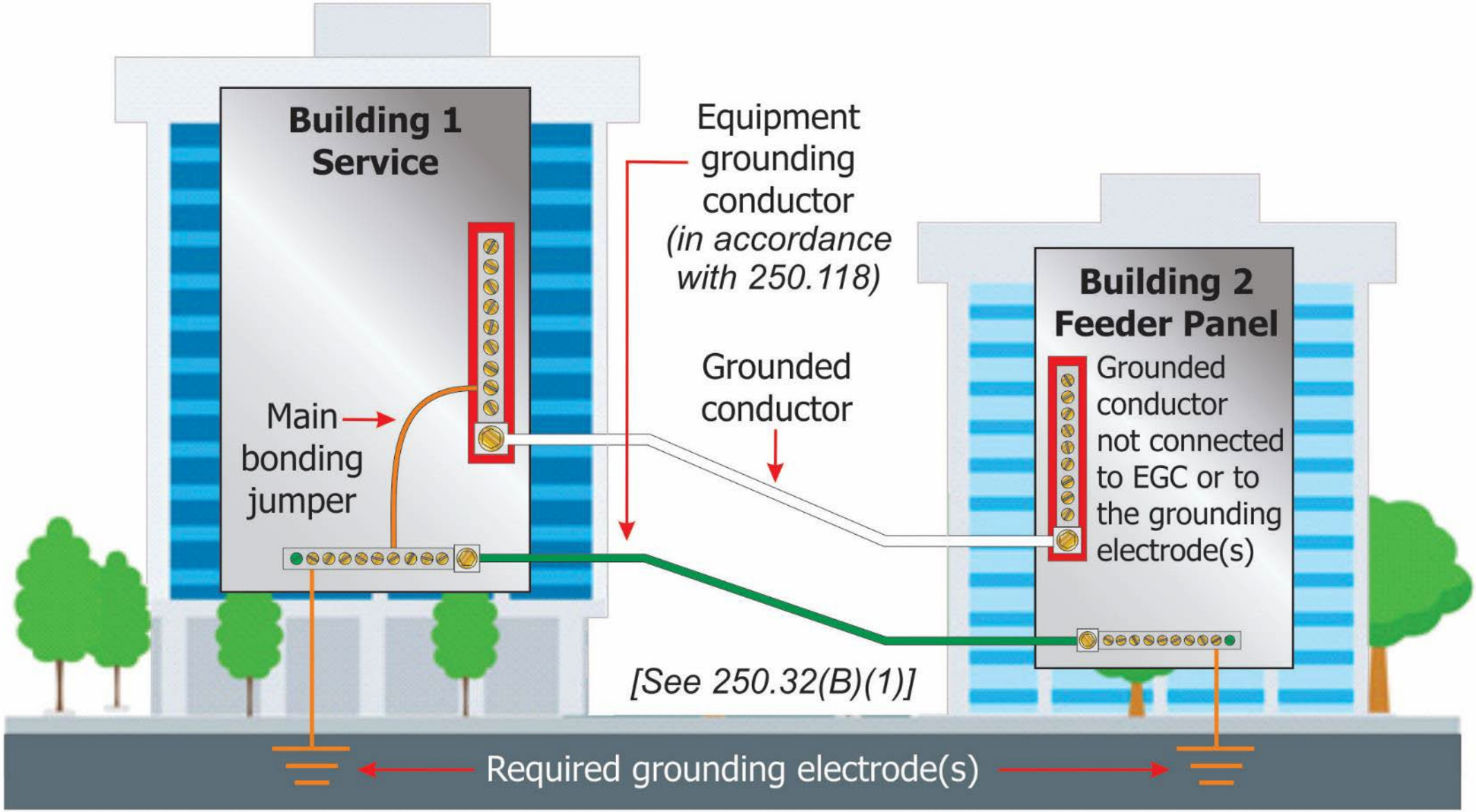
Grounding Electrode Requirements *(cont.)*

- Grounding electrode meeting the requirements of Article 250 Part III must be connected in a manner specified in Section 250.32(B) or (C)
  - Metal underground water pipe electrode – 250.52(A)(1)
  - Metal in-ground support structure electrode of building – 250.52(A)(2)
  - Concrete-encased electrode – 250.52(A)(3)
  - Ground ring electrode – 250.52(A)(4)
  - Electrodes per 250.52(A)(5) through (A)(8) if any of the above electrodes are not present
- *See exception for one branch circuit, including a multiwire branch circuit, that has an equipment grounding conductor*

Equipment Grounding Conductor Required

- Buildings or structures supplied by a feeder(s) or more than one branch circuit are required to include an **equipment grounding conductor** *[see 250.32(B)(1)]*
- **Existing buildings or structures** supplied by a feeder(s) or more than one branch circuit from a grounded system with no equipment grounding conductor and compliant with the *NEC* in effect at the time of installation must comply with the rules at 250.32(B)(1), Exception No. 1
- Exception No. 1 permits the **grounded circuit conductor** *(often a neutral)* run with the supply to the building or structure to serve as the **ground-fault return path** *(grounded again at the disconnecting means for the building or structure)*, but only if all the **very specific conditions** are met

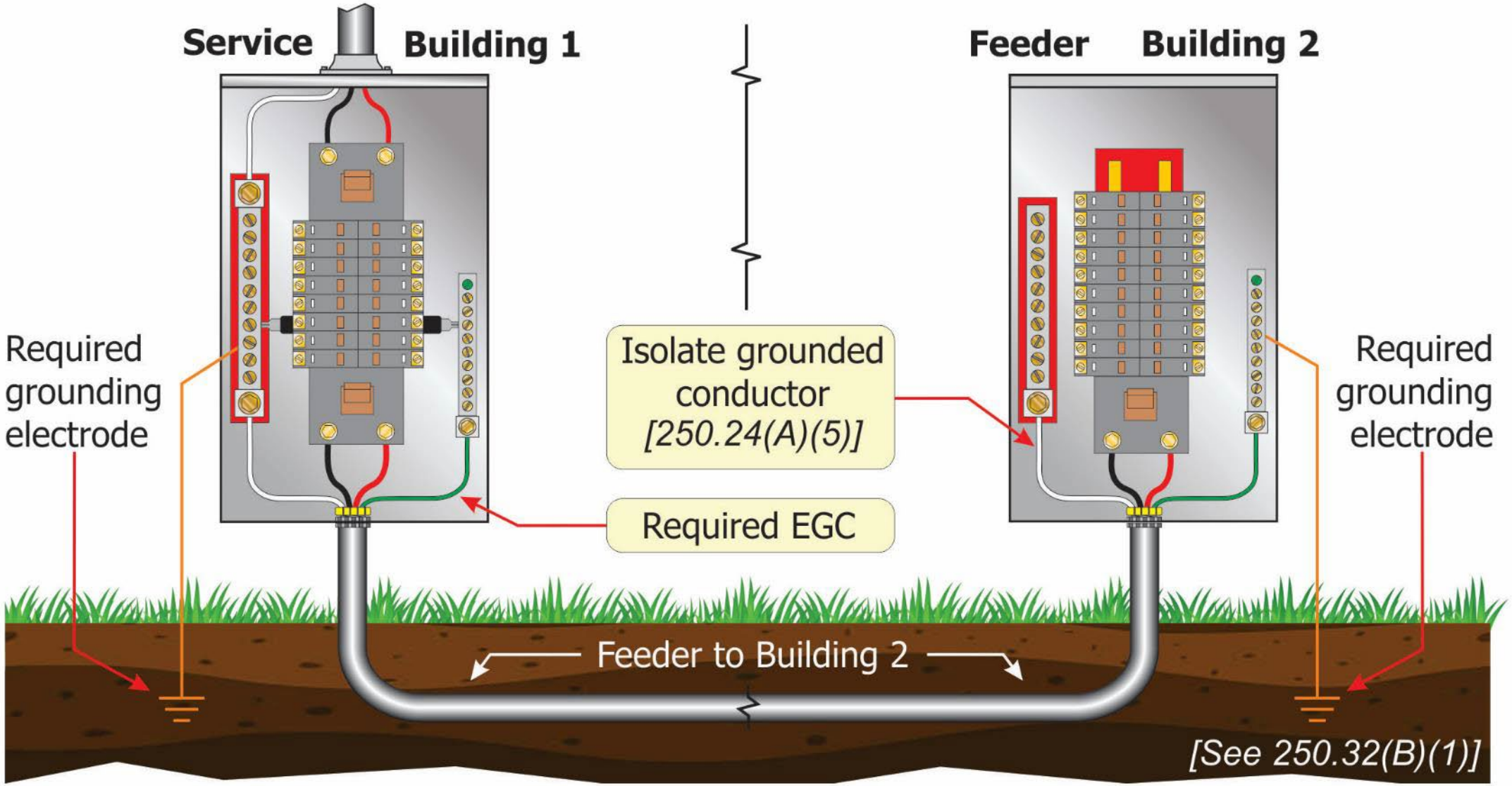
Grounding and Bonding at Seperate Building or Structure



Grounding at separate building or structure using the required equipment grounding conductor

Copyright © IAEI 2020

Grounding and Bonding at Seperate Building or Structure



Grounding and bonding at separate building or structure using required equipment grounding conductor *(EGC)*

Copyright © IAEI 2020

Equipment Grounding Conductor Installed

- In order to comply with 250.32(B)(1), the **number of conductors** for various systems that must be installed is summarized on the next slide
- Without the EGC in the supply feeder or branch circuit, this would be a violation of 250.24(A)(5) and 250.142(B) which states…
  - *Grounded conductor not to be connected to the equipment grounding conductor or to the grounding electrode(s) on the load side of service disconnecting means*

250.32(B)(1) Total Number of Conductors Installed
(Required Equipment Grounding Conductor Installed)

Table 12.1 - ***(Soares G & B Textbook)***

System	Grounded	Ungrounded	EGC	Total
120V	1	1	1	3
120/240V	1	2	1	4
208Y/120V	1	3	1	5
480Y/277V	1	3	1	5

Copyright © IAEI 2020

250.32(B)(1) Ex. No. 1 Total Number of Conductors Installed
(Equipment Grounding Conductor NOT Installed-by Exception)

Table 12.2 - ***(Soares G & B Textbook)***

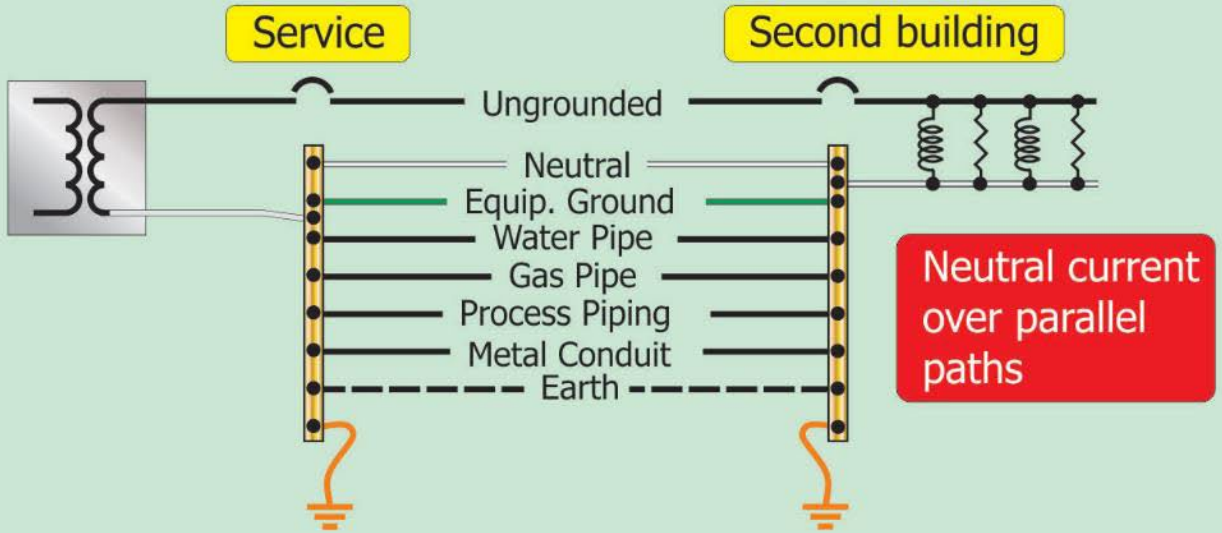
System	Grounded	Ungrounded	EGC	Total
120V	1	1	0	2
120/240V	1	2	0	3
208Y/120V	1	3	0	4
480Y/277V	1	3	0	4

Copyright © IAEI 2020

Current on the Proper Path

- Objective is to limit **“objectionable” currents**
- Current takes the path of least resistance or impedance
- Current will be present in all paths or circuits available
- Where more than one path exists, current will divide among the paths
- Current will divide in opposite proportion to the impedance

Objectionable Current Paths



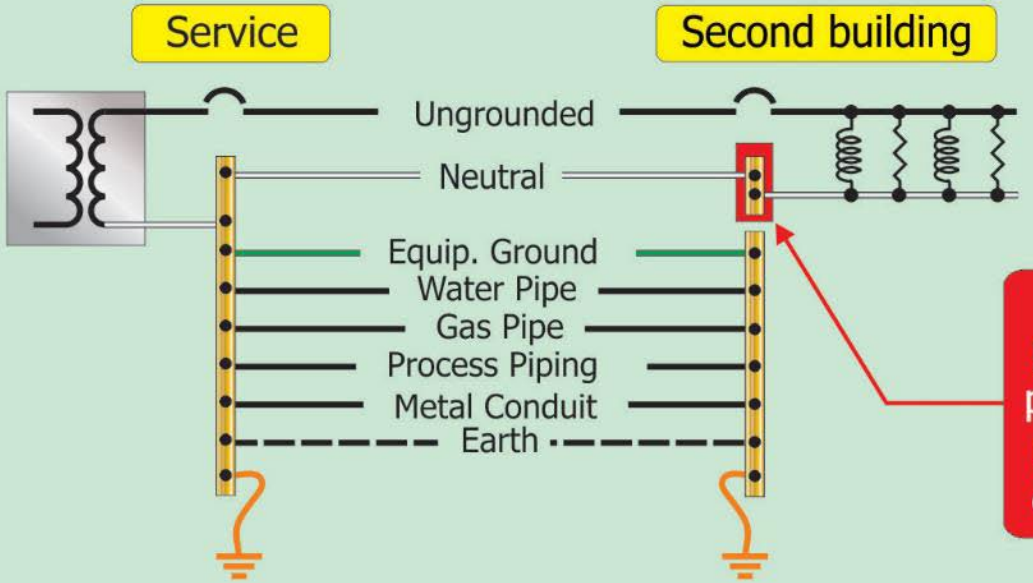
Not Permitted, 250.32(B)(1)

Neutral current over parallel paths

Current will take any and all paths available to try to return to its source

Permitted, 250.32(B)(1)

Metallic paths between separate buildings or other structures are not to have normal neutral current on them



No parallel path for neutral current

Copyright © IAEI 2020

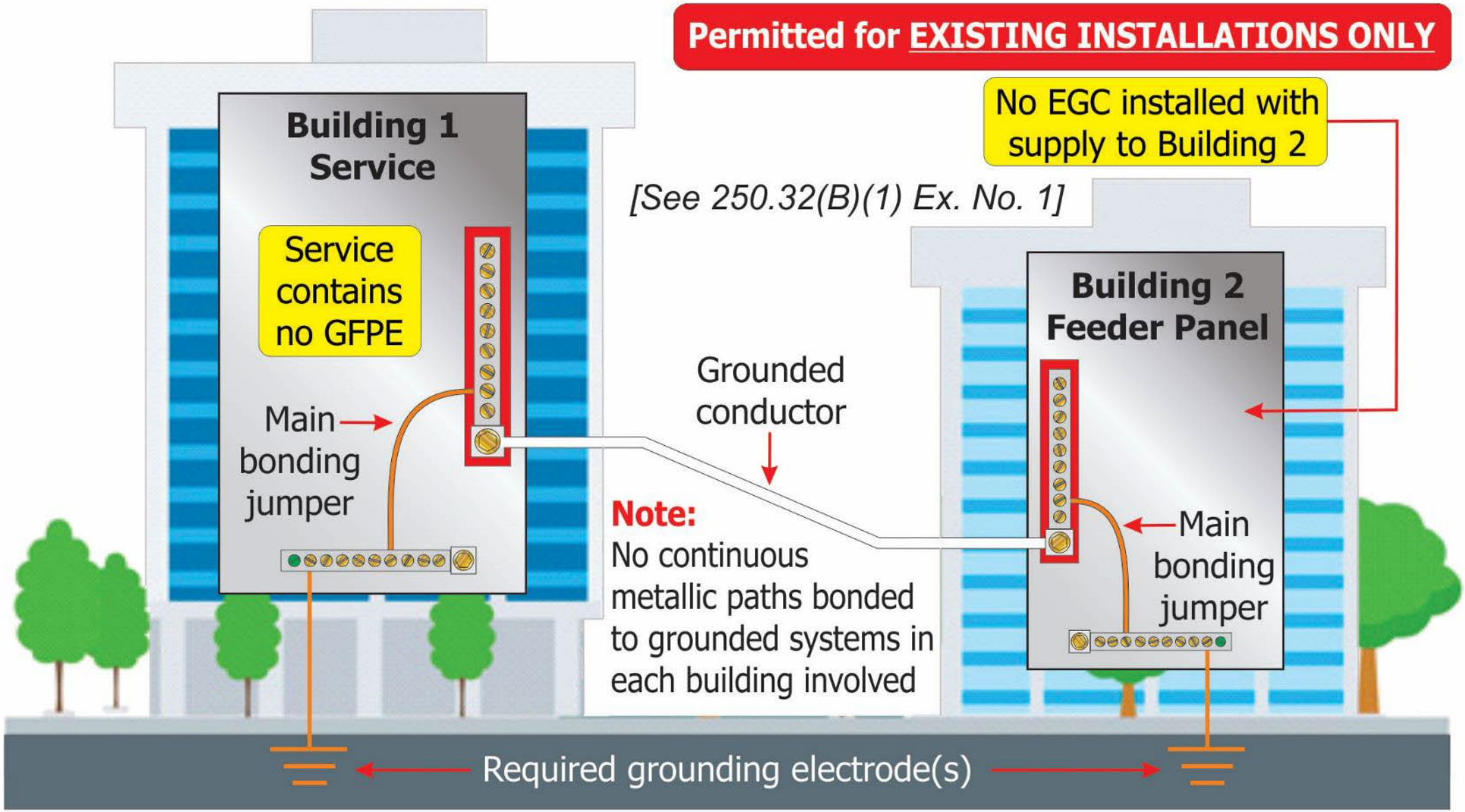
Existing Installations by Exception

- 250.32(B)(1) Ex. No. 1 applies only to **existing installations** where the installation was compliant with the *Code* in effect at the time of the installation
- This exception permits the **grounded (neutral) conductor** to be grounded again at the disconnecting means for the building or structure only if all the specified conditions below are complied with:
    1. An **equipment grounding conductor is not run** with the supply to the building or structure
    2. There are **no continuous metallic paths** bonded to the grounding system in each building or structure involved
    3. **No ground-fault protection of equipment** has been installed on the supply side of the feeder(s)

Size of Grounded Conductor *[Using 250.32(B)(1) Ex. No. 1]*

- For **existing installations** where an **EGC is not installed** to the additional building or structure *(per exception for existing installations only)*, the **grounded circuit conductor** must be sized no smaller than an equipment grounding conductor from Table 250.122
- In this case, the grounded circuit conductor serves three purposes:
  - Permits line-to-neutral loads to be utilized
  - Carries unbalanced loads back to the source
  - Functions as an effective ground fault current path in the event of a ground-fault condition
- Must be sized for the calculated load *(220.61)* and not smaller than the minimum size EGC required from Table 250.122

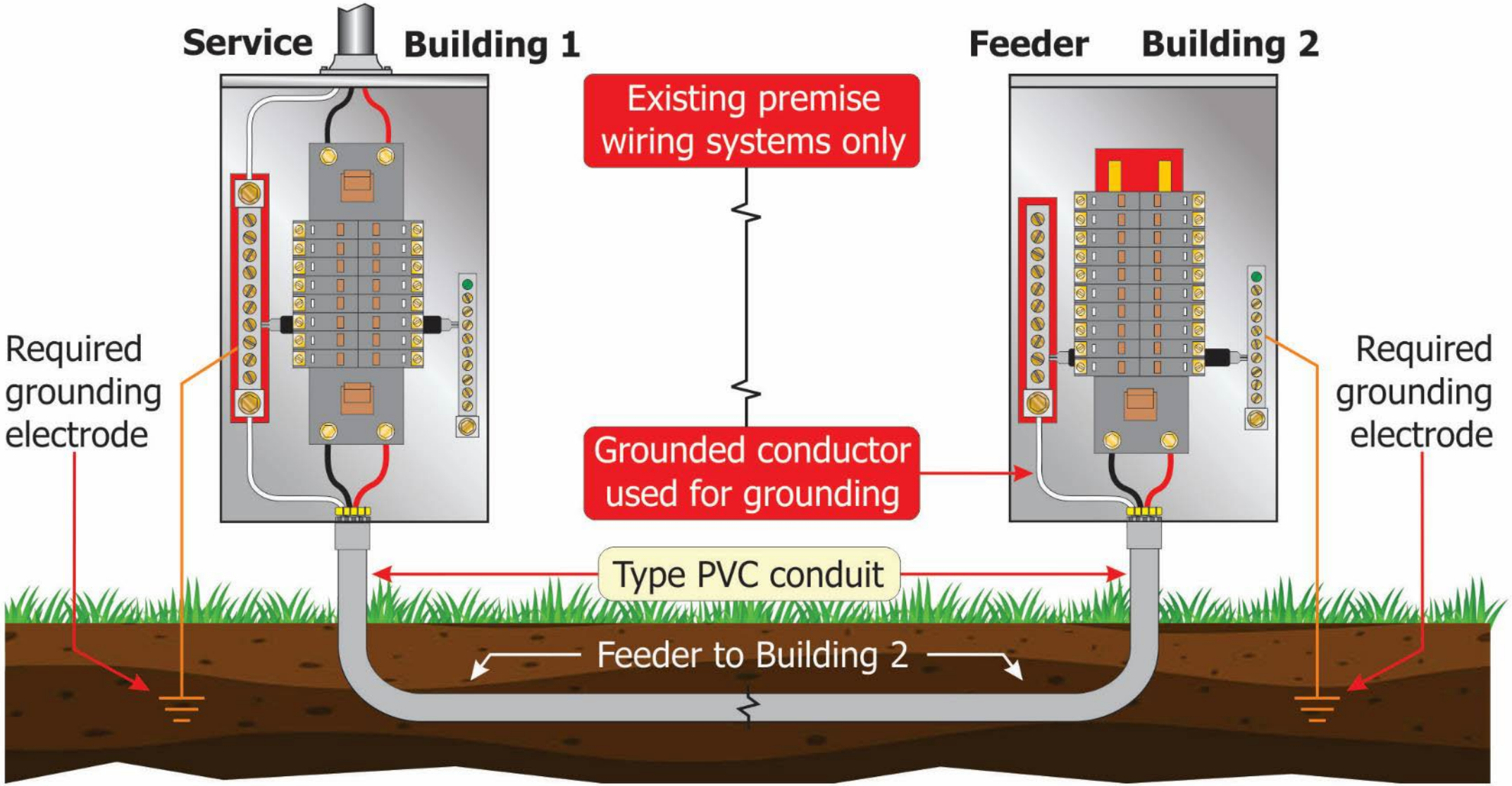
Grounding and Bonding at Seperate Building or Structure



Grounding at separate building or structure using the grounded circuit conductor

Copyright © IAEI 2020

Grounding and Bonding at Seperate Building or Structure



Grounding and bonding at separate building or structure using grounded circuit conductor as permitted by 250.32(B)(1), Ex. No. 1 for existing installations only

Copyright © IAEI 2020

Grounding Electrode Conductor Size and Connections

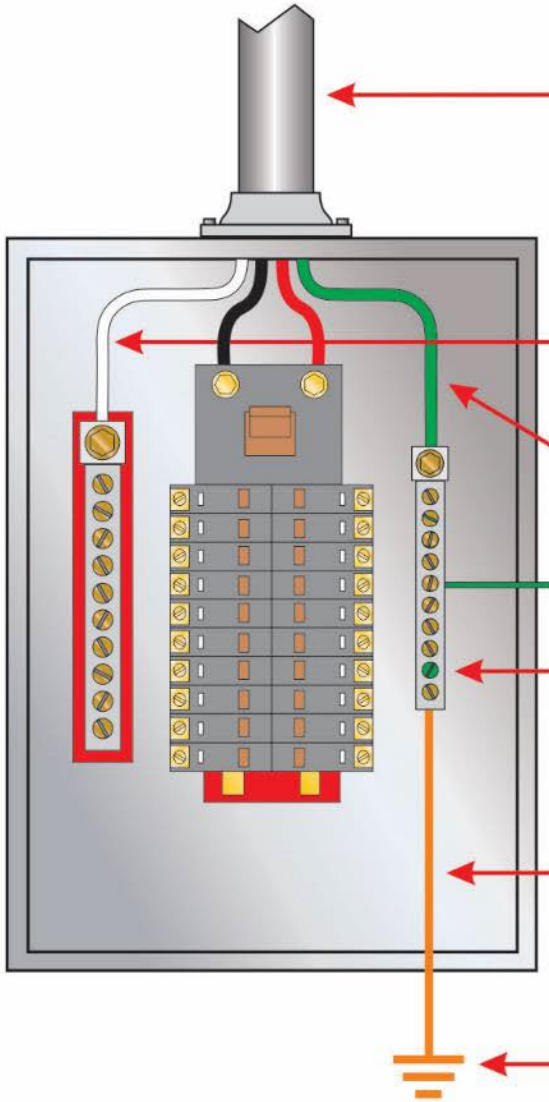
- At the separate building or structure, a **grounding electrode conductor** is used to connect the equipment grounding conductor and equipment to the grounding electrode system that exists or is installed at the additional building or structure
- For existing installations using the grounded conductor for grounding *(fault return path with no EGC)* the grounded circuit conductor is also connected to the grounding electrode system
- This grounding electrode conductor is sized in accordance with **250.66** based on the size of the largest ungrounded conductor supplying the building or structure

Grounding Electrode Conductor Size and Connections *(cont.)*

- The GEC installation must comply with Part III of Article 250 *[see 250.32(E)]*
- Connections of the GEC must be made inside the building or structure disconnecting means to the equipment grounding terminal bar or to the terminal bar for the grounded conductor as appropriate
- The grounding electrode conductor connections are required to meet the requirements of 250.8 *(permitted methods of making grounding and bonding connections to equipment)*

Grounding Electrode Conductor Size

Grounding electrode conductor sizing at separate building or structure for grounded supply system



Feeder to separate building or structure

Grounded system conductor routed to building disconnect

Equipment grounding conductor(s)

Equipment

Main bonding jumper *(Green screw)*

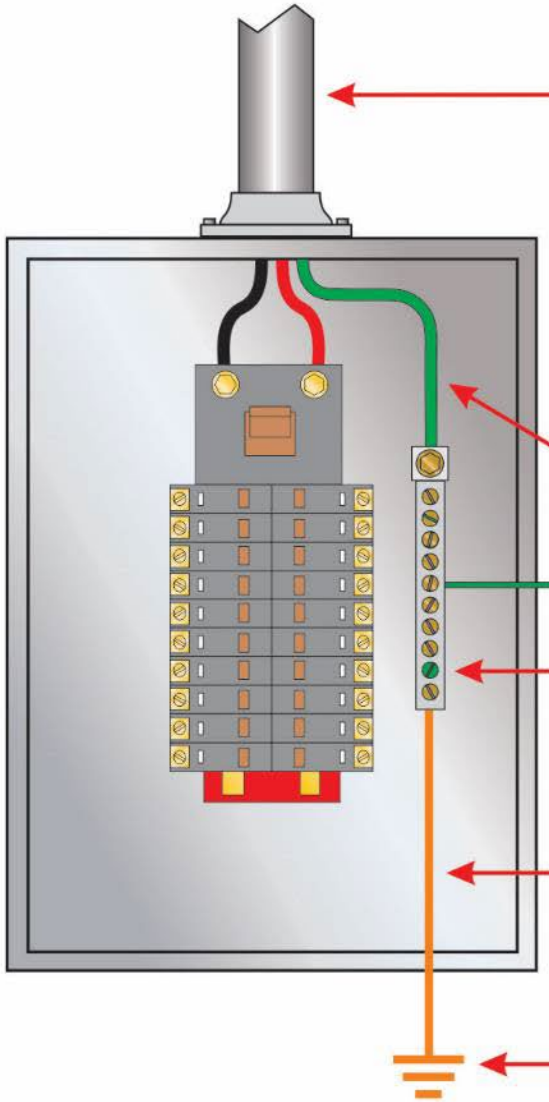
Grounding electrode conductor shall not be smaller than the sizes in 250.66 based on the largest ungrounded supply conductor

Grounding electrode *(system)*

Copyright © IAEI 2020

Grounding Electrode Conductor Size

Grounding electrode conductor sizing at separate building or structure for ungrounded supply system



Feeder to separate building or structure

No grounded conductor installed where an ungrounded system supplies the separate building or structure

Equipment grounding conductor(s)

Equipment

Main bonding jumper *(Green screw)*

Grounding electrode conductor shall not be smaller than the sizes in 250.66 based on the largest ungrounded supply conductor

Grounding electrode *(system)*

Copyright © IAEI 2020

Buildings or Structures Supplied by a Separately Derived System

- Section 250.32(B)(2), addresses the grounding and bonding requirements where the building or structure is served by a feeder derived from a separately derived system
- Section 250.32(B)(2)(a) set the requirements when the feeder has **overcurrent protection at the source** *(where the conductors originate)* as follows:
  - Installation must comply with 250.32(B)(1) *(standard feeder with an equipment grounding conductor to be installed)*

Buildings or Structures Supplied by a Separately Derived System *(cont.)*

- Section 250.32(B)(2), addresses the grounding and bonding requirements where the building or structure is served by a feeder derived from a separately derived system *(cont.)*
- Section 250.32(B)(2)(b) establishes the requirements for the condition where the **overcurrent protection is not at the source** *(where the conductors originate)*:
  - Installation must comply with 250.30(A) *(Grounding Separately Derived AC Systems)*
  - If installed, the **supply-side bonding jumper** shall be connected to the building or structure disconnecting means and to the grounding electrode(s)

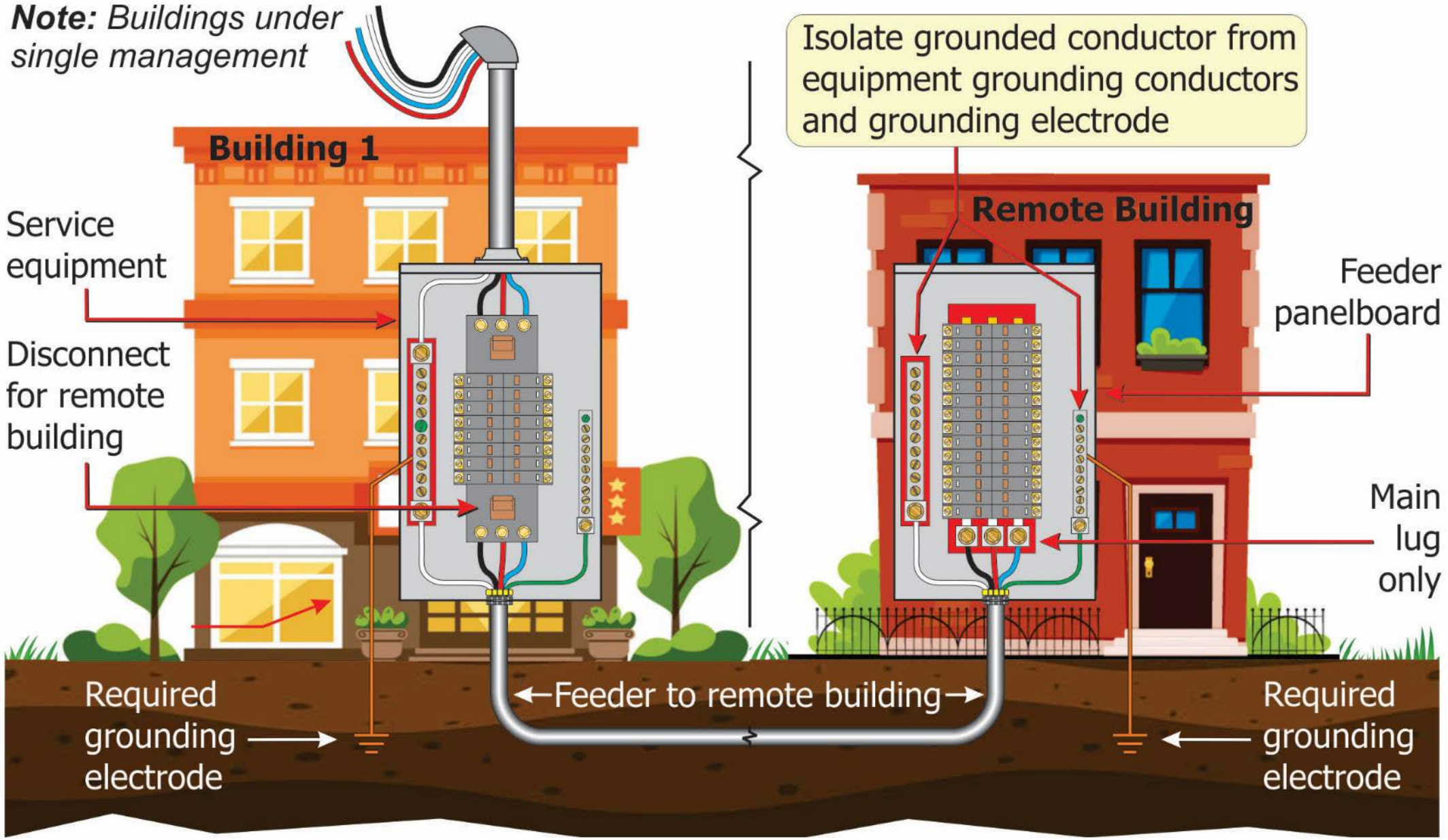
Ungrounded Electrical System(s) to Buildings or Structures Supplied by Feeders or Branch Circuits

- Feeders or branch circuits from **ungrounded systems** to separate buildings or structures are to be installed in accordance with **250.32(C)**
- If the feeder(s) or branch circuit(s) is installed between the buildings, then an **equipment grounding conductor** is required *(just as for grounded systems) [see 250.32(C)(1)]*
- If the feeder is from a separately derived system, either an **equipment grounding conductor** or a **supply side bonding jumper** is required to be installed from the separately derived system to the building *[see 250.32(C)(2)]*
- Where ungrounded ac system equipment is connected to a grounding electrode in or at a building *[as specified in 250.32(C)]*, the grounding electrode shall be used to ground the conductor enclosures and equipment in or on that building

Disconnecting Means for Separate Building or Structure on the Same Premises

- Special rules are provided for large capacity, multibuilding installations or facilities with outdoor generators that are under single management *[see 250.32(D)]*
- These specific provisions are where remote disconnecting means are permitted *[see 225.32 Ex. No. 1 and No. 2, 700.12(D)(5), 701.12(D)(5) and 702.12]*
- These occupancies are to have trained and qualified personnel and have established procedures for safe switching of electrical feeders or branch circuits
- As a result, the disconnecting means are **permitted to be at other locations on the premises** rather than at the building served as generally required by 225.32

250.32(D) Remote Disconnect Permitted



Copyright © IAEI 2020

Mobile Homes and Recreational Vehicles

- Mobile home service equipment must be located remote from the structure but within sight from and not more than **9.0 m (30 ft)** from the mobile home
- At this service equipment, the grounded *(neutral)* conductor is connected to a grounding electrode(s)
- Feeders consisting of four insulated and color-coded conductors *(one of which is an equipment grounding conductor)* must be installed to the mobile home distribution panelboard
- See 550.33(A)

Mobile Homes and Recreational Vehicles *(cont.)*

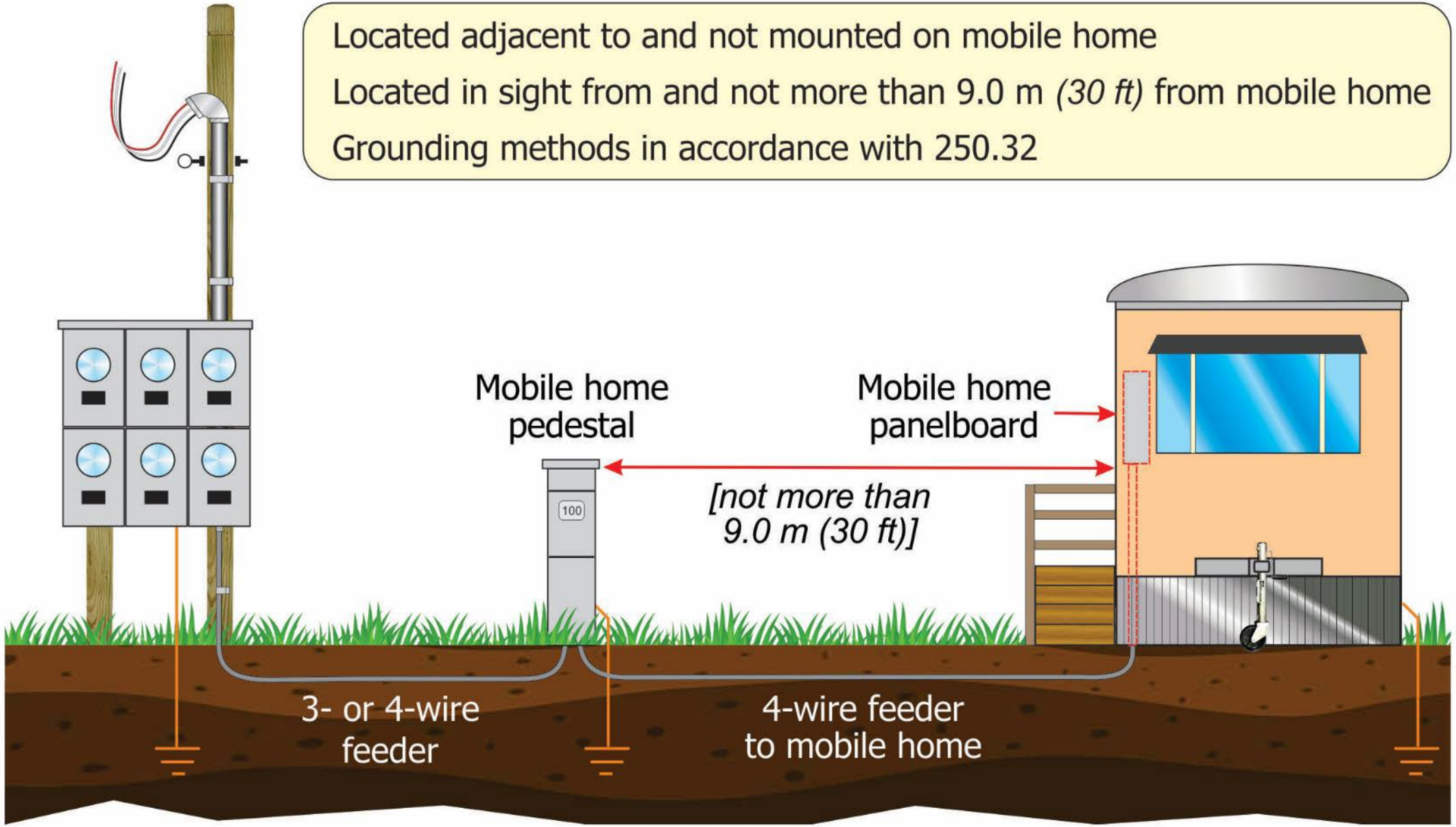
- Section 550.33(A) permits the two options for grounding and bonding:
- Option 1: **(3)-conductor feeder** permitted to be installed between the service located remote and distribution equipment with a **(4)-conductor feeder** *[four insulated conductors in compliance with 550.33(A)]* installed from the mobile home disconnecting means to the mobile home panelboard
- Option 2: Feeder(s) between the service distribution equipment, the remote mobile home disconnecting means, and the mobile home panelboard **all to be (4)-wire** in its entirety

550.32(A) Service Equipment for Mobile Homes

Located adjacent to and not mounted on mobile home

Located in sight from and not more than 9.0 m *(30 ft)* from mobile home

Grounding methods in accordance with 250.32



Copyright © IAEI 2020

Manufactured Homes

- Service equipment permitted to be installed directly on the **manufactured home** *(not mobile home)* under seven conditions:
  1. The manufacturer shall include in its **written installation instructions** information indicating that the home shall be secured in place by an anchoring system or installed on and secured to a permanent foundation
  2. The installation of the service equipment shall comply with Part I through Part VII of Article 230
  3. Means shall be provided for the connection of a grounding electrode conductor to the service equipment and routing it outside the structure
  4. Bonding and grounding of the service shall be in accordance with Part I through Part V of Article 250

Manufactured Homes *(cont.)*

- Service equipment permitted to be installed directly on the **manufactured home** *(not mobile home)* under seven conditions: *(cont.)*
  5. The manufacturer shall include in its written installation instructions one method of grounding the service equipment at the installation site. The instructions shall clearly state that other methods of grounding are found in Article 250
  6. The minimum size grounding electrode conductor shall be specified in the instructions
  7. A warning label shall be mounted on or adjacent to the service equipment. The label shall meet the requirements of 110.21(B) and shall state the following: *(see next slide)*

Warning Label for Manufactured Home Services

Service equipment to be installed directly on the manufactured home under seven conditions *[see 550.32(B)]*

Warning label required by 550.32(B)(7) for manufactured home service equipment

Warning label required to be mounted on or adjacent to the service equipment meeting the requirements of 110.21(B)



Copyright © IAEI 2020

Agricultural Buildings

- The grounding of agricultural buildings is covered in Article 547
- Sections 547.5(F), 547.9(A)(5), 547.9(B)(3), 547.9(C), and 547.10 all include grounding and bonding requirements that amend or add to the general requirements of Article 250
- Where a building or structure houses livestock, an **insulated conductor** *(copper, aluminum or copper-clad aluminum)* must be installed where the **equipment grounding conductor** is installed **underground** from one building or structure to another
- See Chapter 16 of the Soares textbook or PowerPoint for additional information on grounding and bonding in agricultural buildings

Two Buildings in One Structure

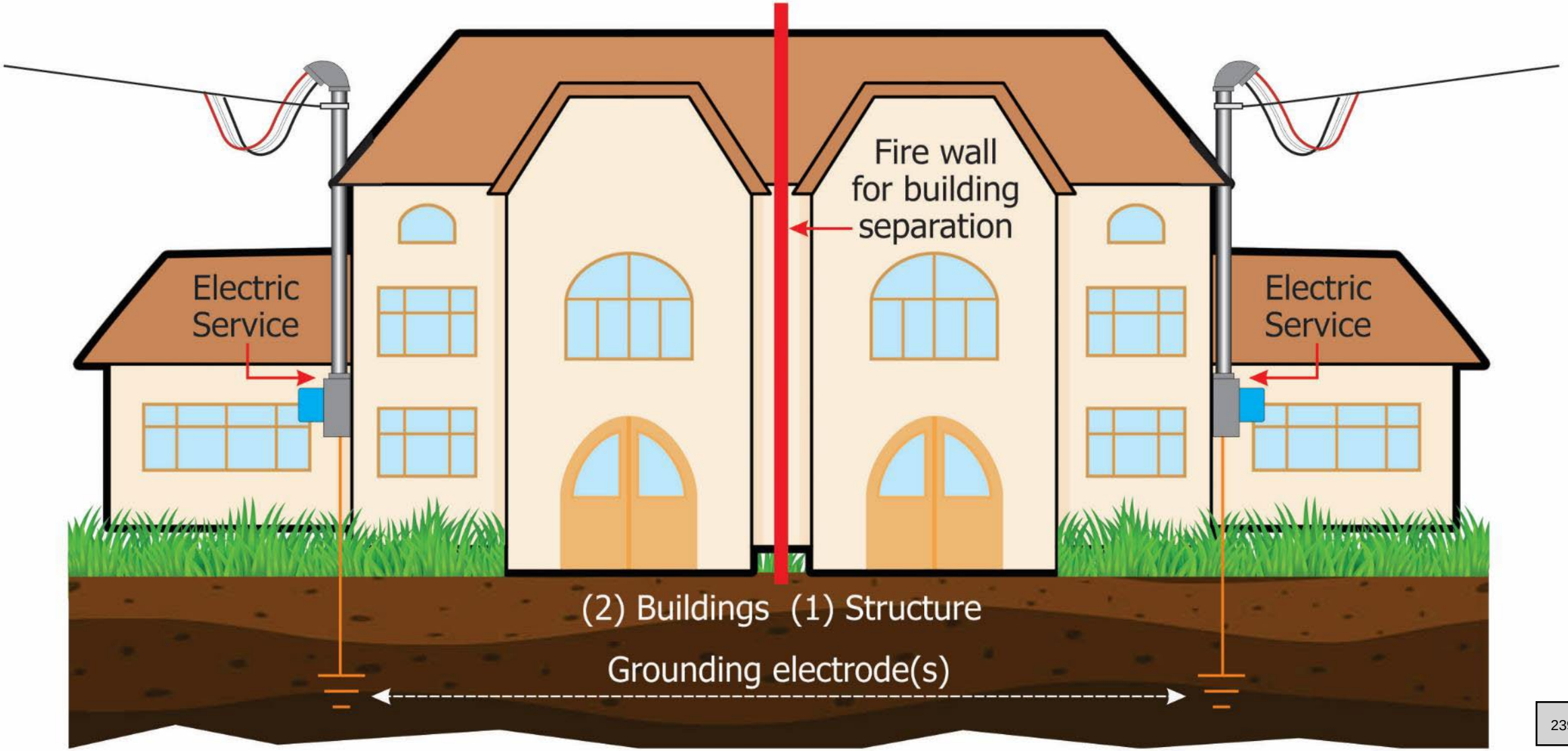
- Not uncommon for more than one “building” to exist in what is a single “structure”
- Two buildings, by definition *(on the same slab or foundation)*, may be served by a single service or by multiple services in accordance with 230.2 where each building is allowed to have its own service
- 250.58 generally requires that all grounding electrodes installed to serve a building or structure to be bonded together

Two Buildings in One Structure *(cont.)*

- Since the fire-rated wall creates two buildings *(by definition)*, bonding of the electrodes together is **permitted *(desirable)* but not required** by *Code*
- By not bonding electrodes from one building to the other, consider other utility services that may provide an electrical connection between electrodes such as telephone or cable, or other similar services that could be supplied to one side and then routed to the other through the first building
- Bonding of these other services could provide a connection *(example: a coaxial shield)* that is not suitable as a grounding electrode bonding conductor and should be avoided
- Next slide shows two buildings in one structure that are separated by a fire-rated wall

Two Buildings on a Common Foundation

Multiple electrodes for multiple services on the same building to be bonded together to meet the requirements of 250.58



Copyright © IAEI 2020

CHAPTER THIRTEEN

BONDING ENCLOSURES AND EQUIPMENT

250 KCMIL
COMPACT STABILOY® AA-8000 AL XLPE
STABILOY® AA-
THWN OR GAS AND OIL RES II 600V
OR GASOLINE AND OIL RESISTANT II OR AWM 600 VOLT
600V (UL) OR AWM

Bonding Enclosures and Equipment

- Bonding is an **ongoing process** in any electrical system from the point of service delivery to final outlet on the system
- Bonding metal parts or enclosures of electrical components and conductors **connects them together** electrically and mechanically, establishing **electrical continuity and conductivity** *(see definition of "Bonding")*
- Bonding has a very important function electrically for both grounded and ungrounded systems
- Bonding metallic parts together puts parts at the **same potential**
- Bonding connection to the grounding electrode at the service or source of separately derived system puts parts at the **ground (earth) potential**

Article 100 Definitions

- ***Bonded (Bonding):*** "Connected to establish electrical continuity and conductivity."
- ***Bonding Conductor or Jumper:*** "A reliable conductor to ensure the required electrical conductivity between metal parts required to be electrically connected."
- ***Bonding Jumper, Equipment:*** "The connection between two or more portions of the equipment grounding conductor."
- ***Bonding Jumper, Main:*** "The connection between the grounded circuit conductor and the equipment grounding conductor, or the supply-side bonding jumper, or both, at the service"
- ***Bonding Jumper, Supply-Side:*** "A conductor installed on the supply side of a service or within a service equipment enclosure(s), or for a separately derived system, that ensures the required electrical conductivity between metal parts required to be electrically connected"

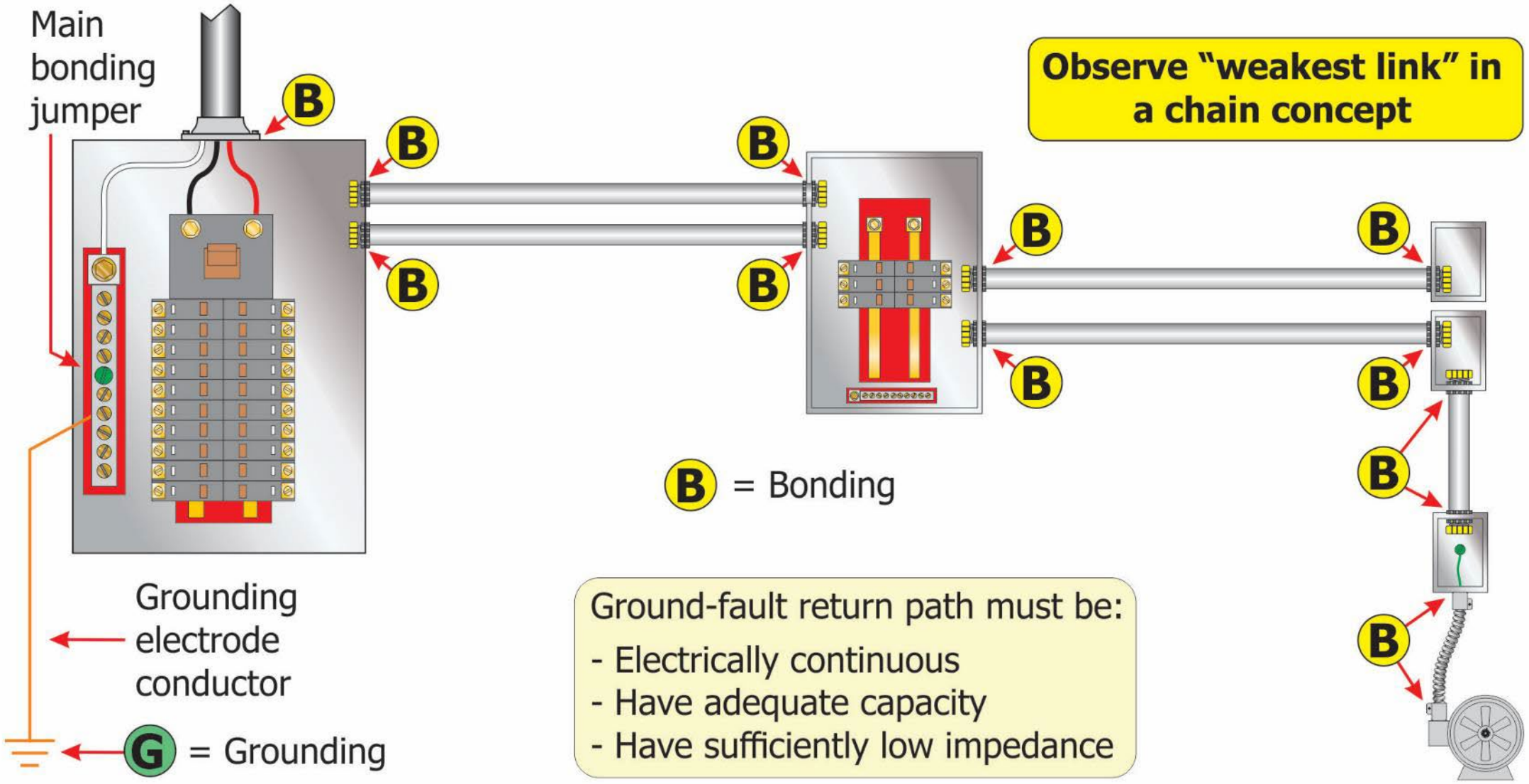
Maintaining Continuity

- The physical assembly of metal parts together may achieve the **intended bonding**…when it does not, required to bond around those connections where bonding is **insufficient** *(metal raceways, fittings, etc.)*
- Effective bonding is necessary to assure **electrical continuity** and capacity to safely conduct any ground fault current likely to be imposed
- Any nonconductive paint, enamel, or similar coating to be removed at threads, contact points, and contact surfaces or have equipment connected by means of fittings designed so as to make such removal unnecessary
- See 250.96(A)

Maintaining Continuity *(cont.)*

- "**Weakest link**" rule applies to the ground-fault return path
- To provide adequate safety, the effective ground-fault current path is required to:
  - Be **electrically continuous**
  - Have **adequate capacity** to conduct safely any fault current likely to be imposed on it
  - Have sufficiently **low impedance** to limit the voltage to ground and to facilitate the operation of the circuit-protective devices
- See 250.4(A)(5) and 250.4(B)(4)

Observe the "Weakest Link" Concept



Bonding to maintain electrical continuity and conductivity

Copyright © IAEI 2020


El uso de interruptores automáticos que no sean de Square D puede afectar negativamente la seguridad del usuario y deteriorar la confiabilidad del equipo. Square D no asume responsabilidad alguna por daños, lesiones o funcionamiento inadecuado del equipo causado por el uso o desperfectos de interruptores automáticos que no sean de Square D.
El uso de estos productos puede afectar negativamente la seguridad del usuario y deteriorar su confiabilidad.
L'utilisation de disjoncteurs autres que Square D risque d'affecter la sécurité de l'utilisateur et la fiabilité du matériel. Square D rejette toute responsabilité pour tout dommage, blessure ou dysfonctionnement résultant de l'utilisation ou de la défaillance de disjoncteurs autres que Square D.
L'utilisation de ces produits peut réduire la sécurité de l'utilisateur et compromettre la fiabilité.
2400

Clean Surfaces

- **Nonconductive coatings** such as paint, lacquer and enamel **must be removed** from threads and other contact surfaces of equipment to be grounded, unless…
  - Connected by means of fittings designed to make such removal unnecessary
- Nonconductive coatings could restrict equipment grounding and impair ground-fault return path
- See 250.96(A) and 250.12

Testing of Conduit Fittings

- The importance of removing paint from enclosures where the conduit or raceway is intended to serve as the fault-current path is further emphasized in a report titled "***Conduit Fitting Ground-Fault Current Withstand Capability***," issued by Underwriters Laboratories on June 1, 1992

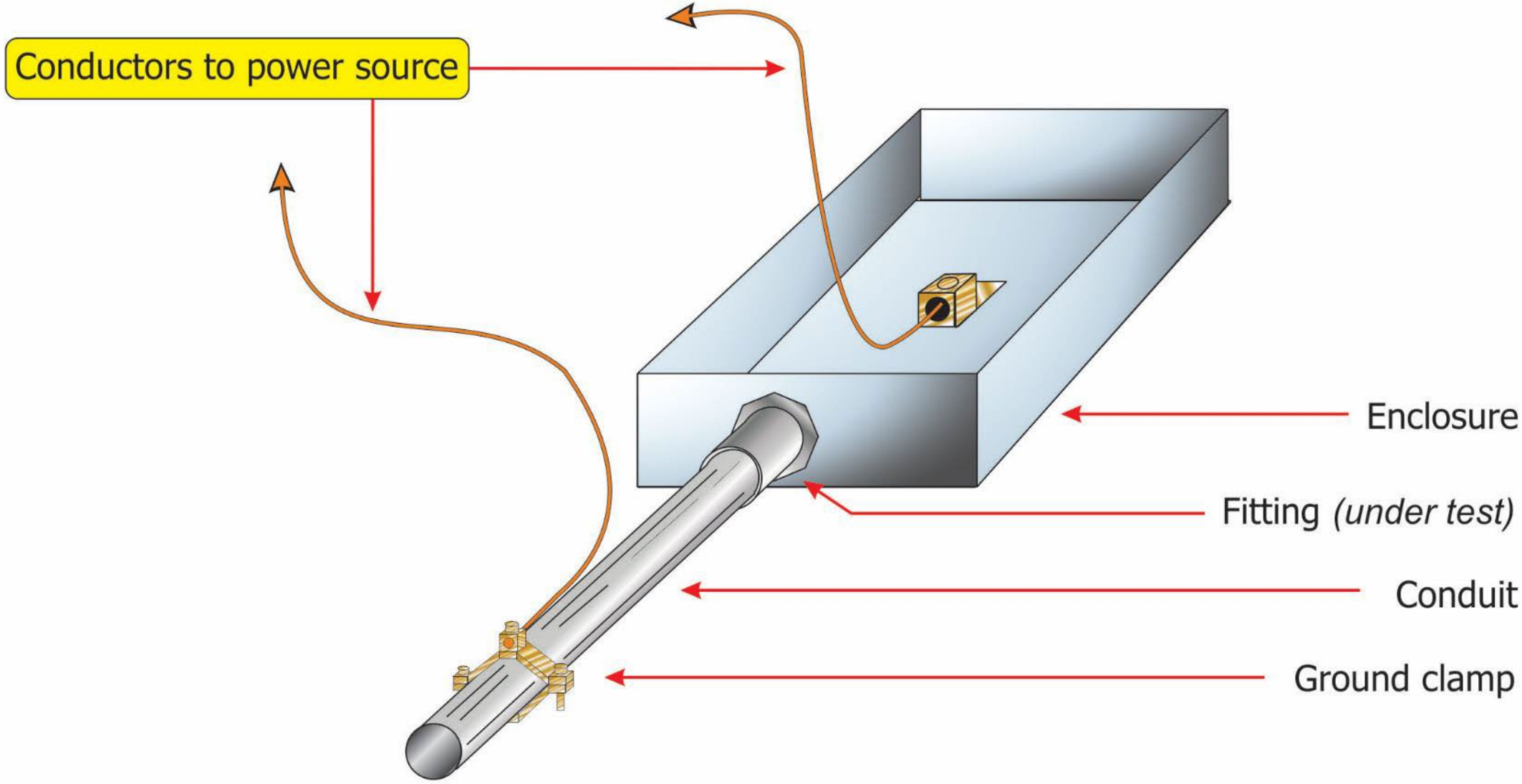
- The following slides illustrate the testing performed by UL on various conduit and tubing fittings to determine suitability during ground-fault conditions

Testing of Conduit Fittings *(cont.)*

- Over 300 conduit-fitting assemblies from ten different manufacturers were subjected to a current test to simulate performance under ground-fault conditions
- A sample assembly consisted of a conduit fitting secured to one end of a two-foot length of conduit and attached to a metal enclosure
- Some of the enclosures were bare metal or galvanized, and others were painted with enamel coating typical of construction of enclosures in the 1990s
- Seven of the more than 300 assemblies tested sustained damage
- A visual examination of sample assemblies that failed showed that melting of the die-cast zinc locknuts occurred as a result of the fault current

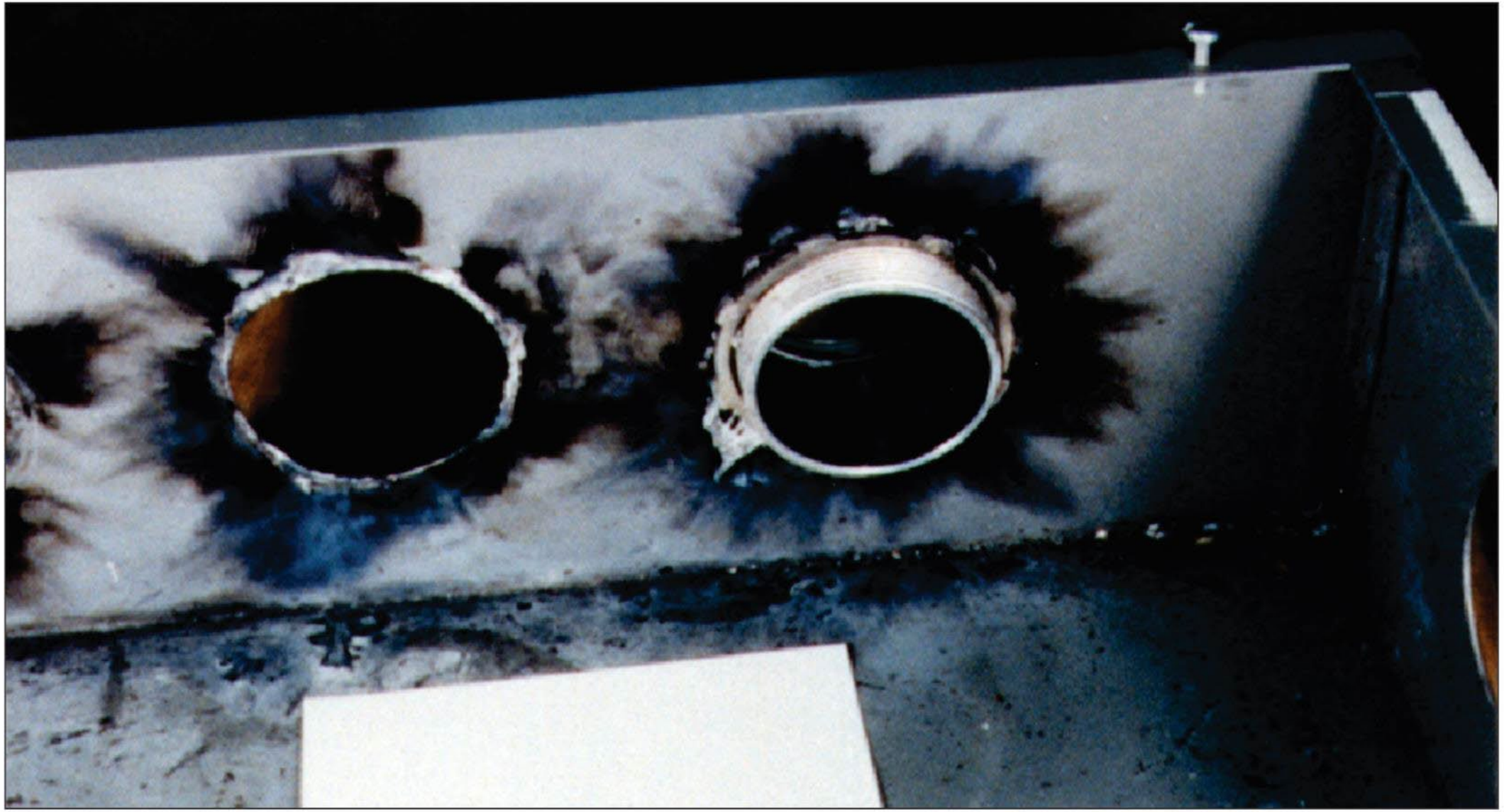
Conduit and Tubing Fitting Test Model

"*Conduit Fitting Ground-Fault Current Withstand Capability*" issued by Underwriters Laboratories on June 1, 1992



Copyright © IAEI 2020

Conduit and Tubing Fitting Test Model



"Conduit Fitting Ground-Fault Current Withstand Capability" issued by Underwriters Laboratories (UL) on June 1, 1992

Copyright © IAEI 2020

Conclusions on Fittings Testing

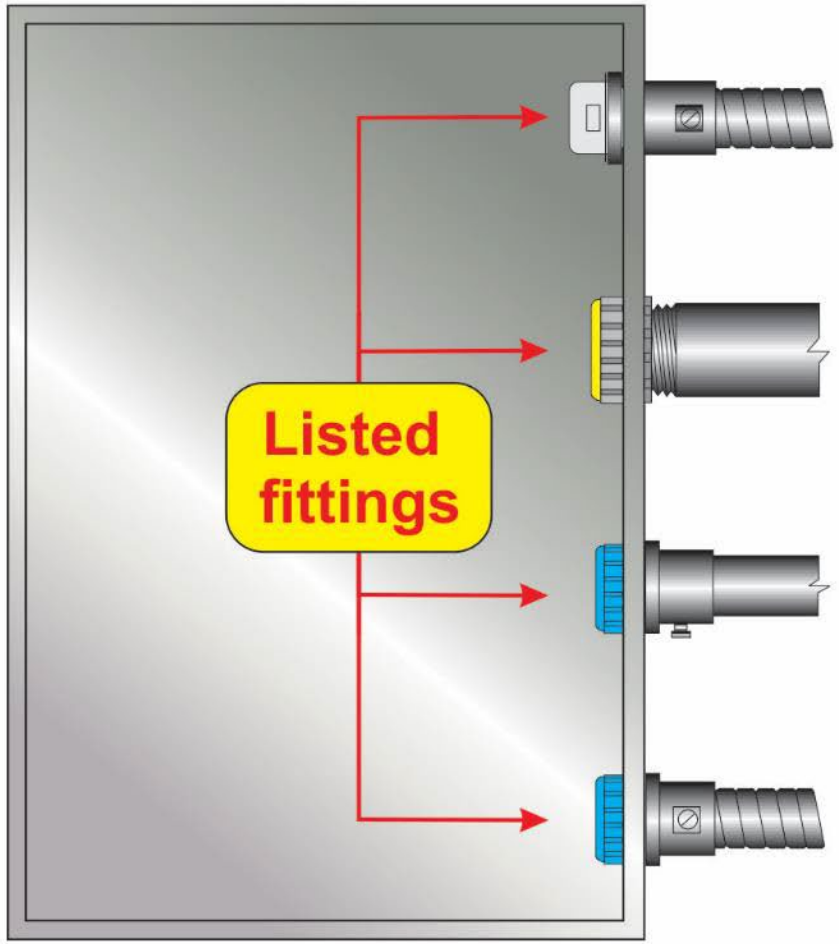
1. Over 300 conduit fitting assemblies from 10 manufacturers were tested…seven assemblies failed
2. Failures probably due to high resistance between fitting and enclosure as fitting locknut did not penetrate the paint
3. Some fittings that did not fail showed signs of arcing and welding
4. Most fitting temperatures matched conduit temperatures
5. Flexible metal conduit temperature was much higher than the temperature of the fittings
6. Fittings providing good electrical contact to both conduit and enclosure will provide **suitable path for fault current**

Bonding for Over 250 Volts

- For circuits having a voltage exceeding 250 volts to ground *(such as 277/480 Volt wye systems)*, the electrical continuity of metal raceways and metal-sheathed cables *(not used for service-conductors)* must also be ensured by specific methods
- See 250.97

250.97 Bonding for Circuits Over 250 Volts

For circuits exceeding 250 volts to ground, the electrical continuity of metal raceways and metal-sheathed cables that are not used for service-conductors must also be ensured by specific methods such as:



- Threadless couplings and connectors for cables with metal sheaths
- Two locknuts, on rigid metal conduit or IMC, one inside and one outside
- Fittings with shoulders that seat firmly against the box or enclosure such as for EMT, flexible metal conduit and cable connectors with one locknut inside
- Listed fittings

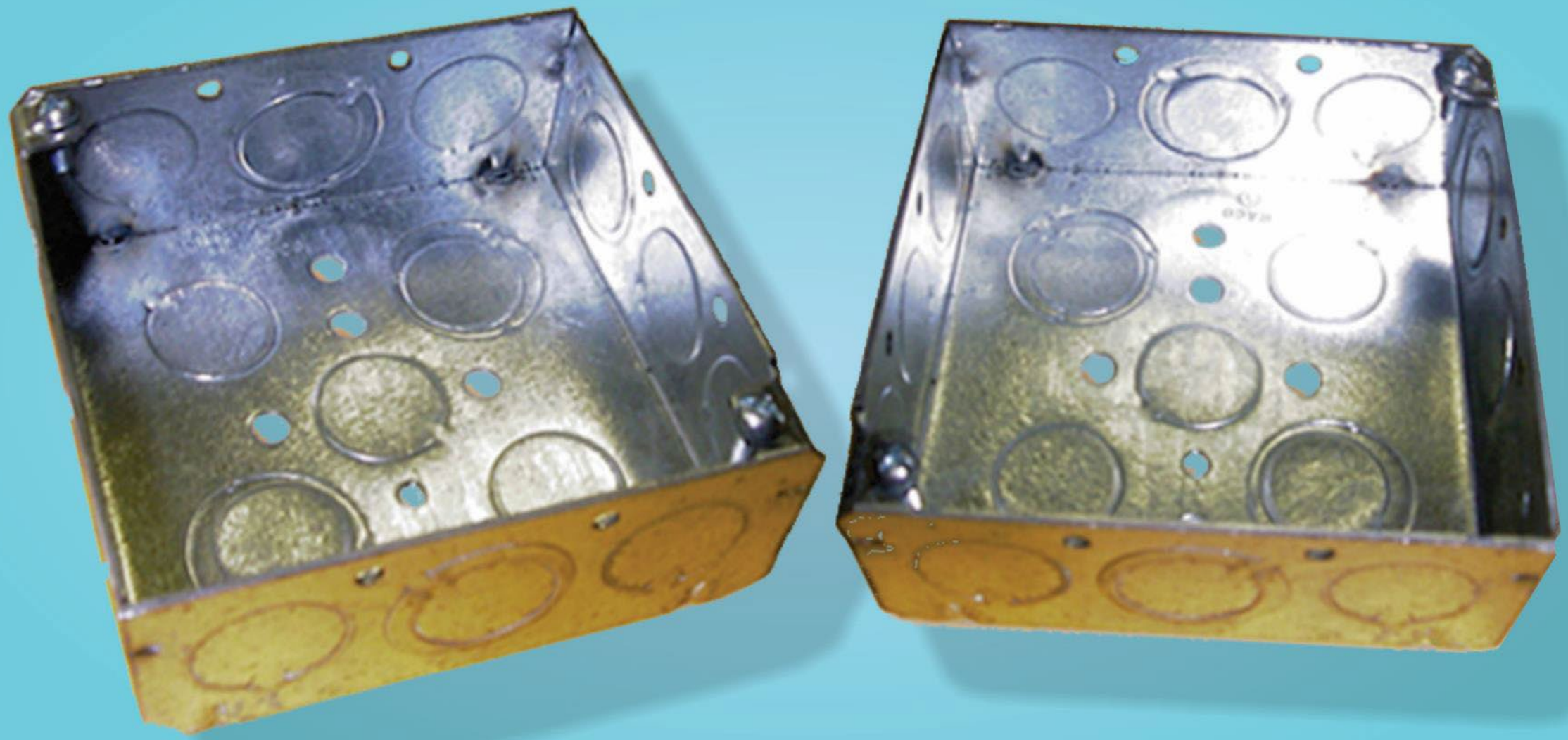
Also permitted:

- Threaded couplings and hubs
- Threadless couplings and connectors
- Bonding jumpers
- Bonding locknuts, bushings, and wedges
- Other approved devices

Copyright © IAEI 2020

Bonding for Over 250 Volts *(cont.)*

- All listed device outlet boxes are specially designed and tested so knockouts perform satisfactorily for over 250-volt-to-ground applications
- Also, see the guide card information under category code **QCIT** for listing details on these device boxes using the UL Product iQ certification database
- These boxes typically have only one eccentric knockout so when the solid knockout is removed, a conduit or fitting locknut makes contact with the base metal of the box to ensure good electrical and mechanical contact
- It should be noted there are some enclosure *(such as for fused and unfused switches)* that are **listed for bonding over and under 250 volts** through the eccentric and concentric knock outs *(these listed products will be specifically marked)*



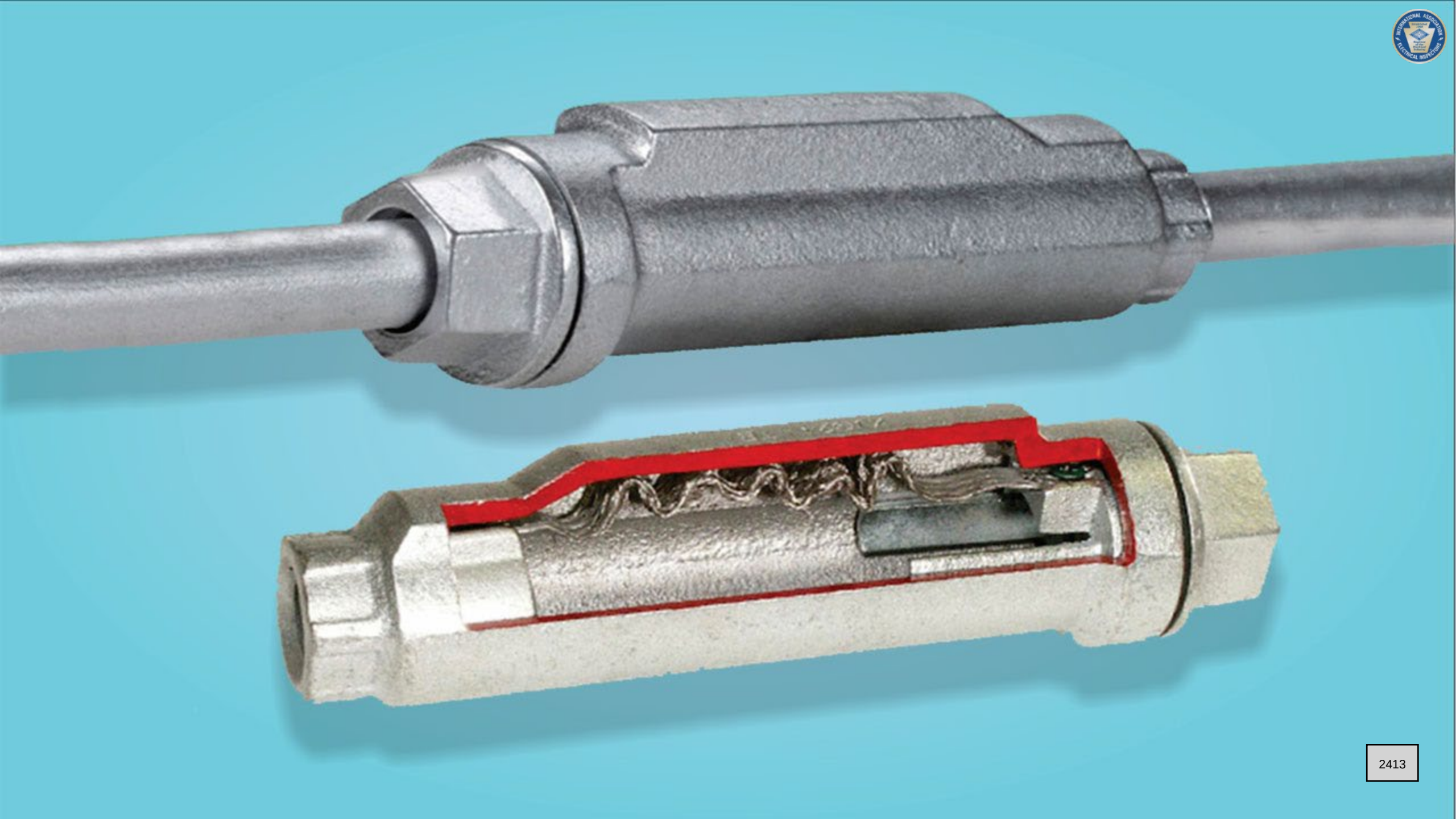
2410

Bonding Loosely Jointed Metal Raceways

- Expansion fittings and telescoping sections of metal raceways are required be made **electrically continuous** by equipment bonding jumpers or other means
- Bonding is required around these types of fittings unless the fitting is listed for providing bonding around the expansion feature of the fitting
- See 250.98



2412



2413

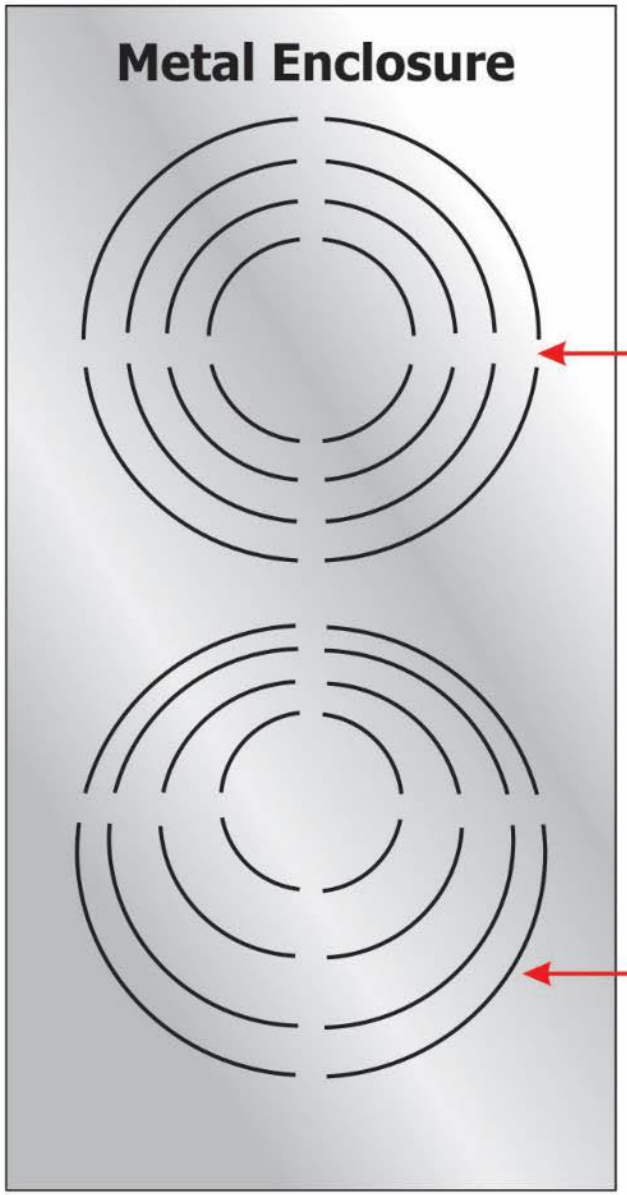
Concentric or Eccentric Knockouts

- Caution needs to be exercised in the use of equipment that has concentric or eccentric knockouts
- Ability to carry fault current must be of concern
- Common to find nibs of adjacent rings damaged during removal of the desired knockout
- Leaves less material available for carrying fault current
- Safest practice is to install bonding bushings around concentric and eccentric knockouts where there is any question about their integrity

Concentric or Eccentric Knockouts *(cont.)*

- Concentric and eccentric knockouts in equipment *(such as cabinets, enclosed switches, junction and pull boxes, auxiliary gutters and wireways)* have **not been generally tested or certified** by an electrical products testing laboratory for their current-carrying ability
- Specific methods provided at **250.97** must be used if those enclosures have eccentric or concentric knockouts

Concentric and Eccentric Knockouts



Concentric Knockouts

May be necessary to bond around concentric knockouts at enclosures such as disconnects and panelboards to ensure current-carrying capacity

Bonding jumpers required around impaired connections such as reducing washers, concentric or eccentric knockouts

Eccentric Knockouts

Eccentric rings present the same obstacle to carrying fault current as concentric knockouts

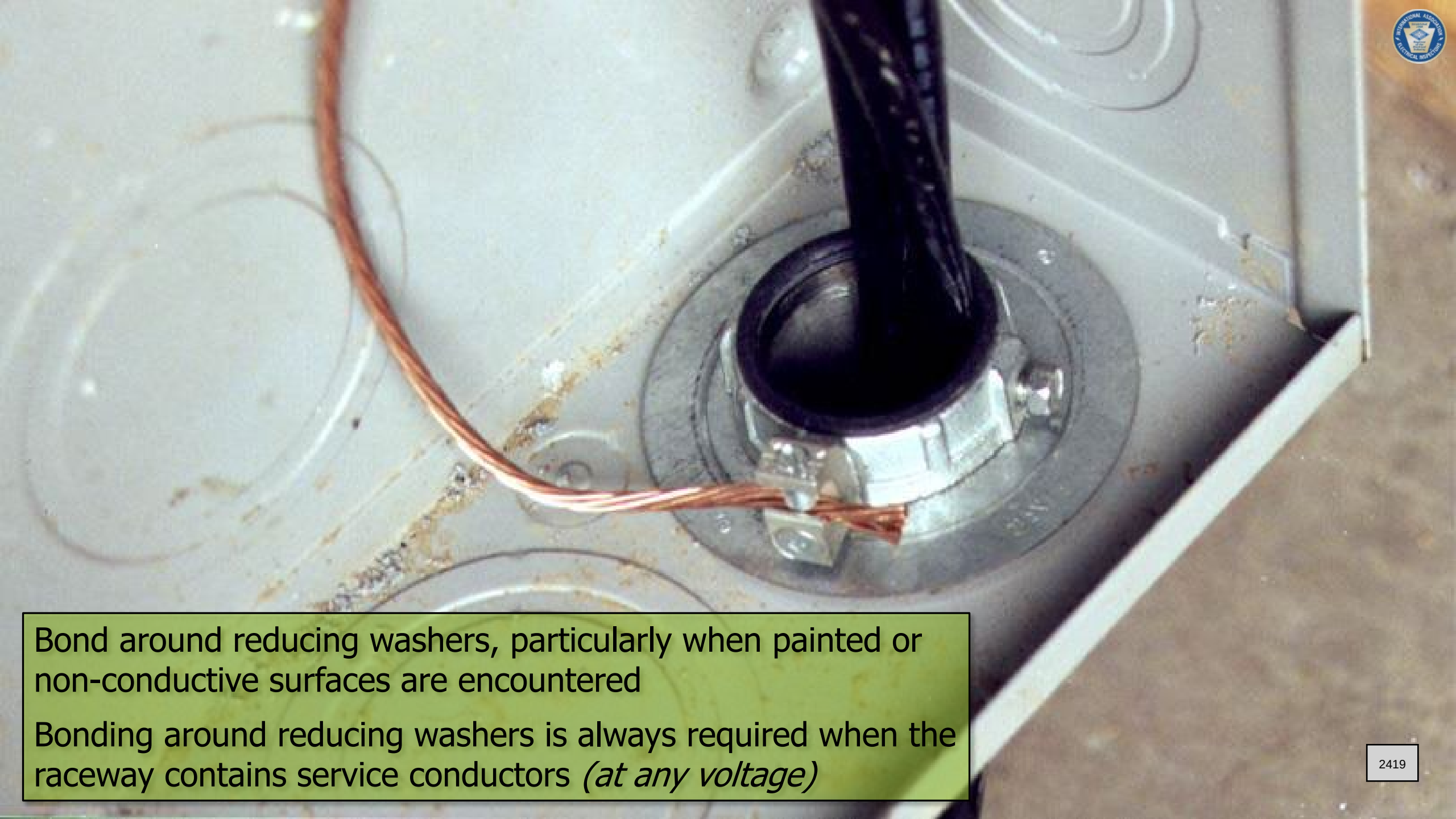
Copyright © IAEI 2020

Reducing Washers

- Reducing washers commonly used where it is desirable or necessary to install conduit or fittings of a size that is smaller than the knockout available in the enclosure
- Reducing washers are evaluated and listed for bonding over and under 250 volts for other than raceways used for service conductors *(see UL Product iQ, category **QCRV**)*
- Bonding around reducer washers at raceways containing service conductors is required by 250.92(B) for any voltage

Reducing Washers *(cont.)*

- Where painted or coated enclosures are encountered and the paint or coating under the washer is not removed, one should always bond around to provide an adequate fault-return path
- Use reducing washers only where all the rings of concentric or eccentric knockouts are removed
- Never permitted to install reducing washers with a ground-fault return path through any remaining rings or nibs from knockouts



Bond around reducing washers, particularly when painted or non-conductive surfaces are encountered

Bonding around reducing washers is always required when the raceway contains service conductors *(at any voltage)*


2420



2421

Attaching Bonding Jumpers

- Good electrical contact must be maintained
- Where installed between grounding electrodes or around water meters and similar equipment, good electrical contact must be maintained
- The arrangement of bonding jumpers must be such that the disconnection or removal of equipment will not interfere with or interrupt the grounding and bonding continuity of the jumper
- See 250.68(B)

Attaching Bonding Jumpers *(cont.)*

- Equipment bonding jumper and equipment grounding conductor connections are required to be made using one or more of the following methods:

  (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

Attaching Bonding Jumpers *(cont.)*

- Equipment bonding jumper and equipment grounding conductor connections are required to be made using one or more of the following methods: *(cont.)*

  (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

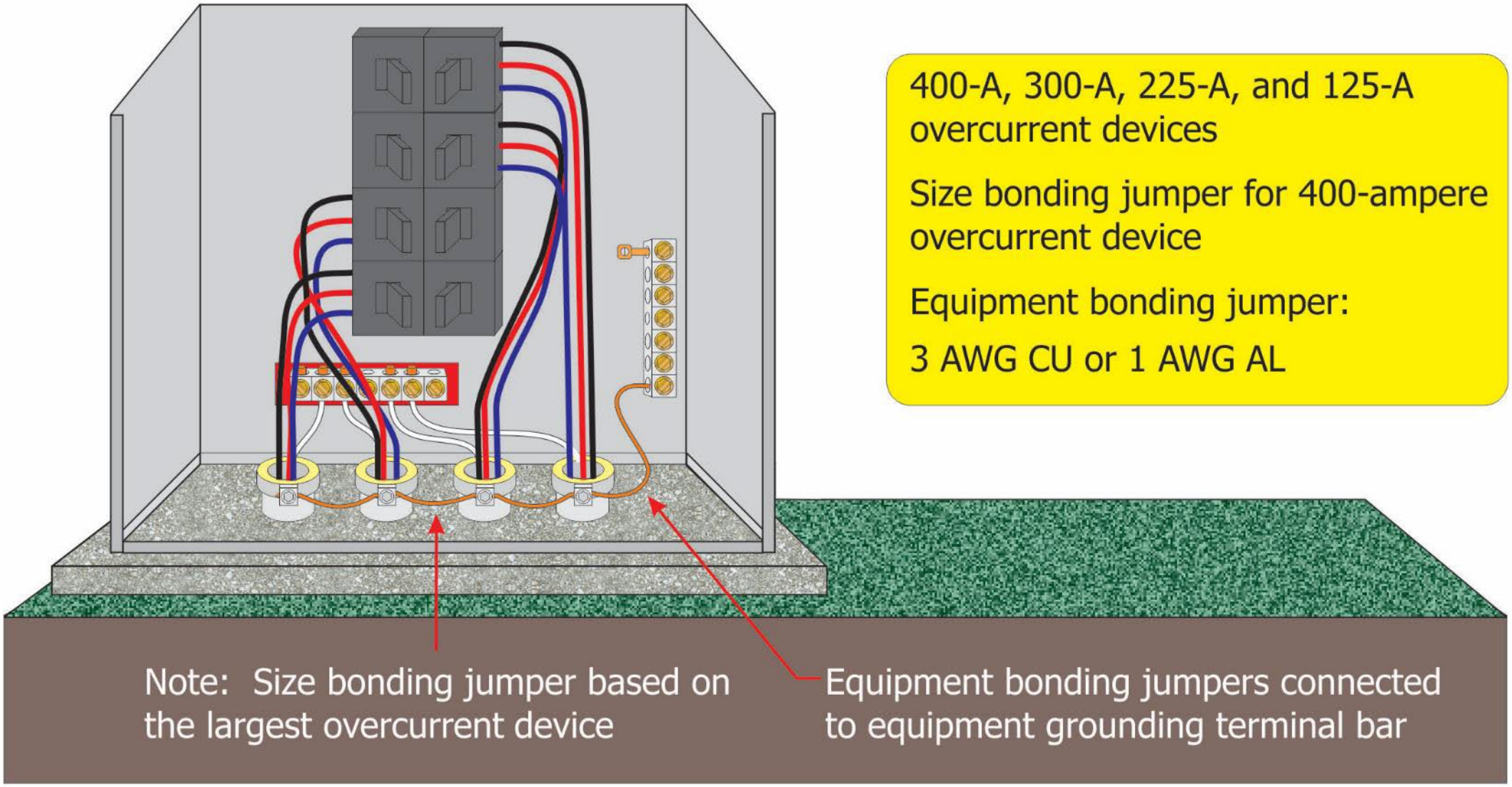
- Connection that depends solely on solder is not acceptable
- See 250.8

Bonding Multiple Raceway Systems *(Load Side)*

- Permitted to use **single equipment bonding jumper** to bond one or **several raceways**
- Size single equipment bonding jumper based on largest overcurrent device ahead of conductors in raceways
- Also permitted to connect **individual equipment bonding jumpers** to **each raceway** individually
- Size individual bonding jumpers in accordance with 250.122 and the individual overcurrent devices
- See 250.102(D)

Bonding Multiple Raceways *(Load Side)*

Common equipment bonding jumper in an open-bottom switchboard or motor control center



400-A, 300-A, 225-A, and 125-A overcurrent devices

Size bonding jumper for 400-ampere overcurrent device

Equipment bonding jumper:

3 AWG CU or 1 AWG AL

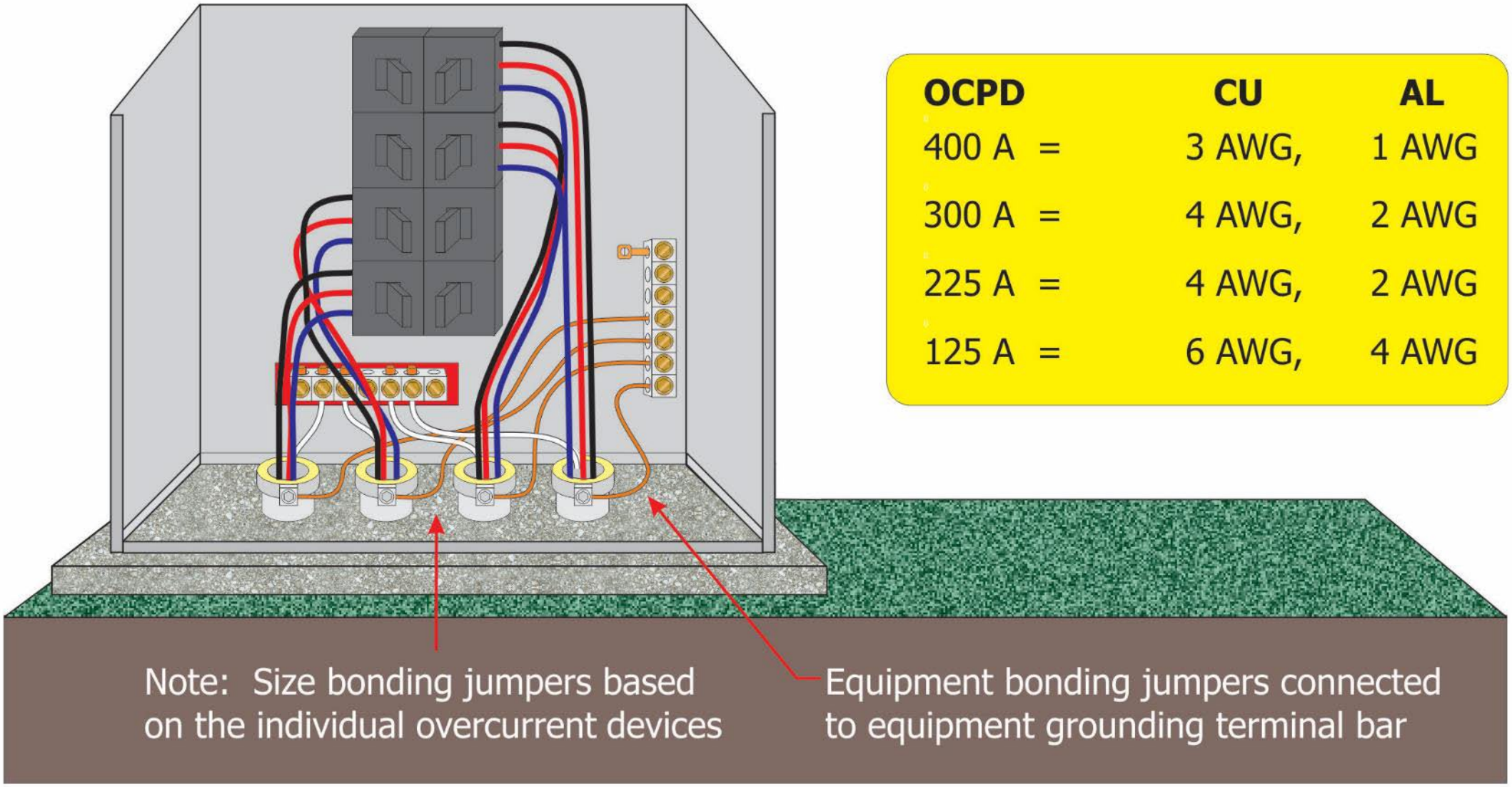
Note: Size bonding jumper based on the largest overcurrent device

Equipment bonding jumpers connected to equipment grounding terminal bar

Copyright © IAEI 2020

Bonding Multiple Raceways *(Load Side)*

Individual equipment bonding jumper(s) in an open-bottom switchboard or motor control center



OCPD	CU	AL
400 A =	3 AWG,	1 AWG
300 A =	4 AWG,	2 AWG
225 A =	4 AWG,	2 AWG
125 A =	6 AWG,	4 AWG

Copyright © IAEI 2020

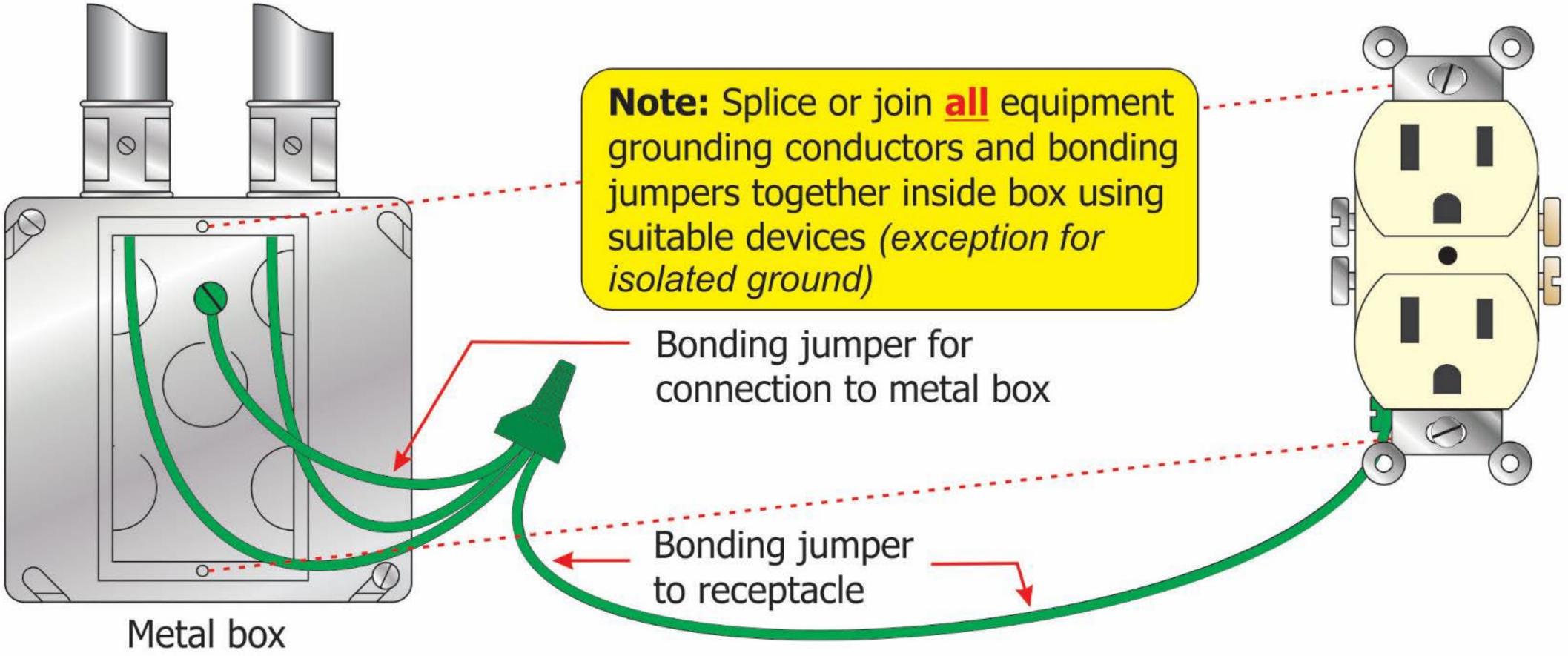
Bonding of Grounding-Type Receptacles

- An equipment bonding jumper is required to be used to connect the equipment grounding terminal of a grounding-type receptacle to a grounded box unless grounded as in 250.146(A) through (D):
  - (A) Surface-mounted boxes
  - (B) Contact devices or yokes
  - (C) Floor boxes
  - (D) Isolated ground receptacles
- Size equipment bonding jumper in accordance with Table 250.122 based on the rating of the overcurrent device protecting the circuit conductors
- See 250.146

Continuity and Attachment of EGC to Boxes

- **All wire-type equipment grounding conductors** associated with any of those circuits in the box must be connected together and to the box
- If the installation uses a metal box, **each set** of equipment grounding conductors is required to be bonded to the metal box
- Exception gives relief to EGCs of an **isolated ground circuit** *(isolated ground receptacle not required to be connected to the other EGCs or to the box)*
- Reference **250.8** *(Connection of Grounding and Bonding Equipment)* for guidance on terminating an EGC or bonding jumper to a metal box or enclosure
- See 250.148

250.146 Bonding of Grounding-Type Receptacles



Connect bonding jumper to grounding terminal of grounding receptacle **unless**:

(A) Boxes mounted on surface *(Metal-to-metal contact)*; (B) Contact devices listed as self-grounding type; (C) Floor boxes listed for grounding; (D) Isolated equipment grounding terminal

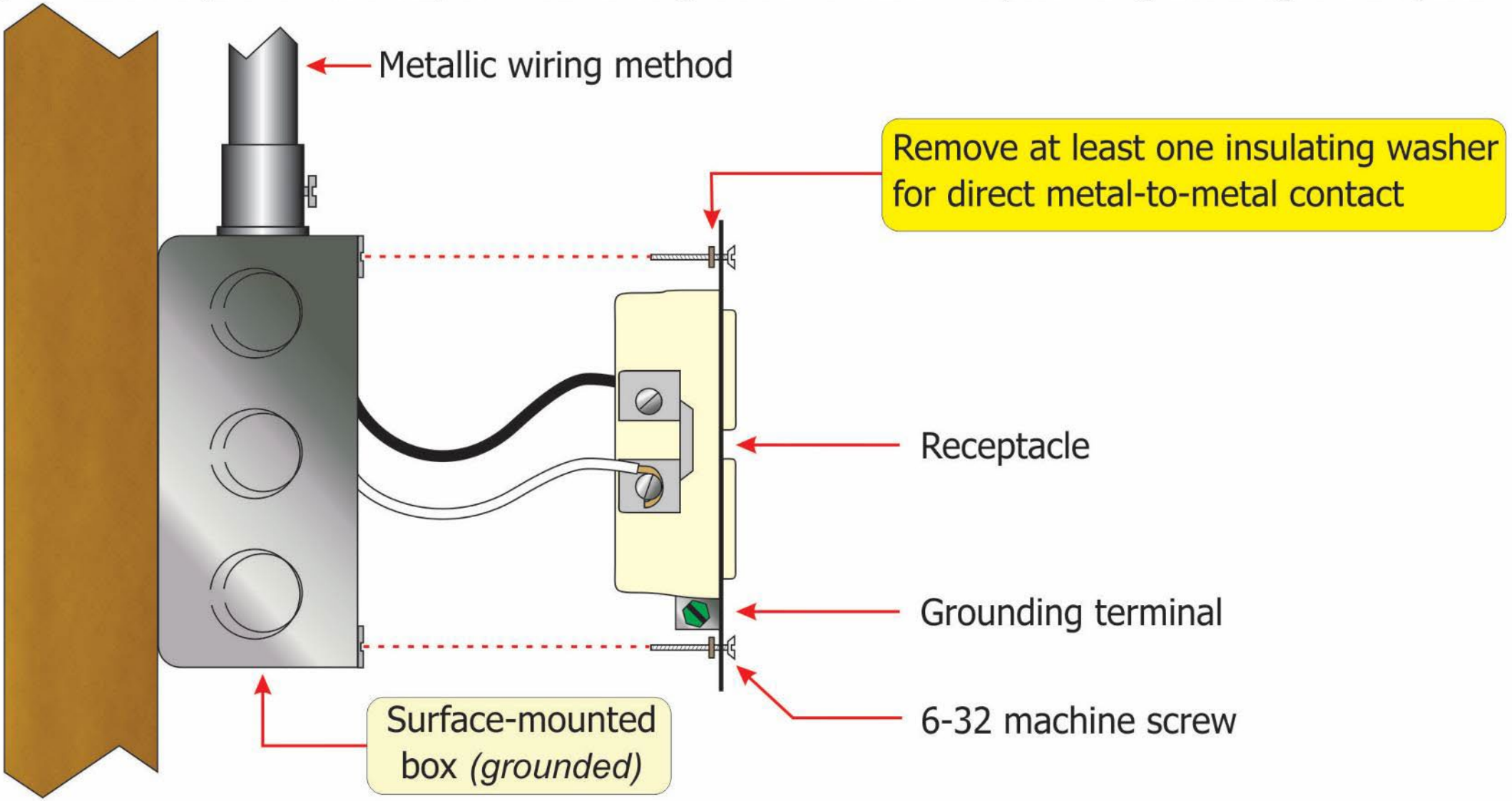
Copyright © IAEI 2020

Bonding of Grounding-Type Receptacles *(cont.)*

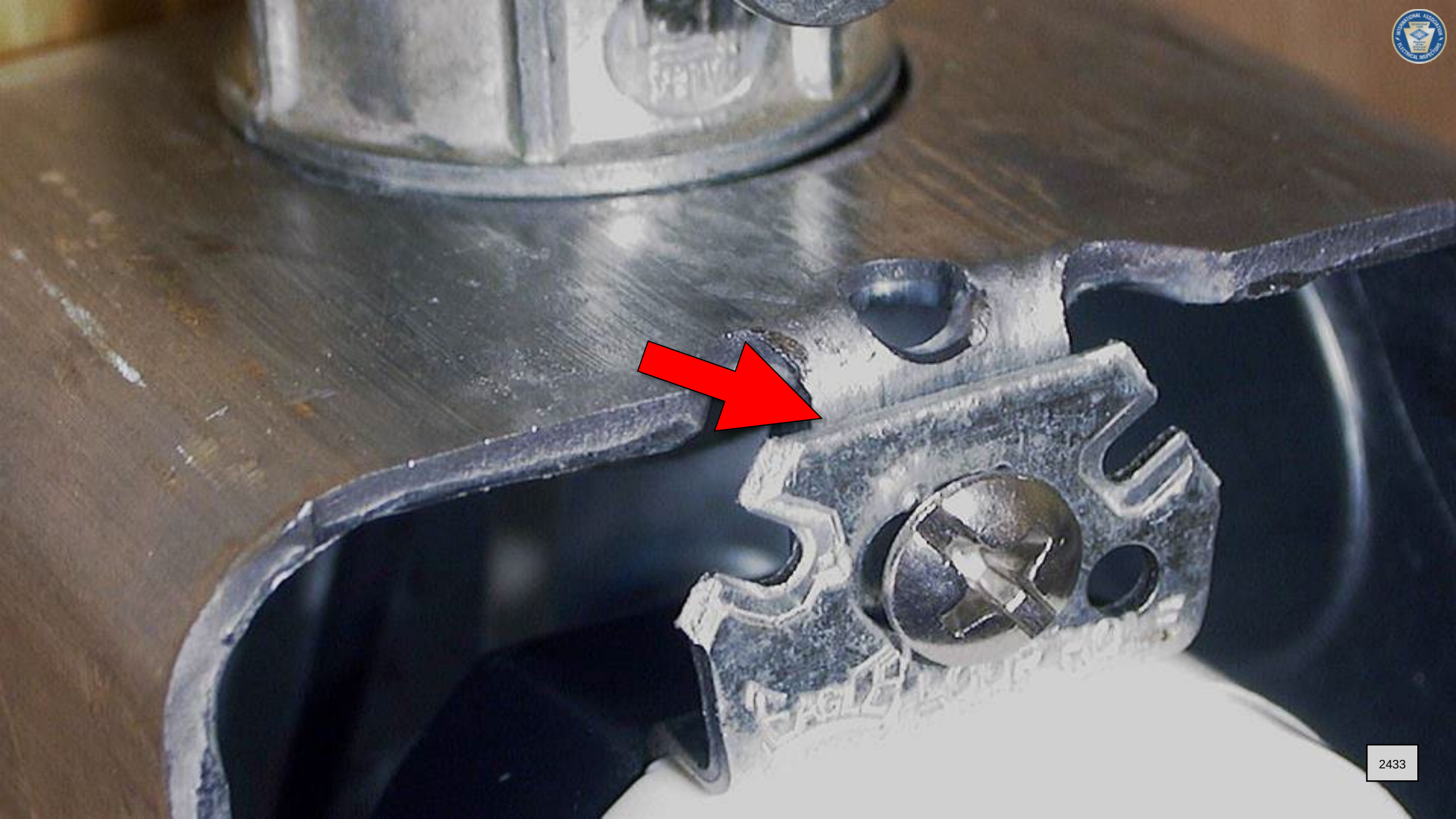
- Surface-Mounted Metal Boxes [250.146(A)]
  - Mounted on surface only
  - Direct metal-to-metal contact
  - Box permitted to provide required effective ground fault current path to receptacle
  - At least one insulating washer *(holding screws)* is required to be removed from the receptacle
  - Raised-cover mounted receptacles permitted for grounding and bonding of receptacle

250.146(A) Surface-Mounted Box

Direct metal-to-metal contact from metal mounting yoke or strap to surface-mounted metal box permitted to provide the required effective ground fault current path for grounding of receptacle



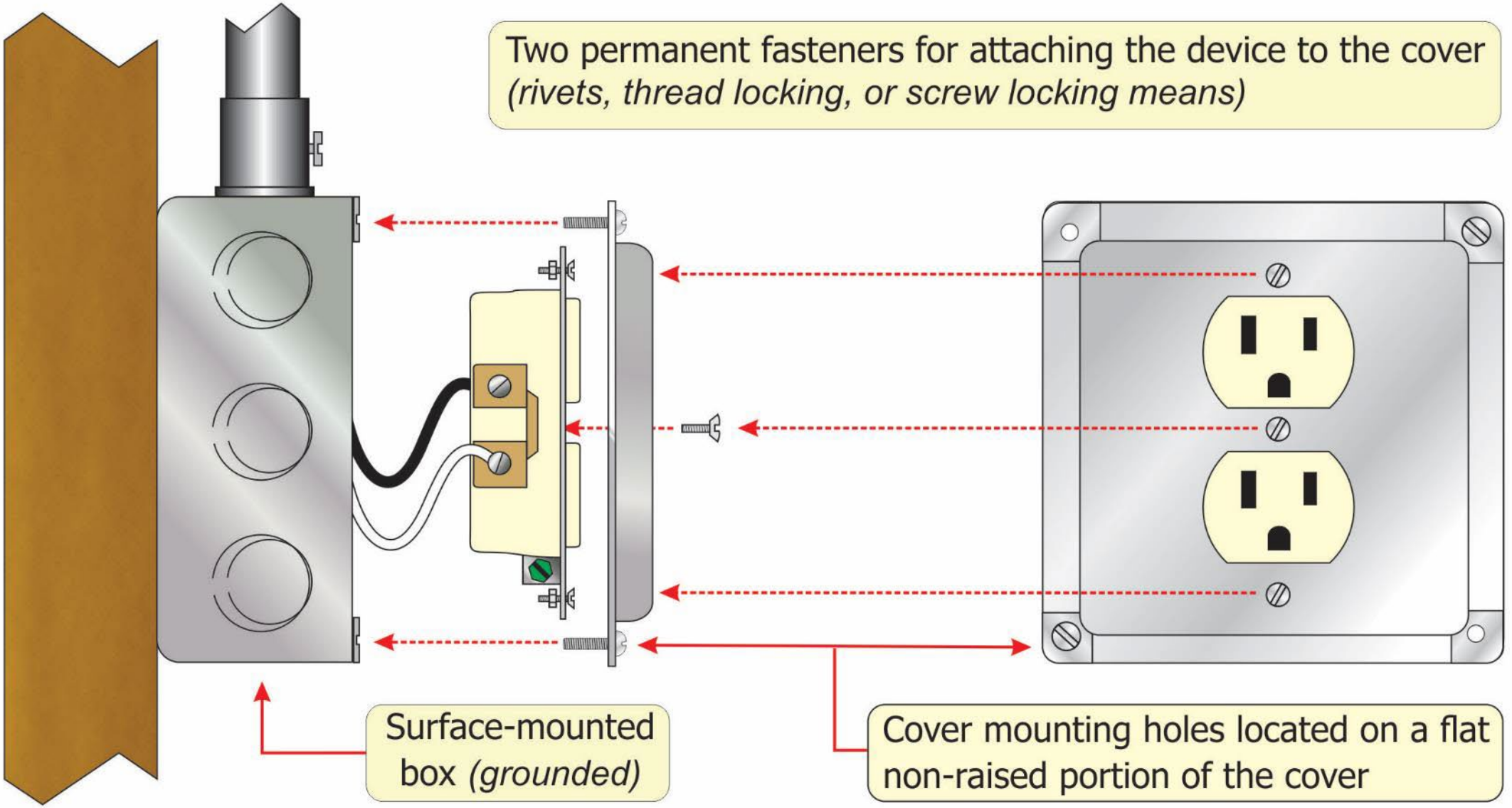
Copyright © IAEI 2020



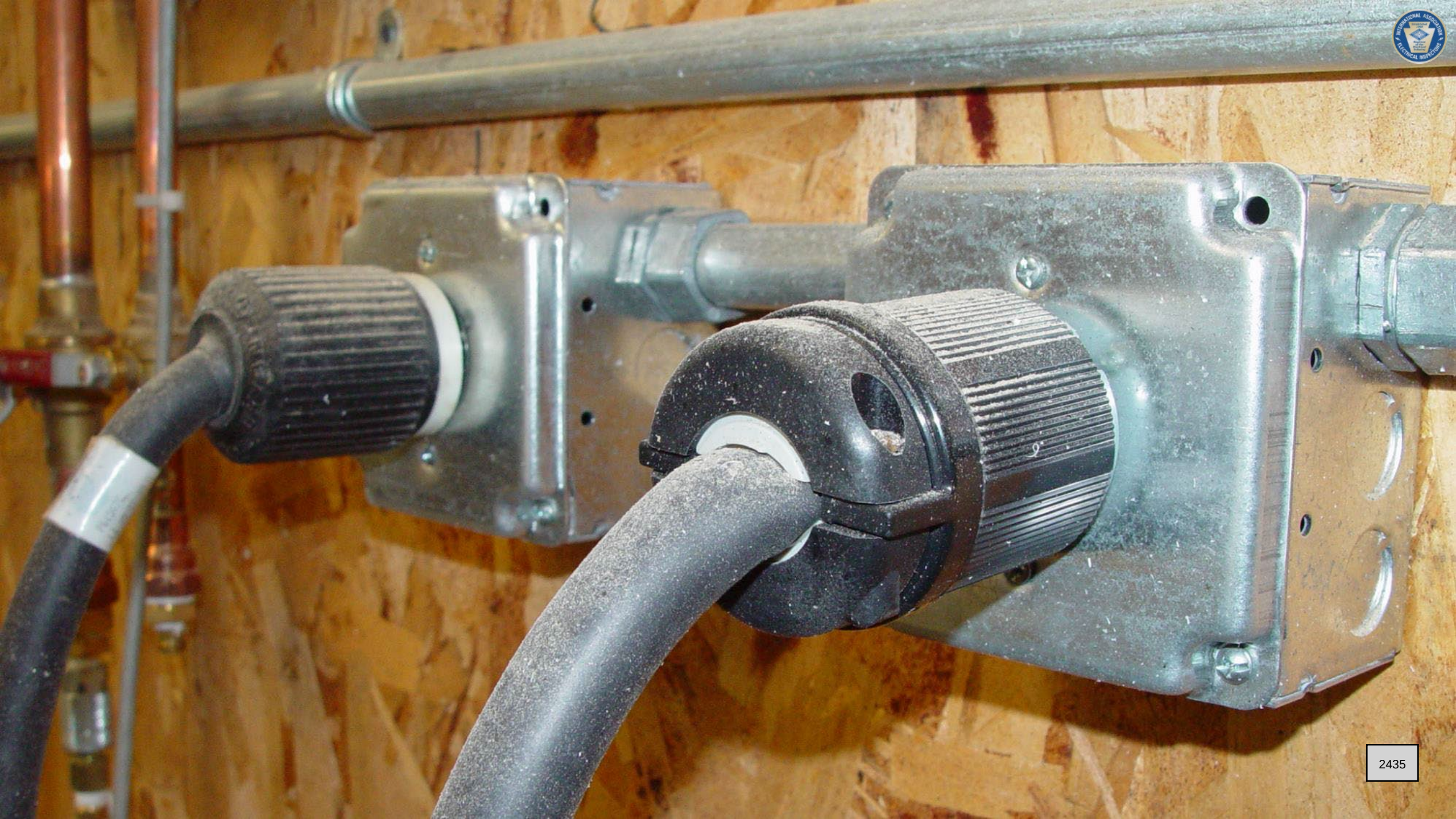
2433

250.146(A) Surface-Mounted Box

Listed exposed work cover is permitted as the grounding and bonding means



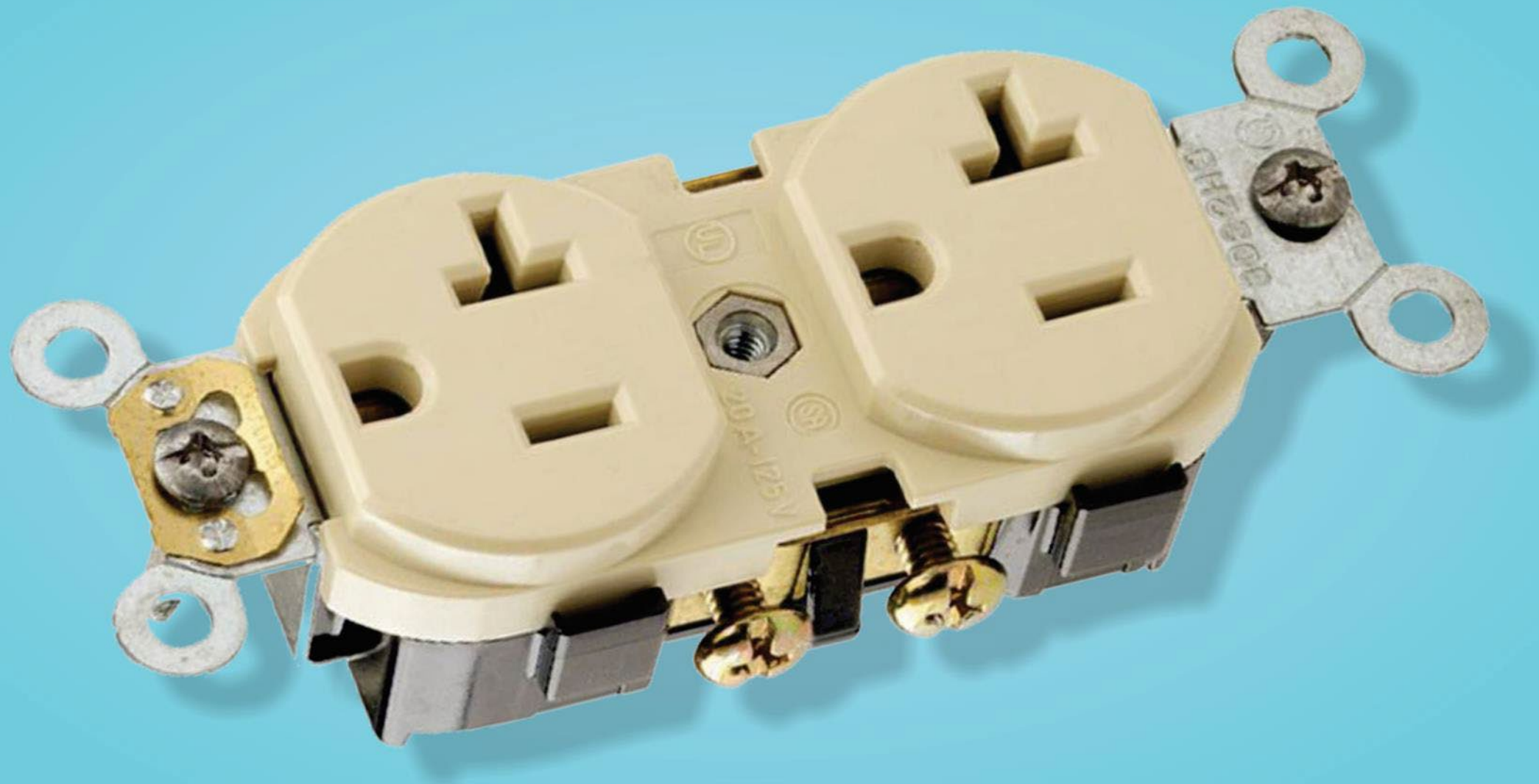
Copyright © IAEI 2020

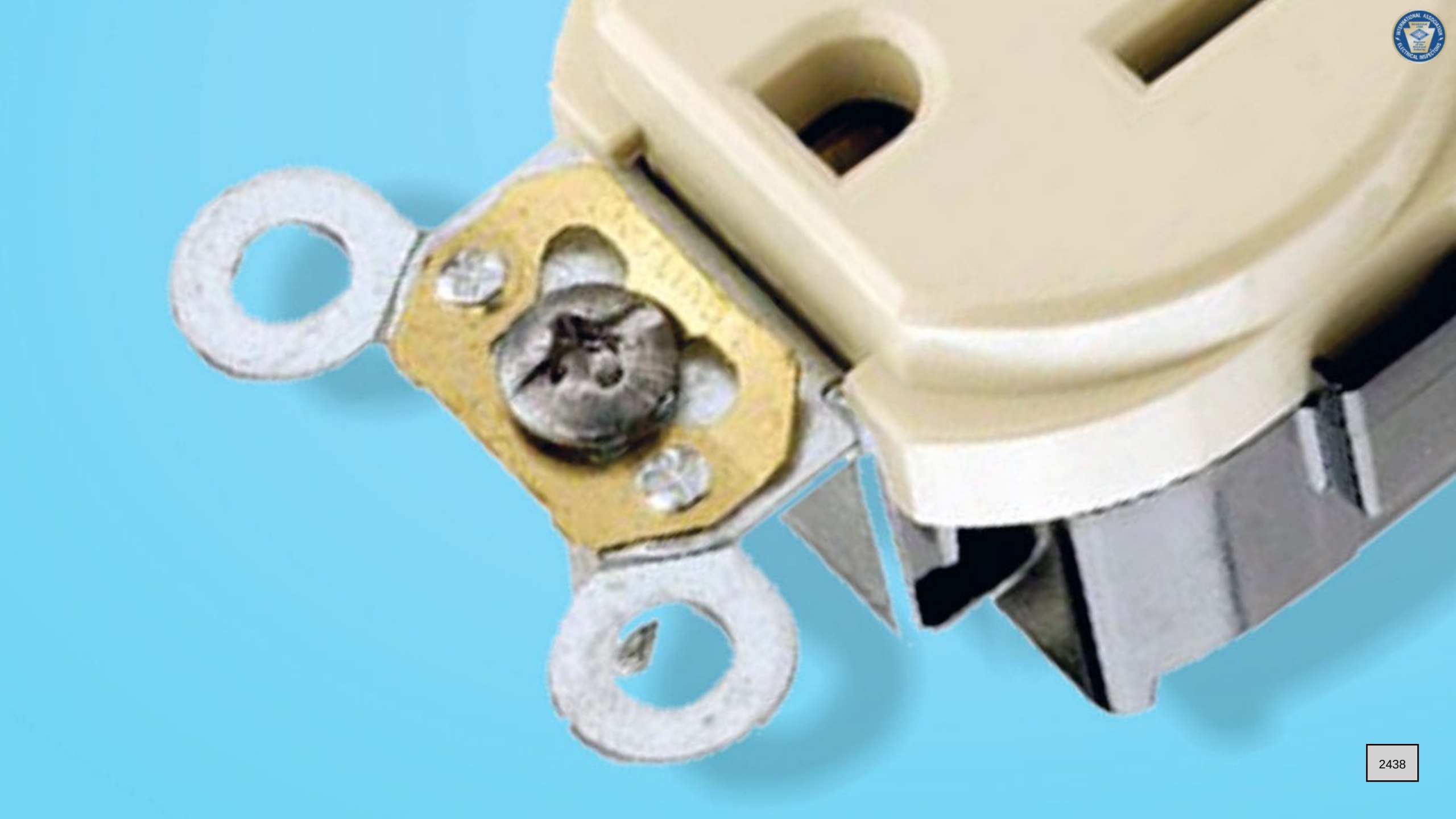


2435

Bonding of Grounding-Type Receptacles *(cont.)*

- Contact Devices or Yokes [250.146(B)]
  - Contact devices or yokes designed and listed as **self-grounding** are permitted in conjunction with the supporting screws to establish the equipment bonding means between the receptacle device yoke and flush-type boxes
  - The use of a self-grounding receptacle is not permitted to be the means to ground the metal box
  - *See 250.148(B) and (C)*


20A-125V



Bonding of Grounding-Type Receptacles *(cont.)*

- Floor Boxes [250.146(C)]
  - **Floor boxes** designed for and listed as providing satisfactory ground continuity between the box and the receptacle device are permitted as a grounding/bonding means between the receptacle device yoke and the floor box

Floor Boxes – 250.146(C)



Courtesy of Pass and Seymour/Legrand

Bonding of Grounding-Type Receptacles *(cont.)*

- Isolated Ground Receptacles [250.146(D)]
  - Where installed for the reduction of electrical noise *(electromagnetic interference)* on the equipment grounding circuit, an **isolated ground receptacle** is permitted
  - Grounding terminal is **purposely insulated** from the receptacle mounting means but is connected to an **insulated EGC** run with the circuit conductors
  - IG EGC **permitted to pass through** one or more panelboards without a connection to the panelboard grounding terminal bar
  - IG EGC **permitted to pass through** boxes, wireways, or other enclosures without being connected to enclosures

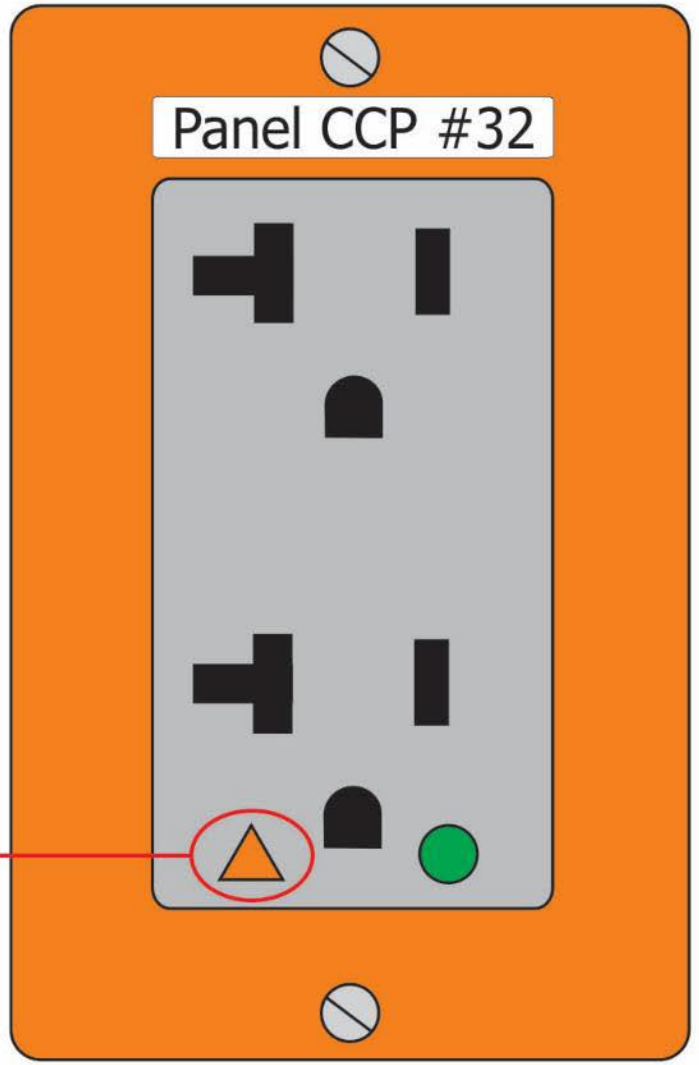
406.3(D) Isolated Ground Receptacles

- Isolated ground receptacles to be identified by **orange triangle** on face *[406.3(D)]*

- To be used only with isolated equipment grounding conductors *[406.3(D)(1)]*

- Isolated ground receptacles installed in nonmetallic boxes shall be covered with a nonmetallic faceplate unless the box has a feature or accessory for grounding the faceplate *[406.3(D)2)]*

- Isolated equipment grounding conductor for isolated ground receptacles permitted to pass through panelboards, boxes, wireways, and other enclosures *[250.146(D)]*



Copyright © IAEI 2020

Installation of Equipment Bonding Jumpers

- **Equipment bonding jumper** is defined in Article 100 as “the connection between two or more portions of the equipment grounding conductor”
- Definition describes the installation of equipment bonding jumpers is being on the **load side** of overcurrent protective devices
- On the **line side** *(supply side)*, such as at the service or source of separately derived system, this jumper is identified as a **supply-side bonding jumper**
- *See 250.102(C) and 250.30(A)(2)*

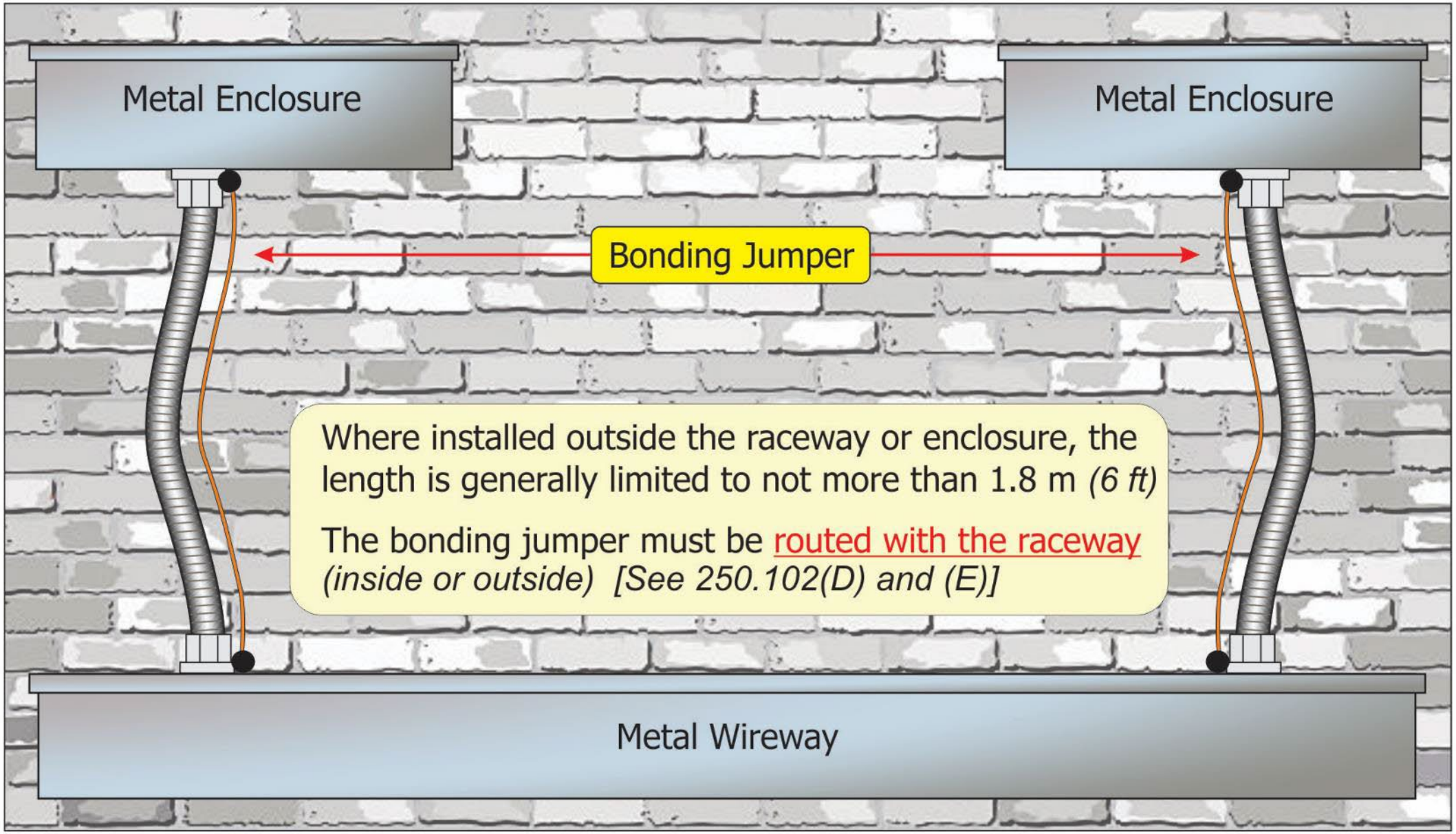
Installation of Equipment Bonding Jumpers *(cont.)*

- Equipment bonding jumpers are permitted to be installed **inside or outside** of a raceway or an enclosure
- If installed **inside** a raceway, it must comply with the requirements of 250.119 *(Identification of EGCs)* and 250.148 *(Continuity and Attachment of EGC to Boxes)*
- If installed on the **outside**, the length of the equipment bonding jumper is generally limited to not more than **1.8 m (6 ft)** and must be routed with the raceway or enclosure *(see exception for outside pole locations)*
- *See 250.102(E)*



2445

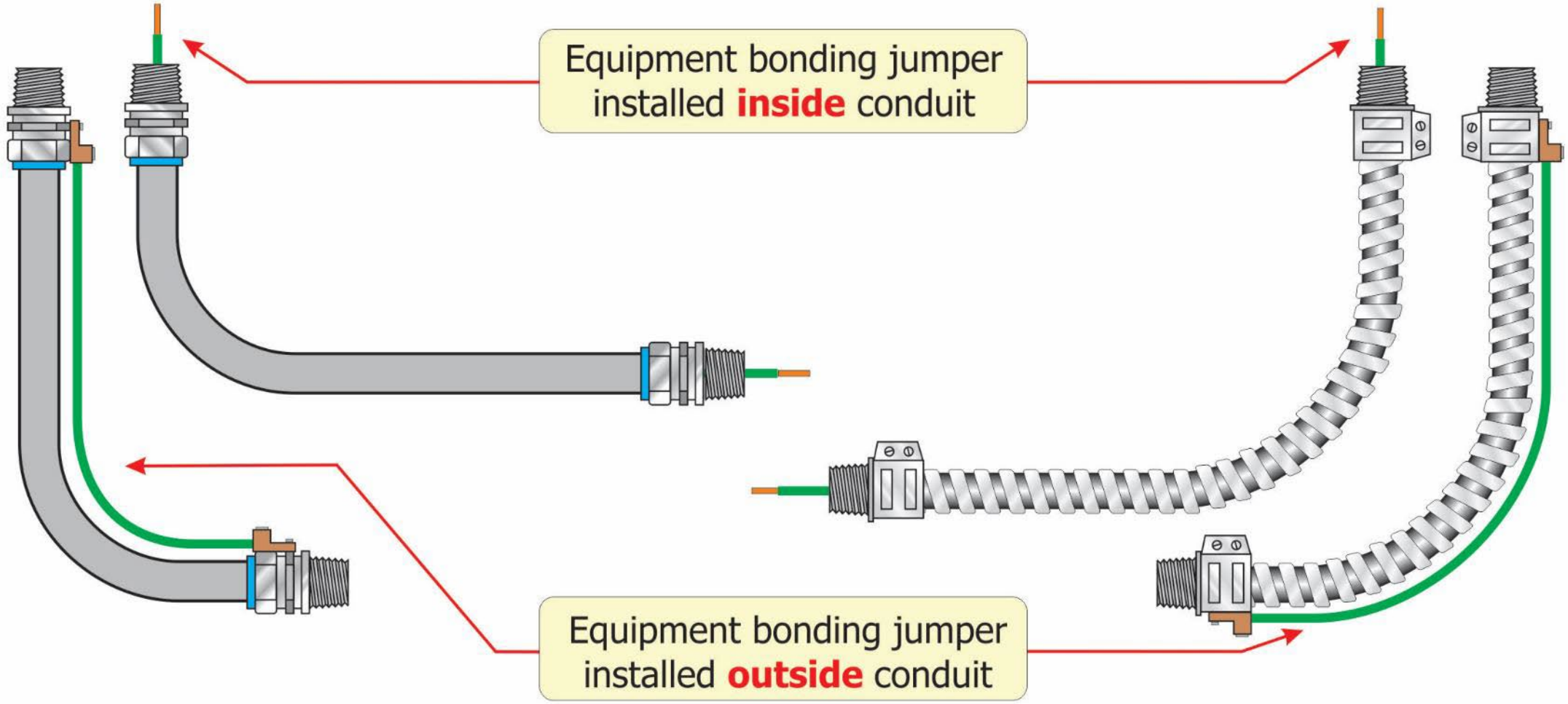
Bonding Jumper Installed Outside of Raceway



Copyright © IAEI 2020

Equipment Bonding Jumper Installation

Flexible metal conduit and liquidtight flexible metal conduit in lengths longer than 1.8 m *(6 ft)* shall not be used as an effective ground-fault current path



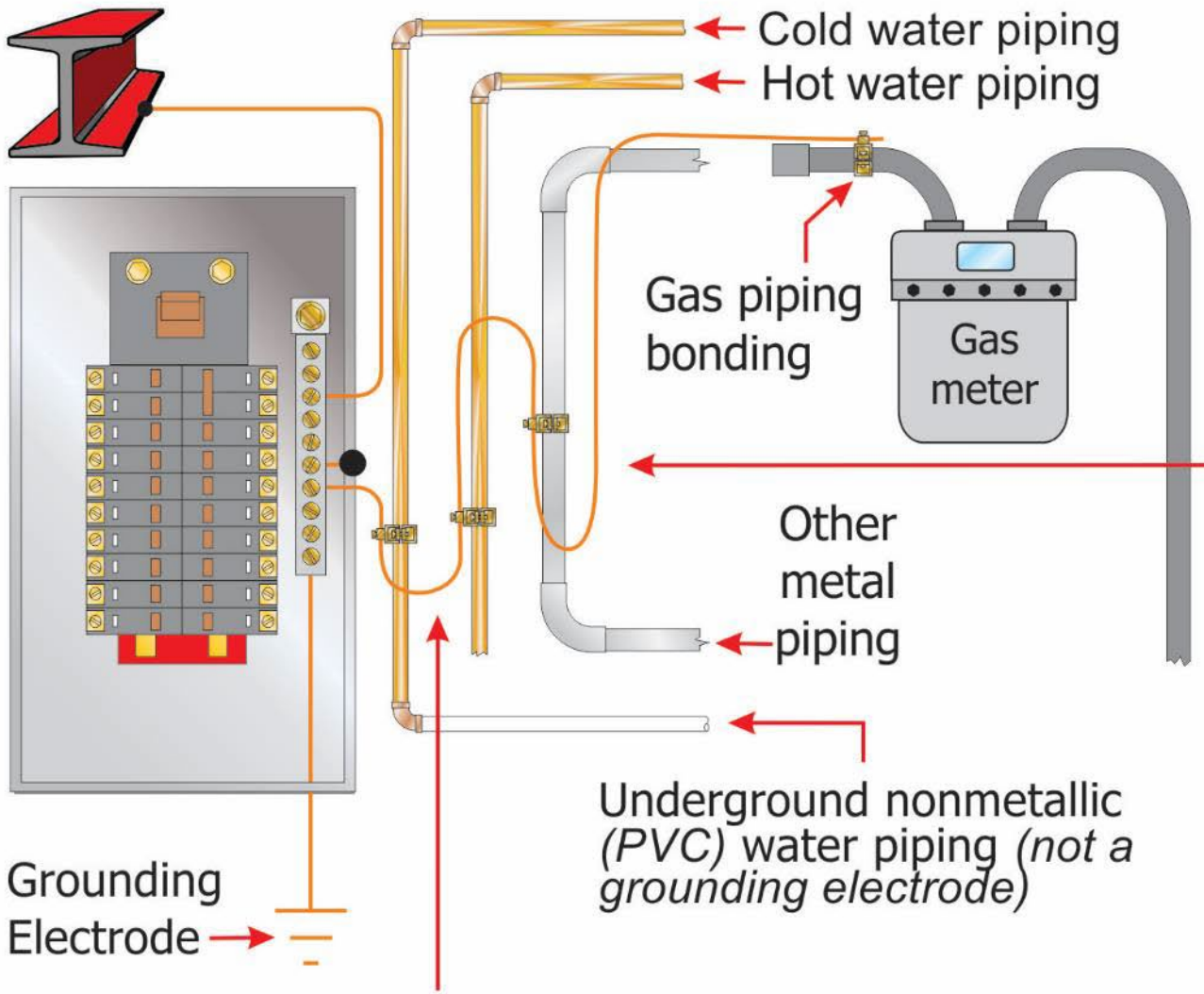
Where equipment bonding jumpers *(internal or external)* are installed, they shall comply with 250.102 *(installation of bonding jumpers, etc.)*

Copyright © IAEI 2020

Bonding of Piping Systems

- Metal water piping systems and other metal piping systems, and structural metal installed within or attached to buildings or structures required to be **bonded** *(not to be confused with grounding and metal underground water piping used as a grounding electrode)*
- Depending on if the metallic piping system is for water or for some other application *(such as gas)*, the specific requirements for **installation and sizing** change
- See 250.104 for bonding of metal piping systems

250.104 Bonding of Piping Systems and Exposed Structural Metal



Metal water piping system: Bonding jumper to be sized per Table 250.102(C)(1) based on the cm area of the service-entrance conductors

Other metal piping: Bonding jumper to be sized based on Table 250.122 for the circuit that is likely to energize the other metal piping system(s)

Exposed structural metal: Bonding jumper to be sized per Table 250.102(C)(1) based on the cm area of the service-entrance conductors

Bonding jumper(s) used to bond metal water piping or exposed structural metal together required to be sized based on Table 250.102(C)(1), but not required to be larger than 3/0 copper or 250 kcmil aluminum or copper-clad aluminum

Copyright © IAEI 2020

Bonding of Piping Systems *(cont.)*

- Included among the items within a building that should be adequately connected ***(bonded)*** to the one common grounding electrode system, the service, and sources of separately derived systems, are:
  - The metallic water piping system *(hot and cold)*
  - The metallic gas piping
  - The metallic sewer piping
  - Any metallic air ducts installed inside or on the exterior of the building
  - The structural metal framing for the building or structure
  - Devices such as TV towers, gutters provided with a deicing system, etc.

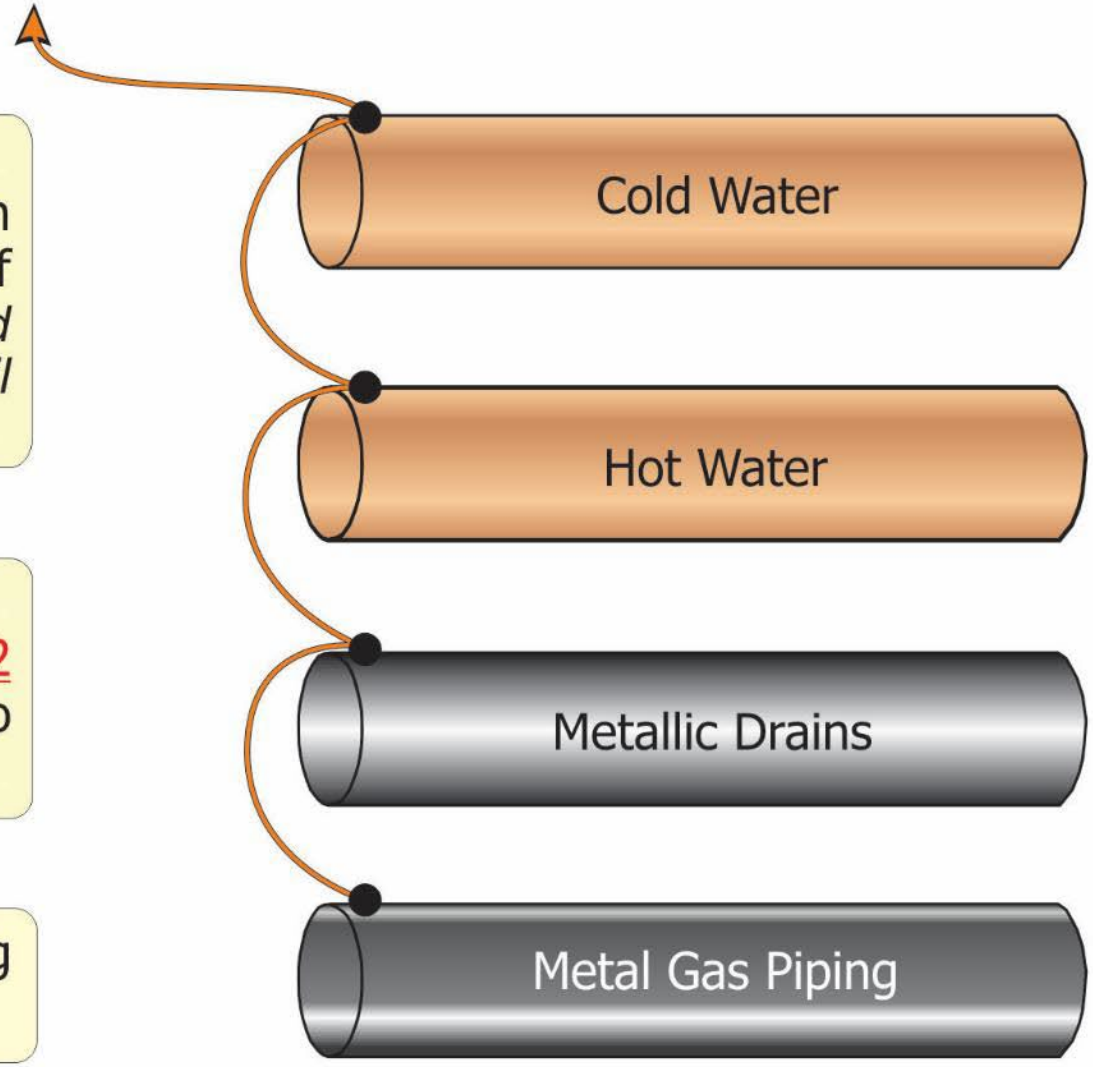
250.104(A) and (B) Bonding Metal Piping Systems

Applies to interior as well as exterior metal piping systems

Metal Water Piping *[250.104(A)]*:
Bonding jumper sized in accordance with Table 250.102(C)(1) based on the cm area of the service-entrance conductors *(not required to be larger than 3/0 copper or 250 kcmil aluminum or copper-clad aluminum)*

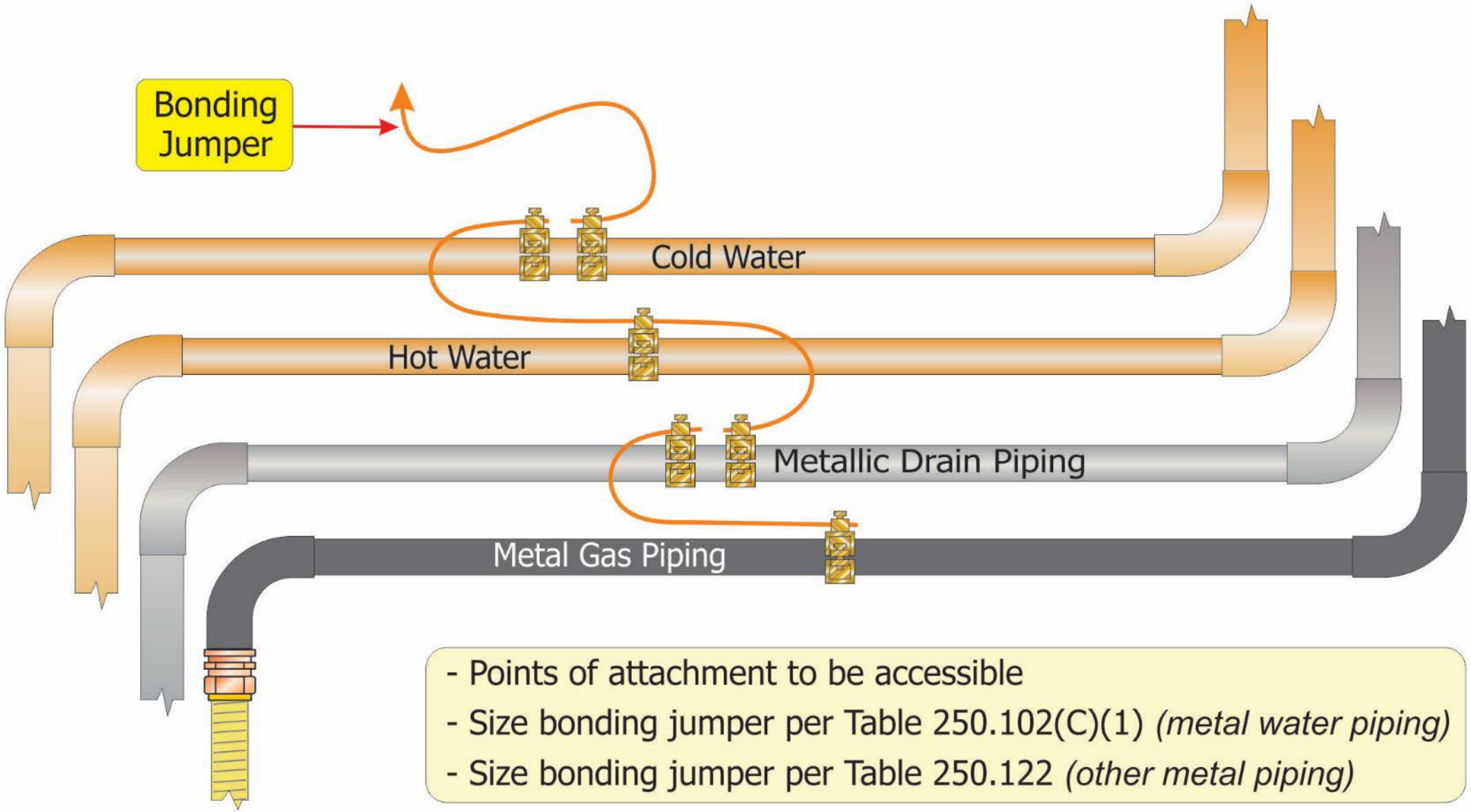
Other Metal Piping *[250.104(B)]*:
Bonding jumper sized based on Table 250.122 using the rating of the circuit that is likely to energize the other metal piping system(s)

Note: Points of attachment of the bonding jumper(s) to be accessible



Copyright © IAEI 2020

250.104(A) and (B) Bonding Jumper Connection to be Accessible



- Points of attachment to be accessible
- Size bonding jumper per Table 250.102(C)(1) *(metal water piping)*
- Size bonding jumper per Table 250.122 *(other metal piping)*

Copyright © IAEI 2020

Bonding of Metal Water Piping Systems

- Metal water piping system(s) installed **within or attached to** a building or structure must be bonded per 250.104(A)(1)
- Where a metallic underground water piping system exists and **qualifies as a grounding electrode** and is connected to a metallic interior water-piping system *(with no insulating fittings or coupling)*, the interior water piping system is automatically and adequately grounded ***(bonded)***
- With the expanding use of nonmetallic piping and insulating couplings or fittings, it is important to be sure that the interior piping not only is **electrically continuous**, but that also it is **adequately grounded by bonding** it to the same grounding electrode used for the premises
- Bonding jumper generally required to be sized in accordance with **Table 250.102(C)(1)** *(based on the size of the service-entrance conductor)*

Bonding of Metal Water Piping Systems *(cont.)*

- Bonding jumpers for connection to the metal water piping systems required to be:
  - Not larger than **3/0 AWG** copper or **250 kcmil** aluminum or copper-clad aluminum
  - Installed in accordance with the general rules for installing grounding electrode conductors in 250.64(A), (B) and (E)
  - Connected in a manner specified in 250.70 *(methods of connection to grounding electrodes)*
  - **Accessible** *(attachment of the bonding jumper(s) to the water piping system)*

Bonding of Metal Water Piping Systems *(cont.)*

- Metal water piping system bonding jumpers permitted to be attached *(bonded)* to:
  - Service equipment enclosure
  - Grounded conductor at the service
  - Grounding electrode conductor *(if of sufficient size)*
  - One or more grounding electrodes used *(GEC or bonding jumper to be of sufficient size)*



2456

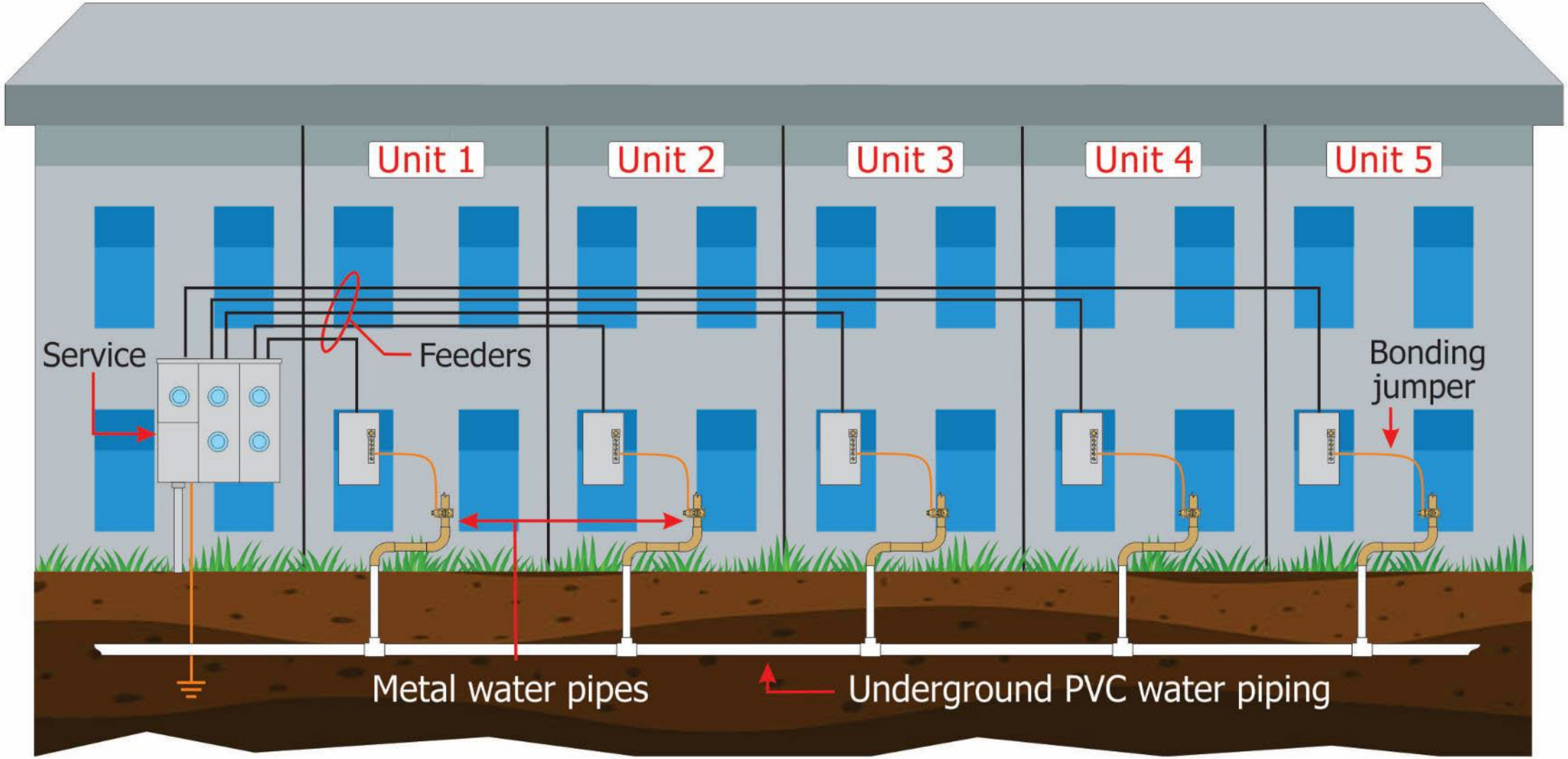

2457

2458

Bonding of Metal Water Piping (Multiple Occupancies)

- Metal water piping system(s) allowed to be bonded to the panelboard or switchboard enclosure *(other than service equipment)* under specific conditions:
  - Building is multiple occupancy, and…
  - Metallic water piping is isolated from all other occupancies by nonmetallic water piping (*nonmetallic means or individual isolation)*
- Bonding jumper sized in accordance with Table 250.122, based on the rating of the overcurrent protective device for the circuit supplying the occupancy
- See 250.104(A)(2) and 250.102(D)

250.104(A)(2) Metal Water Piping Bonding Alternative



Metal interior water pipes permitted to be bonded to panelboard in multiple occupancy buildings under the conditions provided in 250.104(A)(2)

Bonding jumper(s) sized per 250.102(D) and 250.122 based on the rating of the feeder OCPD

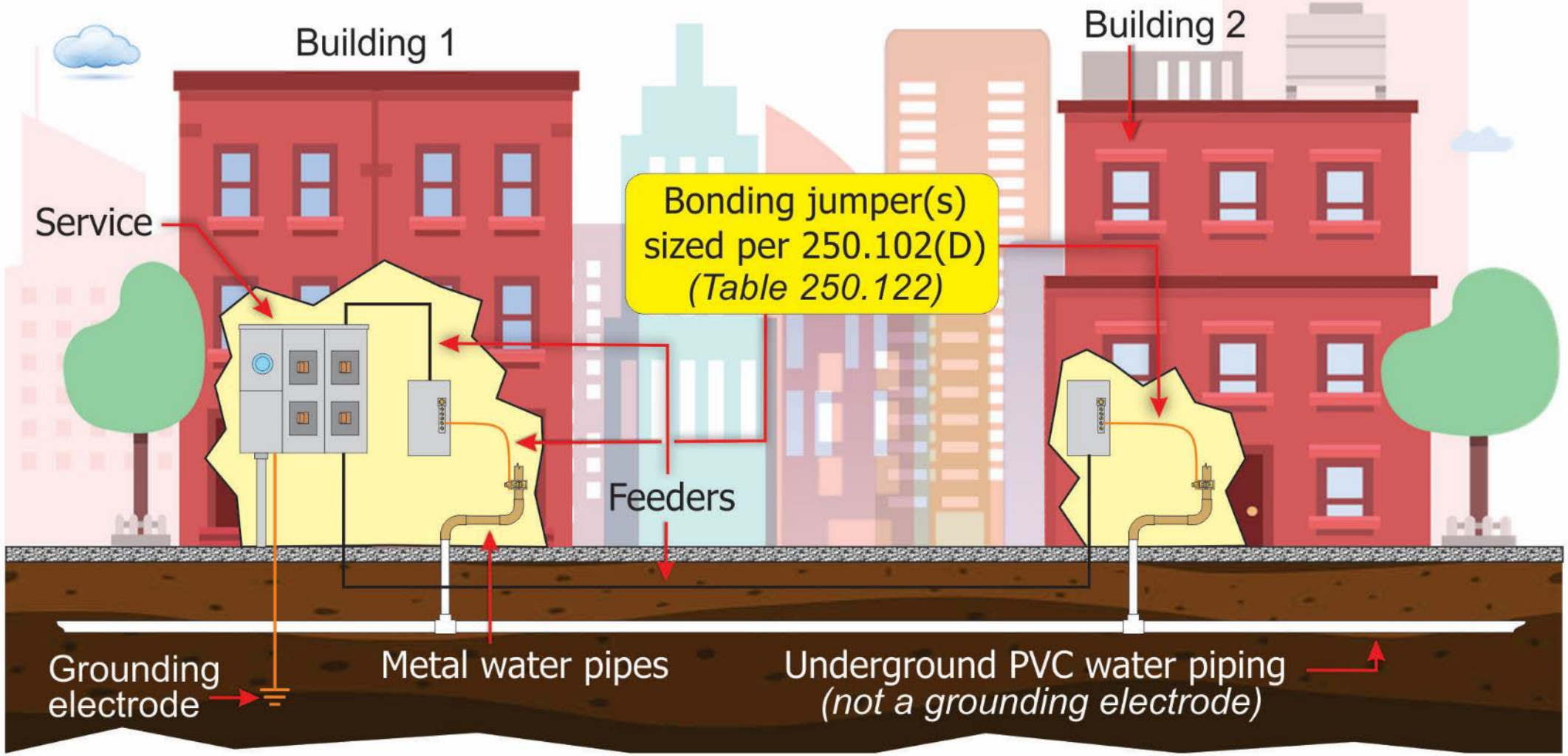
Copyright © IAEI 2020

Bonding of Metal Water Piping (Multiple Buildings)

- At **multiple buildings** or structures supplied by **feeder(s) or branch circuit(s)**, the metal water piping system(s) shall be bonded to one of the following:
  - Building or structure disconnecting means enclosure
  - EGC run with the supply conductors
  - One or more grounding electrodes used
- Size bonding jumper(s) in accordance with **Table 250.122**, based on the ampere rating of the largest overcurrent device supplying the feeder(s) or branch circuit(s) that supply the building or structure
- The bonding jumper is not required to be larger than the largest feeder or branch circuit supplying the building
- See 250.104(A)(3) and 250.102(D)

250.104(A)(3) Buildings or Structures Supplied by Feeder or BC

Bonding jumper(s) used for bonding metal water piping system(s) at multiple buildings or structures supplied by a feeder(s) or branch circuit(s) required to be sized based on 250.102(D) *(Table 250.122)* based on the largest overcurrent device supplying circuits to the buildings or structures



Copyright © IAEI 2020

Bonding of Other Metal Piping Systems

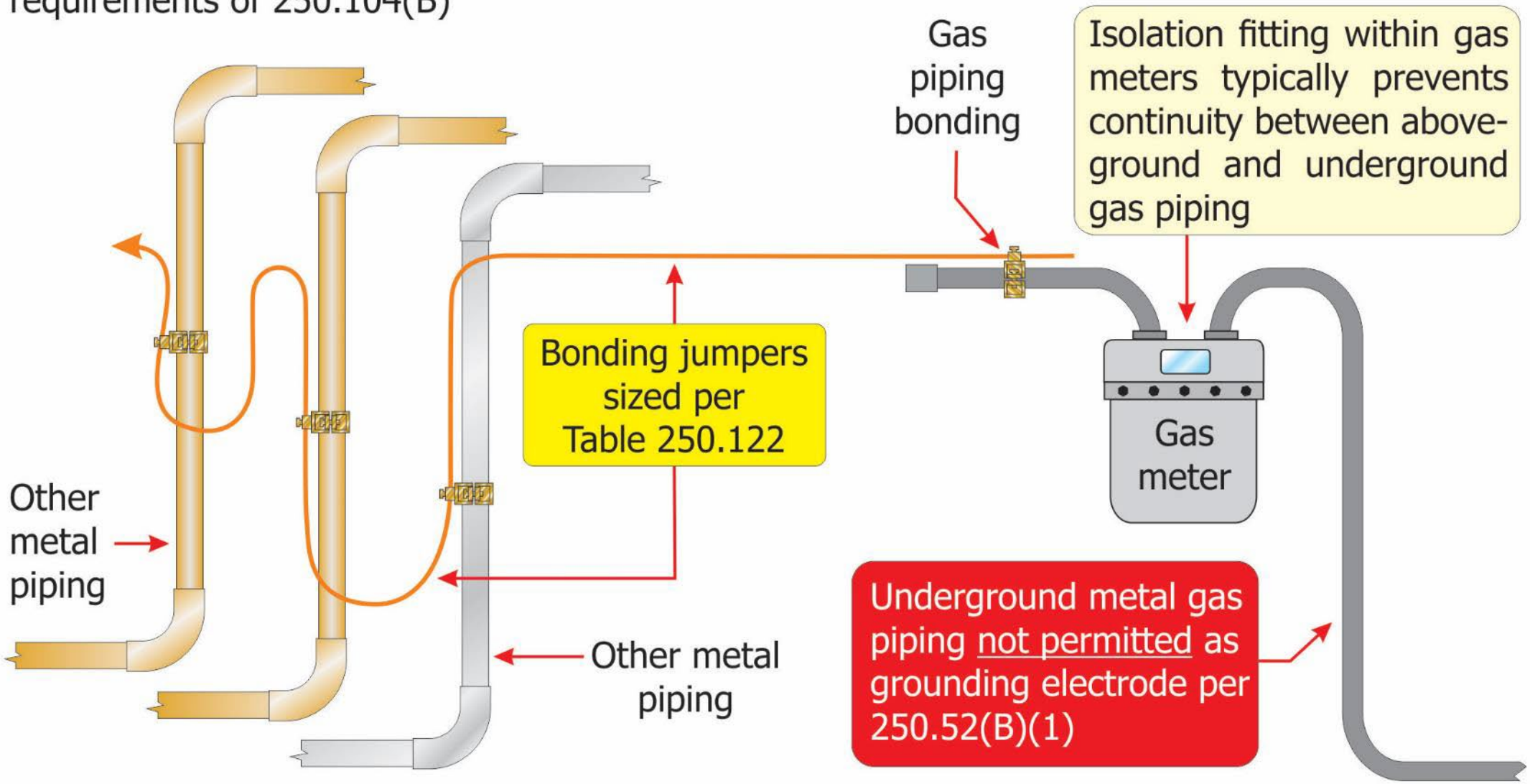
- If installed in or attached to a building or structure, metal piping system(s) provided for other systems ***(including gas piping)*** that is **likely to become energized** shall be bonded
- The equipment grounding conductor **(EGC)** for the circuit that is **likely to energize the piping system** can be used as the bonding conductor
- In addition to using the above EGC to provide the required bonding, the bonding conductor is permitted to be connected to any of the following:
  - Service equipment enclosure
  - Grounded conductor at the service
  - Grounding electrode conductor *(if of sufficient size)*
  - One or more grounding electrodes used *(GEC or bonding jumper to be of sufficient size)*

Bonding of Other Metal Piping Systems *(cont.)*

- Common systems that are required to be bonded include metal piping for gas, pneumatic systems, waste, drain and vent lines, and oxygen, air, and vacuum systems
- Minimum size bonding jumper per **250.122** based on the **circuit likely to energize the piping system**
- Equipment grounding conductor of supply circuit may be used as bonding means
- NFPA 54 *(National Fuel Gas Code)* also requires metal gas piping system(s) to be bonded, which correlates with the requirements of the *NEC*
- See 250.104(B)

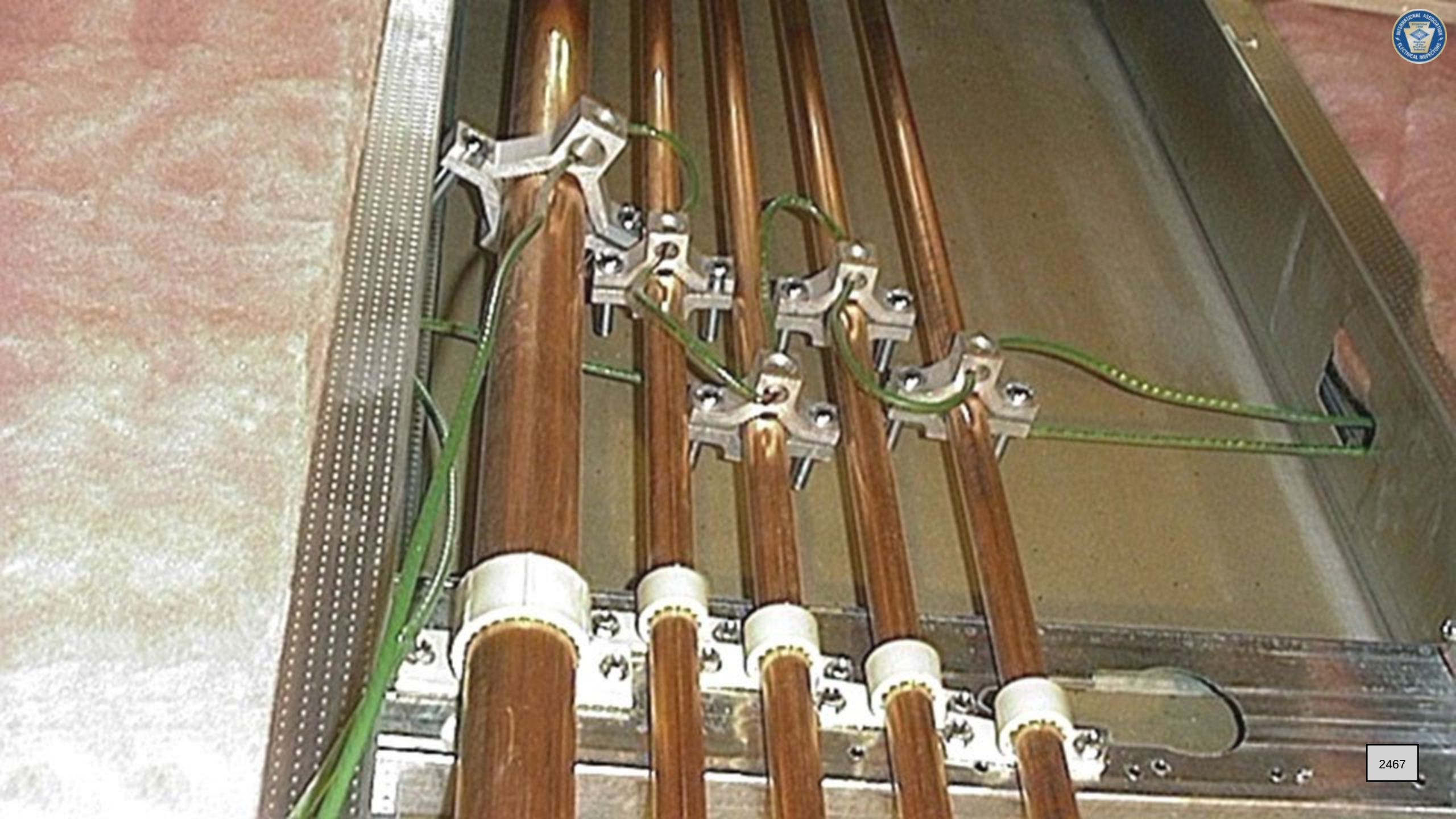
250.104(B) Bonding of Other Metal Piping Required

Bonding of other metal piping systems *(including metal gas piping systems)* is required per the requirements of 250.104(B)



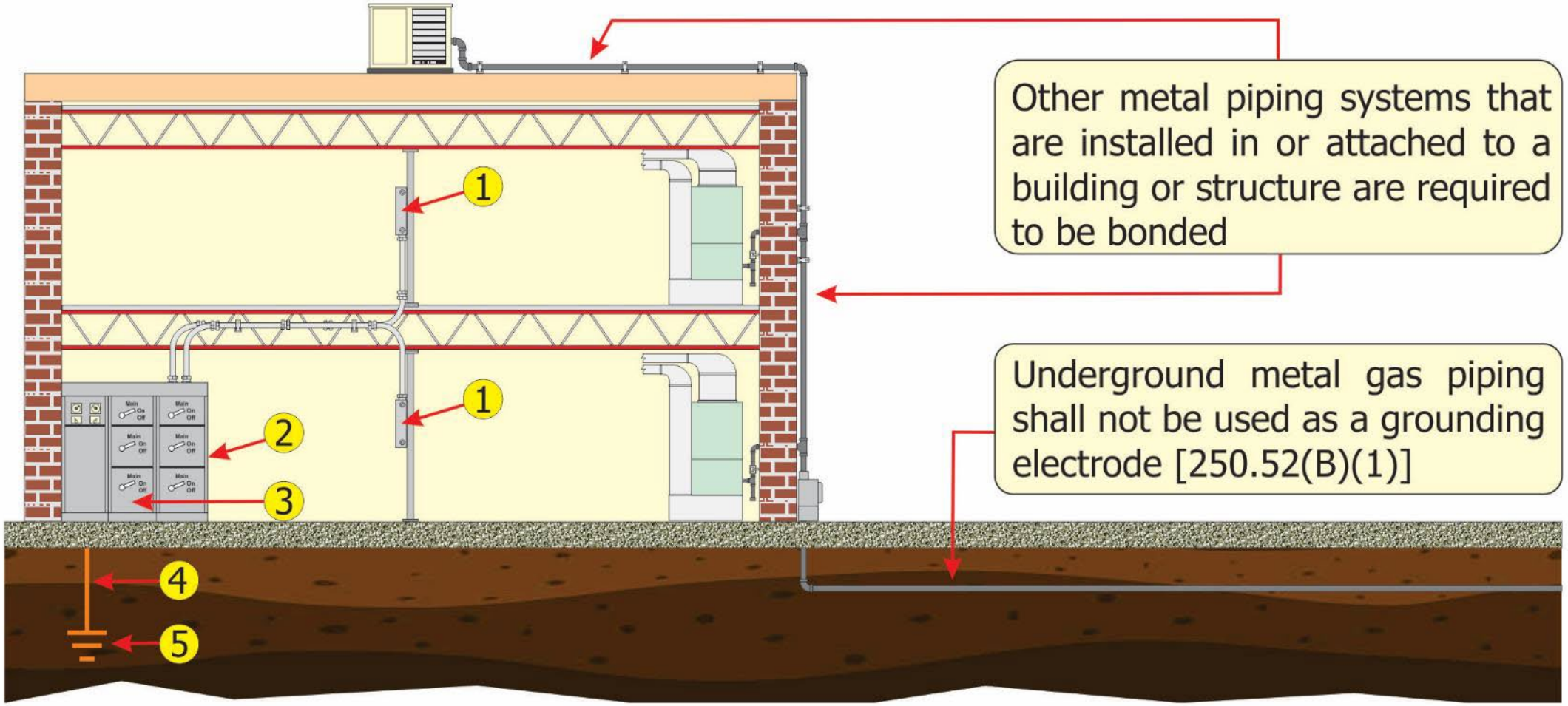
Copyright © IAEI 2020


Air compressor piping
Connected to an electrical system
Rietschle
2466



2467

250.104(B) Bonding of Other Metal Piping Required



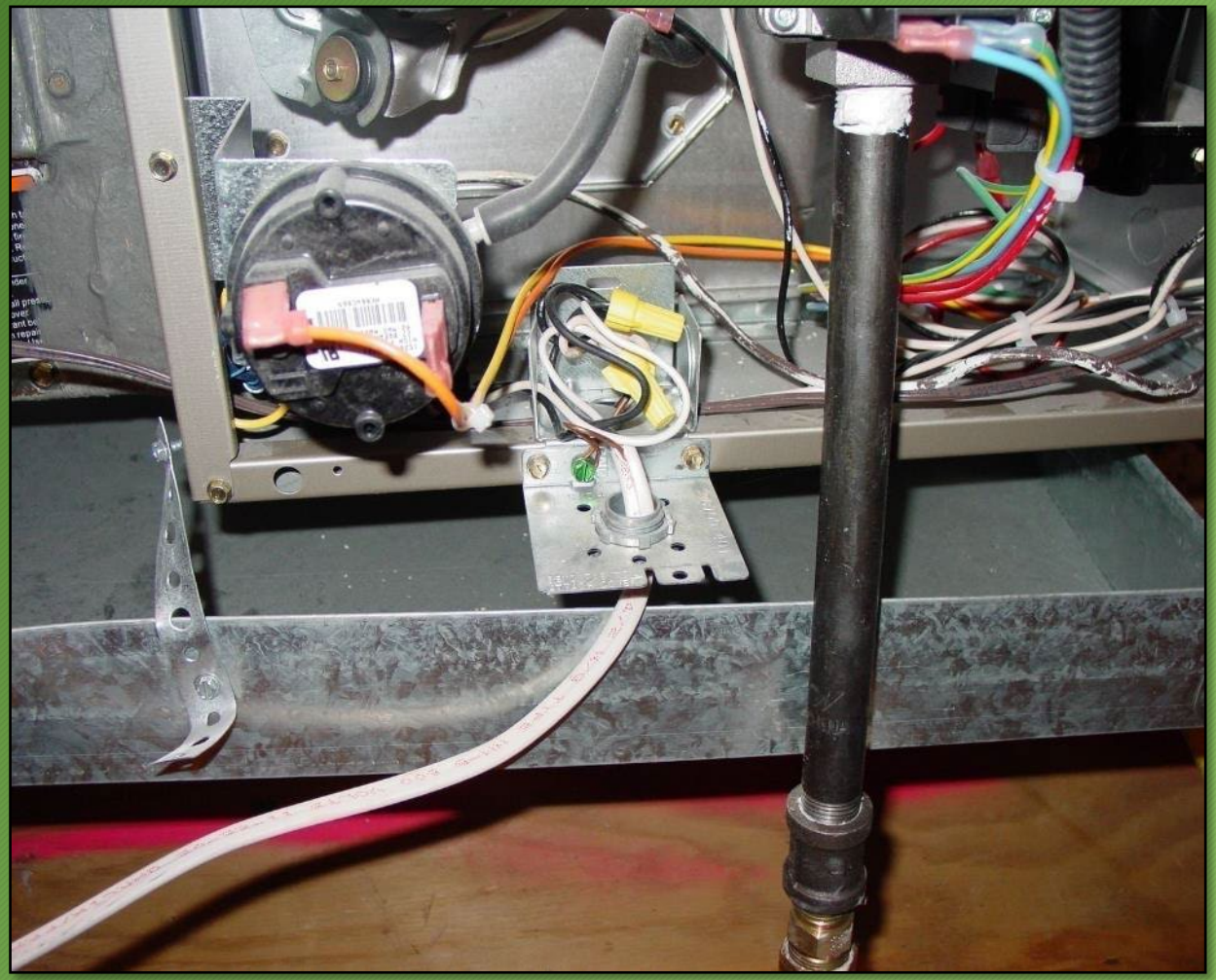
Other metal piping permitted to be bonded to: 1 Equipment grounding conductor of circuit that may energize piping 2 Service equipment enclosure 3 Grounded conductor at service 4 Grounding electrode conductor *(where large enough)* 5 One or more grounding electrodes used

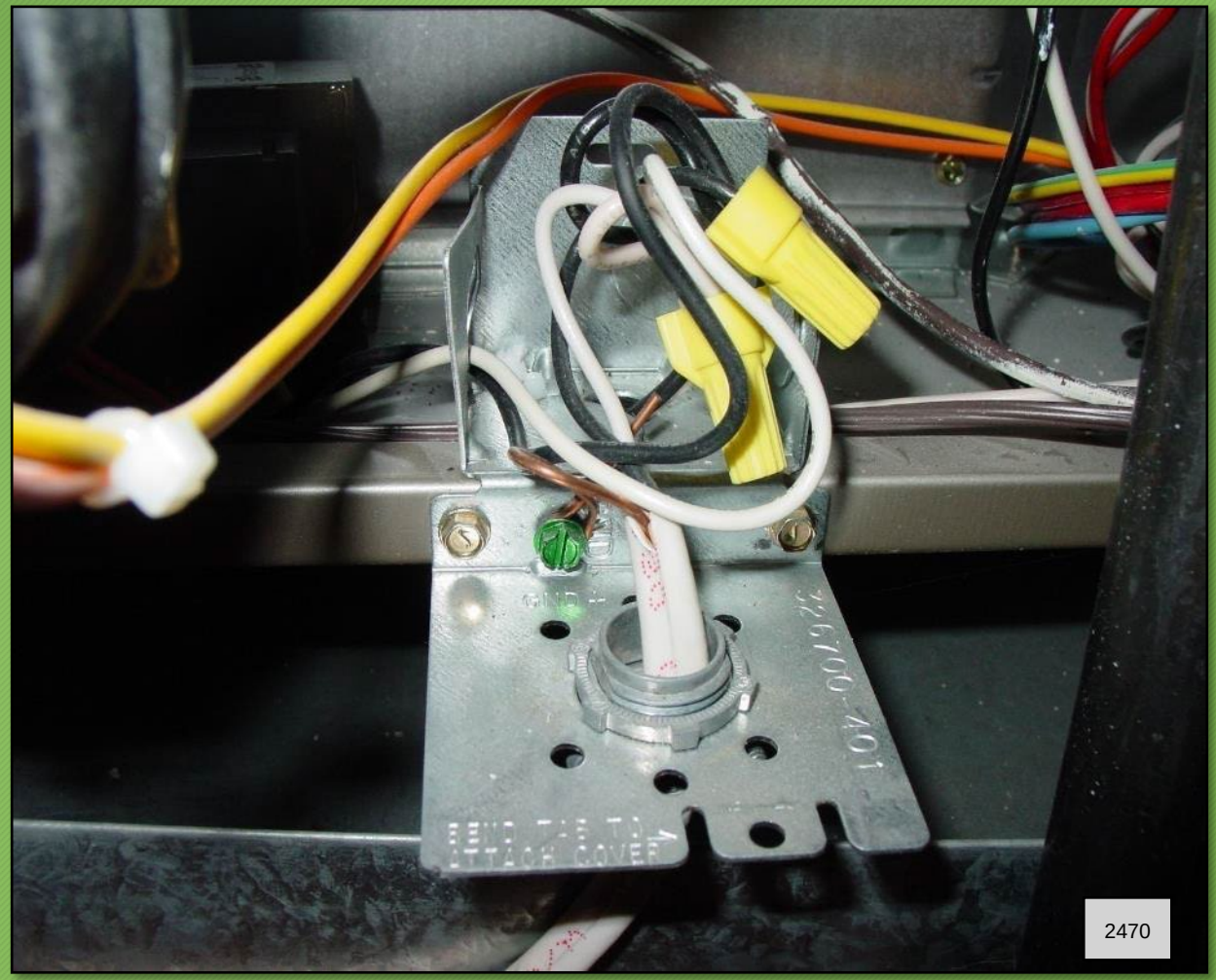
Copyright © IAEI 2020

Bonding of Other Metal Piping Systems *(cont.)*

- **Bonding of Gas Piping:**
  - If installed in or attached to a building or structure, metal gas piping that is **likely to become energized** shall be bonded
  - The **equipment grounding conductor** for the circuit that is likely to energize the piping system can be used for **bonding** of the gas piping
- *See 250.104(B)*

Bonding of Gas Piping






2471

Bonding Structural Steel

- **Exposed structural metal** interconnected to form a metal building frame *(not intentionally grounded)* and is likely to become energized is **required to be bonded**
- Bonding connection required to be made to:
  - Service equipment enclosure
  - Grounded conductor at the service
  - Disconnecting means for buildings or structures supplied by a feeder or branch circuit
  - Grounding electrode conductor *(of sufficient size)*
  - One or more grounding electrodes used *(if GEC or bonding jumper is of sufficient size)*

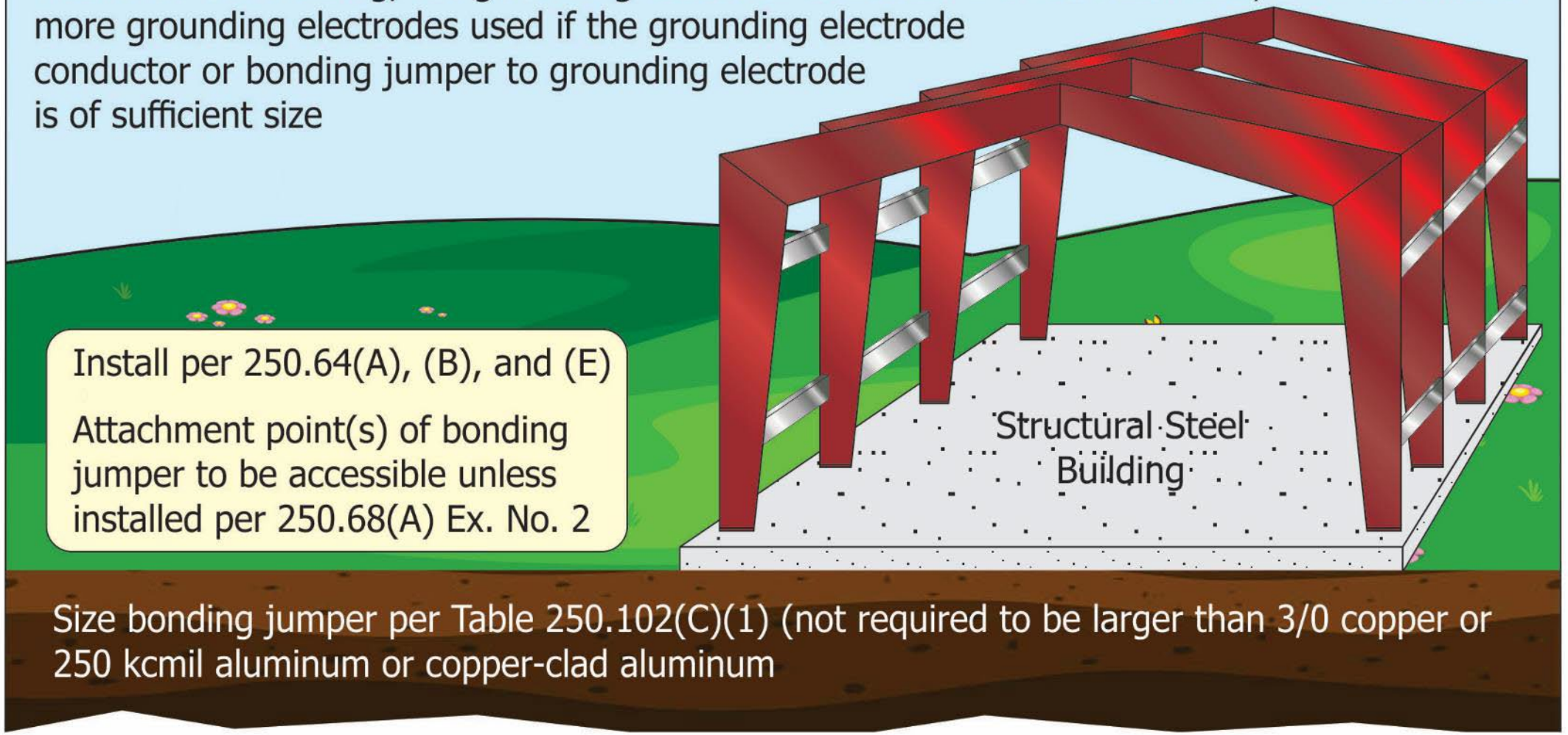
Bonding Structural Steel *(cont.)*

- Applicable to interior or exterior structural framing members of buildings or structures
- Bonding jumper required to be sized using **Table 250.102(C)(1)** and installed in accordance with the rules in 250.64(A), (B) and (E)
- The bonding conductors not required to be larger than **3/0 AWG** copper or **250 kcmil** aluminum or copper-clad aluminum
- The points of attachment of the bonding jumper to the structural steel are required to be accessible *(unless installed in compliance with 250.68(A) Exception No. 2)*
- See 250.104(C)

250.104(C) Bonding Structural Steel

Exposed structural metal framing *(not intentionally grounded)* and is likely to become energized shall be bonded

Bond to the service equipment enclosure, the grounded conductor at service, the disconnecting means for the building, the grounding electrode conductor if of sufficient size, or to the one or more grounding electrodes used if the grounding electrode conductor or bonding jumper to grounding electrode is of sufficient size



Install per 250.64(A), (B), and (E)

Attachment point(s) of bonding jumper to be accessible unless installed per 250.68(A) Ex. No. 2

Size bonding jumper per Table 250.102(C)(1) (not required to be larger than 3/0 copper or 250 kcmil aluminum or copper-clad aluminum

Copyright © IAEI 2020



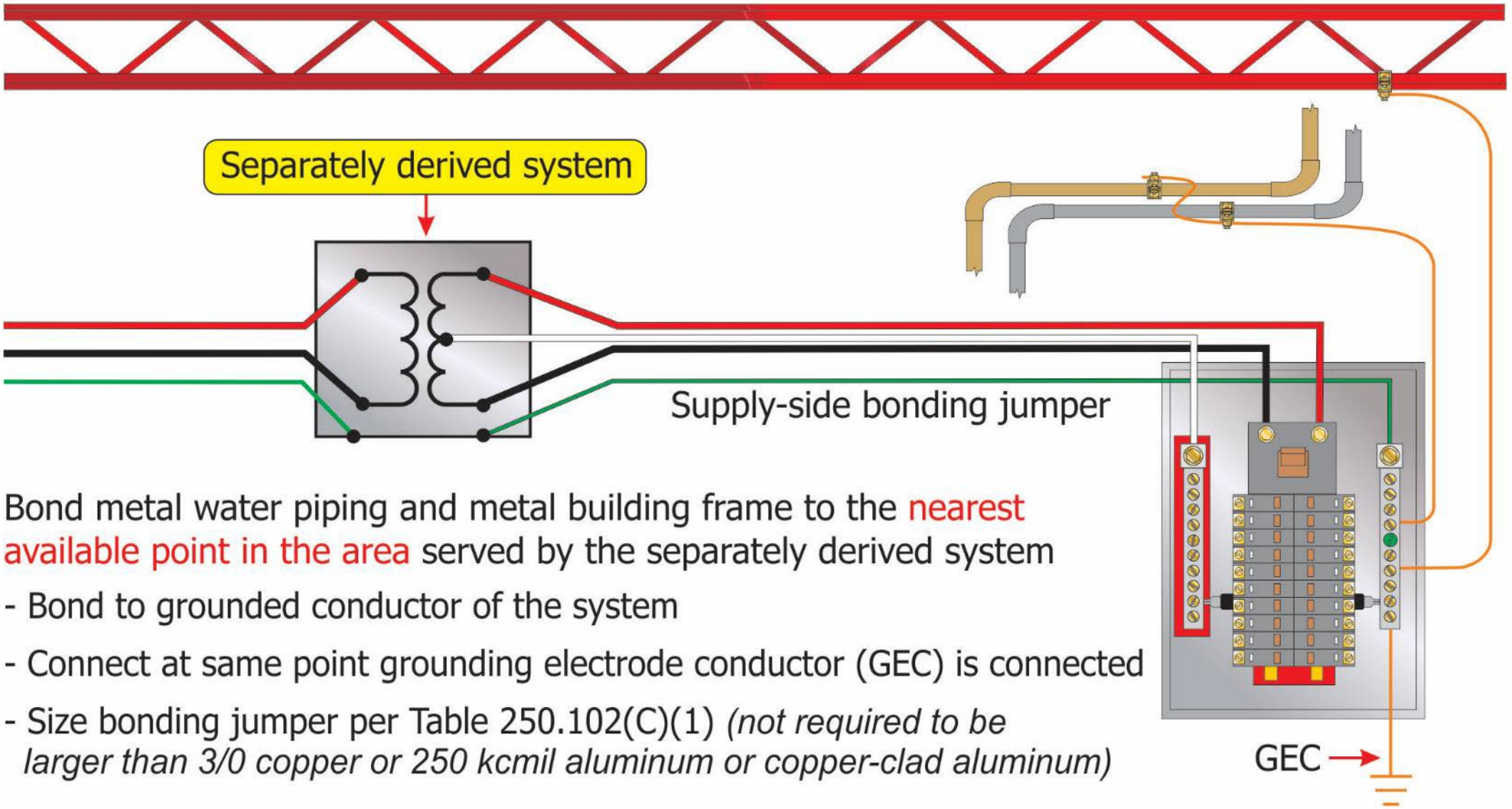
Bonding for Separately Derived Systems

- Metal water piping systems and structural metal building frame required to be bonded to separately derived systems in accordance with 250.104(D)(1) through (D)(3)
  - (D)(1) Metal Water Piping System(s)
  - (D)(2) Structural Steel
  - (D)(3) Common Grounding Electrode Conductor
- 250.30(A)(8) provides correlation between 250.104(D) and 250.30(A) *(grounding requirements for separately derived systems)*

Bonding for Separately Derived Systems *(cont.)*

- Bonding separately derived system is **necessary to establish a reference** to the metal water piping and structural metal in the area served by the separately derived system
- Area served can be determined by locating any equipment or outlets supplied from the separately derived system
- Bonding also provides a **fault-current path** in the event the metal water piping or structural metal becomes energized
- If a **common grounding electrode conductor** is used, it also must be bonded to the metal water piping and structural metal in the area
- Exceptions allow bonding jumpers between metal water piping and structural metal with one bonding jumper to the separately derived system

250.104(D) Bonding Metal Water Piping Systems and Structural Metal



Bond metal water piping and metal building frame to the nearest available point in the area served by the separately derived system

- Bond to grounded conductor of the system
- Connect at same point grounding electrode conductor (GEC) is connected
- Size bonding jumper per Table 250.102(C)(1) *(not required to be larger than 3/0 copper or 250 kcmil aluminum or copper-clad aluminum)*

Copyright © IAEI 2020

CHAPTER FOURTEEN

EQUIPMENT GROUNDING CONDUCTORS

TWO HOLE SIZES -
SMALL HOLE -
NO. 14-8 CU OR NO. 12-8 AL
TWO - NO. 14 OR NO. 12 CU
TWO - NO. 12 OR NO. 10 AL
LARGE HOLE -
NO. 14-4 CU OR NO. 12-4 AL
TWO - NO. 14 OR NO. 12 CU
TWO - NO. 12 OR NO. 10 AL

**LARGE LUG - NO. 4-2/0 CU-AL
BAR - SAME AS * ABOVE

GROUND BAR KIT MOUNTING INST

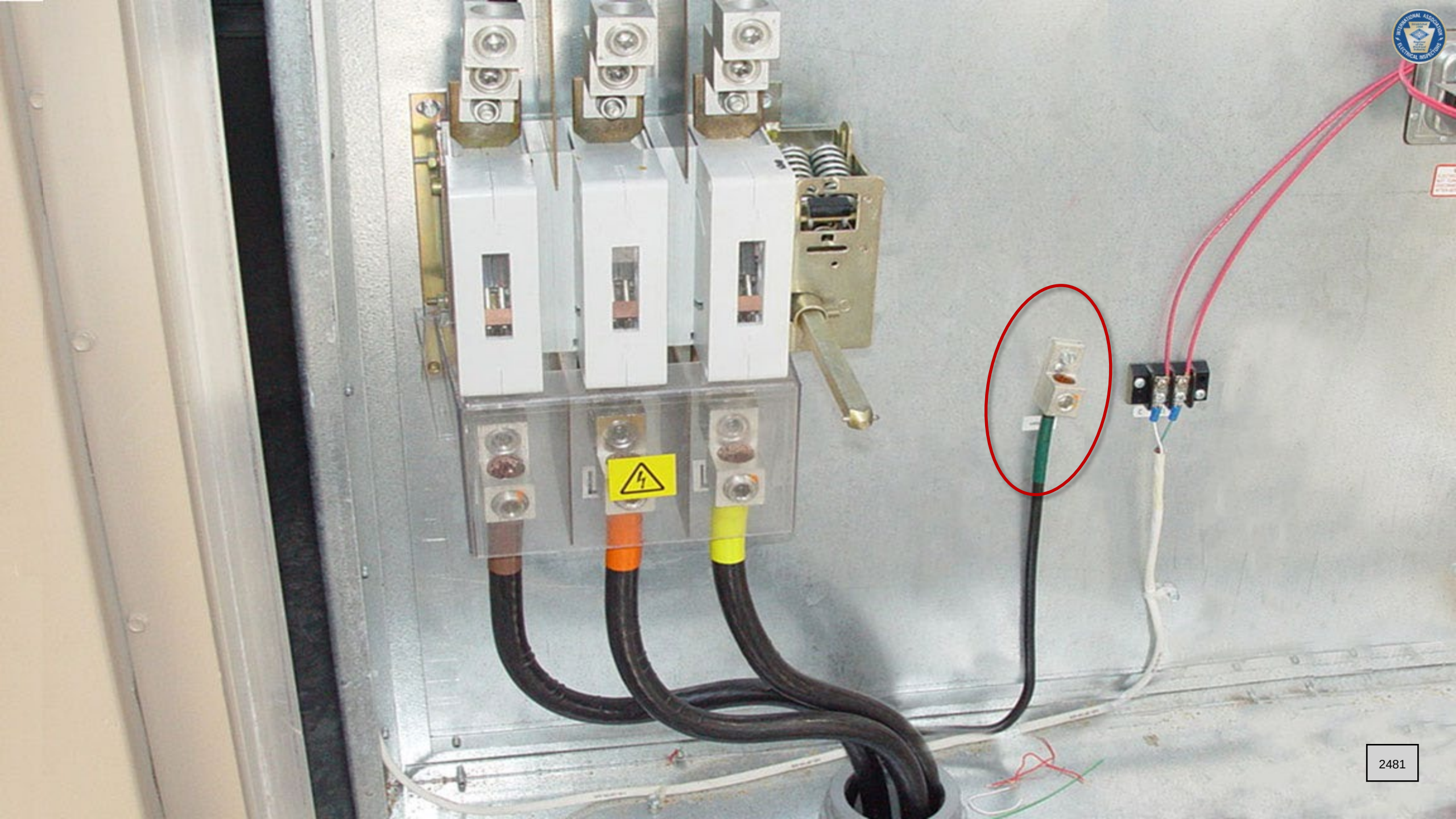
† MINIMUM SPACING REQUIRED
LIVE PARTS AND GROUNDED MET

VOLTAGE	† TH AND O
250 OR LESS	
251 THRU 600	1

IMPORTANT

READ INSTRUCTIONS CAREFULLY TO INS
INSTALLATION OF INTERIOR ASSE

MOUNTING TYPE NQOD INTERIORS IN NQ A



2481

Equipment Grounding Conductors

- Equipment grounding conductors provide two separate but important purposes
- Equipment grounding conductors are intended to:
  - Connect equipment to ground *(earth)* ***(grounding)***
  - Provide an effective ground-fault current path to facilitate overcurrent device operation in ground-fault conditions ***(bonding)***
- Equipment grounding conductors then help **minimize any objectionable potential** above ground on conductors and equipment enclosures

Equipment Grounding Conductors *(cont.)*

- Equipment grounding conductors *(or path for fault current)* must also:
  - Be electrically continuous
  - Have ample capacity to conduct safely any currents likely to be imposed on it
  - Be of the lowest practical impedance
- See 250.4(A)(5)

Article 100 Definitions

- ***Grounding Conductor, Equipment (EGC):*** "A conductive path(s) that is part of an effective ground-fault current path and connects normally non-current-carrying metal parts of equipment together and to the system grounded conductor or to the grounding electrode conductor, or both."
- ***Informational Note No. 1:*** It is recognized that the equipment grounding conductor also performs bonding
- ***Informational Note No. 2:*** See 250.118 for a list of acceptable equipment grounding conductors

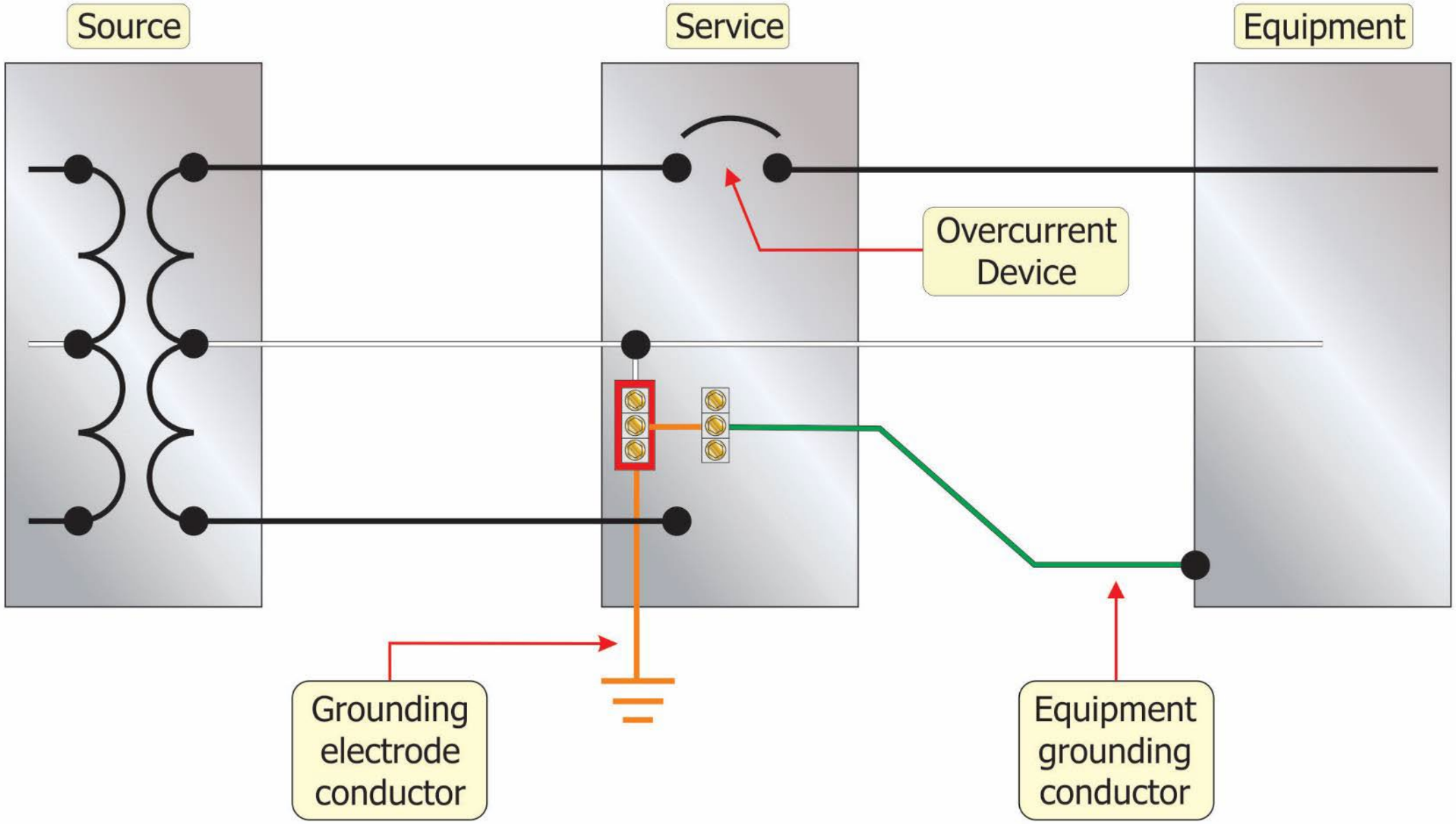
Equipment Grounding Conductors (EGC) in Grounded Systems

- EGC or path is required to extend from the **furthermost point on the circuit** to the power system source *(service equipment or source of separately derived system)*
- Connected to the grounded conductor and grounding electrode conductor on a **grounded system**
- Connected to the disconnecting means enclosure and the grounding electrode conductor for an **ungrounded system**
- For the grounded system, connection is generally made through the **main or system bonding jumper**
- Often, the EGC or path is the conductor enclosure *(conduit, metal cable jacket, etc.)*

Equipment Grounding Conductors (EGC) in Grounded Systems *(cont.)*

- Should insulation failure occur anywhere on a phase conductor and a ground fault develops between the energized conductor and the conductor enclosure, a **ground-fault circuit** will be established
- Ground-fault circuit will therefore be from the source
  - through the supply conductors
  - through the overcurrent devices
  - to the point of fault on the phase conductor *(many times through an arc)*
  - through the equipment grounding conductor
  - through the main bonding jumper
  - to the grounded *(neutral)* conductor and…
- **back to the source**

Ground Fault in Grounded System

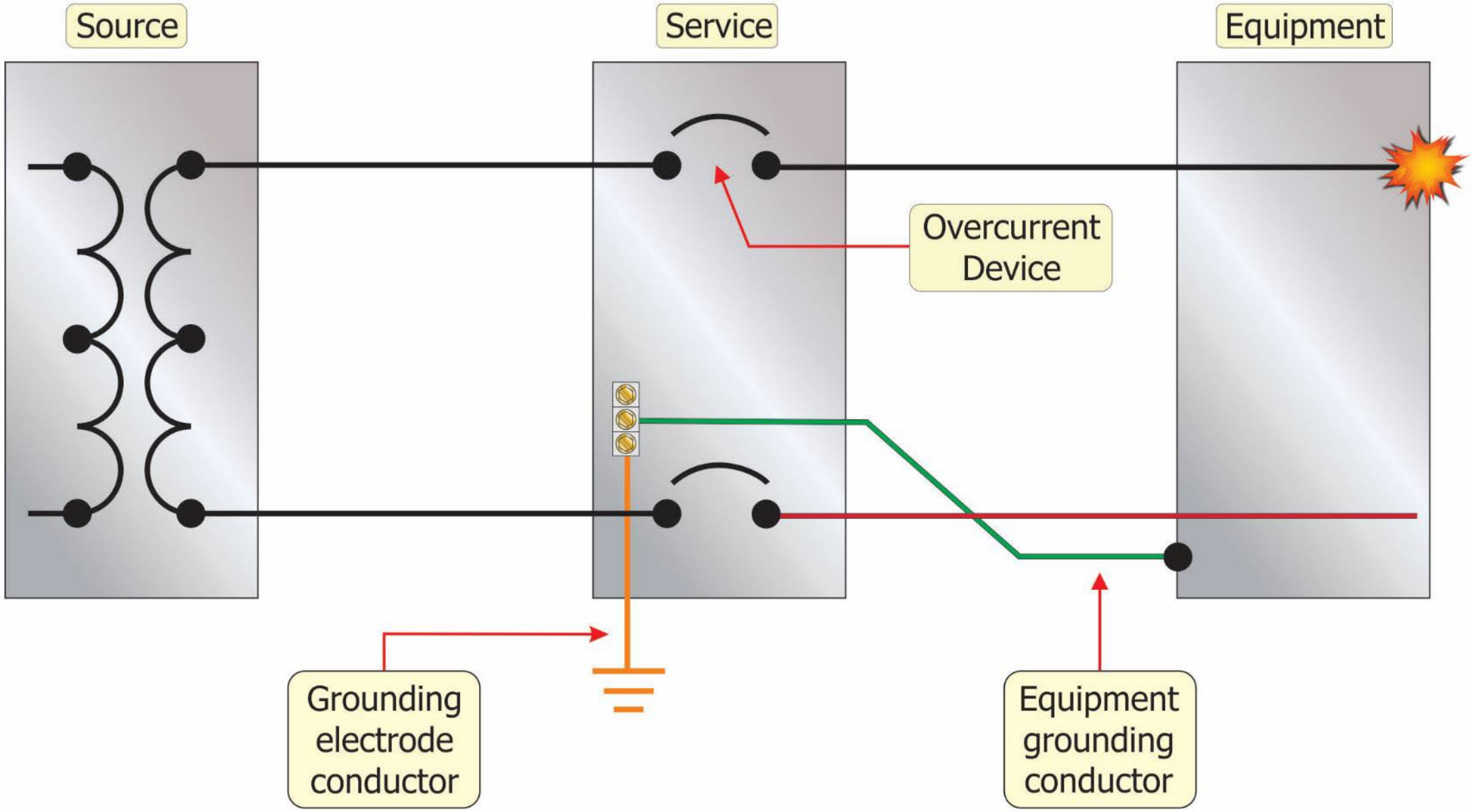


Copyright © IAEI 2020

Equipment Grounding Conductors (EGC) in Ungrounded Systems

- In an ungrounded system, the EGC or path is required to be **permanent and continuous** to the supply equipment grounding point
- Keeps all equipment and conductor enclosures at or near ground potential
- Also provides a **fault-current path** in the event a second ground fault on another phase occurs
- EGC must be the same size as called for in a grounded system if we are to have maximum safety
- Minimum sizes of EGCs given in **Table 250.122** apply equally to an ungrounded system and a grounded system

Ground Fault in an Ungrounded System



Copyright © IAEI 2020

Equipment Grounding Conductor (EGC) Types [250.118]

(1) **Copper conductor** or other corrosion-resistant conductor *(solid or stranded; insulated, covered, or bare)*

(2) Rigid metal conduit **(RMC)**

(3) Intermediate metal conduit **(IMC)**

(4) Electrical metallic tubing **(EMT)**

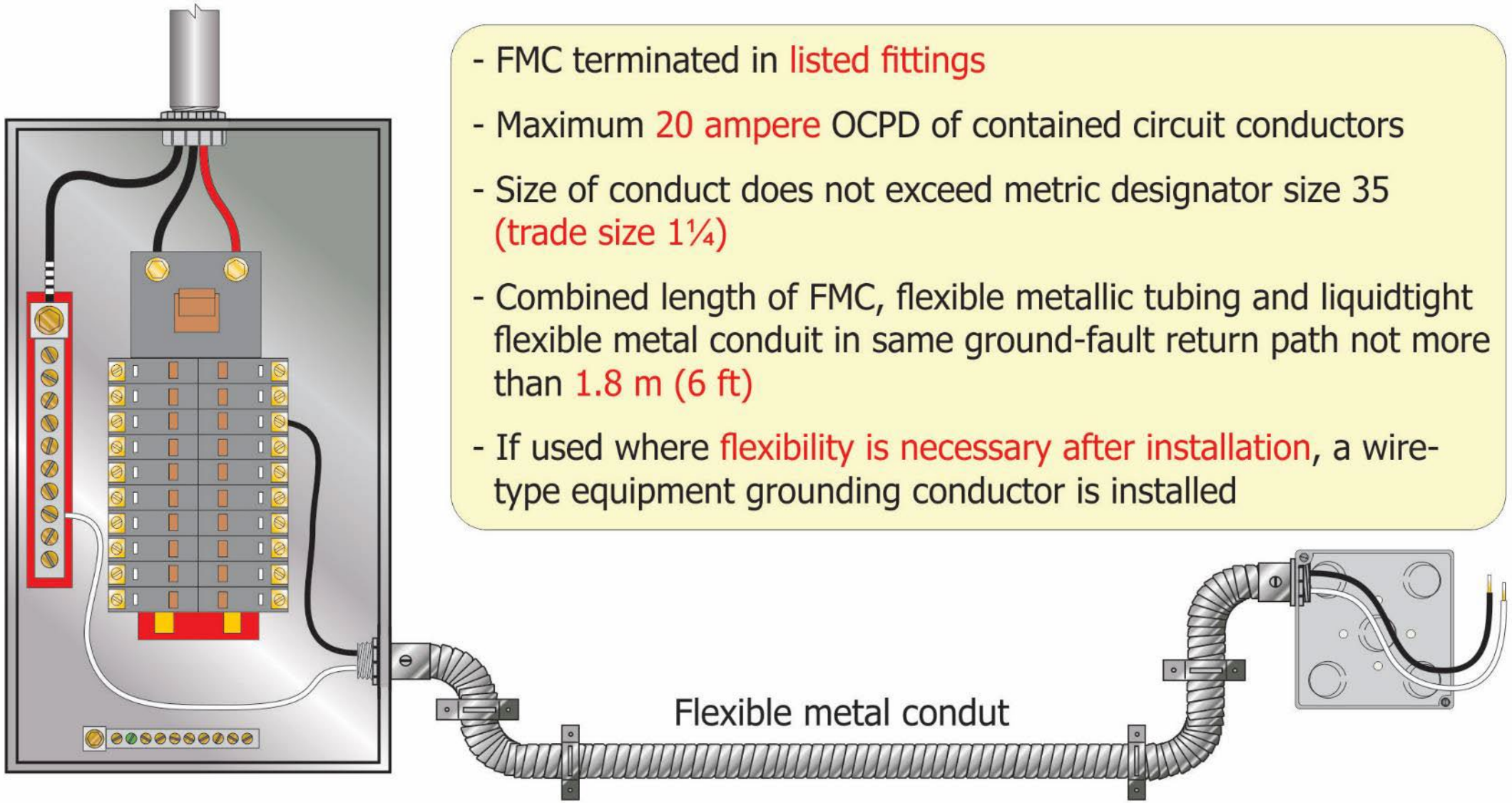
Equipment Grounding Conductor (EGC) Types [250.118] *(cont.)*

(5) **Listed flexible metal conduit** that meets all of the following requirements:

- (a) The conduit is terminated in listed fittings
- (b) Circuit conductors contained are protected at 20 amperes or less
- (c) The size of the conduit does not exceed metric designator 35 (trade size 1¼)
- (d) Combined length in the same effective ground-fault current return path does not exceed 1.8 m (6 ft)
- (e) If used where flexibility is necessary after installation, a wire-type equipment grounding conductor is installed

Flexible Metal Conduit as EGC

Flexible metal conduit (FMC) permitted as equipment grounding conductor (EGC) when meeting all the following conditions:

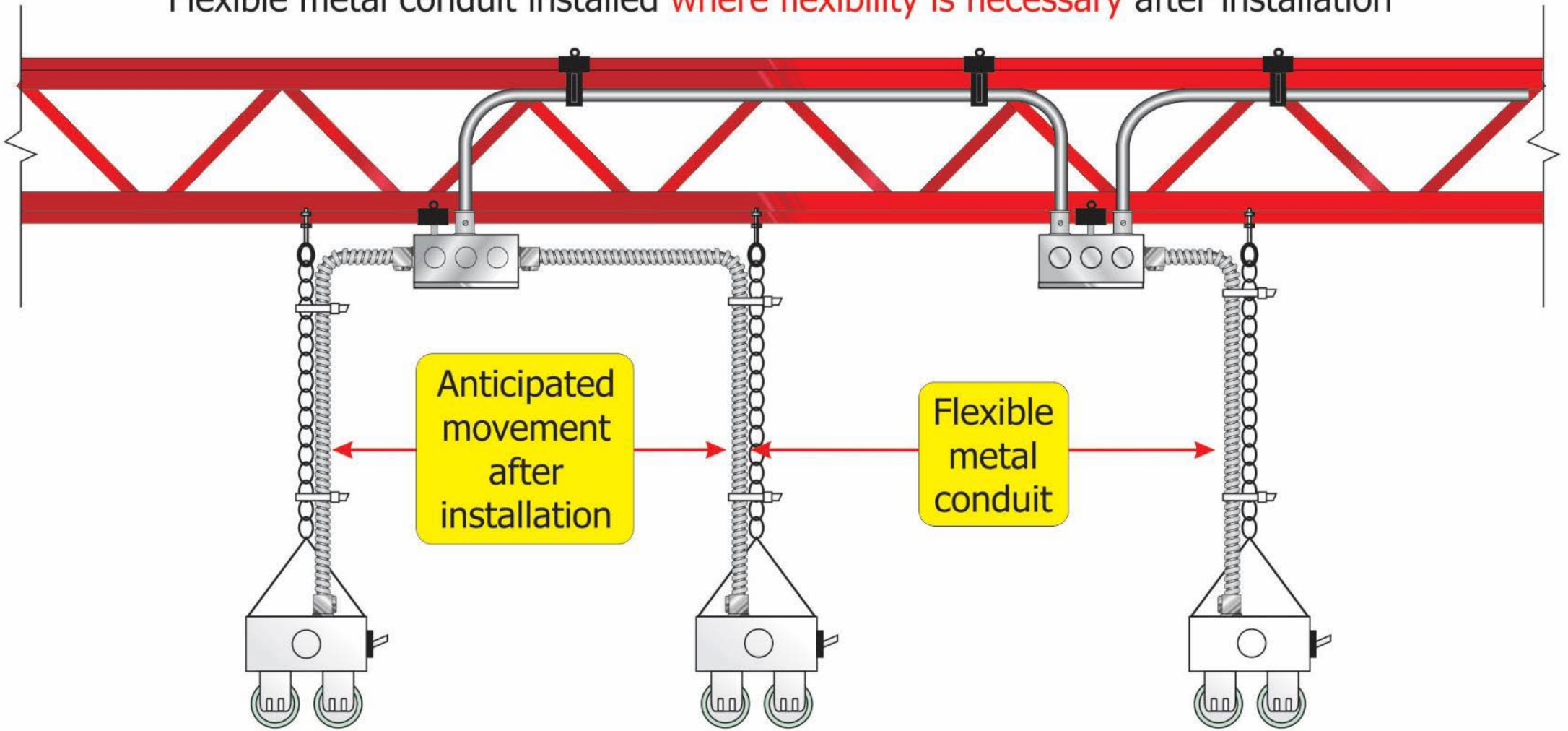


- FMC terminated in listed fittings
- Maximum 20 ampere OCPD of contained circuit conductors
- Size of conduct does not exceed metric designator size 35 (trade size 1¼)
- Combined length of FMC, flexible metallic tubing and liquidtight flexible metal conduit in same ground-fault return path not more than 1.8 m (6 ft)
- If used where flexibility is necessary after installation, a wire-type equipment grounding conductor is installed

Copyright © IAEI 2020

Flexible Metal Conduit as EGC

Flexible metal conduit installed where flexibility is necessary after installation



Wire-type equipment grounding conductor (EGC) is required to be sized using Table 250.122

Copyright © IAEI 2020

Equipment Grounding Conductor (EGC) Types [250.118] *(cont.)*

(6) **Listed liquidtight flexible metal conduit** meeting all the following conditions:

- (a) The conduit is terminated in listed fittings
- (b) For metric designators 12 through 16 (⅜ through ½), conductors are protected at 20 amperes or less
- (c) For metric designators 21 through 35 (¾ through 1¼ in), the conductors are protected at 60 amperes or less; and there is no flexible metal conduit, flexible metallic tubing, or liquidtight flexible metal conduit in metric designators 12 through 16 (trade sizes ⅜ through ½) in the effective ground-fault current return path

Equipment Grounding Conductor (EGC) Types [250.118] *(cont.)*

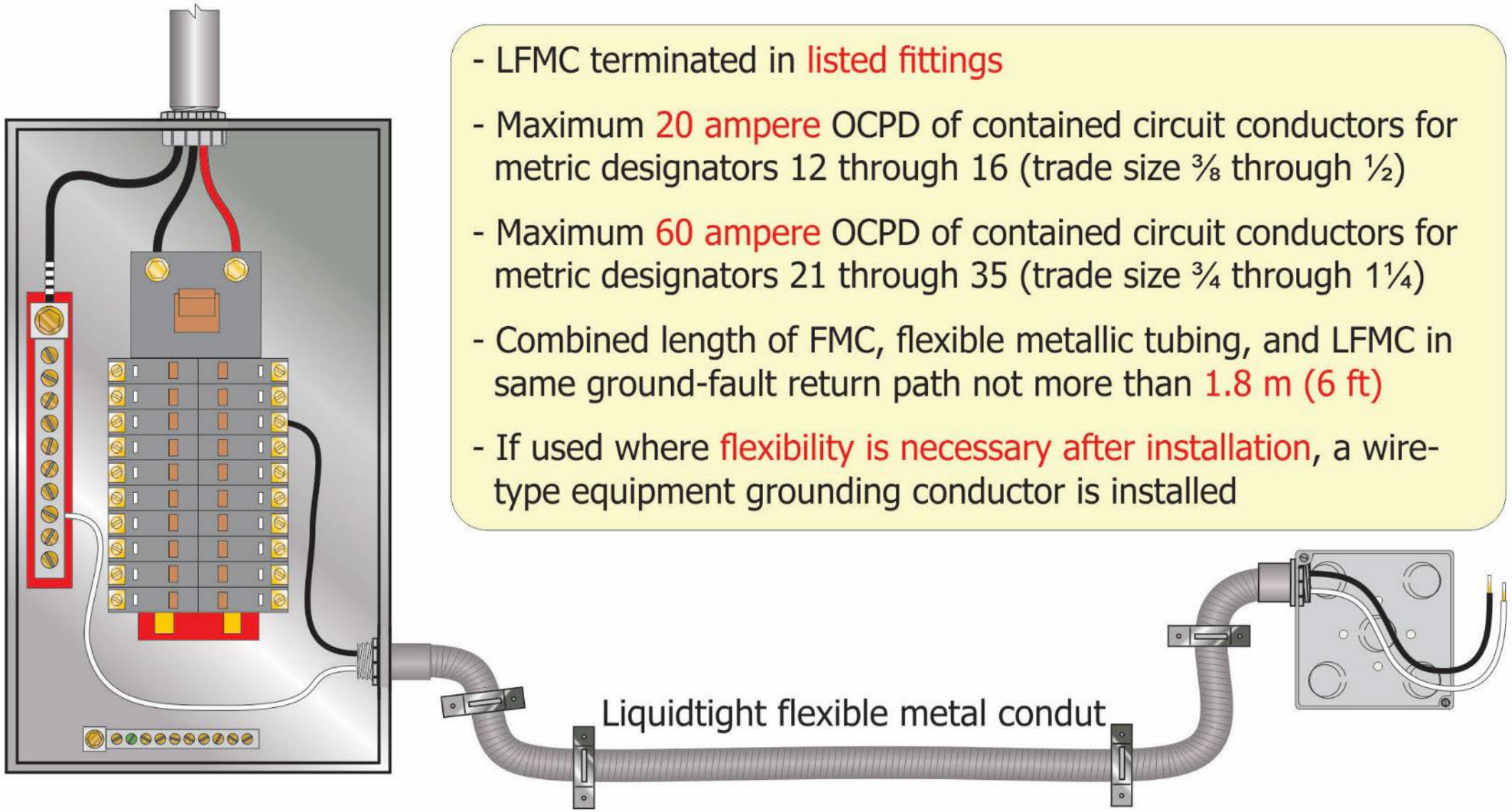
(6) **Listed liquidtight flexible metal conduit** meeting all the following conditions: *(cont.)*

- (d) Combined length of flexible metal conduit, flexible metallic tubing, and liquidtight flexible metal conduit in the effective ground-fault current return path not to exceed 1.8 m (6 ft)
- (e) If used to connect equipment where flexibility is necessary after installation, a wire-type equipment grounding conductor shall be installed

Liquidtight Flexible Metal Conduit as EGC

Liquidtight flexible metal conduit (LFMC) permitted as equipment grounding conductor (EGC) when meeting all the following conditions:

- LFMC terminated in listed fittings
- Maximum 20 ampere OCPD of contained circuit conductors for metric designators 12 through 16 (trade size ⅜ through ½)
- Maximum 60 ampere OCPD of contained circuit conductors for metric designators 21 through 35 (trade size ¾ through 1¼)
- Combined length of FMC, flexible metallic tubing, and LFMC in same ground-fault return path not more than 1.8 m (6 ft)
- If used where flexibility is necessary after installation, a wire-type equipment grounding conductor is installed



Copyright © IAEI 2020

2497



2498

Equipment Grounding Conductor (EGC) Types [250.118] *(cont.)*

(7) **Flexible metallic tubing** where the tubing is terminated in listed fittings and meeting the following conditions:

- (a) Conductors contained in the tubing are protected at not more than 20 amperes
- (b) The combined length of flexible metal conduit and flexible metallic tubing and liquidtight flexible metal conduit in the same effective ground-fault current return path does not exceed 1.8 m (6 ft)

(8) The armor of **Type AC Cable** as provided 320.108

(9) The copper sheath of mineral-insulated, metal-sheathed cable **(Type MI)**

Equipment Grounding Conductor (EGC) Types [250.118] *(cont.)*

(10) **Type MC Cable** that provides an effective ground-fault current path in accordance with one or more of the following:

- (a) Contains an insulated or uninsulated EGC [250.118(1)]
- (b) The combined metallic sheath and uninsulated equipment grounding/bonding conductor of interlocked metal tape-type MC cable that is listed and identified as an EGC
- (c) The metallic sheath or the combined metallic sheath and EGC of smooth or corrugated tube-type MC cable that is listed and identified as an EGC

Equipment Grounding Conductor (EGC) Types [250.118] *(cont.)*

(11) **Cable trays** as permitted in 392.10 and 392.60

(12) **Cablebus** framework as permitted in 370.3

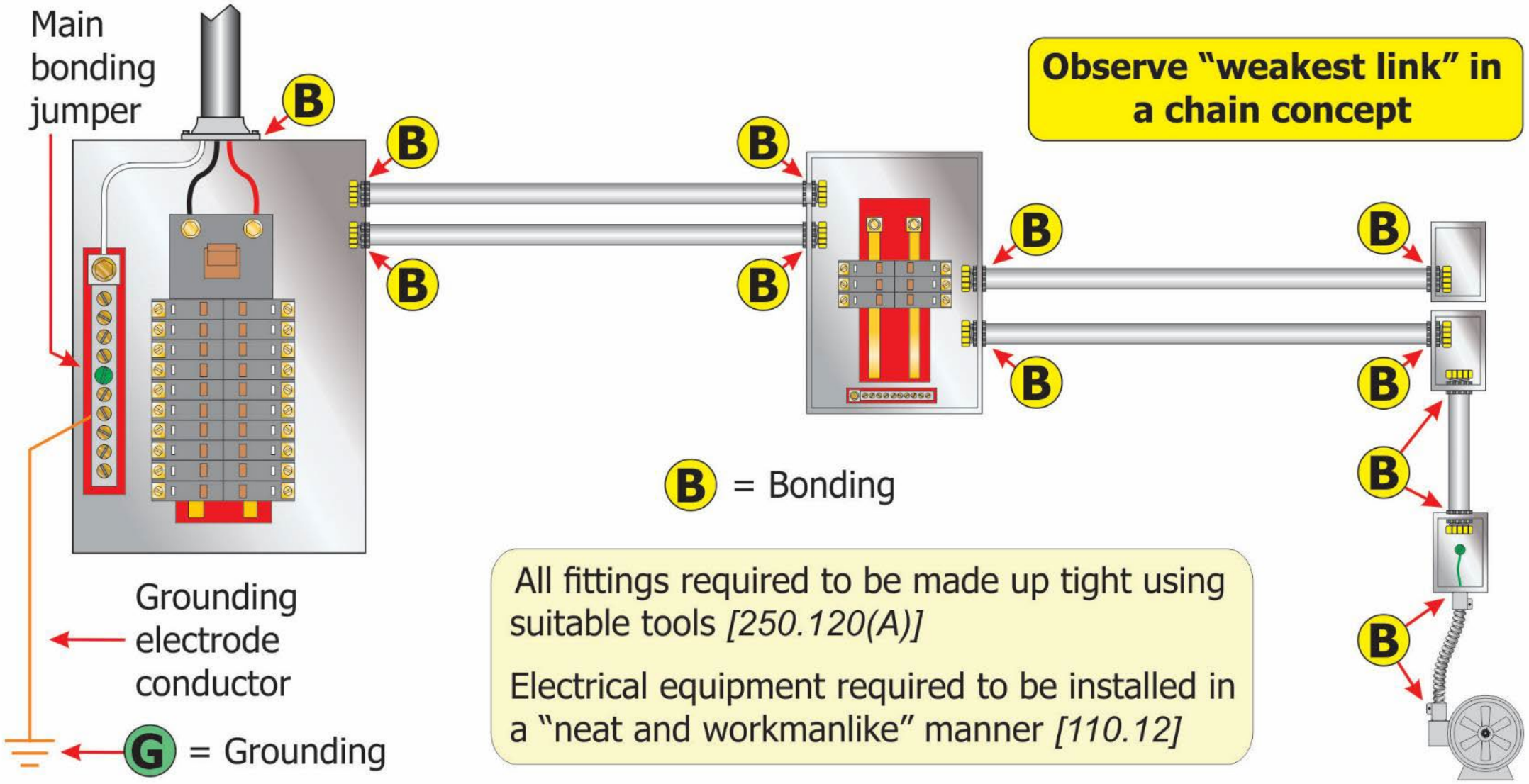
(13) Other listed electrically continuous metal raceways and listed **auxiliary gutters**

(14) **Surface metal raceways** listed for grounding

Conductor Enclosures as EGC

- Conduit runs *(RMC, IMC, EMT, etc.)* are usually adequate as an equipment grounding conductor path where sized for conductor fill per Tables 1, 4, 5 or Informative Annex C of Chapter 9 of the *NEC*
- Must be made up wrench-tight, maintain electrical continuity, and installed in a neat and "workmanlike" manner *[250.120(A) and 110.12]*
- Raceway is anticipated to perform effectively as a current-carrying conductor during ground-fault conditions to facilitate overcurrent device operation *[250.4(A)(5) and (B)(4)]*

Conduit or Tubing as Equipment Grounding Conductor (EGC)



Bonding to maintain electrical continuity and conductivity

Copyright © IAEI 2020

Cables as EGC

- Most cables used as wiring methods are suitable for use as an equipment grounding conductor or contain an equipment grounding conductor
- Where provided, the wire type equipment grounding conductors internal to these cables are sized to **Table 250.122**
- These include:
  - Armored cable (Type AC)
  - Metal-clad cable (Type MC)
  - Nonmetallic-sheathed cable (Type NM)
  - Service-entrance cable (Type SE)
  - Underground feeder cable (Type UF)

Cables as EGC *(cont.)*



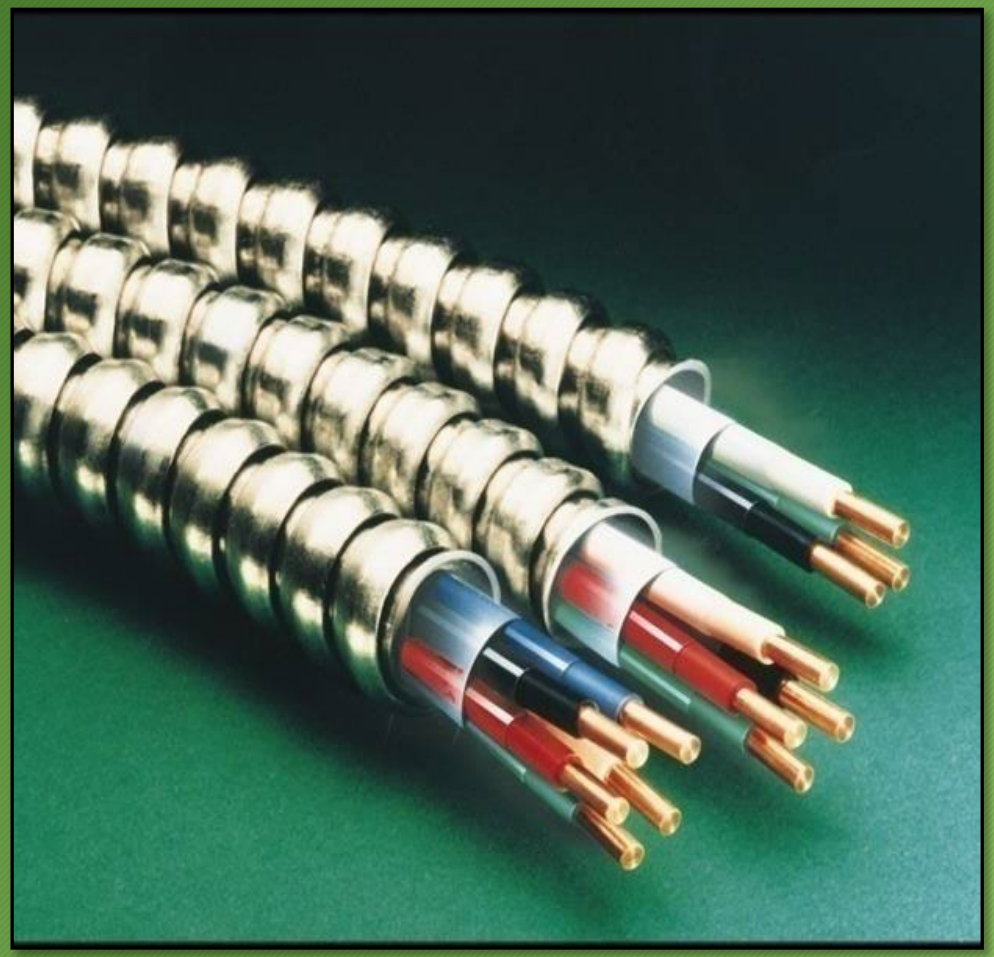
Type AC Cable

- Sizes 14 through 1 AWG CU
- Sizes 12 through 1 AWG AL or CCA
- Armor of flexible metal tape
- Internal bonding strip of copper or aluminum in intimate contact with the armor for the entire length of the cable
- The armor with the internal bonding strip suitable for equipment grounding conductor in accordance with 250.118(8)



2506

Cables as EGC *(cont.)*



Type MC Cable

- Produced in three types:
  - Spiral interlocking metal tape
  - Smooth metal tube
  - Corrugated metal tube
- Has EGC bare or insulated
- Metal sheath and equipment grounding conductor qualify as equipment grounding conductor as specified in 250.118(10)

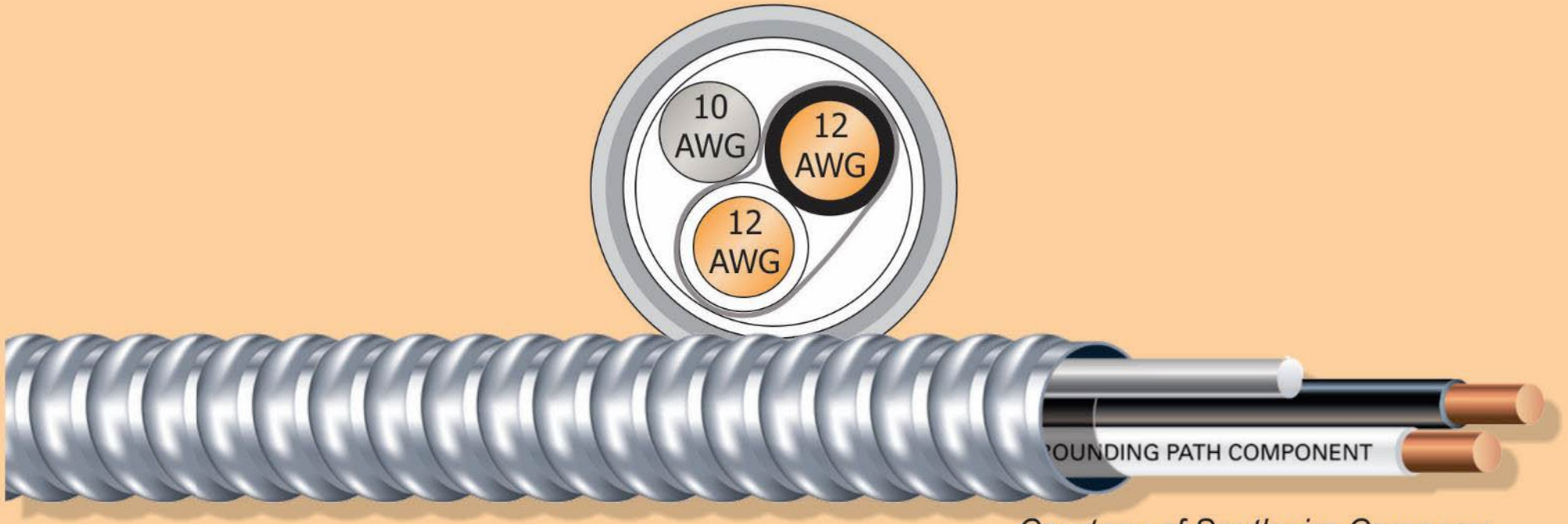
Type MC Cable Armor as Grounding Path

- **Interlocking metal tape** construction includes a bare conductor in the cable assembly in intimate contact with the interlocking tape armor is recognized as an equipment grounding conductor
- These MC cables have **distinct markings** indicating the suitability for the combination metal armor and internal conductor to act as an equipment grounding conductor
- This MC cable and other MC cables are listed and evaluated to **UL Standard 1569**
- Fittings and selected connectors must be listed for use on this type cable for equipment grounding

Type MC Cable Armor as Grounding Path *(cont.)*

- Installing in accordance with the manufacturer's installation instructions is required *[NEC 110.3(B)]*
- This type of MC cable provides **two grounding paths** and is suitable for use where two grounding paths are required by the *NEC (branch circuits in patient care areas or isolated grounding circuits often used for sensitive electronic equipment)*

Type MC Cable Providing Two Grounding Paths



Courtesy of Southwire Company

- Grounding path is equivalent to green copper EGC in conventional Type MC cable
- Armor and AL ground are in direct contact throughout entire cable length
- Grounding path increased based on size of circuit conductors
- Fittings bond the cable to the box
- Less stress on electrical connection

Copyright © IAEI 2020

EGC Not to Serve as Grounding Electrode Conductor

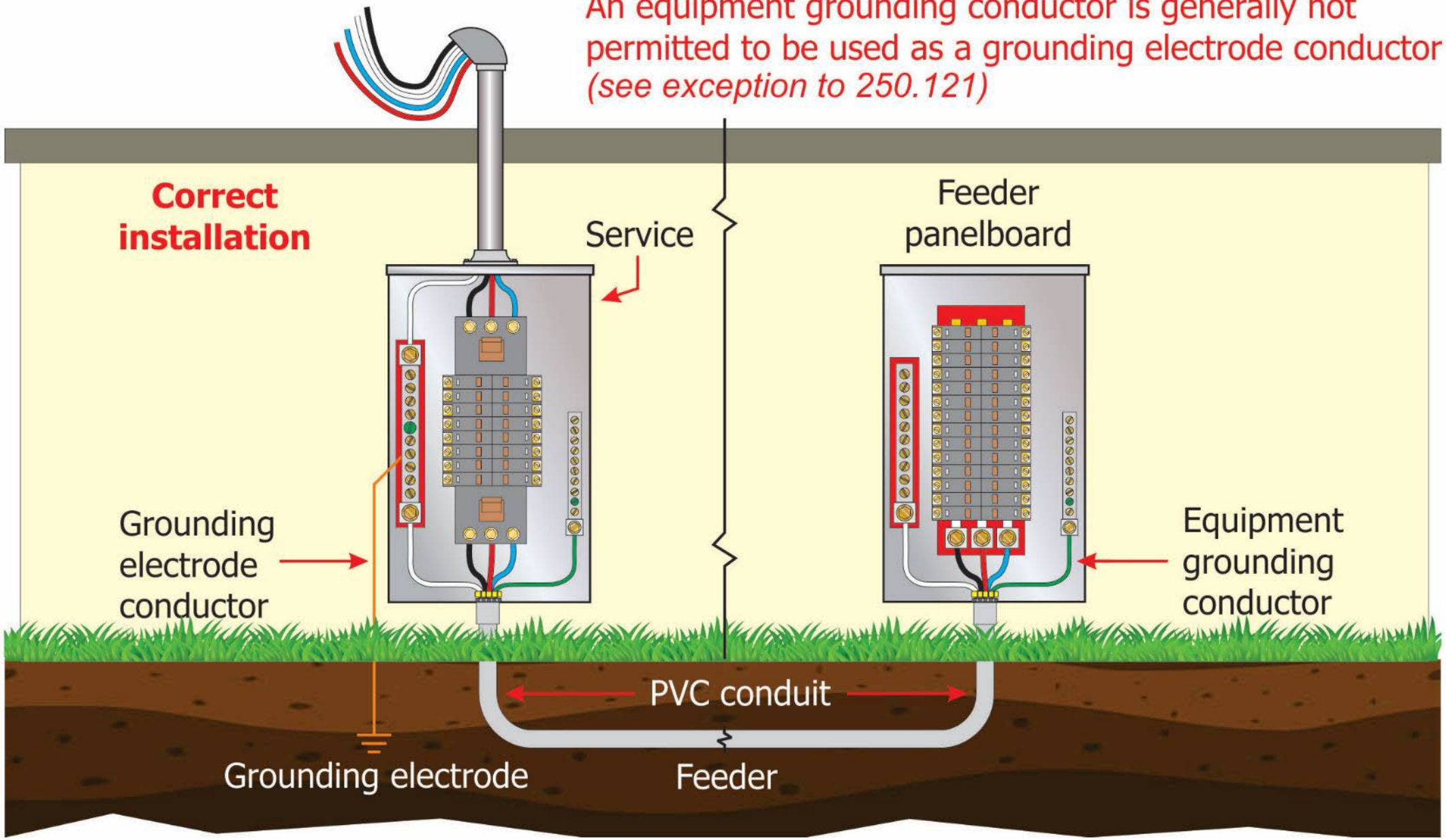
- Equipment grounding conductors generally cannot be used in a dual role as a grounding electrode conductor
- Grounding electrode conductors and equipment grounding conductors serve **two different purposes** in the electrical grounding system
- These conductors are **sized differently** and have many **different installation requirements**
- All of the identified EGCs in 250.118 *(except the wire type)* are not of a construction and material required for grounding electrode conductors as specified in 250.62

EGC Not to Serve as Grounding Electrode Conductor *(cont.)*

- Equipment grounding conductors do not normally carry current while a grounding electrode conductor may carry a small amount of current under normal conditions *[often in parallel with the grounded (neutral) conductor]*
- Exception will allow wire type EGCs to also serve as the grounding electrode conductor where all the applicable requirements in Article 250 Parts II, III, and VI are followed:
  - *Continuous from the equipment to the grounding electrode*
  - *All ferrous metal raceways and enclosures bonded at each end*
  - *Connectors listed for grounding and bonding, etc.*
- *See 250.121*

250.121 Use of Equipment Grounding Conductor

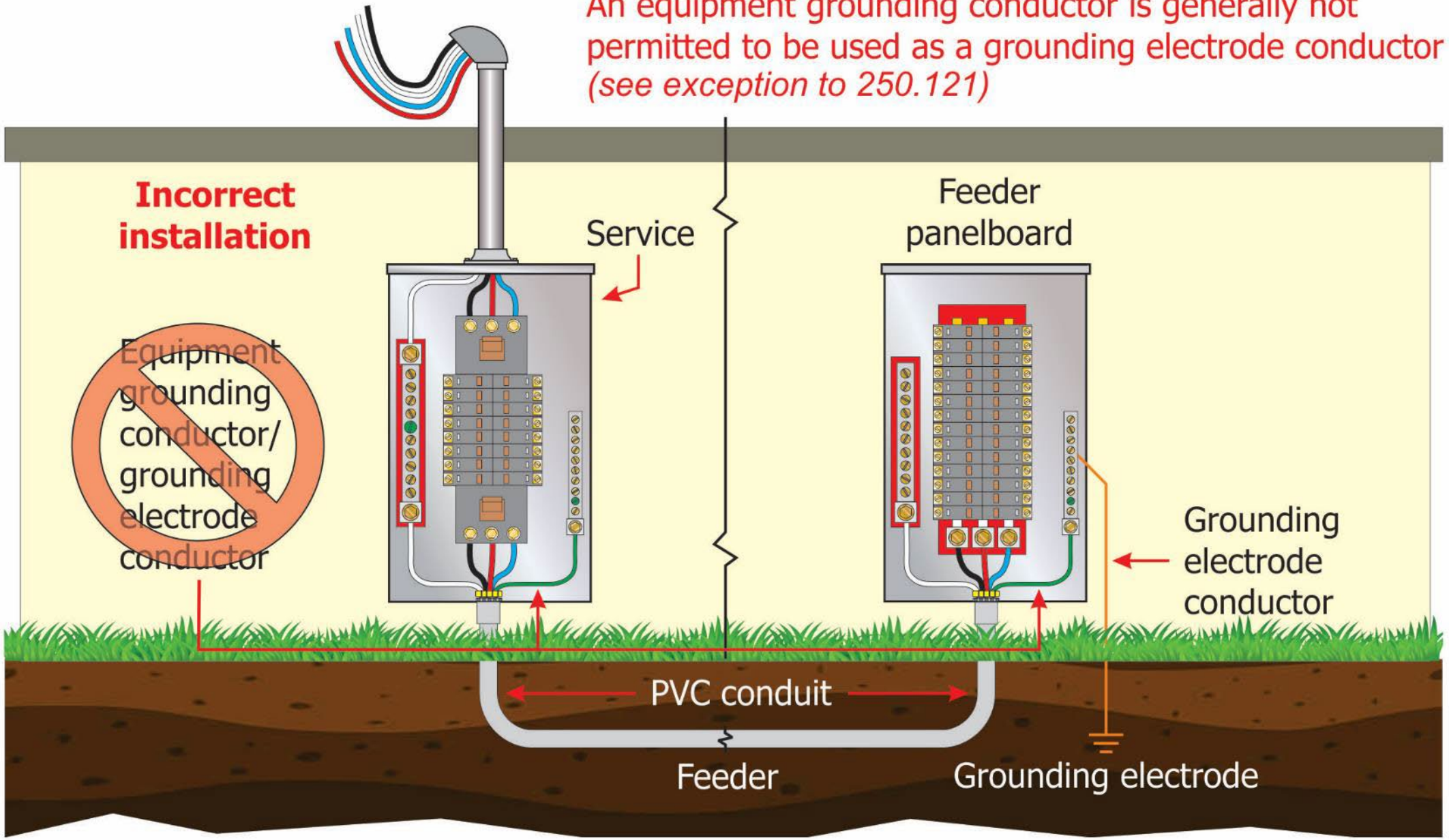
An equipment grounding conductor is generally not permitted to be used as a grounding electrode conductor *(see exception to 250.121)*



Copyright © IAEI 2020

250.121 Use of Equipment Grounding Conductor

An equipment grounding conductor is generally not permitted to be used as a grounding electrode conductor *(see exception to 250.121)*



Copyright © IAEI 2020

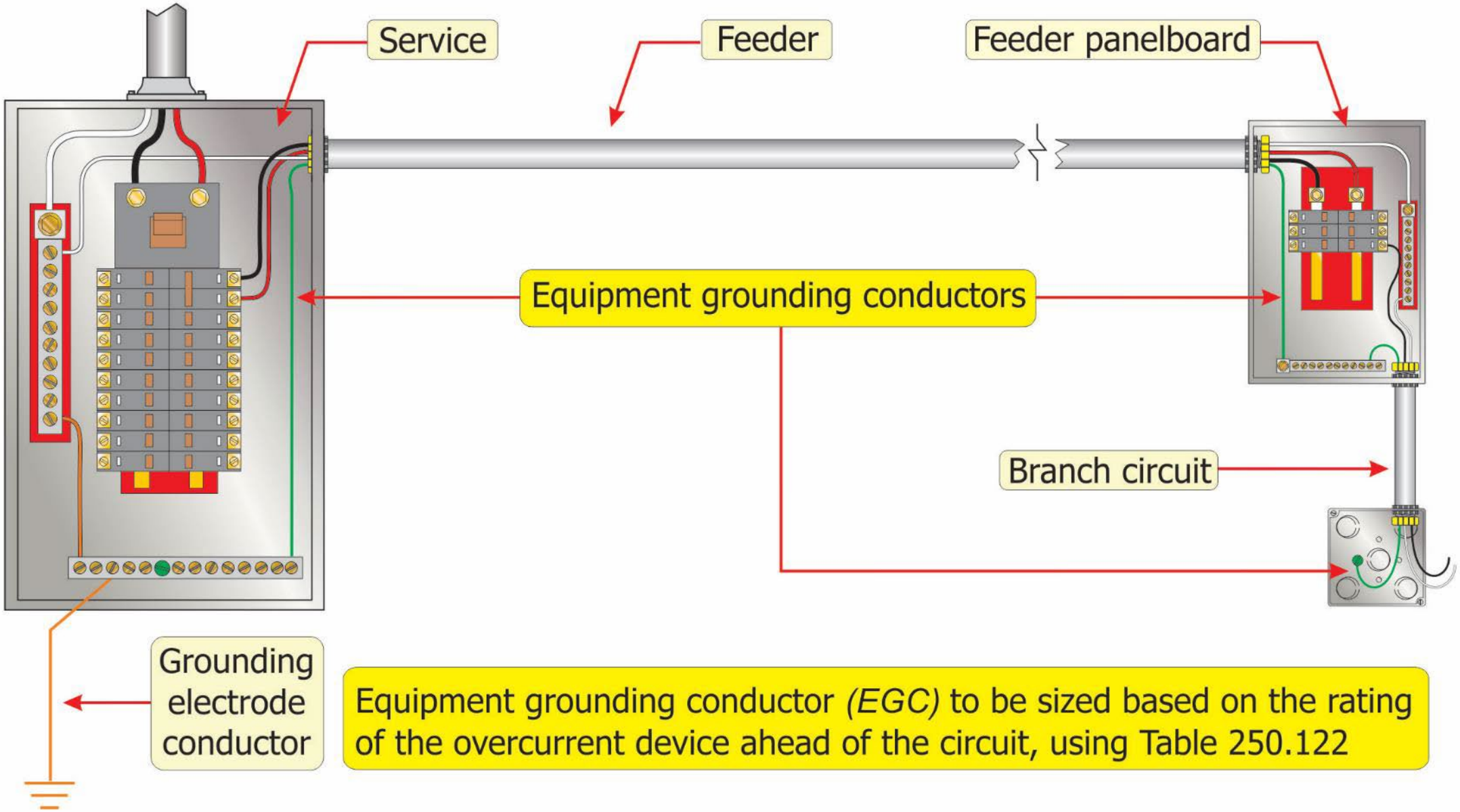
Size of Equipment Grounding Conductors

- Specific requirements for sizing equipment grounding conductors (EGC) are provided as follows:
  - General - 250.122(A)
  - EGCs that are increased in size - 250.122(B)
  - Multiple circuits - 250.122(C)
  - Motor circuits - 250.122(D)
  - Flexible cord and fixture wire - 250.122(E)
  - Conductors in parallel - 250.122(F)

Minimum Size: Equipment Grounding Conductors

- 250.122(A) provides the general requirements for sizing equipment grounding conductors
- Refers to Table 250.122 for determining the minimum size of conductor that is required to be used as an EGC
- The size is based on the ampere rating of the overcurrent protective device ahead of the circuit conductor
- Note: See the note at the bottom of Table 250.122 and 250.4(A)(5) or (B)(4)

250.122(A) Sizing Equipment Grounding Conductors *(EGC)*



Equipment grounding conductor *(EGC)* to be sized based on the rating of the overcurrent device ahead of the circuit, using Table 250.122

Copyright © IAEI 2020

Table 250.122 *(in part)*

Minimum Size Equipment Grounding Conductors for Grounding Raceway and Equipment

Rating or Setting of Automatic Overcurrent Device in Circuit Ahead of Equipment, Conduit, etc., Not Exceeding *(Amperes)*	Size *(AWG or kcmil)*	
	Copper	Aluminum or Copper-Clad Aluminum
15	14	12
20	12	10
60	10	8
100	8	6
200	6	4
300	4	2
400	3	1
500	2	1/0
600	1	2/0
800	1/0	3/0
1000	2/0	4/0
1200	3/0	250
1600	4/0	350

Note: Where necessary to comply with 250.4(A)(5) or 250.4(B)(4), the equipment grounding conductor shall be sized larger than given in this table.

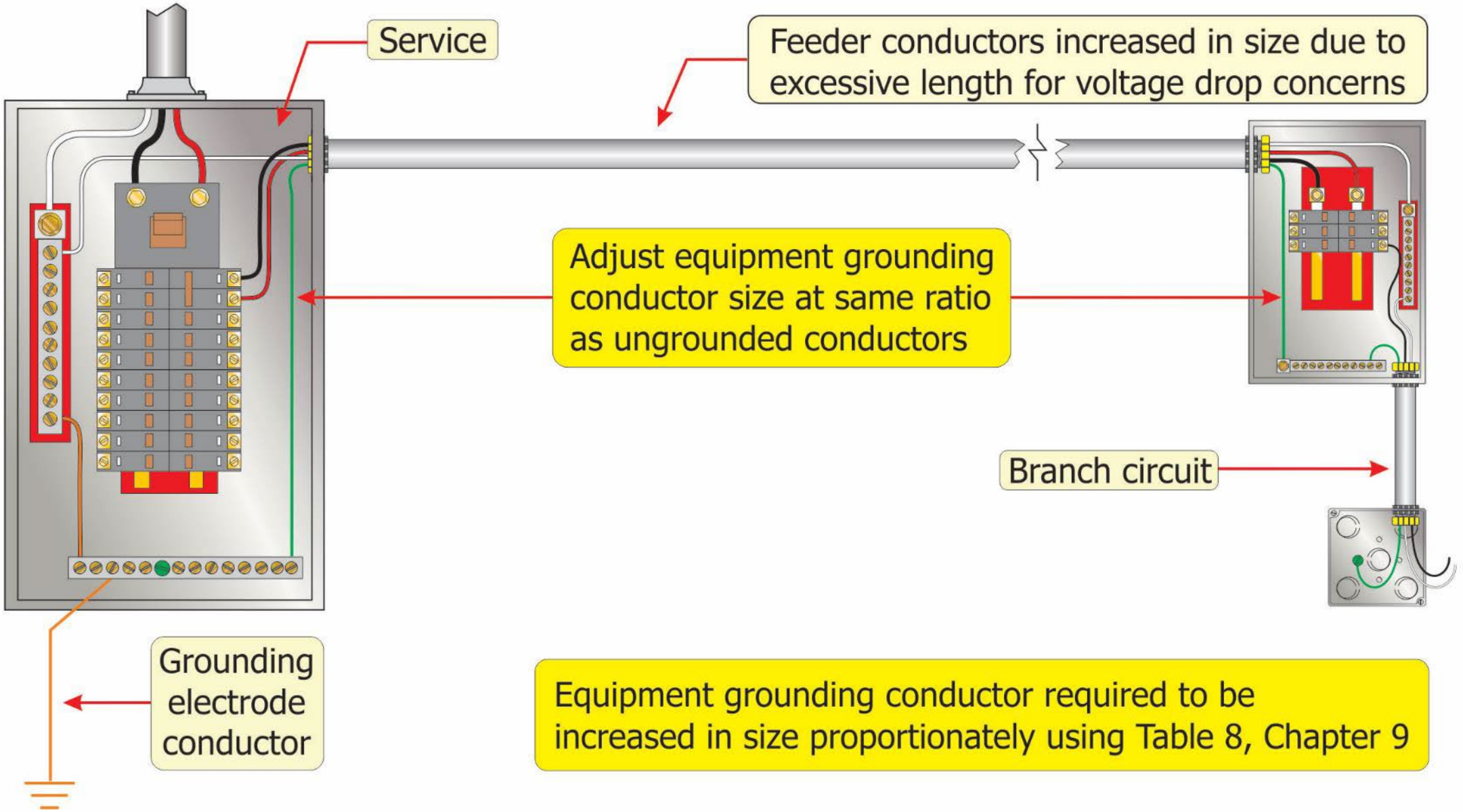
*See installation restrictions in 250.120

Copyright © IAEI 2020

Minimum Size: Equipment Grounding Conductors *(cont.)*

- If ungrounded conductors are increased in size for any reason *[other than as required in 310.15(B) and 310.15(C)]* from the minimum size required, **wire type EGCs** *(if installed)* must be **increased in size proportionately** to the ungrounded conductors
- **Voltage drop** would be an example of a reason to increase the size of the ungrounded conductors
- Wire type EGCs *(if installed)* required to be **increased at not less than the same ratio** the feeder or branch circuit conductors are increased *(except for the application of correction or adjustment factors)*
- *See 250.122(B)*

250.122(B) Adjusting Equipment Grounding Conductor Size



Copyright © IAEI 2020

Increases in Size of Phase Conductors

- If ungrounded conductors are increased in size for any reason *[other than as required in 310.15(B) and 310.15(C)]* from the minimum size required, **wire type EGCs** *(if installed)* must be **increased in size proportionately** to the ungrounded conductors
- Increase equipment grounding conductor by the **same ratio** as the circuit conductors are increased [250.122(B)]
- The kcmil from Table 250.122 or equipment grounding conductor circular mils (cm) from Table 8, Chapter 9 multiplied by the Ratio = Adjusted Required EGC
- *(See example on next slide)*

Adjusting in Proportion

- **Example:**
  - 200-ampere feeder normally requires a 3/0 AWG copper conductor
  - A 6 AWG EGC would normally be installed
  - For excessive voltage drop, the feeder size needs to be increased from 3/0 AWG to 250 kcmil copper
  - 3/0 AWG copper is 167,800 cm per Table 8, Chapter 9 of *NEC*

250,000 cm ÷ 167,800 cm = 1.49

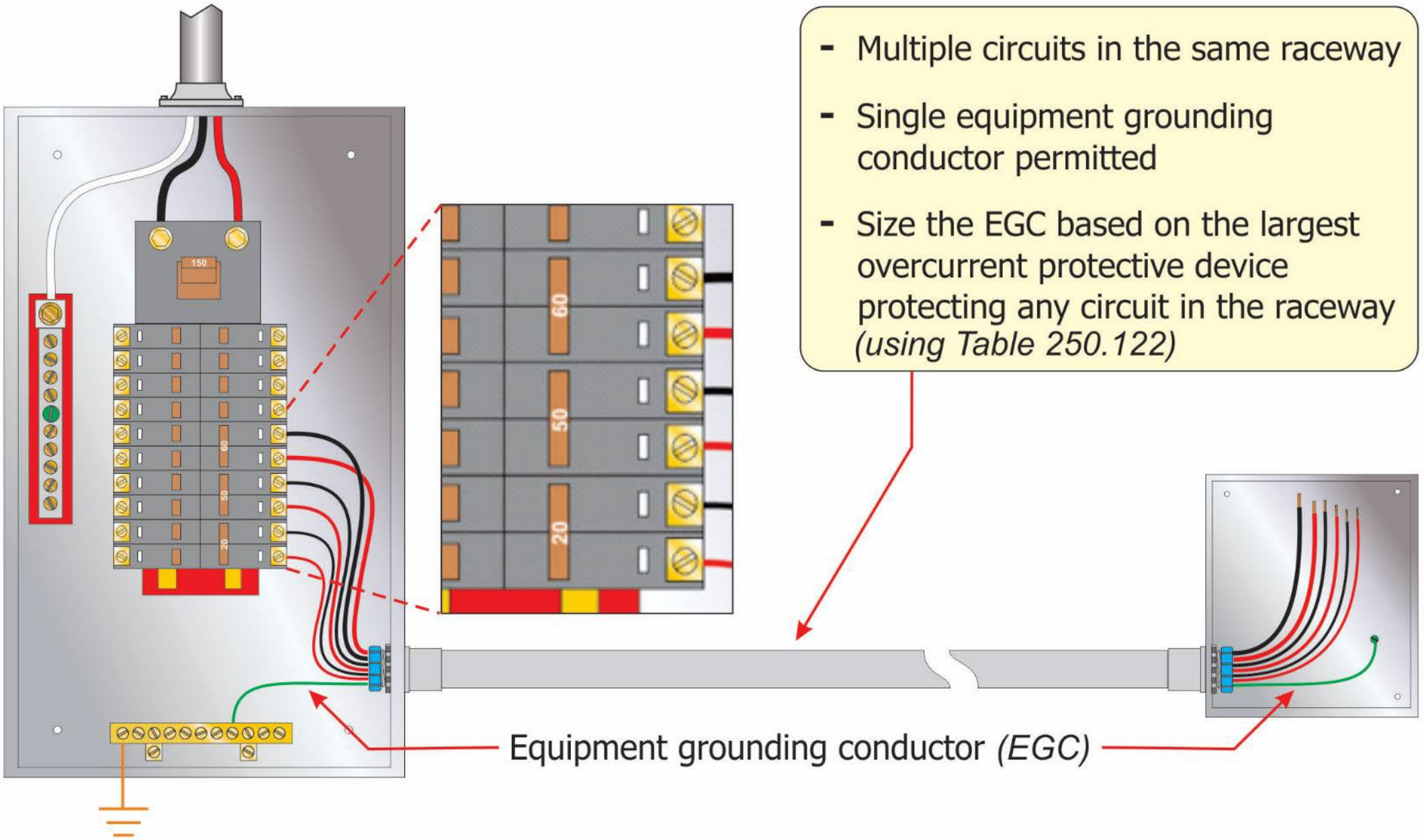
(1.49 is multiplier or ratio increased)

  - 26,240 (cir. mil. of 6 AWG) x 1.49 = 39,098 cm minimum
  - Per Table 8 Chapter 9, the next larger size required would be a 4 AWG copper conductor (41,740 cm)

Single EGC for Multiple Circuits

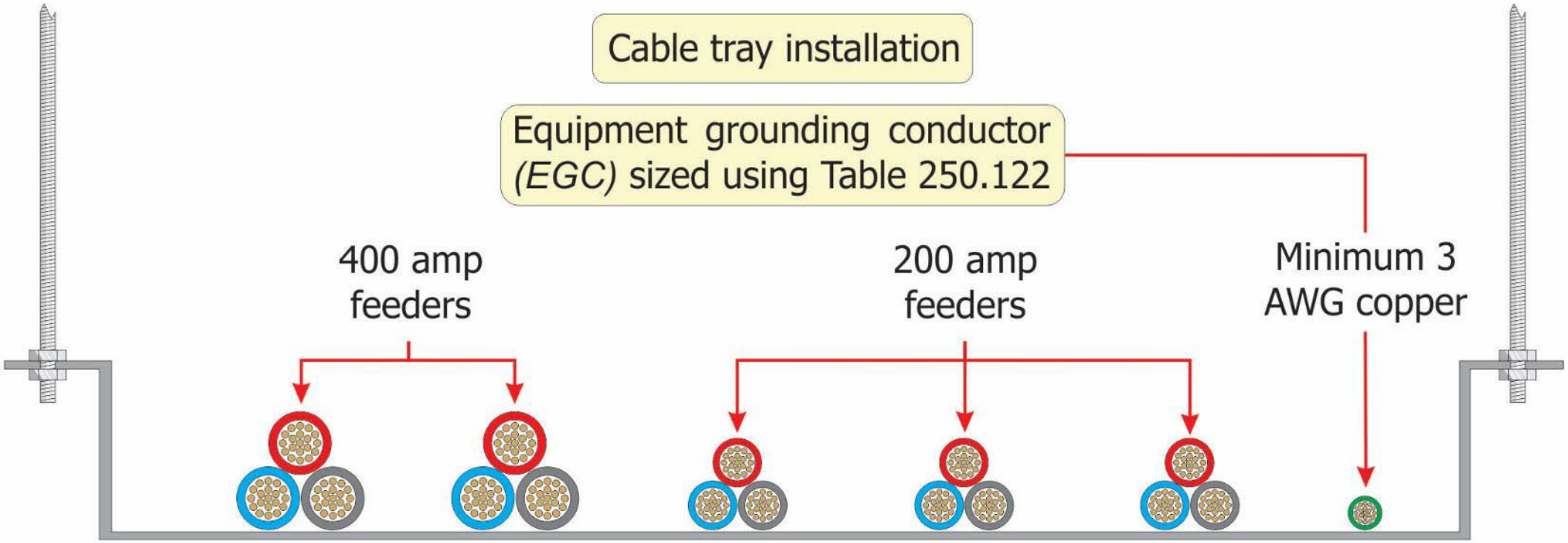
- A single equipment grounding conductor is permitted for multiple circuits installed in the same raceway, cable, or cable tray
- Size using Table 250.122 based on the largest overcurrent protective device ahead of any circuit in the raceway [250.122(C)]
- Equipment grounding conductors installed in cable trays shall meet the minimum requirements of 392.10(B)(1)(c) *(insulated, covered, or bare, 4 AWG or larger)*

250.122(C) Multiple Circuits in the Same Raceway



Copyright © IAEI 2020

250.122(C) Multiple Circuits in Cable Tray



A single equipment grounding conductor is permitted for multiple circuits installed in the same cable tray

The equipment grounding conductor shall be sized based on the rating of the largest overcurrent device protecting the conductors in the tray

Equipment grounding conductors installed in cable trays shall also meet the requirements in 392.10(B)(1)(c) *(min 4 AWG or larger)*

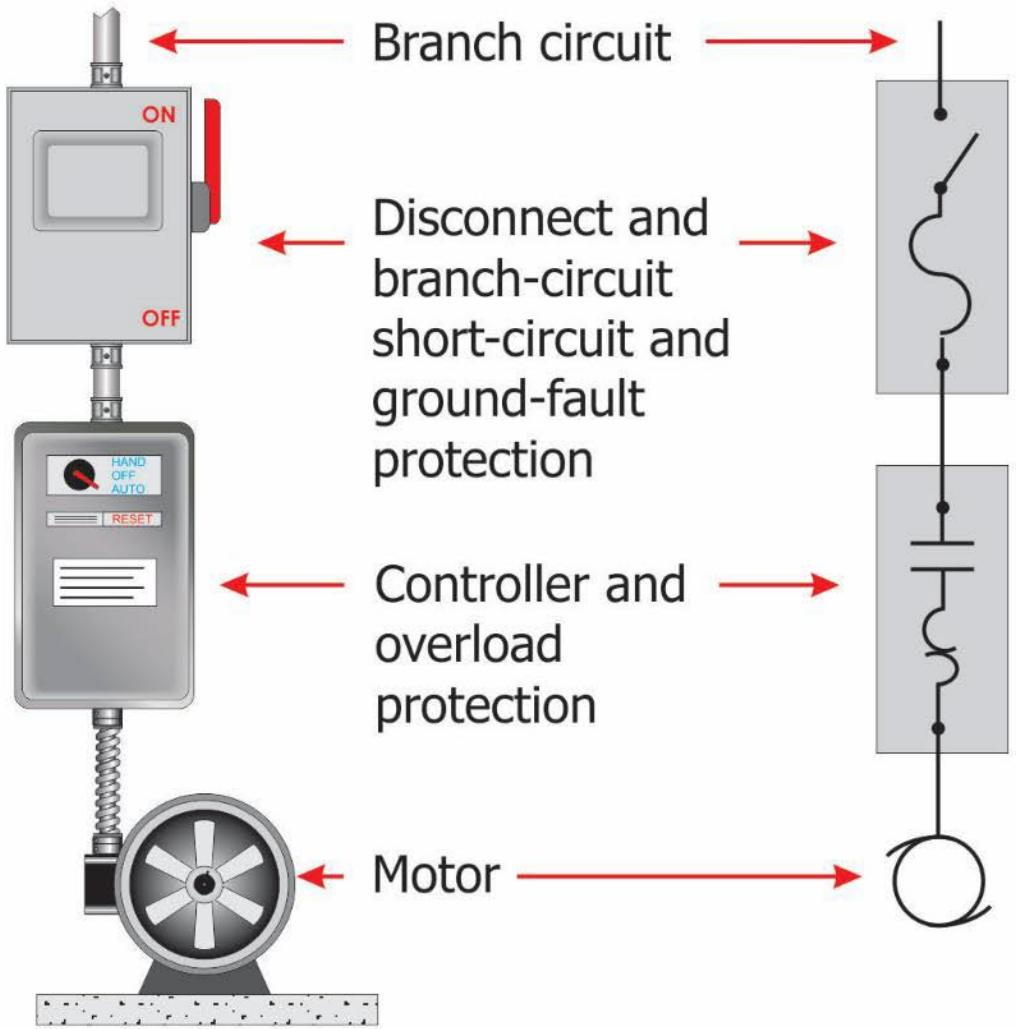
Copyright © IAEI 2020

Equipment Grounding Conductors (EGC) for Motor Circuits

- The general rule for sizing the equipment grounding conductor for motor circuits is contained in 250.122(D)
- EGC shall be sized per 250.122(A) based on the rating of the **branch-circuit short-circuit and ground-fault protective device**
- Where the OCPD is an instantaneous-trip circuit breaker (ITCB) or a motor short-circuit protector (MCP), the EGC shall be sized per 250.122(A) using the maximum permitted rating of a **dual element time-delay fuse** selected for branch-circuit short-circuit and ground-fault protection in accordance with 430.52(C)(1), Ex. No. 1
- *See 250.122(D)(1) and (D)(2)*

250.122(D) Sizing EGCs for Motor Circuits

Size equipment grounding conductor (EGC) based on the rating of the branch-circuit short-circuit and ground-fault protective device, using Table 250.122



Where the overcurrent protective device *(OCPD)* is an instantaneous trip circuit breaker or motor short-circuit protector, the equipment grounding conductor is permitted to be sized using Table 250.122

This is based on the maximum permitted rating of a duel element time-delay fuse selected per 430.52(C)(1), Ex. No. 1

Copyright © IAEI 2020


HVAC Panel

EGCs in Parallel Conductor in Raceways

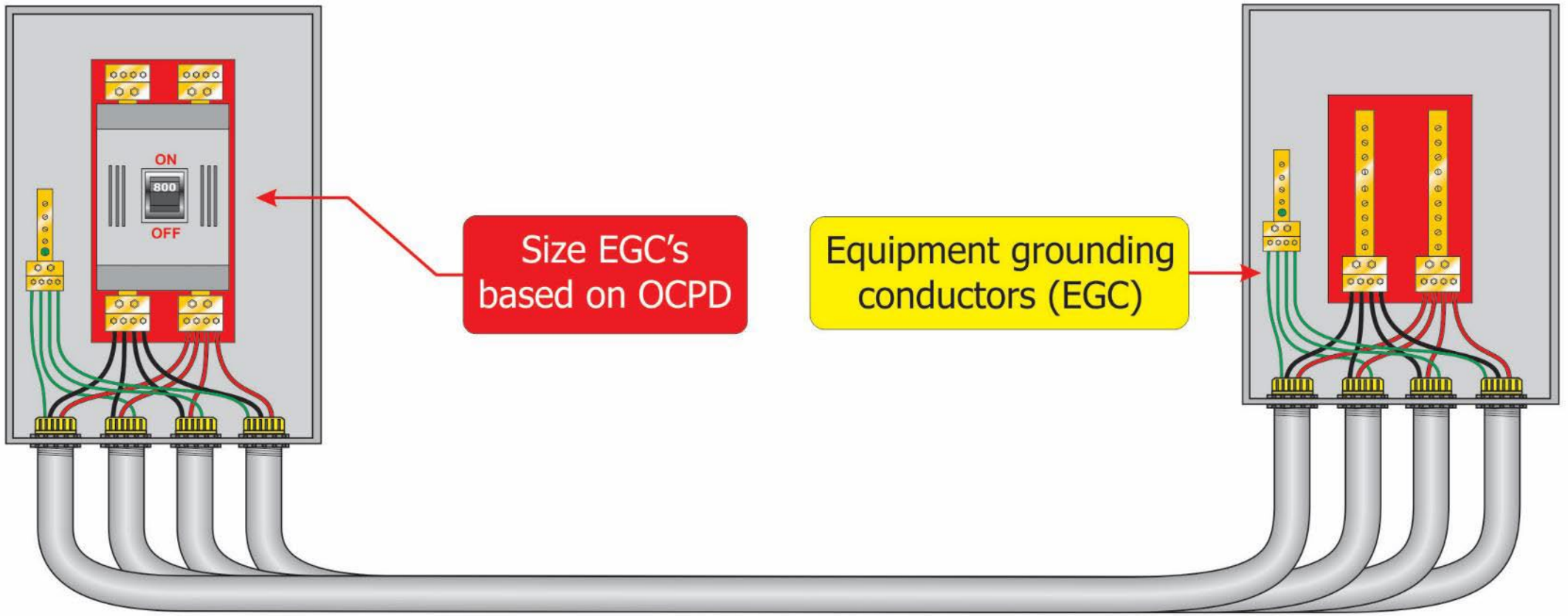
- Parallel conductors consist of **two or more conductors** that comply with 310.10(G), and are connected together at each end to form a **single conducting path**
- Can be in a single raceway or in multiple raceways installed in parallel
- If parallel conductors are installed in a **single raceway** or auxiliary gutter, a single wire-type EGC sized to Table 250.122 based on the rating of the overcurrent protective device permitted
- Where parallel conductors are installed in **multiple raceways** or cables, wire-type EGC *(where used)* must be installed in parallel in **each raceway** or cable as well

EGCs in Parallel Conductor in Raceways *(cont.)*

- Each parallel EGC is required to be sized by Table 250.122, based on the rating of the overcurrent device protecting the parallel run
- **Metal raceways** and **auxiliary gutters** meeting the requirements of 250.118 and **cable trays** meeting 250.118 and Article 392 can be the EGC with or without an additional wire type EGC(s) installed
- See 250.122(F)
- See also 310.10(G) for parallel conductor requirements

250.122(F) EGCs Installed in Parallel

Size equipment grounding conductor (EGC) for parallel runs based on the overcurrent protective device *(OCPD)* ahead of the circuit using Table 250.122



Equipment grounding conductor sized by Table 250.122 is required to be installed in each of the raceways in the parallel set

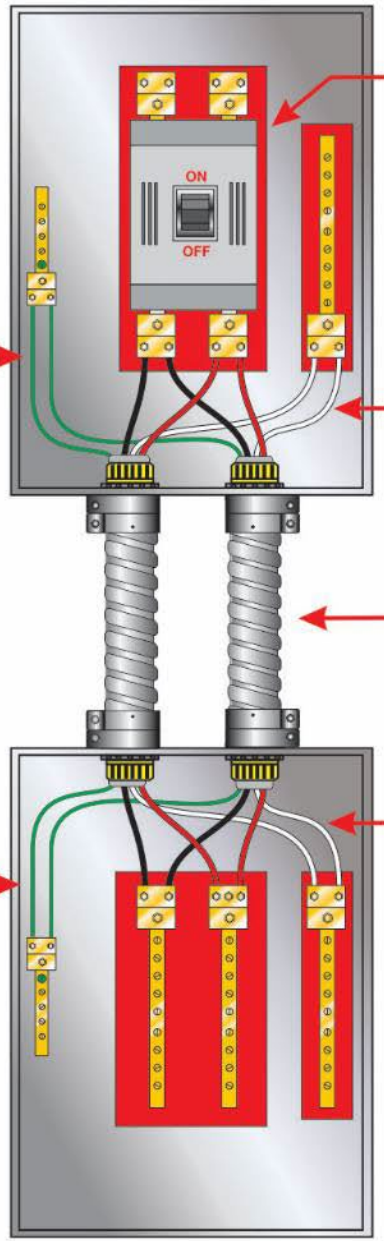
Copyright © IAEI 2020


2532

EGCs in Parallel Conductor in Cables

- In some cases, where cables *(such as Type MC cable)* are installed in parallel, special constructions will be required to comply with the *NEC* requirements on the EGC in the cable
- Listed cables are generally produced with the EGC sized in compliance with a construction standard that complies with Table 250.122, but for cable installed singularly
- These “special” cables can be ordered from the manufacturer although conditions such as minimum length requirements may apply
- The *NEC* separates cables installed in parallel as the sole wiring method, *[see 250.122(F)(2)(a) and (b)]*, also where the cables are installed in a raceway, gutter or cable tray that qualifies as an equipment grounding conductor, *[see 250.122(F)(2)(c) and (d)]*

250.122(F)(2) EGCs in Parallel- Cables



Size equipment grounding conductor (EGC) for parallel runs based on the overcurrent protective device ahead of the circuit, using Table 250.122

Grounded conductors

Cables installed in parallel

Grounded conductors

Equipment grounding conductors

Note: Equipment grounding conductor sized by Table 250.122 is required to be installed in each of the cables in the parallel set

Copyright © IAEI 2020

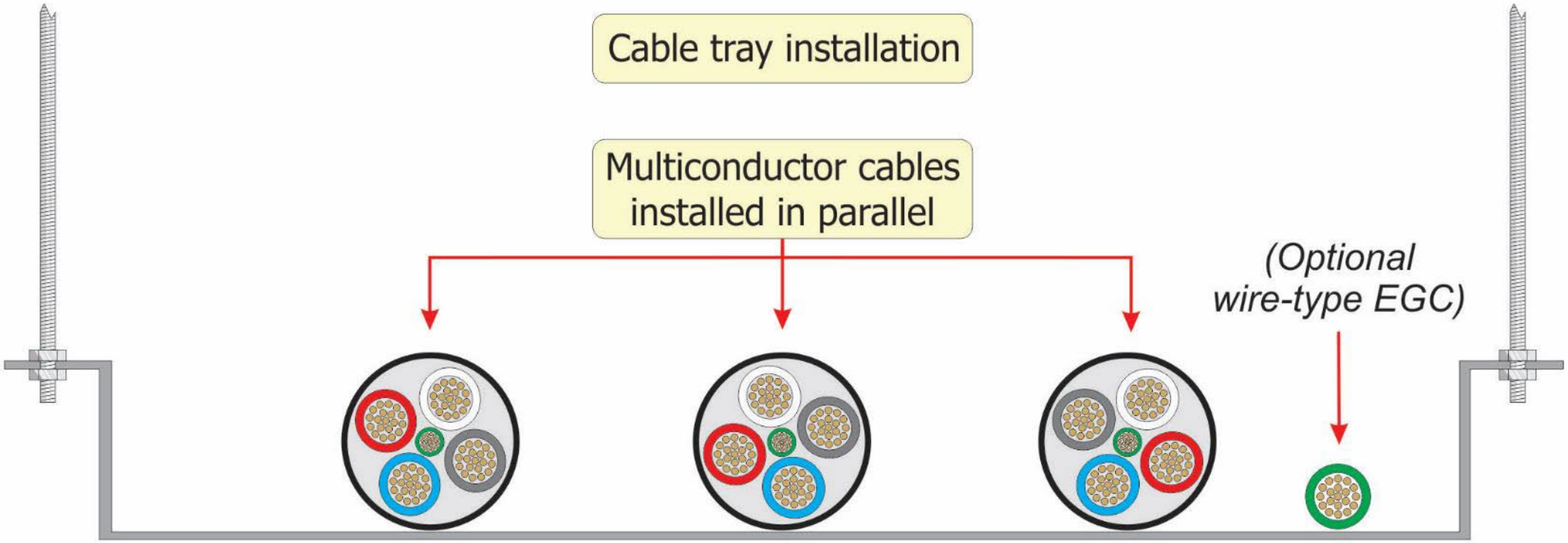
Paralleled Multiconductor Cables Installed in Cable Trays

- If circuit conductors of multiconductor cables are connected in parallel, the equipment grounding conductor(s) (EGC) in each cable are required to be connected in parallel as well
- If multiconductor cables are paralleled in the same raceway, auxiliary gutter, or cable tray, a **single EGC** that is sized in accordance with 250.122 is permitted in combination with the EGCs provided within the multiconductor cables
- Single EGC and all EGCs provided within the multiconductor cables must be **connected together**

Paralleled Multiconductor Cables Installed in Cable Trays *(cont.)*

- EGCs installed in cable trays must meet the minimum requirements of **392.10(B)(1)(c)** *(insulated, covered, or bare, 4 AWG or larger)*
- Cable trays complying with **392.60(B)**, metal raceways in accordance with 250.118, or auxiliary gutters permitted to serve as the equipment grounding conductor
- Except as provided in **250.122(F)(2)(c)** for raceway or cable tray installations, the equipment grounding conductor in each multiconductor cable shall be sized in accordance with 250.122 based on the overcurrent protective device for the feeder or branch circuit
- *See 250.122(F)(2)*

250.122(F)(2) Multiconductor Cables in Parallel in Cable Tray



Where the cable tray is the equipment grounding conductor (EGC) *(with or without a wire type equipment grounding conductor)*, the EGCs within each multiconductor cable are generally required to be sized in accordance with 250.122 based on the overcurrent protective device for the individual feeder or branch circuits

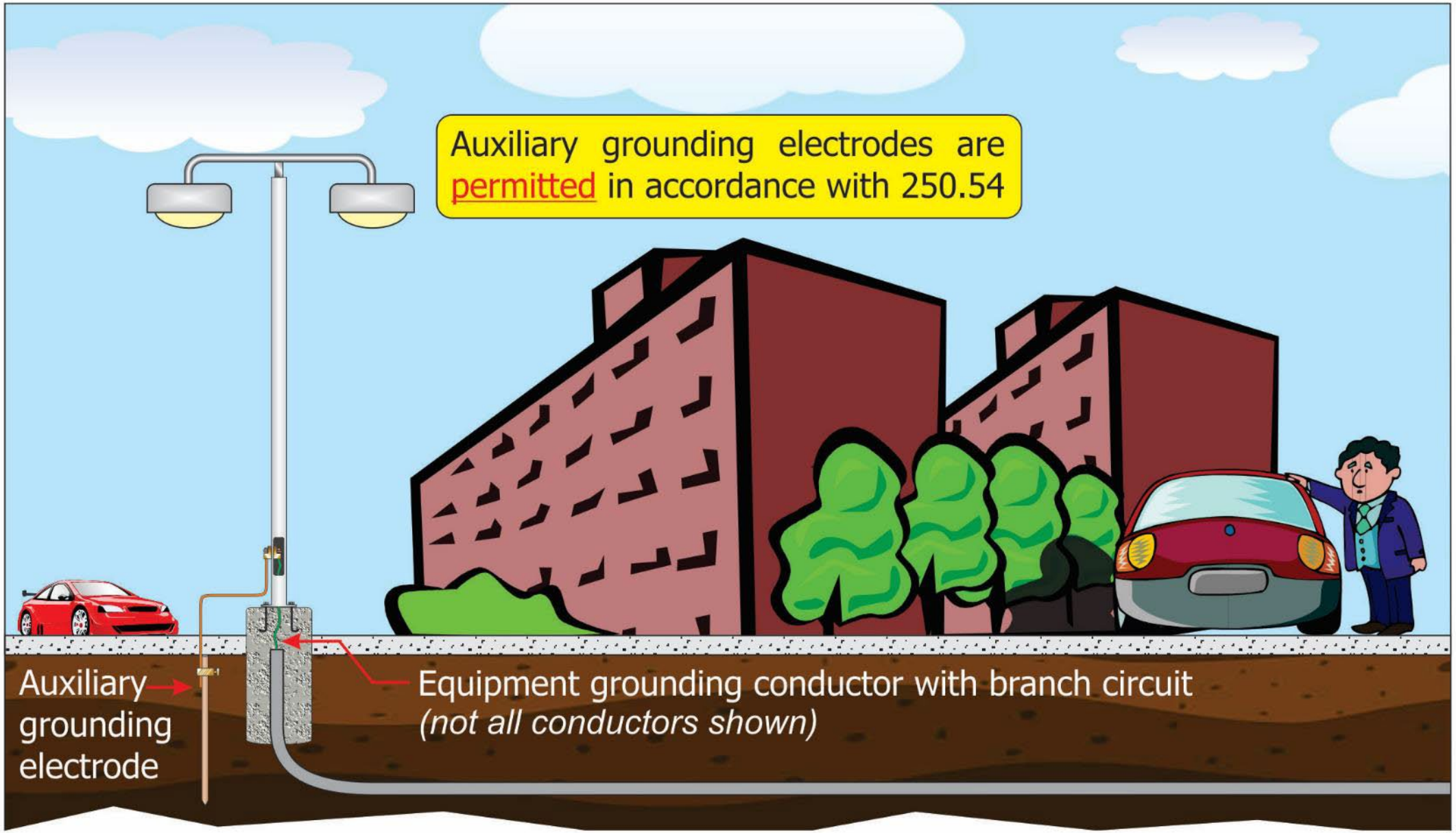
The internal and the external EGCs are required to be bonded together at each end

Copyright © IAEI 2020

Auxiliary Grounding Electrode

- Engineers often specify that ground rods or another electrode be installed to ground **metal lighting poles** and at metal poles for electric signs
- Some manufacturers of computer-controlled machine tools specify that a ground rod be used to locally ground their equipment
- These rods are **permitted** to be used, but are **not required**, and are to be considered **auxiliary grounding electrodes**
- Auxiliary electrodes permitted to be connected to the **equipment grounding conductor** of the branch circuit but cannot be the only means of grounding this or similar equipment
- The earth shall not be considered as an effective ground-fault current path *[see 250.4(A)(5) and 250.4(B)(4)]*
- *See 250.54*

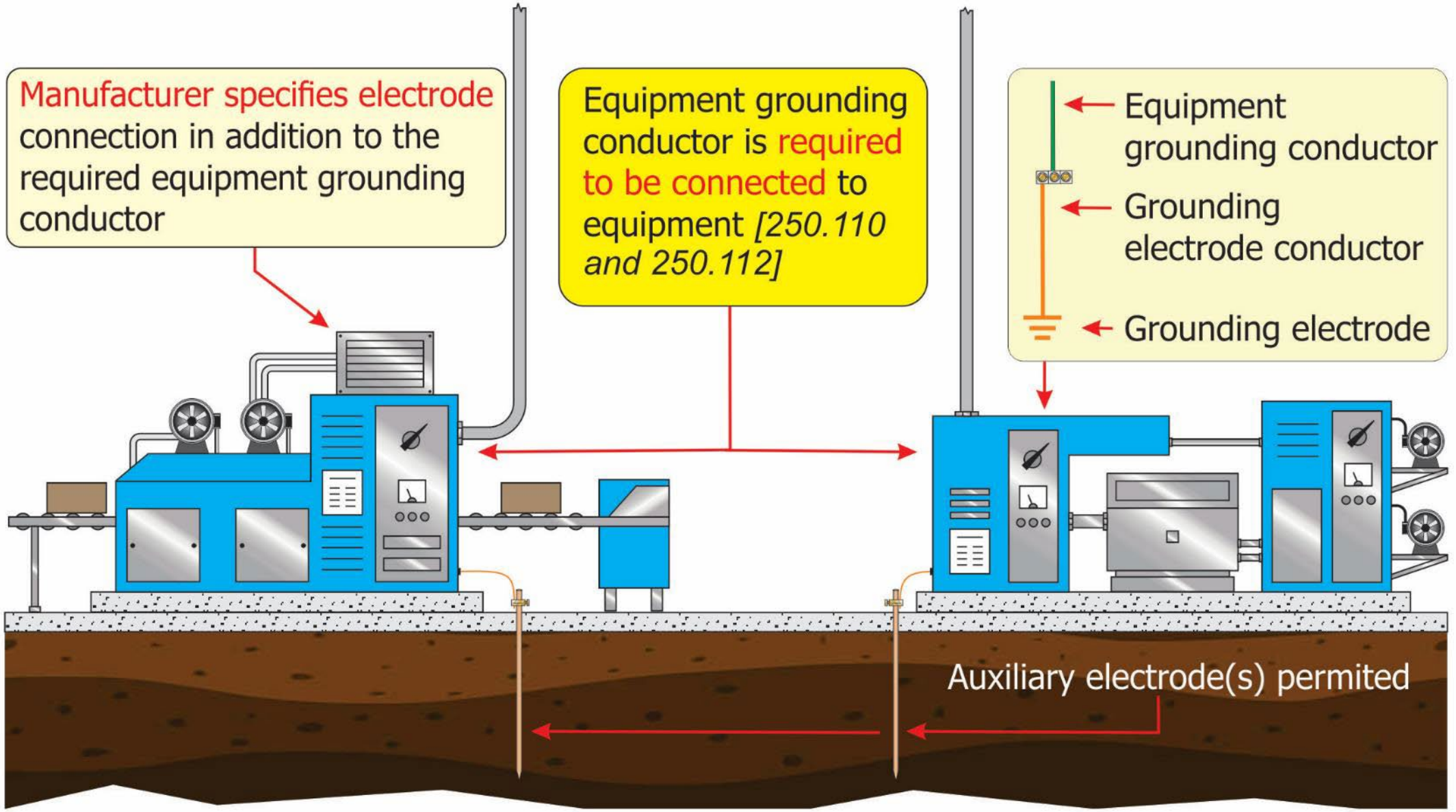
250.54 Auxiliary Grounding Electrodes



The earth shall not be considered as an effective ground-fault current path

Copyright © IAEI 2020

250.54 Auxiliary Grounding Electrodes



The earth shall not be considered as an effective ground-fault current path

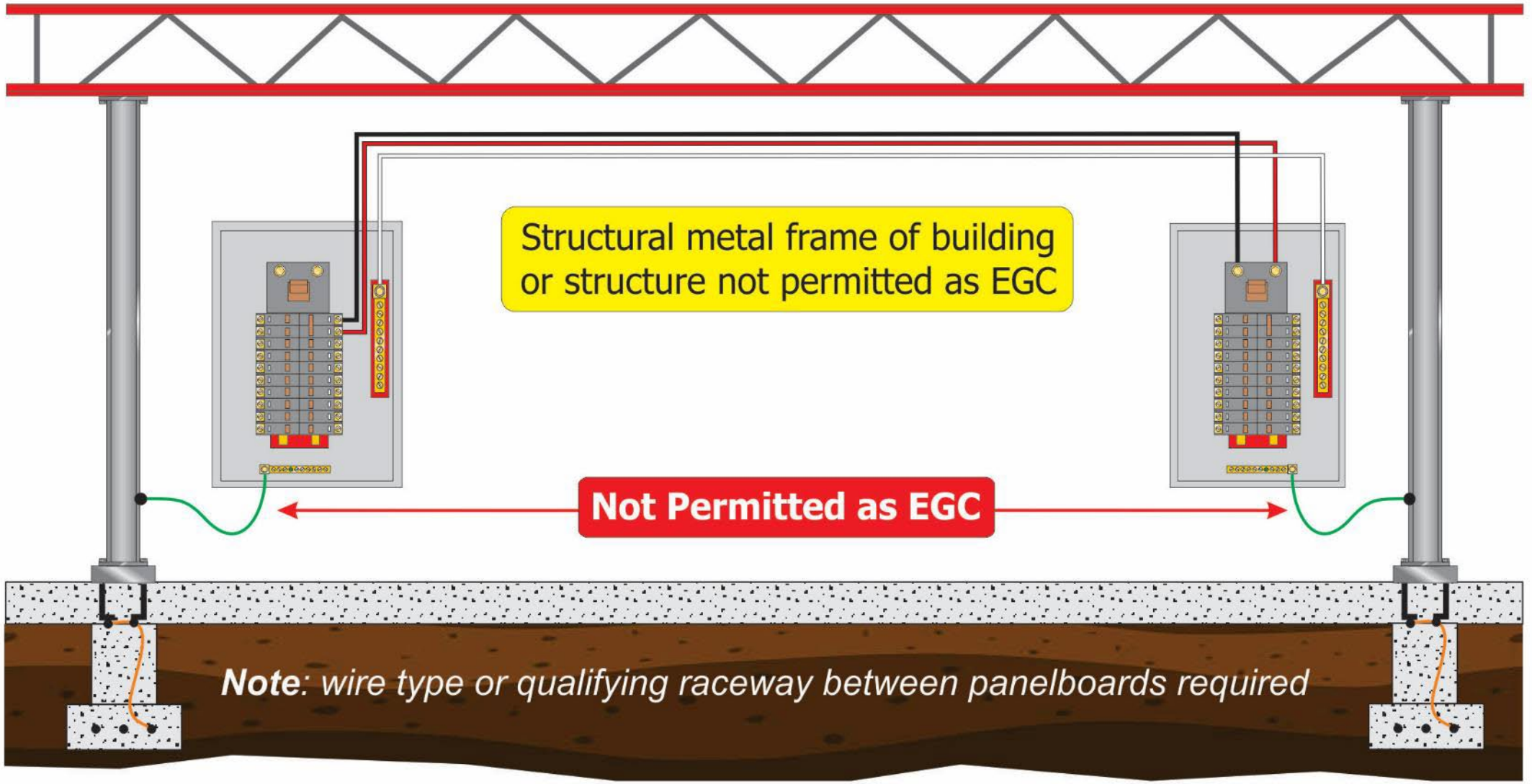
Copyright © IAEI 2020

Use of Building Steel for Grounding

- Normally non-current-carrying metal parts of electrical equipment secured to and in electrical contact with a **metal rack or structure** and connected to an equipment grounding conductor shall be **considered grounded** *[250.136(A)]*
- Support means must be connected to an equipment grounding conductor as specified by 250.134
- **Structural metal frame of a building** is **not permitted** as an equipment grounding conductor for alternating-current (ac) equipment *[250.121(B)]*

250.121(B) Structural Metal Building Frames

Building framing members are not permitted as the required equipment grounding conductor for ac equipment per 250.121(B)



Copyright © IAEI 2020

Grounding for Direct-Current Circuits

- Reactance of the circuit plays a large part in the impedance of the ground-return path with alternating-current (ac) systems
- For an ac system, the impedance of the ground fault return path is a combination of the dc resistance of the path as well as the inductive reactance
- In an ac system, the inductive reactance is directly related to the space between the ungrounded supply conductor to the ground fault and the ground fault return path
- In the case of direct-current (dc) circuits the only limitation on the effective ground-fault current path is ohmic resistance

Grounding for Direct-Current Circuits *(cont.)*

- In a dc system, the space from the ungrounded supply conductor to the ground fault and the return ground fault current path is a lesser concern
- The size of the equipment grounding conductor for dc circuits is treated the same as for ac circuits
- Size taken from Table 250.122 based on the size of the overcurrent device for the service, feeder or branch circuit

Reliability of Raceway as an EGC

- Raceway must be identified and suitable for the environment
- How long conduit acting as the equipment grounding conductor can be expected to remain permanent and continuous will vary depending on:
  - the type of metal raceway
  - the environment it is installed in
  - any supplemental corrosion protection
  - the quality of the installation

Reliability of Raceway as an EGC *(cont.)*

- For design purposes, two categories can be created:
  - Where **little corrosion will exist**, minimal vibration occurs that can loosen connections, where not subject to mechanical damage, and where it can be reasonably expected that the equipment grounding conductor *(in the form of a metal raceway)* will remain **permanent and continuous** for a period of fifty years or more *(if not disturbed)*
  - Where **corrosion in varying degrees will exist**, vibration that can loosen connections is present, where subject to mechanical damage, and where the permanency of the equipment grounding conductor provided by the metal raceway can be questioned

Reliability of Raceway as an EGC *(cont.)*

- Where corrosion exists, equipment grounding conductor sized per Table 250.122 is **recommended** to be installed inside raceway to ground equipment
- Some electrical design engineers and local electrical inspection agencies require that a wire type EGC be installed in each metal conduit or tubing to help ensure the reliability of the EGC path *(not a Code requirement)*
- *See 110.11 and 300.6*

Metal Conduit Underground

- Care must be taken when installing **metallic conduit** and **electrical metallic tubing (EMT)** in the earth, in concrete on or below grade, or where exposed to moisture
- Corrosion protection may be required or desired [300.6]
- Where long-term equipment grounding path by raceway cannot be assured, installation of a wire-type EGC inside raceway is **an option**
- The authority having jurisdiction (AHJ) is required to make a decision regarding the suitability of these raceways for these applications
- *See 344.10 and 300.6*

Additional Metal Conduit Corrosion Protection Required

In Concrete:	Required	Optional
Rigid Steel		X
Intermediate Steel		X
Aluminum Rigid	X	
Steel EMT	On or Below Grade (Additional May be Required)	Above Grade
Aluminum EMT	X	
In Soil:	**Required**	**Optional**
Rigid Steel		X
Intermediate Steel		X
Aluminum Rigid	X	
Steel EMT	Additional May be Required	
Aluminum EMT	X	

Copyright © IAEI 2020


2550



2551

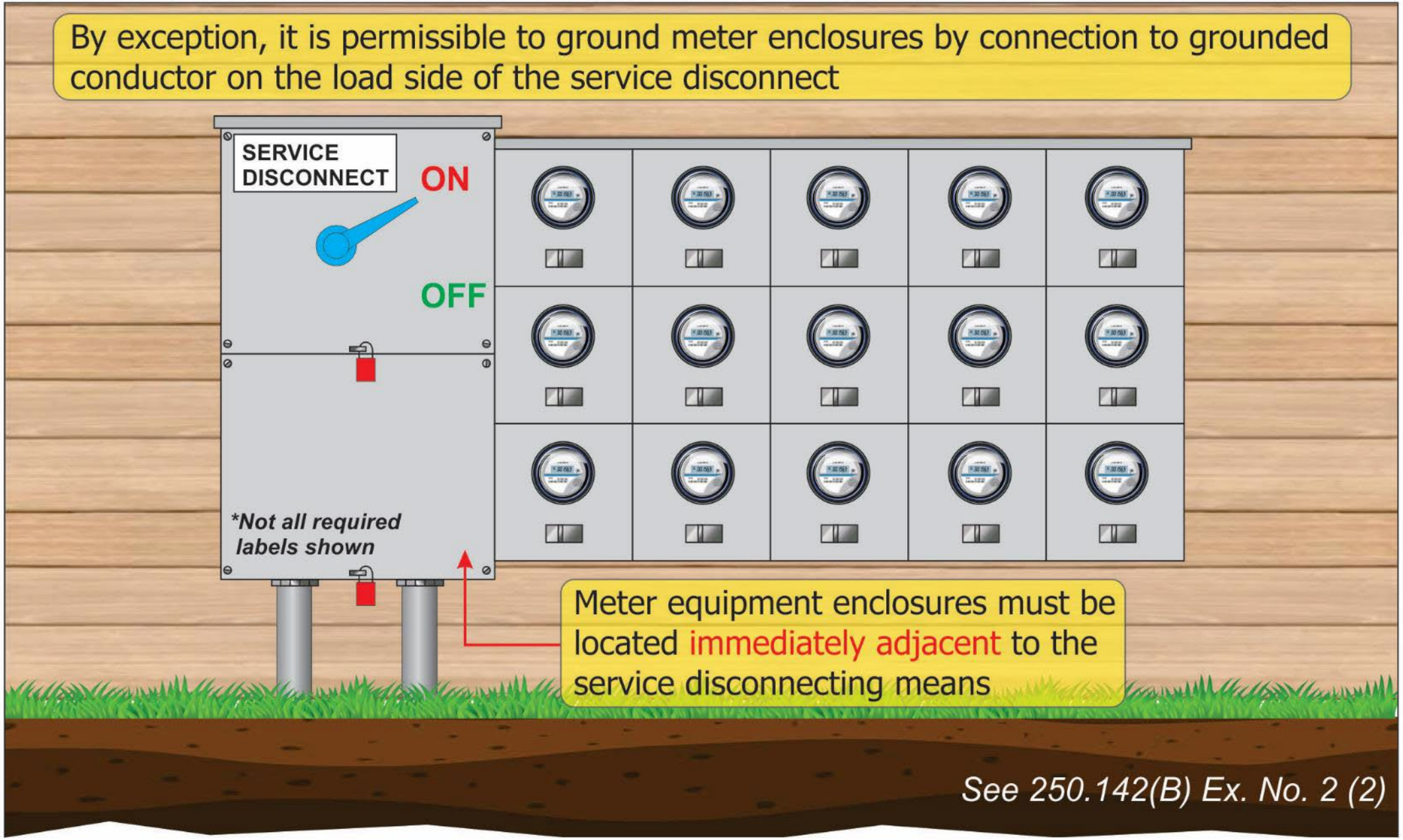
Use of Grounded Conductor for Grounding

- The *Code* generally does not permit the **grounded (neutral) conductor** to be grounded more than once on the **load side** of the service disconnecting means or disconnecting means for a source of separately derived system [250.24(A)(5), 250.30(A), and 250.142(B)]
- **Three conditions** to the general rule exist at 250.142(A):
  - The service supply side raceways and enclosures
  - Grounding the grounded circuit conductor at a remote building or structure *(existing installations only)*
  - Grounding the supply side of separately derived systems

Use of Grounded Conductor for Grounding *(cont.)*

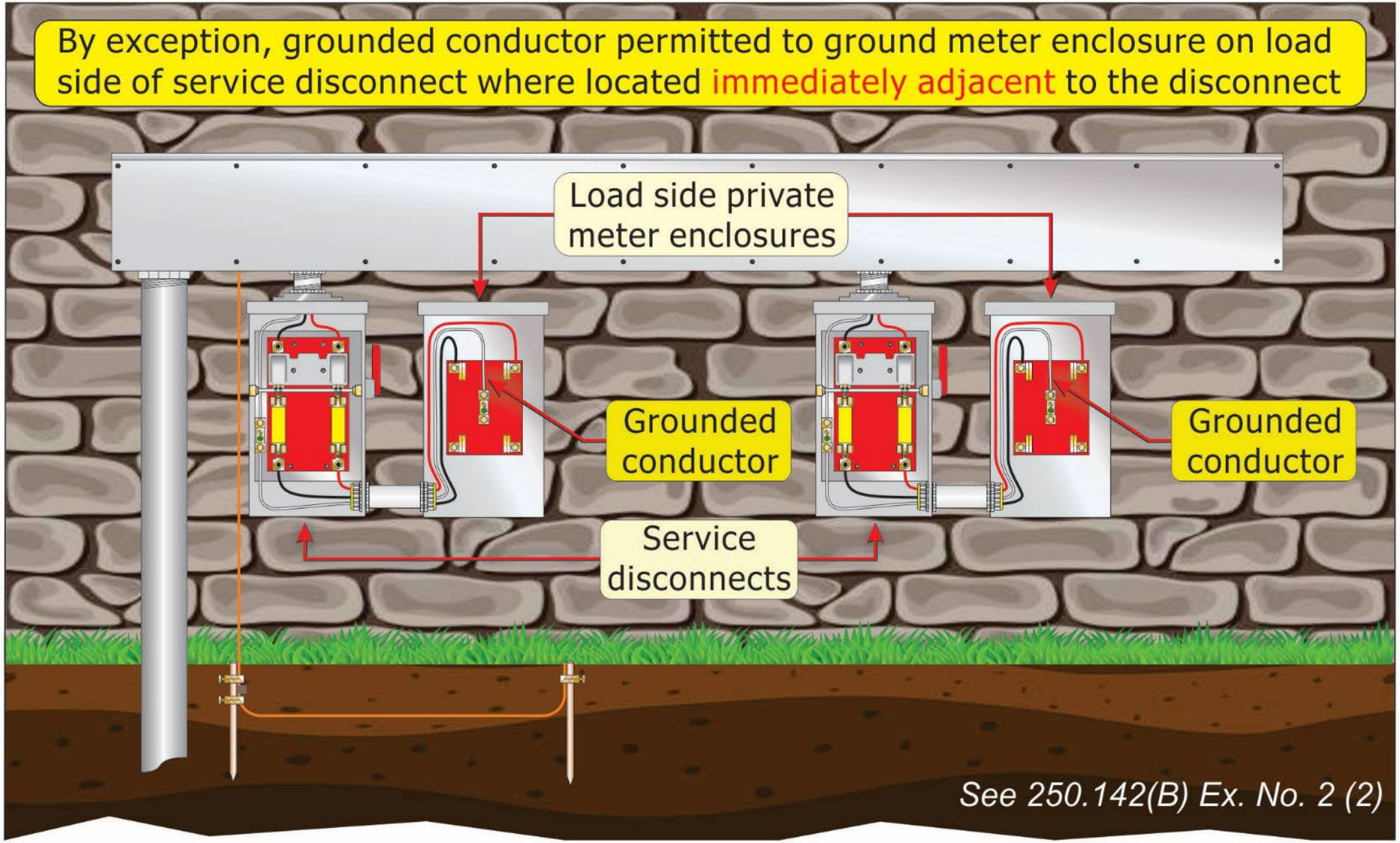
- Section **250.142(B)** covers allowances for the use of the grounded (neutral) circuit conductor for grounding equipment on the load side of the service equipment
- Such practice is generally prohibited except for the following **three specific exceptions**:
  - Frames of ranges, wall-mounted ovens, counter-mounted cooking units, and clothes dryers under the conditions permitted for **existing installations** by 250.140 *[see Chapter 15 of Soares]*
  - Grounding of meter socket enclosures located **immediately adjacent** to service disconnecting means
  - Electrode-type boilers operating at over 1000 volts *[see 490.72(E)(1) and 490.74]*

Grounded Conductor for Grounding Meter Enclosures

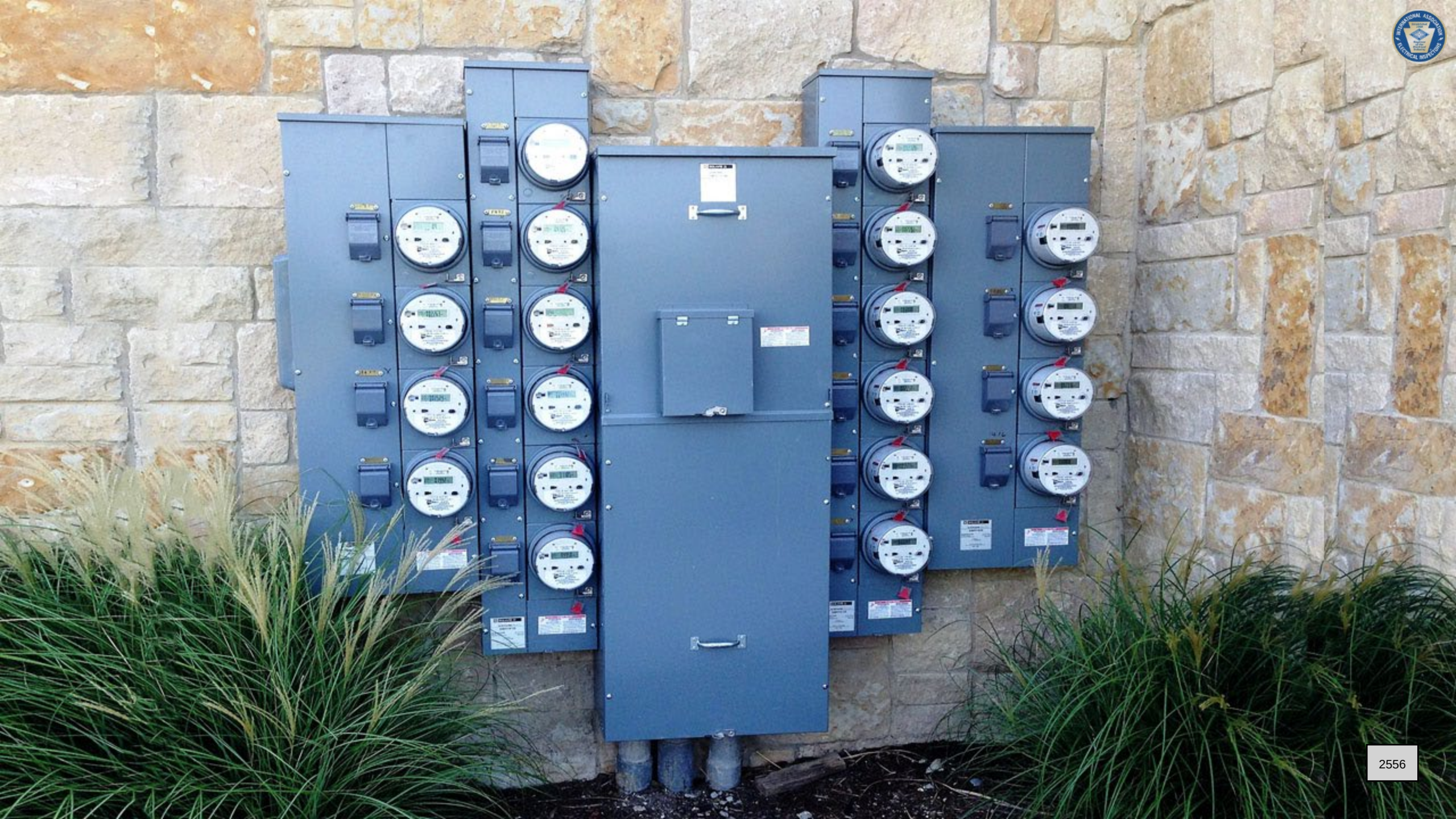


Copyright © IAEI 2020

Grounded Conductor for Grounding Meter Enclosures



Copyright © IAEI 2020



CHAPTER FIFTEEN

ENCLOSURE AND EQUIPMENT GROUNDING





2558

Enclosure and Equipment Grounding

- Enclosures for both service conductors and non-service conductor *(where of metal)* are required to be grounded
- For service conductor enclosures of **grounded systems** grounding is accomplished using the grounded (neutral) conductor and grounding electrode conductor
- For **ungrounded systems** this is accomplished with the grounding electrode conductor and the supply side bonding jumper
- For **non-service conductor enclosures**, the grounding is generally done with the equipment grounding conductor
- *See 250.80 and 250.86*
- Requirement does not mean that simply connecting equipment to a grounding electrode is acceptable or permitted

Enclosure and Equipment Grounding *(cont.)*

- Requirement is to connect to earth ***(grounding)*** as well as provide the continuity and conductivity for an effective ground fault current path ***(bonding)***
- Installation must comply with the requirements of 250.4 *(effective path for fault current)*
- Wherever the *Code* states **"shall be grounded"**, it means effectively grounded as spelled out in 250.4
- Effective ground-fault path always includes providing a **low-impedance path** consisting of an equipment grounding conductor, supply side bonding jumper, or other conductor that has adequate capacity to conduct the maximum fault current it is likely to carry
- It also must be **electrically continuous**

Article 100 Definitions

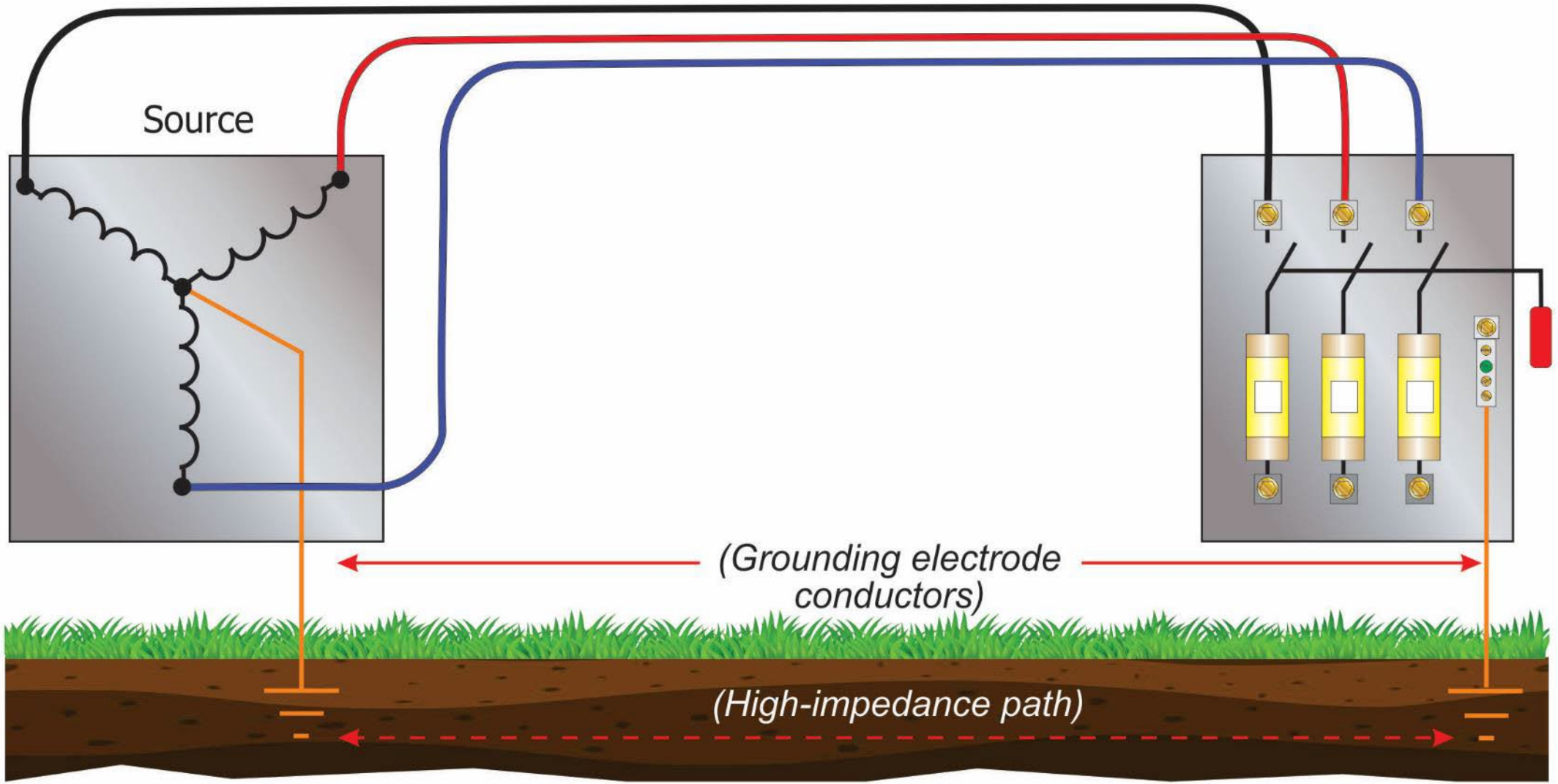
- ***Bonding Conductor or Jumper:*** A reliable conductor to ensure the required electrical conductivity between metal parts required to be electrically connected.
- ***Bonding Jumper, Equipment:*** The connection between two or more portions of the equipment grounding conductor.
- ***Grounded (Grounding):*** Connected *(connecting)* to ground or to a conductive body that extends the ground connection.

Article 100 Definitions *(cont.)*

- ***Grounding Conductor, Equipment (EGC):*** A conductive path(s) that is part of an effective ground-fault current path and connects normally non-current-carrying metal parts of equipment together and to the system grounded conductor or to the grounding electrode conductor, or both.
  - ***Informational Note No. 1:*** It is recognized that the equipment grounding conductor also performs bonding.
  - ***Informational Note No. 2:*** See 250.118 for a list of acceptable equipment grounding conductors.

Grounded Improperly

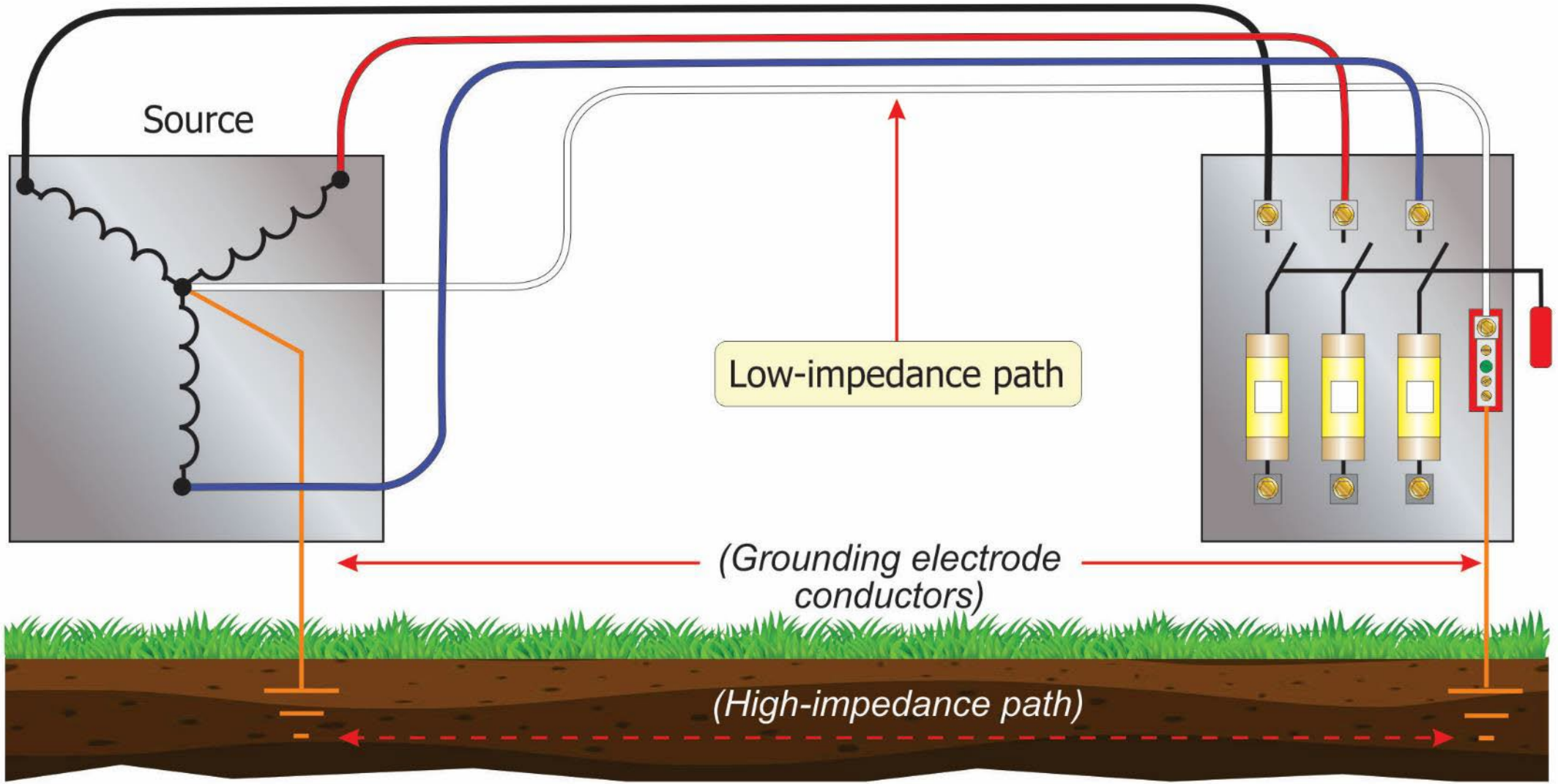
The earth provides only a high-impedance ground-fault return path and is not considered as an effective ground-fault current path



Copyright © IAEI 2020

Grounded Properly

In addition to the high-impedance path provided through the earth, now there is a low-impedance, effective ground-fault current return path



Copyright © IAEI 2020

Equipment Grounding Conductor

- An **equipment grounding conductor (EGC)** required for grounding equipment on the load side of the service or separately derived system
- EGC performs **both grounding and bonding** functions and serves as an **effective ground-fault current path** to facilitate overcurrent device operation
- EGC permitted to consist of a wire type conductor(s) or any of the wiring methods identified in 250.118
- Installing only a grounding electrode conductor to ground equipment *(without having an EGC connected to the grounded service conductor)* is unsafe and not permitted *(see 250.4 and 250.54)*
- While the earth is a path, it cannot be depended upon as the “effective ground fault current path”

Service Raceways and Enclosures

- Service raceways and equipment are generally required to be connected *(bonded)* to the grounded system conductor and the grounding electrode conductor
- Covered in Soares Chapter 9 for “Grounding Electrical Services”
- Exception for isolated underground **metal components** *(such as metal elbows)* from bonding where it is installed in an underground nonmetallic raceway(s) and all parts are isolated from possible contact by a minimum cover of **450 mm (18 inches)**
- *See 250.80 and Exception*

Bonding Jumpers Externally Installed

- Bonding jumpers or conductors and equipment bonding jumpers are permitted to be installed **inside or outside** of a raceway or an enclosure
- If installed on the outside of a raceway or an enclosure…
  - Length **not to exceed 1.8 m (6 ft)**
    - *(Exception for outside pole locations for isolated metal raceways or elbows)*
  - Required to be routed with the raceway or enclosure
- See 250.102(E)



2568

Other Than Service Conductor Enclosures and Raceways

- Metal enclosures and raceways for **other than service conductors** are generally required to be connected to the equipment grounding conductor
- **Three exceptions** to this rule *(see 250.86 and exceptions)*
- **Ex. No. 1:** Metal enclosures and raceways added to existing installations of open wire, knob-and-tube wiring, and nonmetallic-sheathed cable meeting the following conditions are not required to be connected to an EGC:
  - EGC not provided by the wiring method used
  - Metal enclosure or raceway must be:
    - Less than 7.5 m (25 ft) long
    - Free from probable contact with ground or grounded objects
    - Guarded against contact by persons

Other Than Service Conductor Enclosures and Raceways *(cont.)*

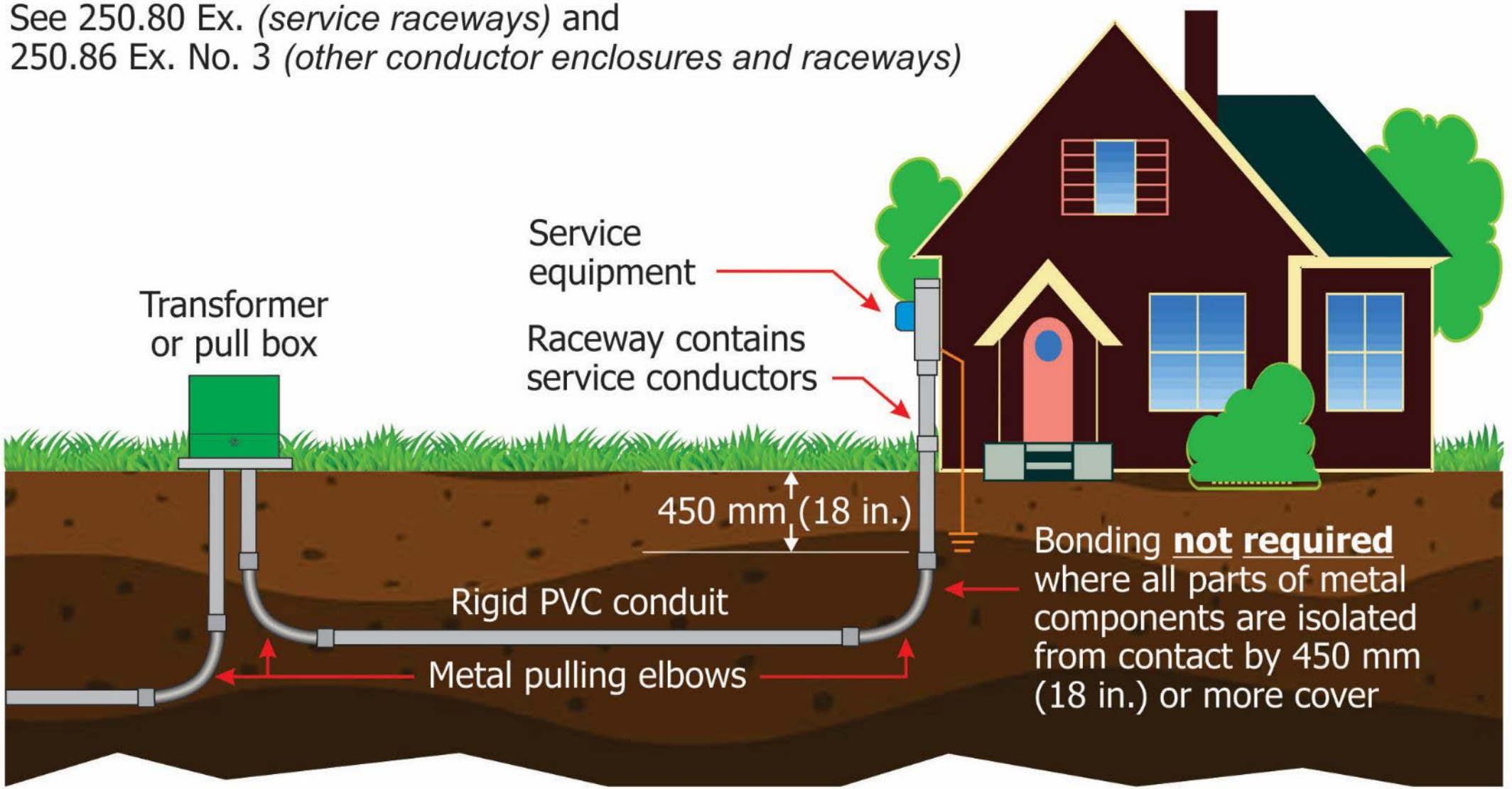
- Metal enclosures and raceways for **other than service conductors** are generally required to be connected to the equipment grounding conductor
- **Three exceptions** to this rule *(see 250.86 and exceptions) (cont.)*
- **Ex. No. 2:** Short sections of metal enclosures where used to protect cable assemblies from physical damage are not required to be connected to an EGC
  - No explanation is given in the *Code* of the term *short sections* of metal enclosures
  - Since the standard length of conduit or tubing is 3.0 m (10 ft), *short sections* should be less than 3.0 m (10 ft)

Other Than Service Conductor Enclosures and Raceways *(cont.)*

- Metal enclosures and raceways for **other than service conductors** are generally required to be connected to the equipment grounding conductor
- **Three exceptions** to this rule *(see 250.86 and exceptions) (cont.)*
- **Ex. No. 3:** Metal components are not required to be connected to an EGC or supply-side bonding jumper where it is installed in a run of nonmetallic raceway and…
  - Isolated from possible contact by a **minimum cover of 450 mm (18 in.)** to any part of the metal component…
  - or is encased in not less than 50 mm (2 in.) of concrete

Metal Elbows Used With Underground Raceway

See 250.80 Ex. *(service raceways)* and
250.86 Ex. No. 3 *(other conductor enclosures and raceways)*



Copyright © IAEI 2020

Grounding of Fixed Equipment

- 250.110 lists (6) six conditions where normally non-current-carrying metal parts of fixed equipment that is **"likely to become energized"** is required to connect to an equipment grounding conductor (EGC)
  1. Within 2.5 m (8 ft) vertically or 1.5 m (5 ft) horizontally of ground or grounded metal objects
  2. Where located in a wet or damp location and not isolated
  3. Where in electrical contact with metal
  4. Where in a hazardous (classified) location *(Articles 500 through 517)*
  5. Where supplied by a wiring method that provides an EGC *(except short sections of raceway used for protection from physical damage)*
  6. Where equipment operates at more than 150 volts to ground

Grounding of Fixed Equipment *(cont.)*

- 250.110 lists (6) six conditions where normally non-current-carrying metal parts of fixed equipment that is **"likely to become energized"** is required to connect to an equipment grounding conductor (EGC)
- Exceptions:
  1. *If exempted by **special permission**, metal frames of electrically heated appliances that have the frames permanently and effectively insulated from ground*
  2. *Distribution apparatus, such as transformer and capacitor cases, mounted on **wooden poles at a height exceeding 2.5 m (8 ft)** above ground or grade level*
  3. *Listed equipment protected by a system of **double insulation**, or its equivalent, shall not be required to be grounded (equipment must be distinctively marked)*

Grounding Specific Equipment

- The *Code* requires that exposed, non-current-carrying metal parts of certain specific equipment *(regardless of voltage)* required to be connected to the EGC of the supply circuit
- Those items are detailed at 250.112 and include:
  - (A) **Switchgear and Switchboard Frames and Structures:** *(with the exception of 2-wire dc switchgear and switchboards where effectively insulated from ground)*
  - (B) **Pipe Organs:** Generator and motor frames unless effectively insulated from ground and the motor driving it
  - (C) **Motor Frames:** As provided in Section 430.242

Grounding Specific Equipment *(cont.)*

- The *Code* requires that exposed, non-current-carrying metal parts of certain specific equipment *(regardless of voltage)* required to be connected to the EGC of the supply circuit
- Those items are detailed at 250.112 and include: *(cont.)*
  - (D) **Enclosures for Motor Controllers:** *(unless attached to ungrounded portable equipment)*
  - (E) **Elevators and Cranes**
  - (F) **Garages, Theaters, and Motion Picture Studios:** *(except pendant lampholders supplied by circuits not over 150 volts to ground)*
  - (G) **Electric Signs:** Electric signs, outline lighting, and associated equipment as provided in 600.7

Grounding Specific Equipment *(cont.)*

- The *Code* requires that exposed, non-current-carrying metal parts of certain specific equipment *(regardless of voltage)* required to be connected to the EGC of the supply circuit
- Those items are detailed at 250.112 and include: *(cont.)*
  - (H) **Motion Picture Projection Equipment**
  - (I) **Remote-Control, Signaling, and Fire Alarm Circuits:** Equipment supplied by Class 1 circuits *(unless operating at less than 50 volts)* and generally required for Class 1 power-limited circuits, Class 2, and Class 3 remote-control and signaling circuits, and fire alarm circuits
  - (J) **Luminaires:** As provided in Part V of Article 410

Grounding Specific Equipment *(cont.)*

- The *Code* requires that exposed, non-current-carrying metal parts of certain specific equipment *(regardless of voltage)* required to be connected to the EGC of the supply circuit
- Those items are detailed at 250.112 and include: *(cont.)*
  - (K) **Skid Mounted Equipment:** *(that supports permanently mounted electrical equipment)*
  - (L) **Motor-Operated Water Pumps:** *(including submersible types)*
  - (M) **Metal Well Casings:** *(where a submersible pump is used in a metal well casing)*

Grounding of Cord-and Plug-Connected Equipment

- Grounding of equipment connected by cord and plug is covered at **250.114**
- Mandatory under certain conditions that non-current-carrying metal parts of cord- and plug-connected equipment *(likely to become energized)* be connected to the equipment grounding conductor (EGC)
- Grounding accomplished using the **correct receptacle** with grounding terminal, a **proper plug** with an intact grounding pin and the **EGC** in the supply cord
- Listed tools, listed appliances, and listed equipment that are protected by a system of **double-insulation** not required to be connected to the EGC
- Double-insulated equipment required to be **distinctively marked** *(see 250.114 Ex.)*

Grounding of Cord-and Plug-Connected Equipment *(cont.)*

- Equipment grounding conductor must be part of cord
- Sized in accordance with Table 250.122
- Proper attachment plugs and caps required
- Attachment plugs, mating connectors, and receptacles shall provide for **first-make, last-break** of the equipment grounding conductor
- *See 250.124(A)*

Grounding of Cord-and Plug-Connected Equipment *(cont.)*

- Exposed non-current-carrying equipment likely to become energized must be connected to an equipment grounding conductor:
  - *Exception: Double insulated tools and appliances*
    - (1) In hazardous (classified) locations
    - (2) Over 150 volts to ground *[Note: 2 exceptions]*
    - (3) In residential occupancies:
      - Five groups of appliances or equipment are given in 250.114(3) a. through e.

Grounding of Cord-and Plug-Connected Equipment *(cont.)*

- Exposed non-current-carrying equipment likely to become energized must be connected to an equipment grounding conductor: *(cont.)*
  - *Exception: Double insulated tools and appliances*
    - (4) In other than residential occupancies:
      - Seven groups of appliances or equipment are given in 250.114(4) a. through g.
    - *Exception: Tools or portable lamps likely to be used in wet locations where supplied through isolation transformers with an ungrounded secondary of not over 50 volts*

Nonelectric Equipment

- The metal parts of the following equipment are required to be connected to the equipment grounding conductor:
  - (1) Frames and tracks of electrically operated **cranes and hoists**
  - (2) Frames of nonelectrically driven **elevator cars**
  - (3) Hand-operated metal shifting ropes or cables of electric **elevators**
- *Informational Note: Where extensive metal in or on buildings or structures may become energized and is subject to personal contact, adequate bonding and grounding will provide additional safety*
- See 250.116

Methods of Grounding Connections

- Important to connect the EGC to the equipment in such a manner that the requirements for having an **effective ground-fault current path** are met
- Equipment grounding conductors and bonding jumpers must be connected to equipment that is required to be grounded by one or more of the following methods per **250.8**:
  - (1) Listed pressure connectors
  - (2) Terminal bars
  - (3) Pressure connectors listed as grounding and bonding equipment
  - (4) Exothermic welding process
    - *Note: Exothermic welding is **not required to be listed**, but it is important to follow the manufacturer's instructions*

Methods of Grounding Connections *(cont.)*

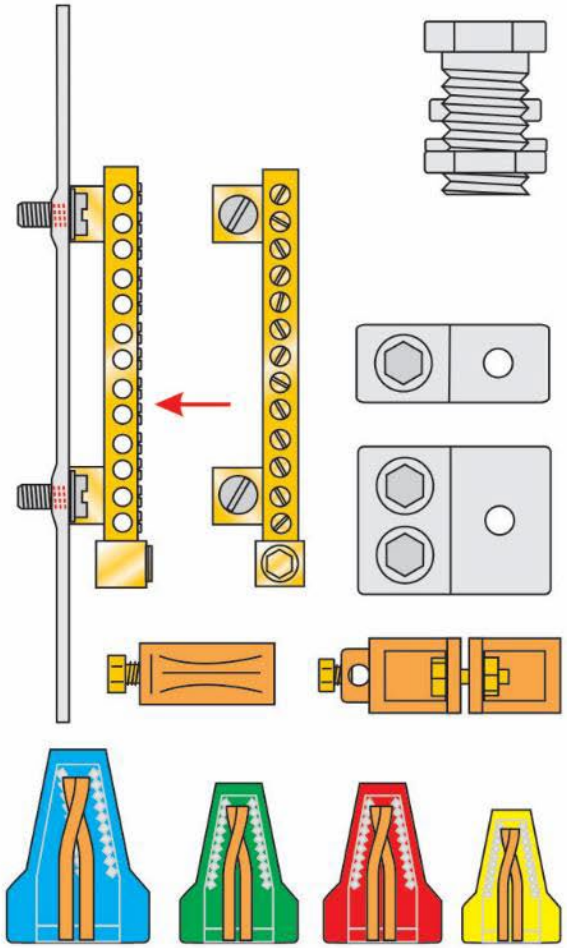
- Equipment grounding conductors and bonding jumpers must be connected to equipment that is required to be grounded by one or more of the following methods per 250.8: *(cont.)*
  - (5) Machine screw-type fasteners that engage not less than two threads or are secured with a nut
  - (6) Thread-forming 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

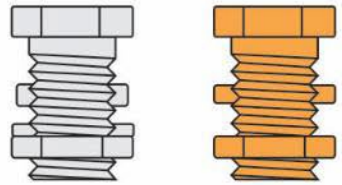
Methods of Grounding Connections *(cont.)*

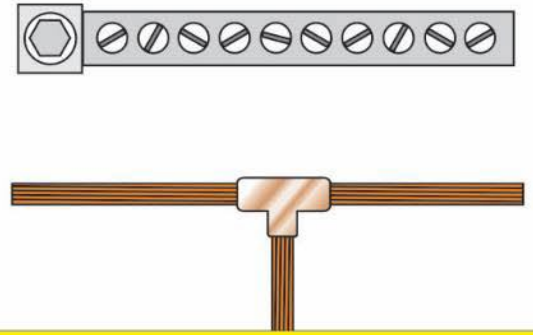
- Proper terminations means ensuring any paint, coatings or other insulating type materials be removed to not interfere with the EGC path
- It should be noted that the connection means specified in 250.8 applies to the **means of connecting to the conductor** as well as the **means to attach the connector to the equipment**
- All means of connection are required to comply with the requirements of **250.8** *(see next slide)*

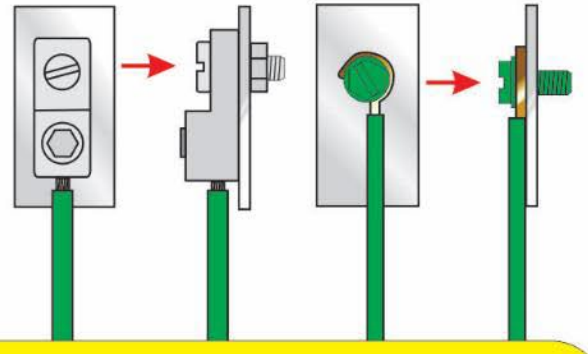
250.8 Grounding and Bonding Connections

(A) Permitted Methods. Equipment grounding conductors, grounding electrode conductors, and bonding jumpers shall be connected by one or more of the following means:









- Listed pressure connectors
- Terminal bars
- Pressure connectors listed as grounding and bonding equipment
- Machine screw-type fasteners engaging two threads minimum or secured by a nut
- Thread-forming screws engaging not less than two threads
- Exothermic welding process
- Connectors part of listed assembly
- Other listed means

Copyright © IAEI 2020

Methods of Grounding Connections



- Connection of grounding and bonding conductors per 250.8
- Equipment grounding conductors connected to enclosure by listed irreversible compression connections

Methods of Grounding Connections *(cont.)* *(Solder Not Permitted)*

- Connections that depend solely on **solder** cannot be used for equipment grounding connections
- During a ground fault condition, EGCs carry large amount of current until overcurrent device clears fault *(and become very hot)*
- Elevated temperature can exceed the **melting point** of the solder and weaken or destroy the connection
- Permissible to secure the connections mechanically and then apply solder to the joint to make the electrical connection
- *See 250.8(B) and 250.148*

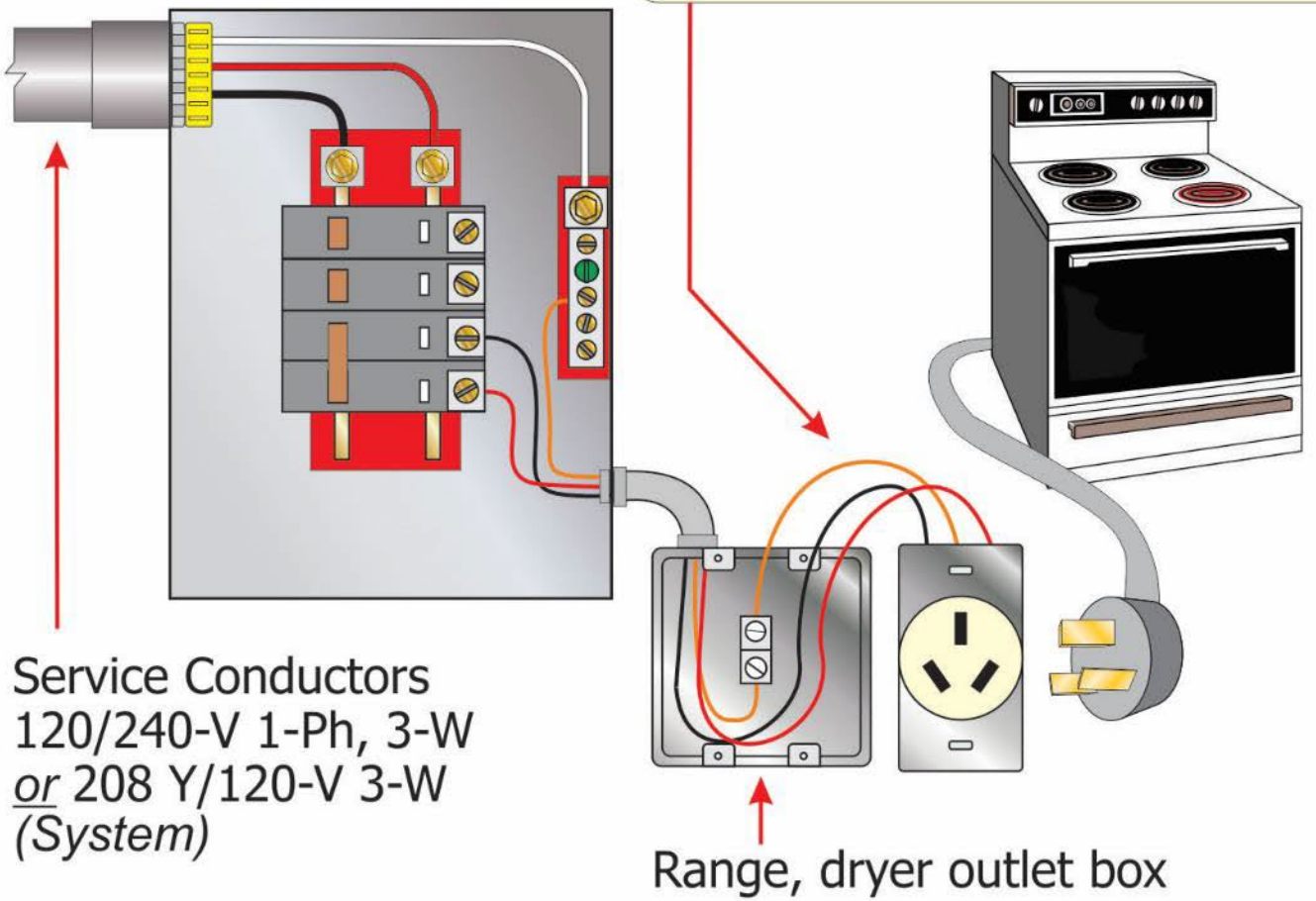
Grounding of Frames of Ranges and Clothes Dryers

- The frames of electric ranges, wall-mount ovens, counter-mounted cooking units, clothes dryers and the related outlet and junction boxes must be connected to the equipment grounding conductor *(see 250.140)*
- **New installations** must comply with the requirements for an **insulated neutral conductor** as well as an insulated or bare equipment grounding conductor *(See 250.134 and 250.138)*
- For **existing branch circuit installations only** *(with no EGC present)* the metal frames are permitted to be connected to the grounded circuit conductor under specific conditions *(See 250.140, Ex.)*

Wiring Methods for Appliances Permitted to be Grounded by the Grounded Circuit Conductor

Existing branch-circuits installations only per 250.140 Exception

Grounded (neutral) conductor permitted for grounding of frames of ranges and clothes dryers if all conditions below are met:



Service Conductors
120/240-V 1-Ph, 3-W
or 208 Y/120-V 3-W
(System)

Range, dryer outlet box

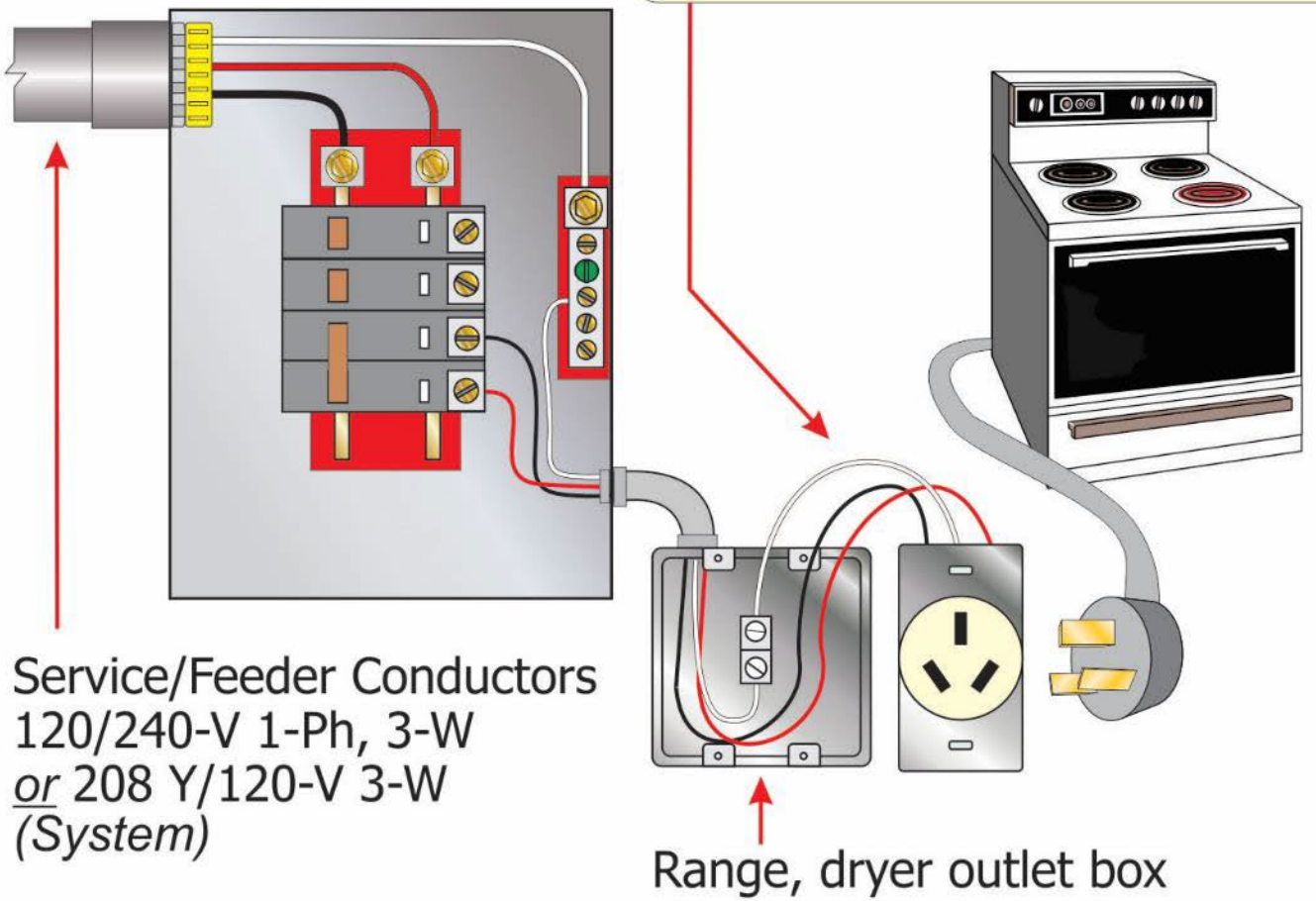
- No EGC is present
- Supply circuit is 120/240-volt, single-phase, 3-wire; or 208Y/120-volt, 3-phase, 4-wire, wye-connected system
- Not smaller than 10 AWG copper or 8 AWG aluminum
- Neutral insulated *(or uninsulated if part of a Type SE cable and the branch circuit originates at service equipment)*
- Grounding contacts of receptacle bonded to equipment

Copyright © IAEI 2020

Wiring Methods for Appliances Permitted to be Grounded by the Grounded Circuit Conductor

Existing branch-circuits installations only per 250.140 Exception

Grounded (neutral) conductor permitted for grounding of frames of ranges and clothes dryers if all conditions below are met:



Service/Feeder Conductors
120/240-V 1-Ph, 3-W
or 208 Y/120-V 3-W
(System)

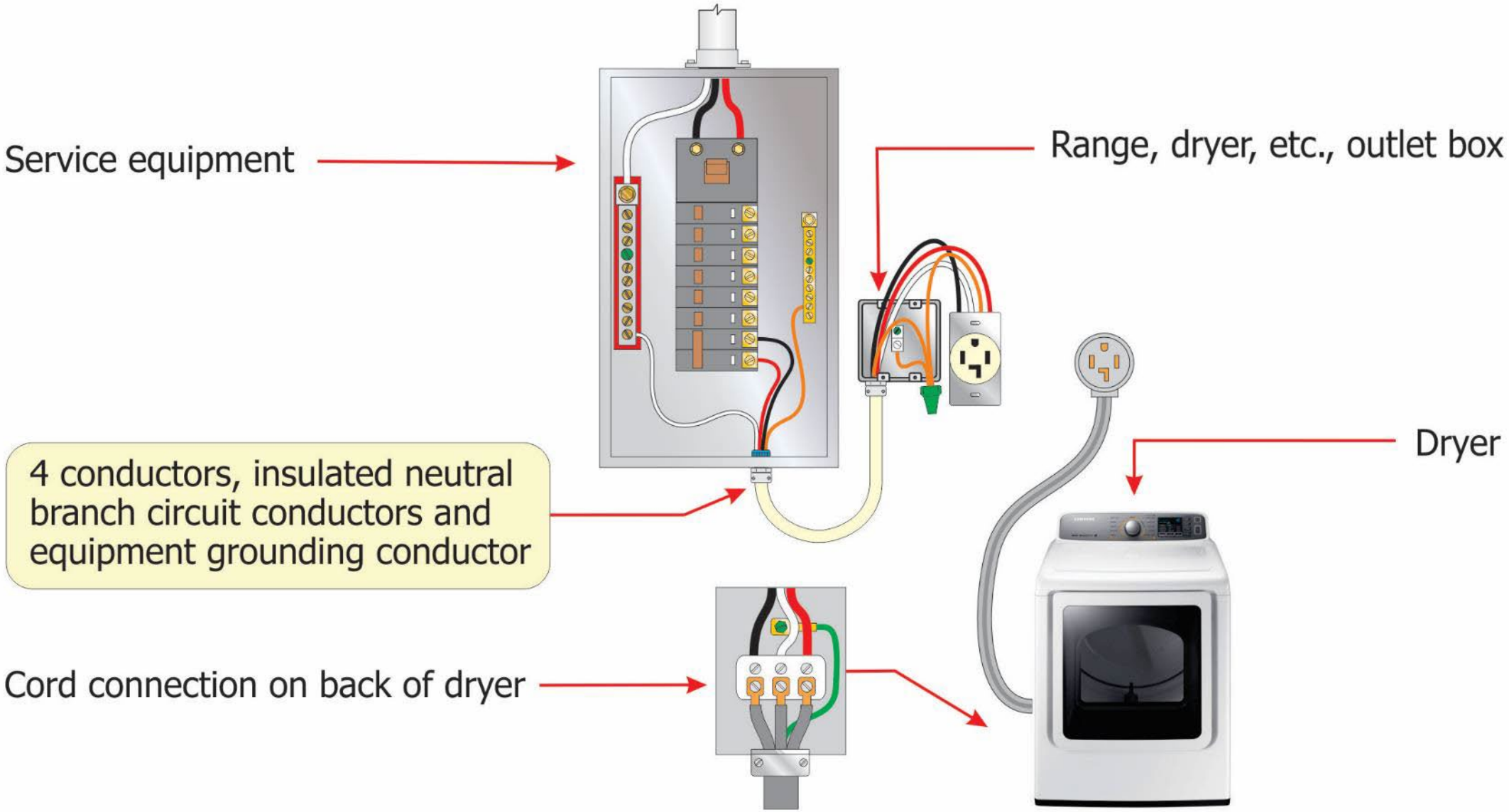
Range, dryer outlet box

- No EGC is present
- Supply circuit is 120/240-volt, single-phase, 3-wire; or 208Y/120-volt, 3-phase, 4-wire, wye-connected system
- Not smaller than 10 AWG copper or 8 AWG aluminum
- Neutral insulated *(or uninsulated if part of a Type SE cable and the branch circuit originates at service equipment)*
- Grounding contacts of receptacle bonded to equipment

Copyright © IAEI 2020

Wiring Methods for New Range and Dryer Circuits

Isolated neutral and equipment grounding conductors at dryer terminals



Copyright © IAEI 2020

2594

Grounding of Panelboards

- Where a **feeder** supplies branch circuits in which equipment grounding conductors (EGC) are required, feeder must provide an EGC in accordance with the provisions of 250.134 to which the EGCs of the branch circuit are to be connected *(see 215.6)*
- All panelboard cabinets and panelboard metal frames are required to be in physical contact with each other and **must be grounded** by connection to an equipment grounding conductor *(see 408.40)*
- Where used as service equipment, the panelboard must be provided with a **main bonding jumper** located inside the cabinet for the purpose of bonding the enclosure to the **grounded service conductor** *[see 408.3(C)]*

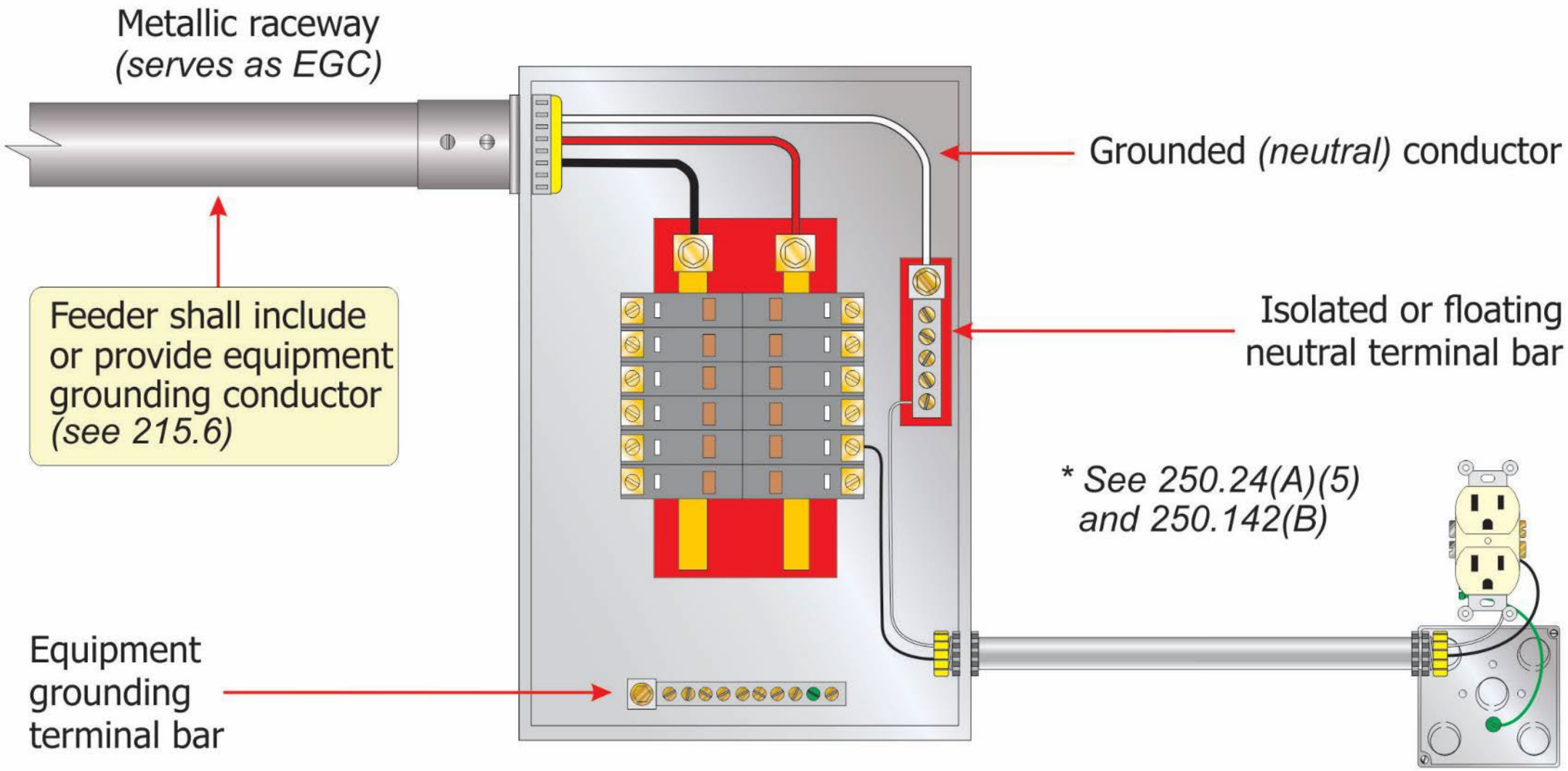
Grounding of Panelboards *(cont.)*

- Grounding and bonding conductors are permitted to terminate on the grounded *(neutral)* terminal or bus where the panelboard is used at a location where the grounded conductor terminal *(neutral conductor)* bar is connected to a grounding electrode
- These locations include:
  - At services
  - At the building disconnecting means for separate buildings or structures served by a feeder(s) or branch circuit(s) *[see 225.32]*
  - For separately derived systems *[see 250.30(A)]*

Grounding of Panelboards *(cont.)*

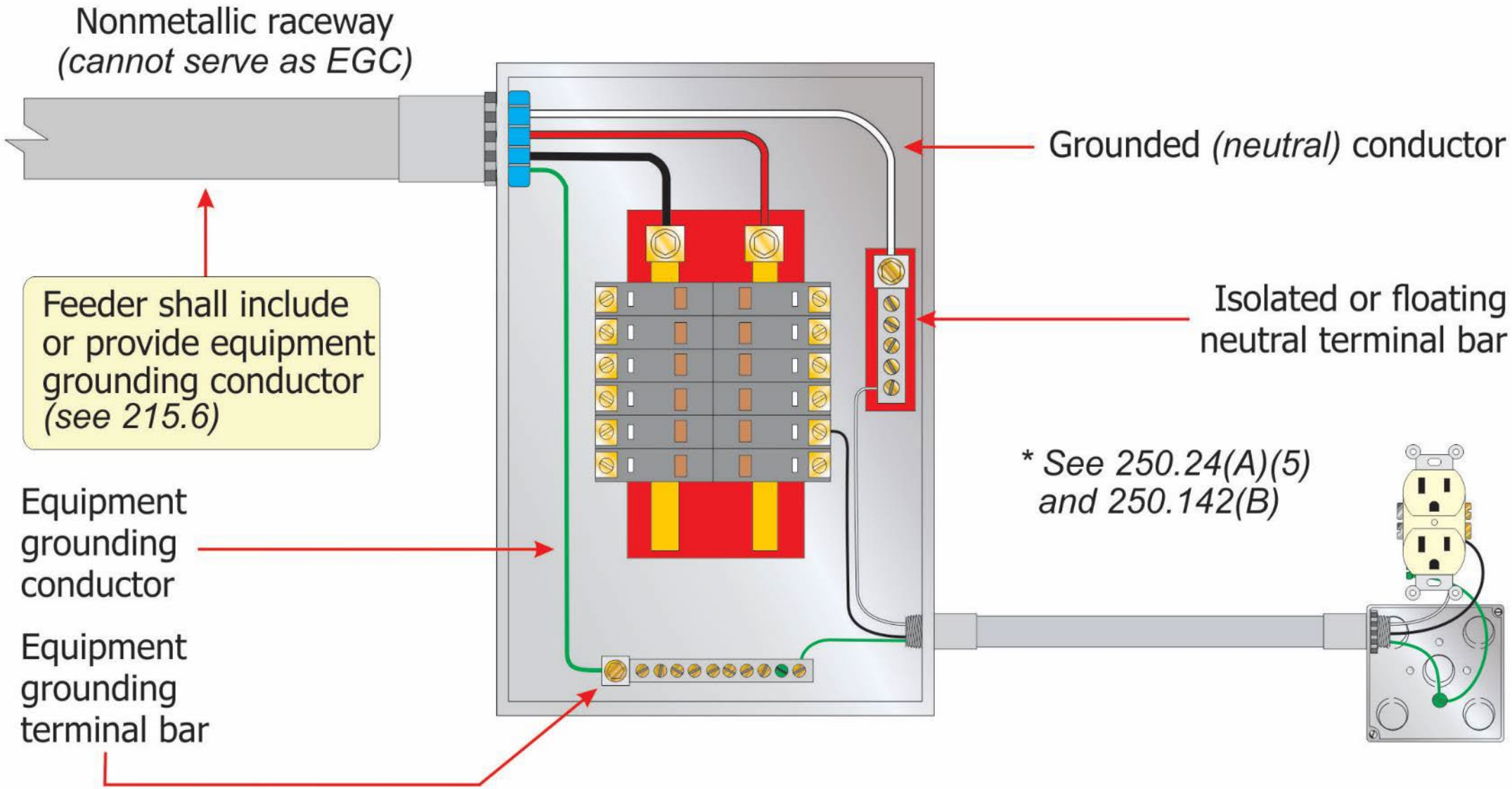
- Grounding connection is generally prohibited from being connected to a grounded conductor *(may be a neutral)* on the load side of the service disconnecting means *[See 250.24(A)(5)]*
- The term "***floating neutral conductor***" is often used to describe the grounded conductor's relationship to the enclosure *(insulated electrically from the enclosure)*
- Exceptions to this general rule are provided for separately derived systems, at separate buildings for existing installations only, and for certain appliances *(electric ranges and clothes dryers on existing branch circuits)*

408.40 Isolated Neutral in Load-Side Panelboard



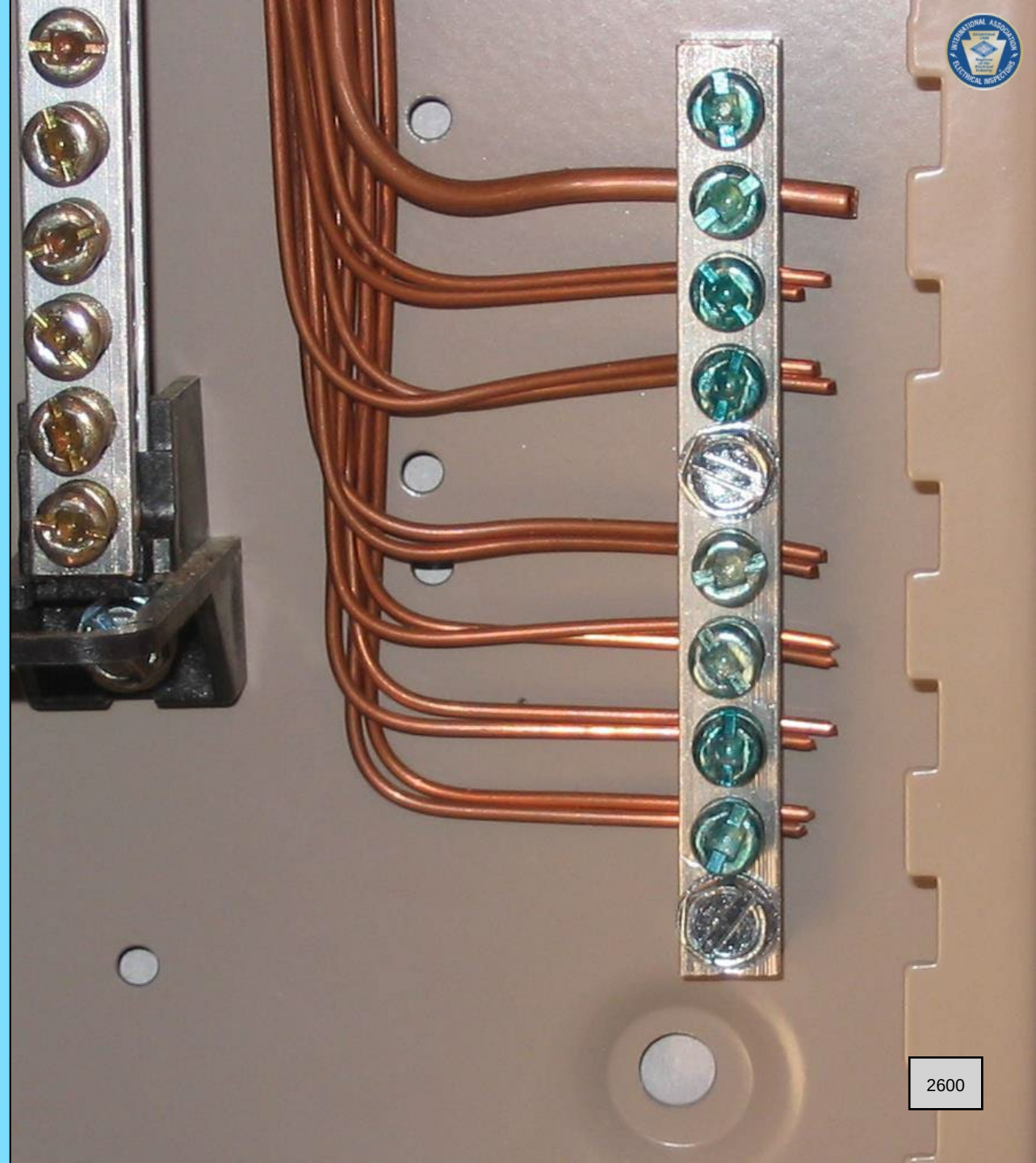
Copyright © IAEI 2020

408.40 Isolated Neutral in Load-Side Panelboard



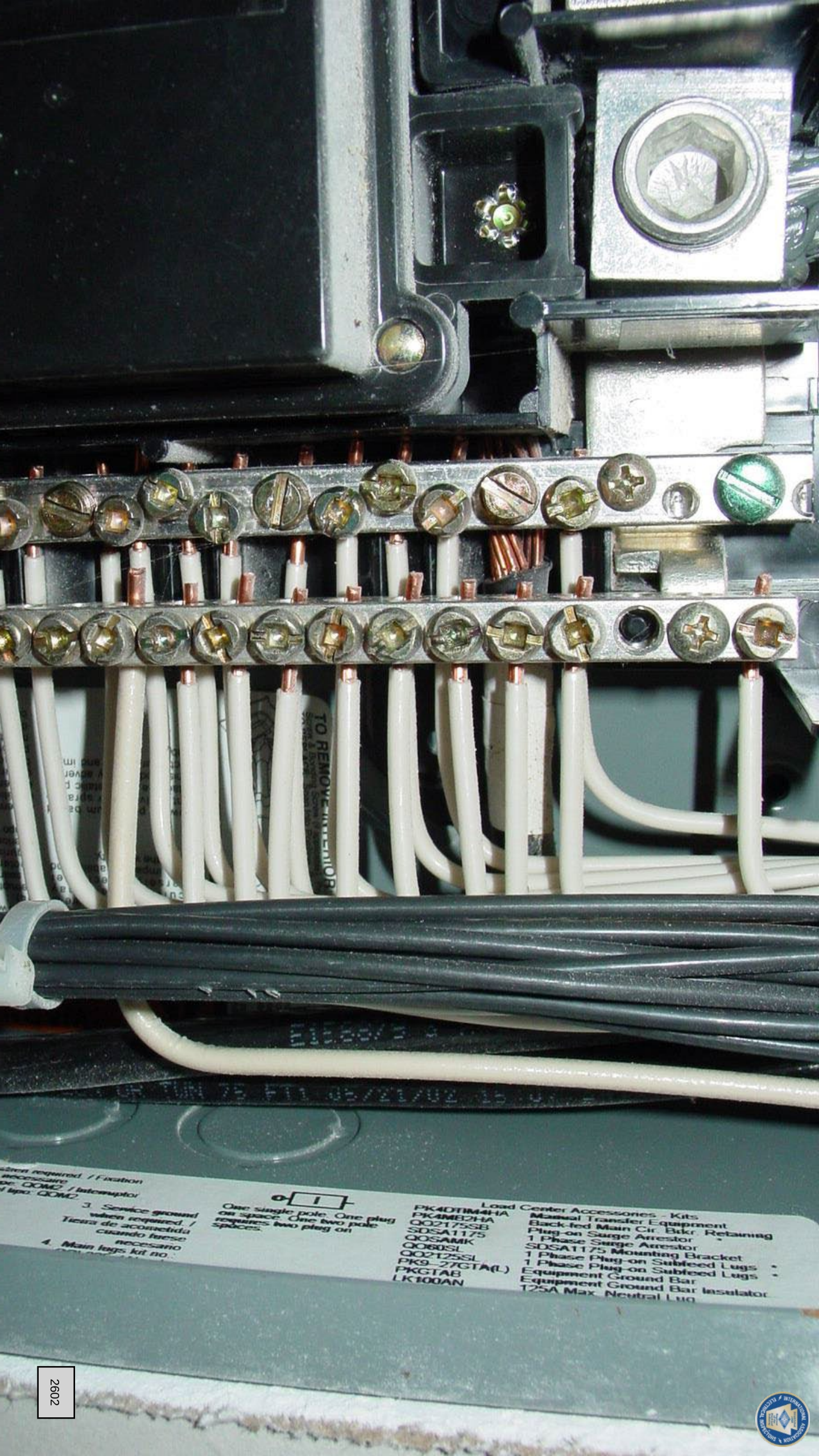
Copyright © IAEI 2020


EQUIPMEN
GROUNDING
TERMINAL


2600

Grounded Conductor Terminations

- Grounded (neutral) conductors are generally limited to **one per terminal** *[see 408.41]*
- Conductor terminals that are identified for more than one grounded conductor per terminal *(parallel conductors)* are acceptable *[408.41 Ex. and 110.14(A)]*
- Grounded conductors and EGCs are generally prohibited from being terminated in the same "hole" of a terminal bar *(even if it is identified for more than one conductor)*
- Some panelboards and equipment are identified for multiple equipment grounding conductors to be terminated under one terminal
- Follow manufacturer's installation instructions *[110.3(B)]*


TO REMOVE INTERIOR
Load Center Accessories - Kits
Manual Transfer Equipment
Back-fed Main Cir. Bkr. Retaining
Plug-on Surge Arrestor
1 Phase Surge Arrestor
SDSA1175 Mounting Bracket
1 Phase Plug-on Subfeed Lugs
1 Phase Plug-on Subfeed Lugs
Equipment Ground Bar
Equipment Ground Bar Insulator
125A Max. Neutral Lug
PK4OTM4HA
PKAM812HA
QO2175SB
SDSA1175
QOSAMK
QO60SL
QO2125SL
PK9_27GTA(L)
PKGTAB
LK100AN
One single pole. One plug on space. One two pole requires two plug on spaces.
3. Service ground when required. / Tierra de acometida cuando fuese necesario
4. Main lugs kit no.

2602

Grounding-Type Receptacles

- Where grounding-type receptacles are installed, the equipment grounding terminal of the receptacle must be connected to an equipment grounding conductor (EGC) of the circuit supplying the receptacle *[see 406.4(C)]*
- Permitted to connect each EGC to a metal box individually using a listed clip, screw, or terminal bar with an equipment bonding jumper connected to the receptacle
- Equipment bonding jumper from the receptacle to the box not required where a device with **listed grounding means** is installed in a metal box that is properly grounded
- These devices are often referred to as **self-grounding receptacles** and are specially designed so one or more of the mounting screws are maintained in contact with the device's metal yoke *(see Chapter 13 of Soares)*
- *Note: Not permitted to ground the box by the use of these self-grounding receptacles*

Isolated Grounding Receptacles

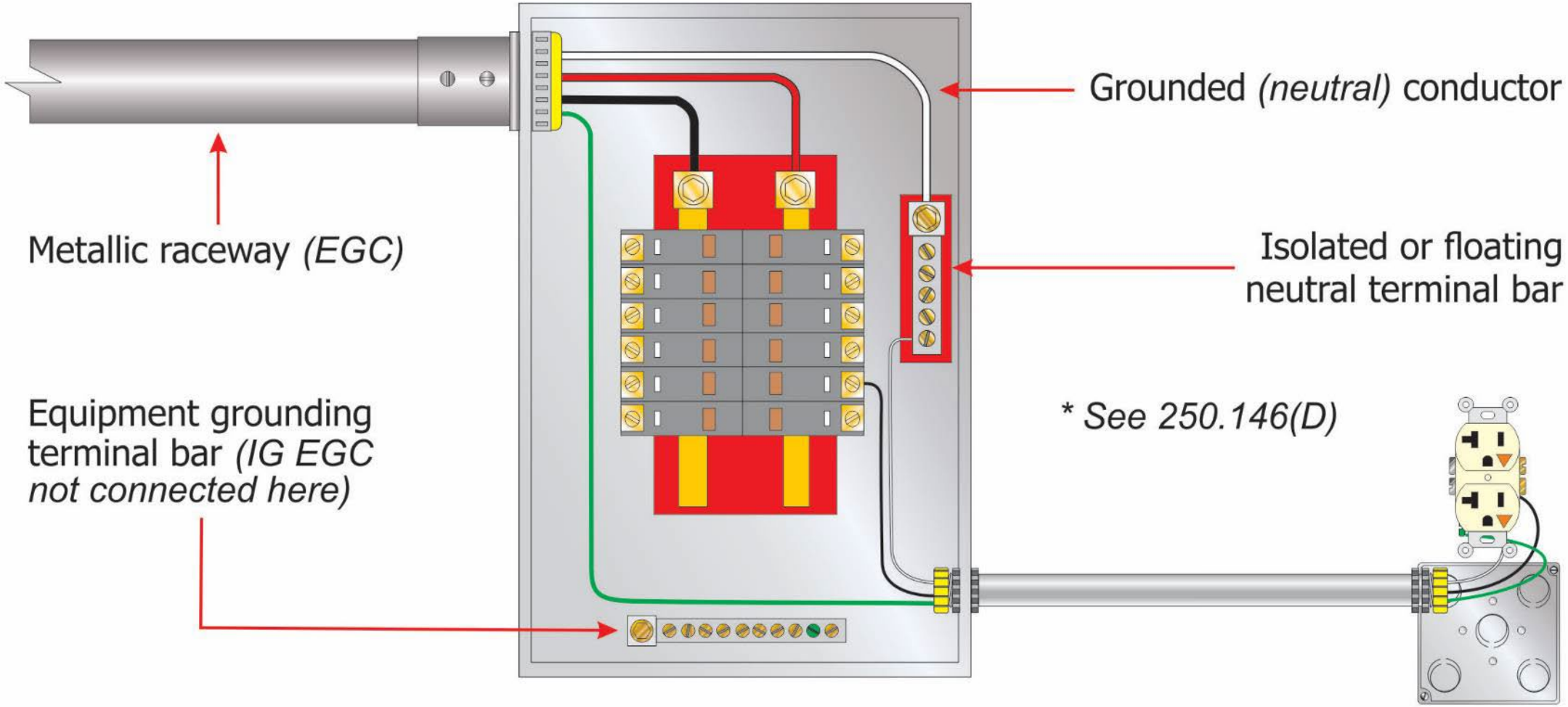
- Receptacles that have the equipment grounding terminal **isolated** from the mounting strap (yoke), and therefore from the box, are commonly installed for such things as computer terminals and cash registers
- This is permitted for the purpose of reducing **electromagnetic interference**
- The grounding terminal of **the isolated grounding receptacle** must be grounded by means of an **insulated equipment grounding conductor** installed with the circuit conductors
- The isolated grounding receptacle insulated EGC is ***permitted*** to pass through one or more panelboards, boxes, wireways, or other enclosures **without connection** to the box or the terminal bar within the panelboard on its way back to the source

Isolated Grounding Receptacles *(cont.)*

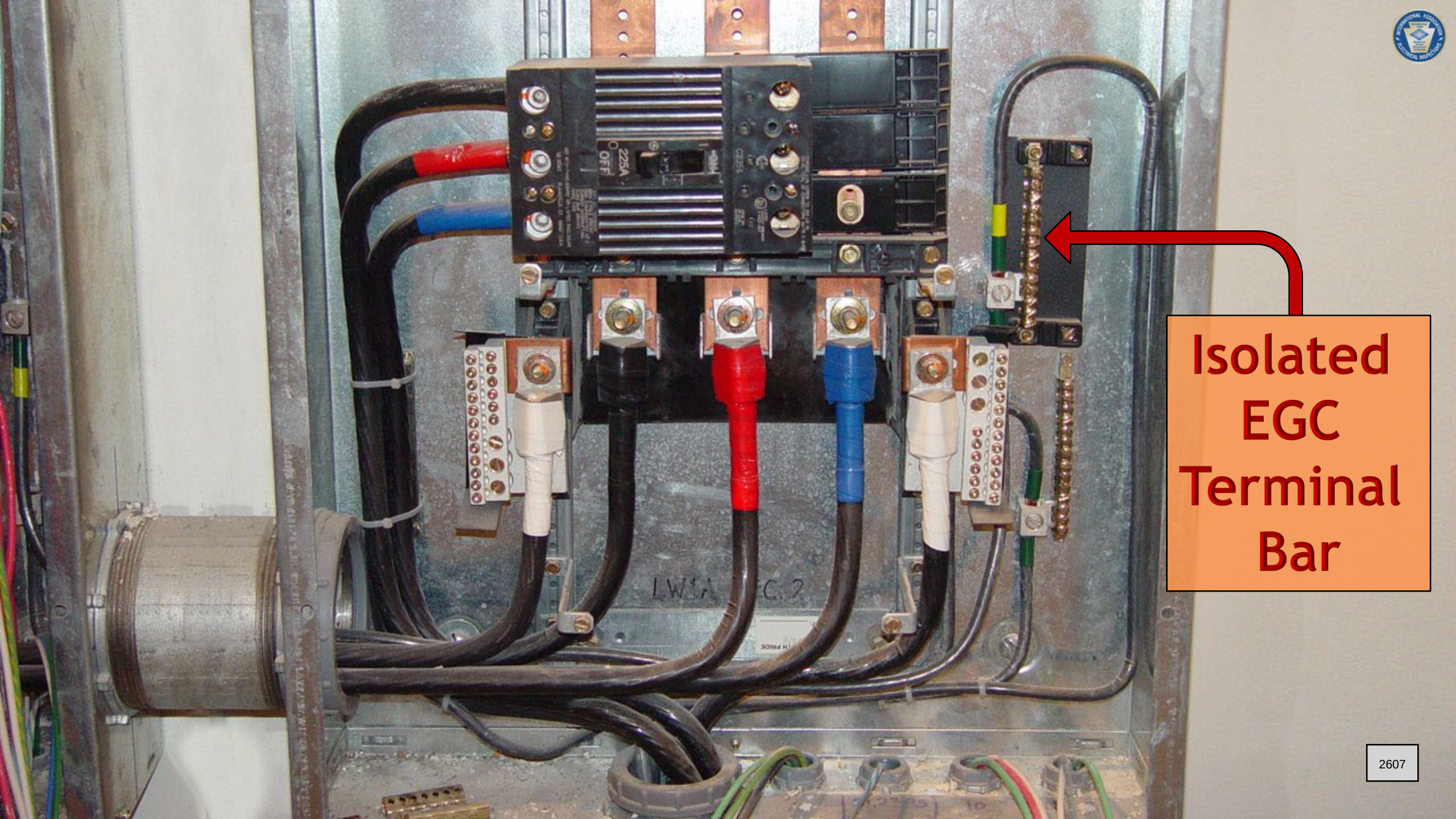
- Insulated equipment grounding conductor must terminate at:
  - The **service equipment** in the same building or structure,
  - At the **disconnecting means** for a feeder or branch circuit to a separate building, or
  - The **source of a separately derived system** where the circuit originates from that separately derived system
- *See 250.146(D) and 408.40, Exception*
- Note: Require it to be identified with **green** *or* **green with one or more yellow stripes** *(very common practice to identify isolated equipment grounding conductors with the latter)*

Isolated Ground Receptacles

Isolated, insulated equipment grounding conductor *(IG) (passing through panel to receptacle)*



Copyright © IAEI 2020

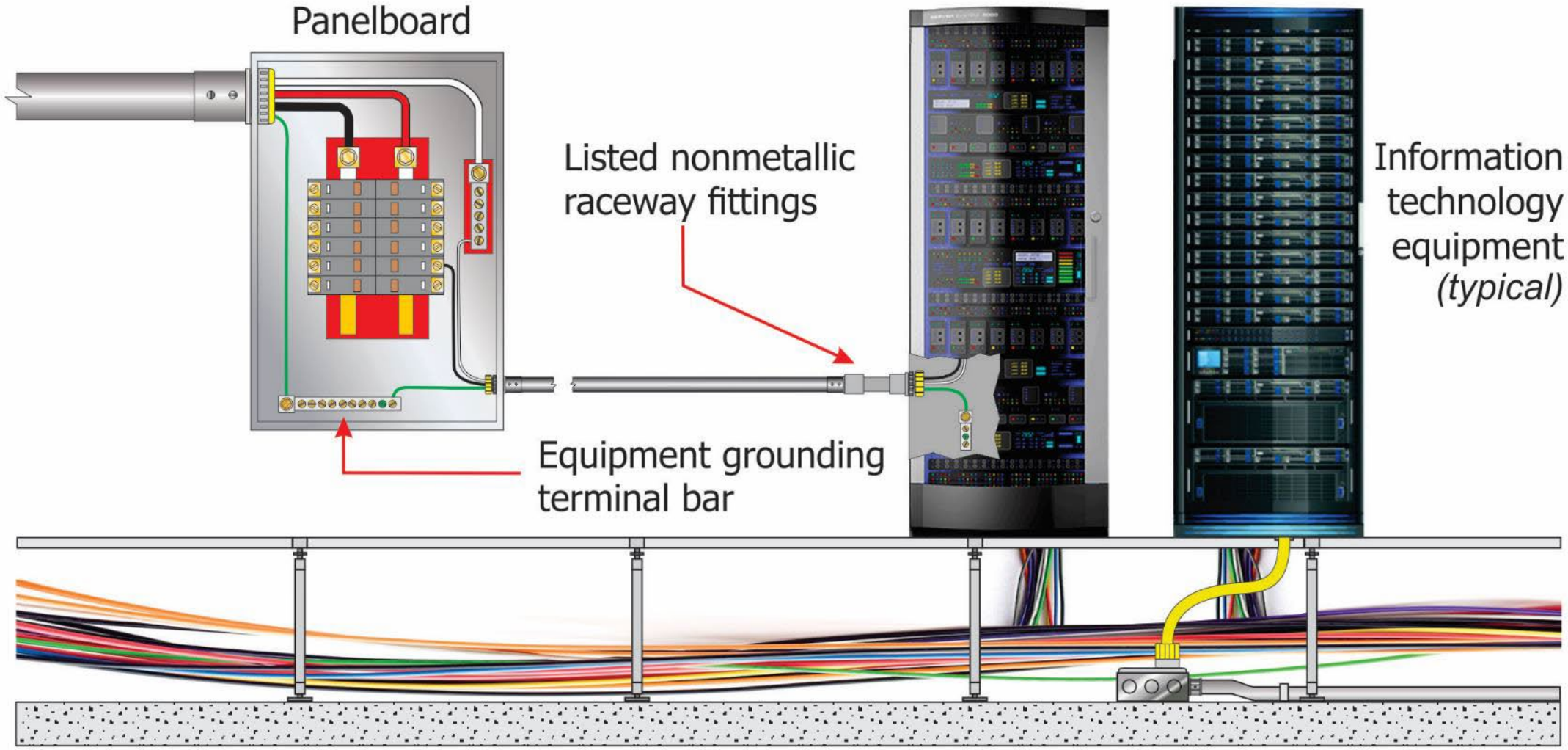

Isolated EGC Terminal Bar

Isolated Equipment Grounding

- Another aspect for isolation to mitigate electro-magnetic interference is provided at **250.96(B)**
- In some cases, equipment enclosures are permitted to be supplied with the metal raceway **isolated** *(separating that equipment grounding path)* with the equipment grounded by connection to an **insulated equipment grounding conductor** contained within the raceway for the branch circuit that supplies the equipment
- A **listed nonmetallic raceway fitting** at the point of connection to the equipment must be installed to complete the isolation of the metallic raceway
- This provision typically applies to listed data processing *(information technology)* equipment

250.96(B) Isolated Equipment Grounding

Listed nonmetallic raceway fitting(s) permitted in metal conduit but insulated equipment grounding conductor is required to be connected to the equipment



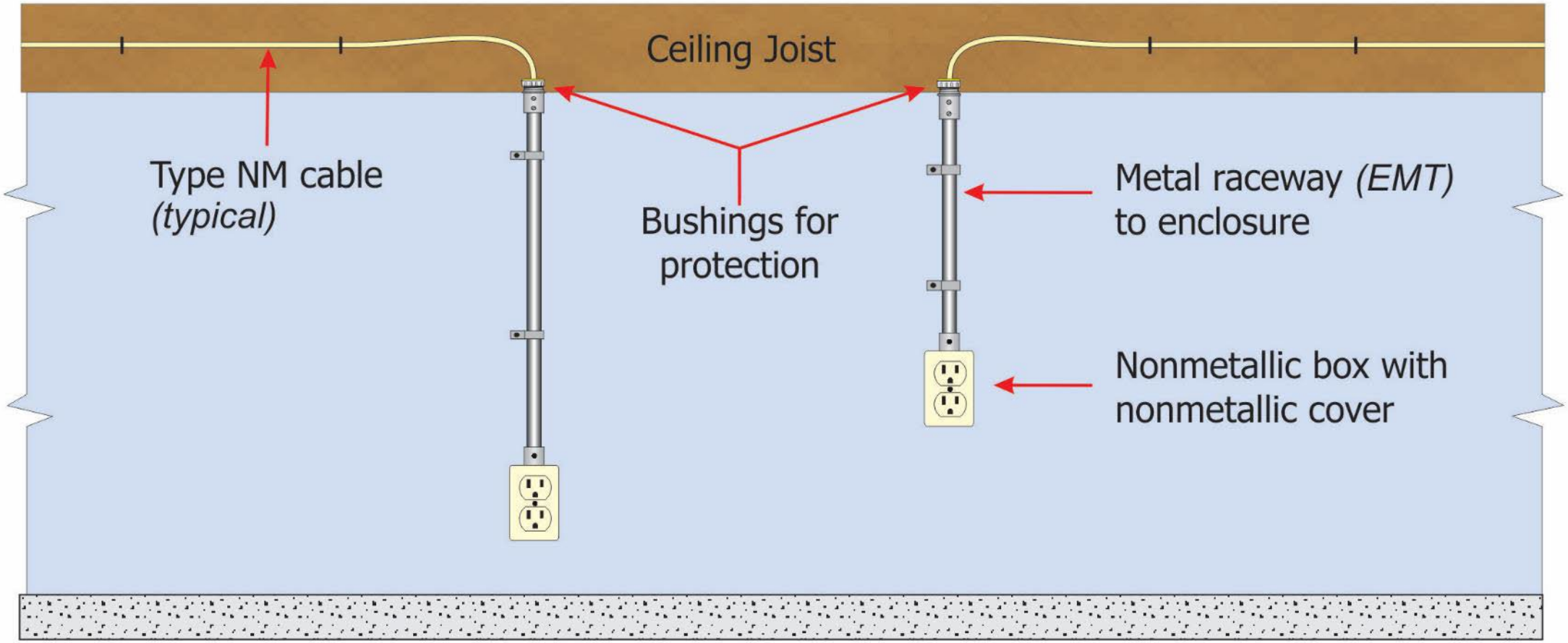
Copyright © IAEI 2020

Short Sections of Raceway

- Metal enclosures and raceways are generally required to be connected to the equipment grounding conductor
- ***Short sections*** of raceway are not required to be connected to the equipment grounding conductor where used to provide support or physical protection of cable assemblies
- See 250.86 Ex. No. 2

250.86 Ex. No. 2 Short Sections of Metallic Raceways

Metal enclosures and raceways for conductors (other than service conductors) are generally required to be connected to the equipment grounding conductor



Short sections of metallic raceways used for protection are not required to be connected to the equipment grounding conductor

Copyright © IAEI 2020

SOARES Grounding and Bonding

Based on the 2020 NEC®

End of Part II - Grounding and Bonding Common Applications

International Association Of Electrical Inspectors

Presented by the International Association of Electrical Inspectors

2612

File Attachments for Item:

EC-11 2023 NEC Changes (Jade Learning)

All certifications (16 hours)

APPLICATION

FOR

Continuing Education Course Approval

Continuing education programs approved for education credit by the Ohio Board of Building Standards may be used for compliance with certification requirements related to code enforcement, plan review, and inspection responsibilities. The credit is to be used to renew the certifications issued by the Ohio Board of Building Standards pursuant to section 3781.10(E) ORC.

Board of Building Standards
6606 Tussing Road, P.O. Box 4009
Reynoldsburg, Ohio 43068-9009
(614) 644-2613 Fax: (614) 644-3147
dic.bbs@com.state.oh.us
www.com.state.oh.us/dic/dicbbs.htm

COURSE SUBMITTER:

Course Submitter: David Modica
(Contact Name)
Organization: JADE Learning
(Organization/Company)
Address: 225 East Robinson St - Suite 570
(Include Room Number, Suite, etc.)
City: Orlando State: FL Zip: 32801
E-Mail: inspector@amersc.com
Telephone: 800-443-5233 Fax: _____
Course Sponsor: JADE Learning

COURSE INFORMATION:

Course Title: 2023 NEC Changes

New Course Submittal: ■ Update Course: ☐ Prior Approval Number: _____

Purpose and Objective: Please see attached outline

Number of Instructional Contact Hours that can be obtained upon completion: 16

If Multi-Session, Number of Instructional Contact Hours Per Session: User-controlled (minimum of 16)

Program Applicable for the Following Participants:

Building Official ☐	Master Plans Examiner ☐	Building Inspector ☐	Fire Protection Inspector ☐	Mechanical Inspector ☐
	Building Plans Exam. ☐			Plumbing Inspector ☐
	Plumbing Plans Exam. ☐			Non-Res IU Inspector ☐
	Electrical Plans Exam. ☐			
	Mechanical Plans Exam. ☐			
	Fire Protect. Plans Exam. ☐			
Res Building Official ☐	Res Plans Examiner ☐	Res Building Inspector ☐	Res Mechanical Inspector ☐	Res IU Inspector ☐

Electrical Safety Inspectors ☒
Location of ESI Course: online at www.jadelearning.com Date(s) of ESI Course(s): anytime

SUBMITTAL CHECKLIST: **Make Sure** all of the Following Information is **Submitted**:		Check Off
Course Submitter:	Name of contact person and their certification numbers, organization, address, fax, phone	X
	Organization sponsoring or requesting the program (if any)	X
Course Title:	Name of course (related to content)	X
Purpose/Objective:	Describe purpose and how course will improve competency of certification(s) listed	X
Contact Hours:	Indicate instructional time and credit requested in hours (e.g.: 0.5 hr, 1 hr, 3.5 hrs)	X
Participants:	Check off each certification for which credit is requested (for which course relates to certification)	X
Content of Program:	Include collated agenda, time schedule, course outline; list specific sections of code, references, and topics covered	X
Course Materials:	Collated workbooks, handouts, hard copy or electronic versions of program is available	X
Instructor(s) Info.:	Resume of professional/educational qualifications & teaching/training experience/BBS certifications	X
Test Materials:	Please see all assessment questions online using audit account listing in outline	X
Completed Application:		X

NOTE: The Board does NOT grant retroactive approval for courses presented prior to approval date.

JADE LEARNING
A TPC COMPANY

Course Name

2023 NEC Changes

Credit Hours

16 Hours

Course Description

This online course reviews the top 200 most important changes to the 2023 National Electrical Code. Changes from Section 100 through Annex K will be covered.

Learning Objectives

At the completion of the course, licensees will be able to:

- Describe the overall layout of the National Electrical Code and the addition of new articles.
- Identify the scope of what is covered and not covered in the Code.
- List which chapters can supplement or modify other chapters.
- Identify updates, additions, and changes to Chapter 1 of the 2023 National Electrical Code.
- Describe changes in the way terms are presented in Article 100, *Definitions*.
- Define terms that are newly defined in the 2023 NEC.
- Outline changes to the general requirements for electrical installations found in Chapter 110 of the 2023 NEC.
- Identify updates, additions, and changes to Chapter 2 of the 2023 National Electrical Code.
- Describe changes for branch circuits found in Chapter 2 of the 2023 NEC.
- Identify the changes to minimum unit load requirements for dwelling units and lighting loads for non-dwelling occupancies found in Chapter 2 of the 2023 NEC.
- Describe changes to emergency disconnects and surge protection for outside branch circuits and feeders found in Chapter 2 of the 2023 NEC.
- Outline the new wiring method for installing underground service conductors.
- List the locations that must be provided with surge protection devices.
- Identify changes for service conductors and service installation requirements found in Chapter 2 of the 2023 NEC.

- Outline the new declaration regarding standard overcurrent device ratings found in Chapter 2 of the 2023 NEC.
- Identify changes to the standard ampere ratings in Table 240.6(A).
- Describe the new requirement that surge protection devices indicate they are functioning properly.
- Identify updates, additions, and changes to Chapter 3 of the 2023 National Electrical Code.
- Summarize the general requirements for wiring methods and materials for systems rated over 1000 volts ac, 1500 volts dc covered in Article 305.
- Outline new requirements for installing screws and other fasteners in cabinets, cutout boxes, and meter socket enclosures found in Chapter 3 of the 2023 NEC.
- Outline new requirements for insulated bus pipe and flexible bus systems found in Chapter 3 of the 2023 NEC.
- Identify updates, additions, and changes to Chapter 4 of the 2023 National Electrical Code.
- Describe the change in scope to Chapter 4 of the 2023 NEC.
- Identify changes and additions to requirements for switches found in Chapter 4 of the 2023 NEC.
- List new locations requiring tamper-resistant receptacles.
- Outline new requirements for receptacles, cord connectors, and attachment plugs found in Chapter 4 of the 2023 NEC.
- Describe new requirements for switchboards, switchgear, and panelboards found in Chapter 4 of the 2023 NEC.
- Identify updates, additions, and changes to Chapter 5 of the 2023 National Electrical Code.
- Describe the changes to Class III Division 1 and Division. 2 locations found in Chapter 5 of the 2023 NEC.
- Outline new requirements for protection of electrical and electronic equipment in hazardous locations.
- Describe changes to permission for flexible connections and restricted industrial establishments in Class I, Division 1 and Division 2 locations.
- Outline new wiring methods for Class III Division 1 locations.

- Explain the new requirements for cannabis oil equipment and cannabis oil systems using flammable materials found in Chapter 5 of the 2023 NEC.
- Identify changes in requirements for electrical construction and installation criteria in health care facilities.
- Identify updates, additions, and changes to Chapter 6 of the 2023 National Electrical Code.
- Outline new and changed requirements for electric vehicle power transfer systems found in Chapter 6 of the 2023 NEC.
- Explain the new and changed requirements for construction and installation of electrical wiring for swimming pools, fountains, and similar installations.
- Identify changed requirements for labeling of photovoltaic equipment floating on bodies of water and rapid shutdown of PV system circuits.
- Define the change in scope for Article 695: Fire Pumps.
- Identify updates, additions, and changes to Chapter 7 of the 2023 National Electrical Code.
- Outline new and changed requirements for emergency systems in Chapter 7 of the 2023 NEC.
- Define the changes in scope for Article 701: Legally Required Standby Systems.
- Identify changed requirements concerning signage and portable generators for optional standby systems found in Chapter 7 of the 2023 NEC.
- Describe new wiring requirements for Class 4 fault-managed power systems.
- Identify changed requirements for installation of circuits and supply-side overvoltage protection in fire alarm systems.
- Identify updates, additions, and changes to Chapter 8, and the Annexes of the 2023 National Electrical Code.
- Describe changes in how Chapters 1 through 7 apply to Chapter 8 of the 2023 NEC.
- Outline new and changed requirements for network-powered broadband communication systems found in Chapter 8 of the 2023 NEC.
- Outline new and changed requirements for conduits Annex C of the 2023 NEC.

Reference Materials NFPA 70 National Electrical Code 2023 Edition

Course Timed Syllabus Attached

Method of Presentation	This online course presents each code section with commentary, a graphic illustration or photograph, and requires the participant to answer multiple choice questions after reviewing the content. Since this is an unadopted version of the National Electrical Code, we will have the below messaging both on the registration page and at the beginning of the course - "This course is based on the 2023 NEC. The 2023 NEC has not been adopted in Ohio. Presented for INFORMATIONAL PURPOSES ONLY"
Schedule and Location	This course may be taken at any time at www.JadeLearning.com. The student may sign in and out of the course as many times as needed to complete the course.
Attendance Verification	This course employs an inactivity timer, which will automatically log a licensee out of the training if the system does not sense a mouse click within 30 minutes. At the end of the course, the licensee must affirm their name, that they are the one who completed the course, and verify that their registration information is correct.
Method of Evaluation	The licensee must complete all 200 multiple choice questions with a score of at least 70% in order to get credit for the course. Question choices are randomized so each participant will have a unique testing experience. The course is also timed; participants will not get credit until they spend at least 960 active minutes in the course.
Online Review Access	To review this course, go to www.JadeLearning.com. Click on the orange Login button on the top right and sign into the learning system using the login information below. Username: OHItester Password: OHItester
Instructor(s)	Jerry Durham (resume attached)
Fee	$159.00

2023 NEC Changes Timed Syllabus

Section	Title	Questions	Minutes
Chapter 1			
1	100. Definitions. Scope.	**1**	**5**
2	Definitions. Attachment Fitting, Weight-Supporting (WSAF) and Receptacle, Weight Supporting Ceiling (WSCR).	**1**	**5**
3	Definitions. Class 4 Circuit, Class 4 Device, Class 4 Power System, Class 4 Receiver, Class 4 Transmitter, Class 4 Utilization Equipment.	**1**	**5**
4	Definitions. Cord Connector.	**1**	**5**
5	Definitions. Counter (Countertop).	**1**	**5**
6	Definitions. Ground Fault Circuit Interrupter, Special Purpose.	**1**	**5**
7	Definitions. Ground-Fault Detector-Interruptor, dc (GFDI).	**1**	**5**
8	Definitions. Grounded Conductor, Impedance.	**1**	**5**
9	Definitions. Grounded System, Impedance.	**1**	**5**
10	Definitions. Panelboard, Enclosed. (Enclosed Panelboard).	**1**	**5**
11	Definitions. Restricted Industrial Establishment	**1**	**5**
12	Definitions. Stored Energy Power Supply System (SEPSS).	**1**	**5**
13	Definitions. Work Surface.	**1**	**5**
14	110.3(A)(8) Cybersecurity.	**1**	**5**
15	110.3(B) Installation and Use.	**1**	**5**
16	110.16(B) Service Equipment and Feeder Supplied Equipment.	**1**	**5**
17	110.17 Servicing and Maintenance of Equipment.	**1**	**5**
18	110.20 Reconditioned Equipment.	**1**	**5**
19	110.26 Spaces About Electrical Equipment.	**1**	**5**
20	110.26(A)(6) Grade, Floor, or Working Platform.	**1**	**5**
21	110.29 In Sight From (Within Sight From, Within Sight).	**1**	**5**
22	110.33(A) Entrance to Enclosure and Access to Working Space. Entrance.	**1**	**5**
Chapter 2			
23	Article 210, Branch Circuits Not Over 1000 Volts ac, 1500 Volts dc, Nominal.	**1**	**5**
24	210.2 Reconditioned Equipment.	**1**	**5**
25	210.5(C)(1) Branch Circuits Supplied from More than One Nominal Voltage System.	**1**	**5**
26	210.8(A)(5) Dwelling Units. Basements.	**1**	**5**
27	210.8(A)(6) Dwelling Units. Kitchens.	**1**	**5**
28	210.8(A)(7) Dwelling Units. Areas with Sinks.	**1**	**5**
29	210.8(B)(1-15) GFCI Protection for Personnel. Other than Dwelling Units.	**1**	**5**
30	210.8(B) GFCI Protection for Personnel. Other Than Dwelling Units. Exceptions.	**1**	**5**
31	210.8(D) GFCI Protection for Personnel. Specific Appliances.	**1**	**5**
32	210.8(F) Outdoor Outlets.	**1**	**5**
33	210.11(C)(4) Dwelling Units. Garage Branch Circuits.	**1**	**5**
34	210.12 Arc-Fault Circuit-Interrupter Protection.	**1**	**5**
35	210.17 Guest Rooms and Guest Suites.	**1**	**5**
36	210.18 Branch-Circuit Ratings. Rating.	**1**	**5**
37	210.23 Permissible Loads, Multiple-Outlet Branch Circuits.	**1**	**5**
38	Table 210.24(1) Summary of Branch-Circuit Requirements- Copper Conductors.	**1**	**5**
39	210.52(A)(2) Wall Space.	**1**	**5**
40	210.52(C)(1) Countertops and Work Surfaces. Wall Spaces.	**1**	**5**
41	210.52(C)(2) Countertops and Work Surfaces. Island and Peninsular Countertops and Work Surfaces.	**1**	**5**
42	210.52(C)(3). Receptacle Outlet Locations.	**1**	**5**
43	210.52(D) Bathrooms.	**1**	**5**

44	210.70 Lighting Outlets Required.	**1**	**5**
45	210.70(A)(1),(2) Dwelling Units. Additional Locations.	**1**	**5**
46	215.15 Barriers.	**1**	**5**
47	215.18 Surge Protection.	**1**	**5**
48	220.41 Dwelling Unit(s), Minimum Unit Load.	**1**	**5**
49	220.42 Lighting Load for Non-Dwelling Occupancies.	**1**	**5**
50	220.57 Electric Vehicle Supply Equipment (EVSE) Load.	**1**	**5**
51	220.110 Receptacle Loads.	**1**	**5**
52	220.120 Receptacle Loads.	**1**	**5**
53	Article 225, Outside Branch Circuits and Feeders.	**1**	**5**
54	225.41 Emergency Disconnects.	**1**	**5**
55	225.42 Surge Protection.	**1**	**5**
56	230.7 Other Conductors.	**1**	**5**
57	230.24(A) Above Roofs.	**1**	**5**
58	230.30(B) Wiring Methods.	**1**	**5**
59	230.62(C) Barriers.	**1**	**5**
60	230.67 Surge Protection.	**1**	**5**
61	230.71(B) Two to Six Service Disconnecting Means.	**1**	**5**
62	230.85 Emergency Disconnects.	**1**	**5**
63	Article 235, Branch Circuits, Feeders, and Services Over 1000 Volts ac, 1500 Volts dc, nominal.	**1**	**5**
64	240.4(B) Overcurrent Devices Rated 800 Amperes or Less.	**1**	**5**
65	Table 240.6(A) Standard Ampere Ratings for Fuses and Inverse Time Circuit Breakers.	**1**	**5**
66	242.9 Indicating.	**1**	**5**
67	Article 245, Overcurrent Protection for Systems Rated Over 1000 Volts ac, 1500 volts dc.	**1**	**5**
68	250.64(G) Enclosures with Ventilation Openings.	**1**	**5**
69	250.68(C) Grounding Electrode Conductor Connections.	**1**	**5**
70	250.118 Types of Equipment Grounding Conductors.	**1**	**5**
71	250.130 Equipment Grounding Conductor Connections.	**1**	**5**
72	250.130(C) Replacement of Nongrounding Receptacle or Snap Switch and Branch Circuit Extensions.	**1**	**5**
73	250.140 Frames of Ranges and Clothes Dryers.	**1**	**5**
74	250.148 Continuity of Equipment Grounding Conductors and Attachment in Boxes.	**1**	**5**
75	250.186 Grounding Service-Supplied Alternating-Current Systems.	**1**	**5**
Chapter 3			
76	300.4(E) Cables, Raceways, or Boxes Installed in or Under Metal-Corrugated Roof Decking.	**1**	**5**
77	Table 300.5(A) Minimum Cover Requirements.	**1**	**5**
78	Article 305, General Requirements for Wiring Methods and Materials for Systems Rated Over 1000 volts ac, 1500 volts dc, Nominal.	**1**	**5**
79	310.15(B)(2) Rooftop.	**1**	**5**
80	312.10 Screws or Other Fasteners.	**1**	**5**
81	314.27(E) Weight-Supporting Ceiling Receptacles and Weight-Supporting Attachment Fittings.	**1**	**5**
82	314.29(B) Underground.	**1**	**5**
83	334.10 Uses Permitted.	**1**	**5**
84	334.15(B) Protection from Physical Damage.	**1**	**5**
85	334.40(B) Boxes and Fittings.	**1**	**5**
86	344.28 Reaming and Threading.	**1**	**5**
87	352.10 Uses Permitted.	**1**	**5**
88	352.44 Expansion Fittings.	**1**	**5**

89	Article 369, Insulated Bus Pipe (IBP)/ Tubular Covered Conductors (TCC) Systems.	**1**	**5**
90	Article 371, Flexible Bus Systems.	**1**	**5**
Chapter 4			
91	404.1 Scope.	**1**	**5**
92	404.2(C) Switches Controlling Lighting Loads.	**1**	**5**
93	404.14(D) Snap Switch Terminations.	**1**	**5**
94	404.16 Reconditioned Equipment.	**1**	**5**
95	404.30 Switch Enclosures with Doors.	**1**	**5**
96	406.3(D) Receptacle Terminations.	**1**	**5**
97	406.4(G) Protection of Floor Receptacles.	**1**	**5**
98	406.6(D) Receptacle Faceplate (Cover Plates) with Integral Night Light and/or USB Charger.	**1**	**5**
99	406.9(A),(B) Damp Locations, Wet Locations.	**1**	**5**
100	406.9(C) Bathtub and Shower Space.	**1**	**5**
101	406.12 Tamper-Resistant Receptacles.	**1**	**5**
102	408.4(B) Source of Supply.	**1**	**5**
103	408.38 Enclosure.	**1**	**5**
104	408.43 Panelboard Orientation.	**1**	**5**
105	410.10(D) Bathtub and Shower Areas.	**1**	**5**
106	410. Part XVII. Special Provisions for Germicidal Irradiation Luminaires.	**1**	**5**
107	422.16(B) Specific Appliances.	**1**	**5**
108	422.18 Ceiling-Suspended (Paddle) Fans.	**1**	**5**
109	422.22 Utilizing Separable Attachment Fittings.	**1**	**5**
110	424.93 Installation.	**1**	**5**
111	430.113 Energy from More Than One Source.	**1**	**5**
112	440.8 Single Machine and Location.	**1**	**5**
113	440.11 General.	**1**	**5**
114	445.19 Emergency Shutdown of Prime Mover.	**1**	**5**
Chapter 5			
115	500.1 Scope.	**1**	**5**
116	500.5(D) Class III Locations.	**1**	**5**
117	500.7 Protection Techniques.	**1**	**5**
118	500.8(E)(3) Unused Openings.	**1**	**5**
119	501.10(A)(2) Flexible Connections.	**1**	**5**
120	501.30(B) Bonding.	**1**	**5**
121	502.30(B), 503.30(B) Bonding.	**1**	**5**
122	503.10(A) Class III, Division 1.	**1**	**5**
123	505.8 Protection Techniques.	**1**	**5**
124	505.15(C) Zone 2.	**1**	**5**
125	505.16(B) Zone 1.	**1**	**5**
126	Article 512, Cannabis Oil Equipment and Cannabis Oil Systems Using Flammable Materials.	**1**	**5**
127	517.6 Patient Care-Related Electrical Equipment.	**1**	**5**
128	517.10(B) Not Covered.	**1**	**5**
129	517.14 Panelboard Bonding.	**1**	**5**
130	517.20(A) Receptacles and Fixed Equipment.	**1**	**5**
131	517.22 Demand Factors.	**1**	**5**
132	517.30 Sources of Power.	**1**	**5**
133	517.70 Applicability.	**1**	**5**
134	518.5 Supply.	**1**	**5**
135	547.26 Physical Protection.	**1**	**5**

136	547.44 Equipotential Planes and Bonding of Equipotential Planes.	**1**	**5**
137	550.16(C)(1) Exposed Non-Current-Carrying Metal Parts.	**1**	**5**
138	550.32 Service Equipment.	**1**	**5**
139	550.33(A) Feeder Equipment.	**1**	**5**
140	551.40(D) Loss of Ground Device.	**1**	**5**
141	555.14 Equipotential Planes and Bonding of Equipotential Planes.	**1**	**5**
142	555.15 Replacement of Equipment.	**1**	**5**
143	555.36(C) Emergency Electrical Disconnect.	**1**	**5**
Chapter 6			
144	620.22 Branch Circuits for Car Lighting, Receptacles, Ventilation, Heating, and Air Conditioning.	**1**	**5**
145	620.23 Branch Circuits for Machine Room, Control Room/Machinery Space, Control Space, or Truss Interior Lighting and Receptacle(s).	**1**	**5**
146	625.40 Electric Vehicle Branch Circuit.	**1**	**5**
147	625.42 Rating.	**1**	**5**
148	625.43 Disconnecting Means.	**1**	**5**
149	625.49 Island Mode.	**1**	**5**
150	625.102 Installation.	**1**	**5**
151	626.1 Scope.	**1**	**5**
152	630.8 Ground-Fault Circuit-Interrupter Protection for Personnel.	**1**	**5**
153	646.19 Entrance to and Egress from Working Space.	**1**	**5**
154	680.5 GFCI and Special Purpose GFCI (SPGFCI) Protection.	**1**	**5**
155	680.12 Equipment Rooms, Vaults, and Pits.	**1**	**5**
156	680.21(D) Pool Pump Motor Replacement.	**1**	**5**
157	680.22(A) Receptacles.	**1**	**5**
158	680.26 Equipotential Bonding.	**1**	**5**
159	680.32 Ground Fault Protection Required.	**1**	**5**
160	680.43 Indoor Installations.	**1**	**5**
161	680.54(B),(C), Bonding, Equipotential Bonding of Splash Pads.	**1**	**5**
162	680.58 GFCI, SPGFCI Protection for Adjacent Receptacle Outlets.	**1**	**5**
163	680.59 GFCI and SPGFCI Protection for Permanently Installed Nonsubmersible Pumps.	**1**	**5**
164	680.83 Equipotential Bonding.	**1**	**5**
165	690.4(G) PV Equipment Floating on Bodies of Water.	**1**	**5**
166	690.12(D) Buildings with Rapid Shutdown.	**1**	**5**
167	694.7 Construction and Maintenance.	**1**	**5**
168	695.1 Fire Pumps. Scope.	**1**	**5**
Chapter 7			
169	700.3 Tests and Maintenance.	**1**	**5**
170	700.4(B) Selective Load Management.	**1**	**5**
171	700.11 Wiring, Class-2-Powered Emergency Lighting Systems.	**1**	**5**
172	700.12(C) Supply Duration.	**1**	**5**
173	700.12(E) Stored-Energy Power Supply Systems (SEPSS).	**1**	**5**
174	701.1 Scope.	**1**	**5**
175	701.12(C)(3) Public Gas System, Municipal Water Supply.	**1**	**5**
176	701.32 Selective Coordination.	**1**	**5**
177	702.7(A) Standby.	**1**	**5**
178	702.12(B) Portable Generators 15kw or Less.	**1**	**5**
179	705.10 Identification of Power Sources.	**1**	**5**
180	706.7 Commissioning and Maintenance.	**1**	**5**
181	Article 724, Class 1 Power-Limited Circuits and Class 1 Power-Limited Remote-Control and Signaling Circuits.	**1**	**5**

182	Article 725, Class 2 and Class 3 Power-Limited Circuits.	**1**	**5**
183	725.3(A) Spread of Fire or Products of Combustion.	**1**	**5**
184	Article 726, Class 4 Fault-Managed Power Systems.	**1**	**5**
185	750.6 Listing.	**1**	**5**
186	760.24 Mechanical Execution of Work.	**1**	**5**
187	760.33 Supply-Side Overvoltage Protection.	**1**	**5**
Chapter 8			
188	800.3 Other Articles.	**1**	**5**
189	800.100(B)(2) Electrode. In Buildings or Structures with Grounding Means.	**1**	**5**
190	800.100(B)(3) In Buildings or Structures Without an Intersystem Bonding Termination or Grounding Means.	**1**	**5**
191	800.113 Installation of Cables Used for Communication Circuits, Communications Wires, Cable Routing Assemblies, and Communications Raceways.	**1**	**5**
192	800.179 Wires and Cables.	**1**	**5**
193	810.15 Grounding or Bonding.	**1**	**5**
194	830.40(B) Low-Power Circuits.	**1**	**5**
195	830.47 Underground Network-Powered Broadband Communications Cables Entering Buildings.	**1**	**5**
196	830.133(C) Splicing of Medium-Powered Network-Powered Communications Cables.	**1**	**5**
197	830.160 Bends.	**1**	**5**
Chapter 9 and Annexes			
198	Chapter 9, Table 1.	**1**	**5**
199	Annex C, Table C.1 Conduit, Tubing, and Cable Tray Fill Tables for Conductors and Fixture Wires of the Same Size.	**1**	**5**
200	Annex K, Use of Medical Electrical Equipment in Dwellings and Residential Board-and-Care Occupancies.	**1**	**5**
	Totals:	**200**	**1000**
	Student Minimum Time Required:		**960**

Jerry L Durham

Certificates/Licenses

North Carolina Electrical Inspector Level III
North Carolina Plumbing Inspector Level I
North Carolina Mechanical Inspector Level I
Washington Electrical Adminstrator #DURHAJL821PQ
ICC Kentucky E1 Electrical Inspector, Masters Electrician, Journeyman Electrician
NCCER Core and Electrical Curriculum Instructor Certification

Work Experience

Instructor (JADE Learning, LLC) **2018 - Present**
Write and develop course curriculum, technical articles, and related learning materials. Teach in-person classroom courses.

Electrical Inspector- LVL 3 (Alamance County Government) **2015 - 2018**
Code enforcement officer, enforcing all guidelines set forth in the National Electrical Code and applicable State-issued code amendments, as they apply to residential and commercial electrical installations throughout the state of North Carolina.

Electrical Instructor (Alamance Community College) **2017- Present**
Taught from six to thirty NC electrical inspectors per 40-hour training session. Taught basic electrical theory, Ohm's Law, circuitry, voltage drop calculations, box/pipefill calculations, junction and pull-box calculations, conductor derating and adjustment calculations, residential-service-calculations, and National Electrical Code.

Code Enforcement Officer (Louisville Metro Government) **2009 - 2015**
City inspector, charged with determining property maintenance and health and safety code compliance and/or infractions for dwellings (interior/exterior), commercial structures, properties, parcels and lots. Included enforcement of local, state and federal code requirements pertaining to building, zoning, electrical, plumbing, HVAC and Land Development in the Louisville Metro area. The department's electrical instructor, performing classroom setting electrical instruction.

Electrical Instructor (ABC Trade School) **2010 - 2014**
Instructor of 25 electrical trade students participating in their first through fourth year of a four-year electrical apprenticeship program. Also performed state approved Masters and Journeyman State Licensing preparatory courses.

Electrical Instructor (IEC Trade School) **2009 - 2010**
Instructor of 25 electrical trade students in a four-year apprenticeship program.

Licensed Electrician (Curtsinger Electric Company) **2003 - 2009**
Managed multiple electrical remodel and new-build projects, performing interior/exterior lighting design, installation and system troubleshooting. Diagnosis and repair of residential and commercial electrical, phone and cable installations. Continual training of apprentices in the areas of customer care, electrical theory/diagnosis, repair/installation and effective time management.

North Carolina Code Officials

Qualification Board

STANDARD CERTIFICATE

This is to certify that

JERRY LEE DURHAM

ID# 21791

HAVING GIVEN SATISFACTORY EVIDENCE SHOWING ALL THE NECESSARY QUALIFICATIONS WITH REGARD TO CHARACTER, EDUCATION, AND EXPERIENCE AS REQUIRED BY THE ACT OF THE GENERAL ASSEMBLY OF JUNE 13, 1977, AS AMENDED, WAS EXAMINED – DULY CERTIFIED – AWARDED THIS CERTIFICATE – AND IS HEREBY AUTHORIZED TO SERVE WHILE EMPLOYED BY A CITY, A COUNTY, OR THE STATE AS

ELECTRICAL INSPECTOR LEVEL III

IN THE STATE OF NORTH CAROLINA

IN TESTIMONY WHEREOF: THE CODE OFFICIALS QUALIFICATION BOARD ISSUES THIS CERTIFICATE UNDER THE SEAL OF THE BOARD AND SIGNATURES OF THE CHAIRMAN AND SECRETARY:

THIS **25TH** DAY OF **APRIL 2017**

27643
CERTIFICATE NUMBER

Attest: Brenda Lyerly
Secretary

Bill Arundell
Chairman

2625

Department of Labor and Industries
PO Box 44460
Olympia, WA 98504-4460

DURHAM, JERRY LEE-FRANK-ONLO

Cert: AD DURHAJL821PQ

Certified as provided by Law as:
Administrator
(AD01) - GENERAL

Effective Date: 10/19/2018
Expiration Date: 2/5/2024

627

DURHAM, JERRY LEE-FRANK-ONLO
2828 ALAMANCE RD
BURLINGTON NC 27215

File Attachments for Item:

EC-12 2023 NEC Code Changes Part 1 (Wink Electric)

All certifications (5 hours)

Ohio | Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: CLIFFORD WINKER

Organization: WINK ELECTRIC

Address: 5640 BROAD N. RIDGEVILLE OH 44039

E-mail: WINKELECTRIC@HOTMAIL.COM Telephone: 440 346 4125

Website: WINKELECTRIC.NET

Conference Sponsor (if applicable)_____ Conference Email:_____

Check here if Course Renewal:_____ Prior course number _____ (*i.e. BBS2018-429*)

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: 2023 NEC CODE CHANGES PART I

Course instructor: CLIFFORD WINKER

Course description: CODE CHANGES 2023 REVIEW

Instructional hours per session: 5 Number of Sessions: 1

Course Date(s) and Location:_____

Special Content:

Code Administration:_____ Conference Course: _____

Existing Buildings: _____ Conference Name: _____

Electrical Instruction: X Conference location:_____

Plumbing Instruction:_____

Course to be offered online? YES **On Demand** X **Webinar**_____

Course Website: WINKELECTRIC.NET

Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation)*:

_____

Course applicable for the following certifications

Residential Certifications Only: _____ Commercial Certifications: X

Administrative Course, All Certifications: _____

Application materials included:

_____ Course Outline or Course Learning Objectives

_____ Presentation Materials/Slides (not required for roundtable courses)

_____ Assessment Materials (for online courses)

_____ Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

Clifford Winkel
5640 Broad Blvd.
North Ridgeville, Ohio 44039
440-346-4125
winkelectric@hotmail.com

BIO

Hello, my name is Cliff Winkel and I am an electrical contractor operating out of North Ridgeville, Ohio. I have been an electrician since 1990 beginning with simple house remodels and rewiring working for various companies. In 1997 I started working for an outfit out of Cleveland, Ohio which dealt with commercial, residential, and industrial applications. In 2000 I applied, tested, passed, and received my Ohio Electrical Contractor's License (#23838) and started my own business, Winkelectric. In 2004 I applied, tested, passed and received my Ohio Electrical Safety Inspector's License (#1862). In 2005 I applied for, and received my Approved Training Agency License (#517). I also am licensed as a fire alarm contractor and am entry level NABCEP certified in photovoltaic installations. I also currently have a NICET level III fire alarm certification. In 2005, 2009 – 2022 I taught OCLIB electrical continuing education classes for electrical contractors (focused on 2005 2008 2011 and 2014/2017/2020 code changes and grounding). From 2000 to current I am continuing work as an electrical contractor. Some of the projects I have been involved in projects including residential buildings, commercial shopping centers, cellular tower land sites, and industrial high voltage maintenance and testing work. I have been registered and operated in numerous municipalities throughout Ohio.

Clifford Winkel

Wink Electric
11/14/22

Wink Electric Class Syllabus
2023 NEC Code Changes Part I
5 hour continuing education class

Saturday 2/4/22 8A-1P, Saturday 3/4/22 8A-1P
Saturday 4/15/22 8A-1P, Tuesday 8/8/22 8A-1P
Saturday 9/23/22 7A-12P, Saturday 11/18/22 7A-12P
Instructor: Clifford Winkel

February location: Fields Sweet School 8540 Root Rd North Ridgeville, Ohio 44039
March location: Jims Electric 39221 Center Ridge Rd North Ridgeville, Ohio 44039
April location: Net Electric 12925 Pearl Rd Strongsville, Ohio 44136
August Location Wink Electric Inc – 34400 Lorain Rd, North Ridgeville, Ohio 44039
September location: Wolff Brothers – 38777 Taylor Parkway North Ridgeville, Ohio 44039
November location: City of Elyria – 1194 Gulf Rd Elyria, Ohio 44035

Office Hours:

Please feel free to call our office at any time if any need arises. Our office hours are Monday through Friday 8am – 4pm. For any immediate issues, you can contact me vie cell phone at 440-346-4125

Course Objectives:

- Review National Electrical Code changes to the 2023 NEC.
- Apply covered 2023 NEC codes to circumstances in the field with discussion of practical use and actual examples of 2023 NEC applications.
- Use the ability to relate to the changes with the class from an instructor who also works in the field.
- As detailed below, there are certain changes we will be discussing. Due to the amount of changes I wish to cover, we will run a part I and a part II of this course. Both courses will be 5 hours in length to give shorter class time per day. With 5 hour classes, I believe the amount of retention will be higher opposed to a 10 hour class.

Teaching Approach and Methods:

Portions of this course will be taught in the traditional lecture note taking format. However, a large part of the class will involve class discussions, sample illustrations, handouts, and hands on code book participation. All class members will be asked to bring their 2023 NEC book. There will also be preordered 2020 NEC books available for sale on site if any class member does not own one yet. Every hour there will be a ten minute period for open discussion. At the end of the class every applicant will fill out their individual attendance form and it will be signed then, with identification verification.
.

Schedule of Topics and time schedule

7AM – 8AM

Code	Discussion
General	Discuss any of the following codes pertaining to 2020 NEC code updates. Confirm with class that this will go into effect once 2020 NEC is adopted.

Wink Electric Class Syllabus
2023 NEC Code Changes Part I
5 hour continuing education class

Saturday 2/4/22 8A-1P, Saturday 3/4/22 8A-1P
Saturday 4/15/22 8A-1P, Tuesday 8/8/22 8A-1P
Saturday 9/23/22 7A-12P, Saturday 11/18/22 7A-12P
Instructor: Clifford Winkel

February location: Fields Sweet School 8540 Root Rd North Ridgeville, Ohio 44039
March location: Jims Electric 39221 Center Ridge Rd North Ridgeville, Ohio 44039
April location: Net Electric 12925 Pearl Rd Strongsville, Ohio 44136
August Location Wink Electric Inc – 34400 Lorain Rd, North Ridgeville, Ohio 44039
September location: Wolff Brothers – 38777 Taylor Parkway North Ridgeville, Ohio 44039
November location: City of Elyria – 1194 Gulf Rd Elyria, Ohio 44035

ARTICLE 100 DEFINITIONS – Discuss all definitions now being found in article 100 of the NEC. Definitions shall not contain requirements or recommendations. If a definition only applies to one articles, the article number will appear in parentheses after the definition.

90.5 (C) Mandatory Rules, Permissive Rules – Subdivision (C) was revised to state that unless a standard referenced in the NEC contains a date, that reference is to be considered the latest edition of the standard.

ARTICLE 100 Bonding jumper, equipment bonding jumper, main bonding jumper, supply-side bonding jumper, system bonding jumper, solidly grounded, equipment grounding conductor. - Discuss revisions to definitions for simplicity.

ARTICLE 100 Accessible – Discuss revision to define obstacles which would cause installations to not be accessible.

ARTICLE 100 Class 4 Circuit – Discuss new definition.

ARTICLE 100 Counter (Countertop) – Discuss new definition pertaining to countertop installations.

ARTICLE 100 Energy Management System – Discuss new definition pertaining to energy management system installations.

ARTICLE 100 Feeder Assembly – Discuss new definition pertaining to feeder assemblies in pre-wired facilities.

Wink Electric Class Syllabus
2023 NEC Code Changes Part I
5 hour continuing education class

Saturday 2/4/22 8A-1P, Saturday 3/4/22 8A-1P
Saturday 4/15/22 8A-1P, Tuesday 8/8/22 8A-1P
Saturday 9/23/22 7A-12P, Saturday 11/18/22 7A-12P
Instructor: Clifford Winkel

February location: Fields Sweet School 8540 Root Rd North Ridgeville, Ohio 44039
March location: Jims Electric 39221 Center Ridge Rd North Ridgeville, Ohio 44039
April location: Net Electric 12925 Pearl Rd Strongsville, Ohio 44136
August Location Wink Electric Inc – 34400 Lorain Rd, North Ridgeville, Ohio 44039
September location: Wolff Brothers – 38777 Taylor Parkway North Ridgeville, Ohio 44039
November location: City of Elyria – 1194 Gulf Rd Elyria, Ohio 44035

ARTICLE 100 Fibers/Flyings Combustible – Discuss new definition covering combustible fibers and flyings.

ARTICLE 100 Impedance Grounding Conductor – Discuss new definition for Grounded Conductor, Impredance.

ARTICLE 100 In Sight – Discuss revision of definition of In Sight pertaining to sections of code.

ARTICLE 100 Likely to become energized.- Discuss new definition of likely to become energized pertaining to other sections of the NEC>

ARTICLE 100 Load Management – Discuss new definition for load management

ARTICLE 100 Restricted Industrial Establishment – Discuss new definition pertaining to hazardous area locations.

ARTICLE Servicing – Discuss new definition pertaining to maintenance and repair activities.

ARTICLE 100 Transformer – Discuss new definition of transformer (which there was no definition before).

ARTICLE 100 Work Surface – Discuss new definition establishing the difference between work surface and countertop.
8:00 – 9:00

Wink Electric Class Syllabus
2023 NEC Code Changes Part I
5 hour continuing education class

Saturday 2/4/22 8A-1P, Saturday 3/4/22 8A-1P
Saturday 4/15/22 8A-1P, Tuesday 8/8/22 8A-1P
Saturday 9/23/22 7A-12P, Saturday 11/18/22 7A-12P
Instructor: Clifford Winkel

February location: Fields Sweet School 8540 Root Rd North Ridgeville, Ohio 44039
March location: Jims Electric 39221 Center Ridge Rd North Ridgeville, Ohio 44039
April location: Net Electric 12925 Pearl Rd Strongsville, Ohio 44136
August Location Wink Electric Inc – 34400 Lorain Rd, North Ridgeville, Ohio 44039
September location: Wolff Brothers – 38777 Taylor Parkway North Ridgeville, Ohio 44039
November location: City of Elyria – 1194 Gulf Rd Elyria, Ohio 44035

ARTICLE 110.3(A) – Examination, identification, installation, use, and listing (Product certification) of equipment – Discuss new number 8 now including cybersecurity as something that needs considered and evaluated.

ARTICLE 110.3(B) – Examination, identification, installation, use, and listing (Product certification) of equipment – Discuss new informational note discussing the use of QR codes to gather information.

ARTICLE 110.14(A) – Terminals. Discuss the use of electrical opposed to mechanical connections.

ARTICLE 110.16(B) – Service equipment and feeders supplied equipment. Discuss revised amperage threshold for labeling.

ARTICLE 110.17 – Servicing and maintenance of equipment. Discuss revised code to limit service and maintenance of equipment to qualified persons.

ARTICLE 110.20 – Reconditioned equipment. Discuss new language defining what is considered acceptable to being reconditioned.

ARTICLE 110.21(A)(1) – Equipment markings. Discuss requirements for equipment marking for affixing labels on all electrical equipment.

ARTICLE 110.21(A)(2) – Reconditioned equipment. Discuss language that clarifies that the original listing mark is to be removed or made permanently illegible.
9:00 – 10:00

ARTICLE 110.21(B)(1) – Field applied hazard marking. Discuss revision pertaining to field applied hazard markings.

ARTICLE 110.22(A) – General. Discuss revised text clarifying when the identification of a disconnecting means is required or not required.

ARTICLE 110.26 – Spaces about electrical equipment. Discuss language pertaining to doors impeding access from electrical equipment areas.

ARTICLE 110.26 (A)(6) – Grade, floor, or working platform. Discuss new language pertaining to keeping areas clear of objects.

ARTICLE 110.29 – In sight from (within sight). Discuss new language pertaining to spaces about electrical equipment.

ARTICLE 110.33(A) – Entrance. Discuss language for working space for equipment over 1000 volts.

ARTICLE 110.34(A) – Working space and guarding. Discuss revisions regarding the conditions of the work space about equipment.

10AM – 10:15 BREAK

10:15AM – 11:15AM

ARTICLE 210.2 – Reconditioned equipment. Discuss relocation from 210.15 to 210.2 as it applies to branch circuitry.

Wink Electric Class Syllabus
2023 NEC Code Changes Part I
5 hour continuing education class

Saturday 2/4/22 8A-1P, Saturday 3/4/22 8A-1P
Saturday 4/15/22 8A-1P, Tuesday 8/8/22 8A-1P
Saturday 9/23/22 7A-12P, Saturday 11/18/22 7A-12P
Instructor: Clifford Winkel

February location: Fields Sweet School 8540 Root Rd North Ridgeville, Ohio 44039
March location: Jims Electric 39221 Center Ridge Rd North Ridgeville, Ohio 44039
April location: Net Electric 12925 Pearl Rd Strongsville, Ohio 44136
August Location Wink Electric Inc – 34400 Lorain Rd, North Ridgeville, Ohio 44039
September location: Wolff Brothers – 38777 Taylor Parkway North Ridgeville, Ohio 44039
November location: City of Elyria – 1194 Gulf Rd Elyria, Ohio 44035

ARTICLE 210.8(A)(6) – Dwelling units kitchens. Discuss expansion of GFCI protection in kitchens (cord and plug).

ARTICLE 210.8(A) – Dwelling units bathrooms. Discuss revision of GFCI protection regarding exhaust fans.

ARTICLE 210.8(A)(8) – GFCI Protection for personnel. – Discuss weight supporting attachment fitting and GFCI protection of said fitting.

ARTICLE 210.8(B)(4) – Other than dwelling units. Discuss addition of buffet style locations requiring GFCI protection.

ARTICLE 210.8(B)(7) – Other than dwelling units sinks. Discuss addition of cord and plug connected equipment to code language.

ARTICLE 210.8(B)(13) – Other than dwelling units aquariums. Discuss addition of new item 13 discussing aquariums and bait wells.

ARTICLE 210.8(D) – Specific appliances. Discuss additional language pertaining to specific appliances listed in 218.8(D).

ARTICLE 210.8(F) – Outdoor outlets. Discuss revision regarding replacements of existing receptacles and their GFCI requirements.

ARTICLE 210.11(C)(4) – Branch circuits required. Discuss revision regarding the use of 15 amp circuits feeding garage areas.

ARTICLE 210.11(C)(4) – Branch circuits required. Discuss new exception 4 allowing 20 amp garage bay circuits to feed other items.

ARTICLE 210.12 – AFCI protection. Discuss and review reformatted section.

ARTICLE 210.12(D)(3) – Other occupancies. Discuss new language adding sleeping areas to other occupancy types.

ARTICLE 210.17 – Guest rooms and suites. Discuss revision adding requirements for assisted living buildings and their receptacle layouts.

ARTICLE 210.19 – Minimum ampacity and size. Discuss revision regarding the use of circuit size vs conductor ampacity.

ARTICLE 210.23 – Permissable loads. Discuss 10 amp branch circuitry language added to the 2023 NEC.

ARTICLE 210.52(C) – Dwelling units islands/peninsulas. Discuss revisions regarding placement of receptacles in islands/peninsula areas.

ARTICLE 210.52(G) – Basements, garages, accessory buildings. Discuss clarification of the security receptacle not meeting the requirements of 210.52(G).

Wink Electric Class Syllabus
2023 NEC Code Changes Part I
5 hour continuing education class

Saturday 2/4/22 8A-1P, Saturday 3/4/22 8A-1P
Saturday 4/15/22 8A-1P, Tuesday 8/8/22 8A-1P
Saturday 9/23/22 7A-12P, Saturday 11/18/22 7A-12P
Instructor: Clifford Winkel

February location: Fields Sweet School 8540 Root Rd North Ridgeville, Ohio 44039
March location: Jims Electric 39221 Center Ridge Rd North Ridgeville, Ohio 44039
April location: Net Electric 12925 Pearl Rd Strongsville, Ohio 44136
August Location Wink Electric Inc – 34400 Lorain Rd, North Ridgeville, Ohio 44039
September location: Wolff Brothers – 38777 Taylor Parkway North Ridgeville, Ohio 44039
November location: City of Elyria – 1194 Gulf Rd Elyria, Ohio 44035

ARTICLE 210.70 – Lighting outlets required. Discuss revision adding laundry areas to list of areas requiring wall mounted control devices.

ARTICLE 215.15 – Barriers. Discuss new language requiring barriers for line voltage breaker situations.

ARTICLE 215.18, 225.42, 230.67 – SPD. Discuss the expansion of SPD requirements in the 2023 NEC.

ARTICLE 220.1 – Scope. Discuss new language pertaining to calculations for health care facilities, marina, boatyards, and docking facilities.

ARTICLE 220.5 – Floor areas. Discuss new language including unused/unfinished areas of buildings to load calculations.

ARTICLE 220.57 – Electric Vehicle Supply Equipment. Discuss new section pertaining to load calculations for EVSE.

ARTICLE 220.70 – EMS. Discuss new language calculating load demands for EMS systems.

ARTICLE 220.110 – Receptacle loads. Discuss new tables pertaining to receptacle loads in patient care spaces.

11:15 – 12:15

Wink Electric Class Syllabus
2023 NEC Code Changes Part I
5 hour continuing education class

Saturday 2/4/22 8A-1P, Saturday 3/4/22 8A-1P
Saturday 4/15/22 8A-1P, Tuesday 8/8/22 8A-1P
Saturday 9/23/22 7A-12P, Saturday 11/18/22 7A-12P
Instructor: Clifford Winkel

February location: Fields Sweet School 8540 Root Rd North Ridgeville, Ohio 44039
March location: Jims Electric 39221 Center Ridge Rd North Ridgeville, Ohio 44039
April location: Net Electric 12925 Pearl Rd Strongsville, Ohio 44136
August Location Wink Electric Inc – 34400 Lorain Rd, North Ridgeville, Ohio 44039
September location: Wolff Brothers – 38777 Taylor Parkway North Ridgeville, Ohio 44039
November location: City of Elyria – 1194 Gulf Rd Elyria, Ohio 44035

ARTICLE 220.120 – Marinas, boatyards, etc. Discuss relocation of 555.6 to 220.120.

ARTICLE 225.5/225.7 – Deletion. Discuss deletion of 225.5 and 225.7 referring this information to articles 215 and 220.

ARTICLE 225.41 – Emergency disconnects. Discuss new language requiring emergency disconnects for one and two family dwelling units being served by feeders.

ARTICLE 230.62(C) – Barriers. Discuss revision regarding requirements of barriers in service equipment.

ARTICLE 230.67(A) – SPDs. Discuss change in language from dwelling units to list specific occupancies.

ARTICLE 230.71(B) – Two to six service disconnecting means. Discuss language requiring transfer switches to be listed as service equipment.

ARTICLE 230.71(B) EXCEPTION – Discuss exception grandfathering older installations installed in accordance with older versions of the NEC.

ARTICLE 230.85 – Emergency disconnects. Discuss new sub divisions regarding the use of emergency disconnects.

ARTICLE 240.2 – Reconditioned equipment. Discuss relocation of 240.62 and 240.88.

ARTICLE 240.4(B) – Overcurrent devices 800 amps or less. Discuss addition of adjustable trip overcurrent devices to 240.6(A).

ARTICLE 240.4(D)(3) – 14 AWG copper clad aluminum. Discuss addition of copper clad aluminum to 240.4(D).

ARTICLE 240.6(D) – Remotely accessible adjustable trip circuit breakers. Discuss revision to allow remote access to adjustable trip circuit breakers.

ARTICLE 240.7 – Listing requirements. Discuss new section requiring listing of these GFPE and GFCI devices.

ARTICLE 240.11 – Selective coordination. Discuss new requirement clarifying feeder overcurrent devices and their interaction with service overcurrent devices.

ARTICLE 240.16 – Interrupting ratings. Discuss new requirement regarding minimum interrupting ratings.

ARTICLE 240.24(A) – Accessibility – Exception. Discuss revision regarding updating "similar enclosures".

ARTICLE 240.2E (E) – Not located in bathrooms. Discuss revision clarifying over current devices not being acceptable in bathroom areas.

ARTICLE 242.2 – Reconditioned equipment. Discuss new language stating SPDs cannot be reconditioned.

ARTICLE 242.9 – Indicating. Discuss requirement for indicating lights for SPDs.

ARTICLE 250.24 – Grounding of AC systems. Discuss revision to clarify requirements of parallel installations.

ARTICLE 250.24 (D)(2) – Grounding of AC systems. Discuss revision clarifying parallel service conductor installations.

ARTICLE 250.50, 250.52(A)(3)(1), 250.52 (B)(2) – Grounding electrode system. Discuss change of language regarding concrete encased electrodes.

Wink Electric Class Syllabus
2023 NEC Code Changes Part I
5 hour continuing education class

Saturday 2/4/22 8A-1P, Saturday 3/4/22 8A-1P
Saturday 4/15/22 8A-1P, Tuesday 8/8/22 8A-1P
Saturday 9/23/22 7A-12P, Saturday 11/18/22 7A-12P
Instructor: Clifford Winkel

February location: Fields Sweet School 8540 Root Rd North Ridgeville, Ohio 44039
March location: Jims Electric 39221 Center Ridge Rd North Ridgeville, Ohio 44039
April location: Net Electric 12925 Pearl Rd Strongsville, Ohio 44136
August Location Wink Electric Inc – 34400 Lorain Rd, North Ridgeville, Ohio 44039
September location: Wolff Brothers – 38777 Taylor Parkway North Ridgeville, Ohio 44039
November location: City of Elyria – 1194 Gulf Rd Elyria, Ohio 44035

ARTICLE 250.64(G) – Enclosures with vent openings. Discuss new requirements not allowing vented areas to be used to install GEC.

ARTICLE 250.70 – Methods of grounding and bonding. Discuss revision to grounding electrode installation methods.

ARTICLE 250.94(A) – Intersystem bonding termination. Discuss revision in intersystem bonding terminal requirements.

ARTICLE 250.118(A) – Types of EGC. Discuss new item (6)(F) that was added along with the special rules associated with it.

ARTICLE 250.130 – EGC connections. Discuss revision adding snap switches.

ARTICLE 250.140 – Frames of ranges and dryers. Discuss revision trying to streamline understanding of this section.

ARTICLE 250.148 – Continuity of EGC. Discuss revision adding subdivision (A) clarifying connections of EGC in boxes.

ARTICLE 300.4 (E) EX 1/2 – Discuss revision discussing concrete located on a metal corrugated roof.

ARTICLE 300.4 (G) – Fittings. Discuss revision dealing with bushing being installed before installation.

TABLE 300.5 – Minimum cover requirements. Discuss revision adding EMT to the table.

ARTICLE 300.5 (D) – Protection from damage. Discuss deletion of “direct buried” language.

ARTICLE 300.6 (A) – Ferrous metal equipment. Discuss revision of language.

File Attachments for Item:

EC-13 2023 NEC Code Changes Part 2 (Wink Electric)

All certifications (5 hours)

Wink Electric Class Syllabus
2023 NEC Code Changes Part II
5 hour continuing education class

Saturday 2/11/22 8A-1P, Saturday 3/11/22 8A-1P
Saturday 4/22/22 8A-1P, Tuesday 8/15/22 8A-1P
Saturday 9/23/22 1P-6P, Saturday 11/18/22 1P-6P
Instructor: Clifford Winkel

February location: Fields Sweet School 8540 Root Rd North Ridgeville, Ohio 44039
March location: Jims Electric 39221 Center Ridge Rd North Ridgeville, Ohio 44039
April location: Net Electric 12925 Pearl Rd Strongsville, Ohio 44136
August Location Wink Electric Inc – 34400 Lorain Rd, North Ridgeville, Ohio 44039
September location: Wolff Brothers – 38777 Taylor Parkway North Ridgeville, Ohio 44039
November location: City of Elyria – 1194 Gulf Rd Elyria, Ohio 44035

Schedule of Topics and time schedule

7AM – 8AM

ARTICLE 300.11 (C) – Raceways used as means of support. Discuss revision adding class 3 circuits as a conductors allowed to be supported in this fashion.

ARTICLE 300.14 – Length of free conductors at openings. Discuss revision allowing splicing of short conductors.

ARTICLE 300.17 – Number and size of conductors in raceways. Discuss revision in language safeguarding conductors during and after installation.

ARTICLE 300.25 – Exit enclosures. Discuss language adding the use of fire barriers in addition to being separated from the building.

ARTICLE 300.26 – Remote control and signaling circuits. Discuss new 300.26 with these types of circuitry.

TABLES 310.16, 310.17, 310.20 – Ampacity of conductor tables. Discuss deletion of XHWN from the 90 degree tables.

ARTICLE 312.10 – Screws and other fasteners. Discuss new section dealing with field installed screws.

ARTICLE 314.5 – Screws and other fasteners. Discuss new section dealing with screws and other fasteners entering enclosures.

ARTICLE 315.1 – Dimensions of boxes. Discuss revision adding language about side entries.

ARTICLE 315.1 – Scope. Discuss new language regarding the voltages covered by article 315.

ARTICLE 320.23 (A) – Cables run across framing members. Discuss revision of language to framing members opposed to joists.

Wink Electric Class Syllabus
2023 NEC Code Changes Part II
5 hour continuing education class

Saturday 2/11/22 8A-1P, Saturday 3/11/22 8A-1P
Saturday 4/22/22 8A-1P, Tuesday 8/15/22 8A-1P
Saturday 9/23/22 1P-6P, Saturday 11/18/22 1P-6P
Instructor: Clifford Winkel

February location: Fields Sweet School 8540 Root Rd North Ridgeville, Ohio 44039
March location: Jims Electric 39221 Center Ridge Rd North Ridgeville, Ohio 44039
April location: Net Electric 12925 Pearl Rd Strongsville, Ohio 44136
August Location Wink Electric Inc – 34400 Lorain Rd, North Ridgeville, Ohio 44039
September location: Wolff Brothers – 38777 Taylor Parkway North Ridgeville, Ohio 44039
November location: City of Elyria – 1194 Gulf Rd Elyria, Ohio 44035

ARTICLE 322.56 (B) – Taps. Discuss revision dealing with flat cable being marked and not necessarily colored.

ARTICLE 330.112 (A) – 1000 volts or less MC cable. Discuss revision of language in the MC section.

ARTICLE 342.20 (B) – Maximum. Discuss revision of largest size of IMC allowed to be installed.

ARTICLE 344.28 – Reaming and threading. Discuss revision in language regarding PVC coated rigid.

ARTICLE 352.44 (B) – Expansion fittings. Discuss new requirements for expansion joints.

ARTICLE 358.48 – Revision. Discuss revision regarding joining methods.

ARTICLE 358.20 (B) – Maximum. Discuss revision allowing up to 6" EMT to be used.

ARTICLE 404.1 – Scope. Discuss new informational note regarding wall mounted devices.

ARTICLE 404.14 (D) – Snap switch terminations. Discuss new language dealing with 14 awg wire and snap switches.

ARTICLE 404.16 – Reconditioned equipment. Discuss new language prohibiting reconditioning of switches.

ARTICLE 404.30 – Switch enclosures. Discuss new **requirements** for doors with switch mechanisms.

ARTICLE 406.2 – Reconditioned equipment. Discuss relocation from 406.3 (A) and 406.7 to new section 406.2.

Wink Electric Class Syllabus
2023 NEC Code Changes Part II
5 hour continuing education class

Saturday 2/11/22 8A-1P, Saturday 3/11/22 8A-1P
Saturday 4/22/22 8A-1P, Tuesday 8/15/22 8A-1P
Saturday 9/23/22 1P-6P, Saturday 11/18/22 1P-6P
Instructor: Clifford Winkel

February location: Fields Sweet School 8540 Root Rd North Ridgeville, Ohio 44039
March location: Jims Electric 39221 Center Ridge Rd North Ridgeville, Ohio 44039
April location: Net Electric 12925 Pearl Rd Strongsville, Ohio 44136
August Location Wink Electric Inc – 34400 Lorain Rd, North Ridgeville, Ohio 44039
September location: Wolff Brothers – 38777 Taylor Parkway North Ridgeville, Ohio 44039
November location: City of Elyria – 1194 Gulf Rd Elyria, Ohio 44035

8:00 – 9:00

ARTICLE 406.30 (D) – Receptacle terminations. Discuss new language regarding the limitations of 15 amp branch circuits.

ARTICLE 406.4 (D)(3) – GFCI protection. Discuss revision of language to require listing of products.

ARTICLE 406.4 (D)(8) – GFPE protection. Discuss new language requiring GFPE protection when replacing devices in areas which require it.

ARTICLE 406.6 (D) – Receptacle faceplates. Discuss revision regarding lighting faceplates and what kind of screws are allowable.

ARTICLE 406.9 (C) – Bathtub and shower space. Discuss revision regarding limitations of receptacles around these areas.

ARTICLE 406.12 – TR receptacles. Discuss revision in language attempting to streamline language regarding areas where TR receptacles are required.

ARTICLE 408.4 – Descriptions required. Discuss revision regarding circuit directories.

ARTICLE 408.9 – Replacement panelboards. Discuss revision in requirements for replacement panelboards.

ARTICLE 408.38 – Enclosure. Discuss revision regarding listing of equipment with available arc fault current greater than 10k.

ARTICLE 408.43 – Panelboard orientation. Discuss revision prohibiting panelboards being installed in a face gown position.

ARTICLE 409.60 – Bonding. Discuss reorganization of this article.

ARTICLE 409.70 – Surge protection. Discuss new section requiring surge protection for industrial control panels.

Wink Electric Class Syllabus
2023 NEC Code Changes Part II
5 hour continuing education class

Saturday 2/11/22 8A-1P, Saturday 3/11/22 8A-1P
Saturday 4/22/22 8A-1P, Tuesday 8/15/22 8A-1P
Saturday 9/23/22 1P-6P, Saturday 11/18/22 1P-6P
Instructor: Clifford Winkel

February location: Fields Sweet School 8540 Root Rd North Ridgeville, Ohio 44039
March location: Jims Electric 39221 Center Ridge Rd North Ridgeville, Ohio 44039
April location: Net Electric 12925 Pearl Rd Strongsville, Ohio 44136
August Location Wink Electric Inc – 34400 Lorain Rd, North Ridgeville, Ohio 44039
September location: Wolff Brothers – 38777 Taylor Parkway North Ridgeville, Ohio 44039
November location: City of Elyria – 1194 Gulf Rd Elyria, Ohio 44035

ARTICLE 410.2 – Reconditioned equipment. Discuss revision adding LED drivers and lamps to items that are prohibited from recondition.

ARTICLE 410.10 (F) – Luminaires installed in or under roof decking. Discuss revision requiring 1 ½" space under roof decking.

ARTICLE 410.71 – Disconnecting means for luminaires. Discuss relocation from 410.71 to this section.

ARTICLE 410 PART XVII – Special provisions for germicidal irradiation luminaires. Discuss new part XVII added to the NEC.

ARTICLE 410.184 – GFCI and SPGFCI protection. Discuss revision clarifying when to use these types of devices.

ARTICLE 422 – Appliances. Discuss deletion of sections 422.3, 422.4, 422.15, 422.23, 422.46, 422.50.

ARTICLE 422.16 (B)(2) – Built in dishwashers and compactors. Discuss revision to provisions regarding pass through cords in these installations.

ARTICLE 422.18 – Paddle fans. Discuss revision prohibiting certain kinds of ceiling fan installations.

ARTICLE 424.10 – General – Discuss deletion of special permission.

ARTICLE 424.48 – Installation of cables in walls. Discuss new section allowing heating cables to be installed in walls.

ARTICLE 424.93 (C) – Installation of heating panels in walls. Discuss new section allowing heating panels to be installed in walls.

ARTICLE 425.10 – General. Discuss deletion of special permission.

Wink Electric Class Syllabus
2023 NEC Code Changes Part II
5 hour continuing education class

Saturday 2/11/22 8A-1P, Saturday 3/11/22 8A-1P
Saturday 4/22/22 8A-1P, Tuesday 8/15/22 8A-1P
Saturday 9/23/22 1P-6P, Saturday 11/18/22 1P-6P
Instructor: Clifford Winkel

February location: Fields Sweet School 8540 Root Rd North Ridgeville, Ohio 44039
March location: Jims Electric 39221 Center Ridge Rd North Ridgeville, Ohio 44039
April location: Net Electric 12925 Pearl Rd Strongsville, Ohio 44136
August Location Wink Electric Inc – 34400 Lorain Rd, North Ridgeville, Ohio 44039
September location: Wolff Brothers – 38777 Taylor Parkway North Ridgeville, Ohio 44039
November location: City of Elyria – 1194 Gulf Rd Elyria, Ohio 44035

9:00 – 10:00

ARTICLE 426.14 – Special permission. Discuss deletion of special permission.

ARTICLE 426.28 – Ground fault protection. Discuss revision recognizing manufacturer's requirements on snow melting equipment.

ARTICLE 427.35 – Scope. Discuss deletion of article 427.35.

ARTICLE 430.1 – Scope. Discuss revision of figure 430.1.

ARTICLE 430.2 – Reconditioned motors. Discuss new section regarding guidance on reconditioning motors.

ARTICLE 440.8 – Single machine and location. Discuss revision to 440.8 prohibiting mini split installation in certain areas.

ARTICLE 440.11 – General – Discuss revision requiring locking of disconnects.

ARTICLE 440.14 – Location. Discuss revision regarding workspace clearance for HVAC equipment.

ARTICLE 445.18 (A) & 445.19 – Disconnecting means and emergency shutdown. Discuss revision allowing disconnection to be behind hinged covers.

ARTICLE 450.2 – Interconnection of transformers. Discuss new section adding guidance for transformer interconnection.

ARTICLE 470.2 – Reconditioned equipment. Discuss new section prohibiting reconditioning of resistors.

ARTICLE 495 – Equipment over 1000 volts AC. Discuss requirements formerly found in 490 are now found in article 495.

ARTICLE 500.4 – Documentation. Discuss revision in documentation requirements by the

AHJ.

Wink Electric Class Syllabus
2023 NEC Code Changes Part II
5 hour continuing education class

Saturday 2/11/22 8A-1P, Saturday 3/11/22 8A-1P
Saturday 4/22/22 8A-1P, Tuesday 8/15/22 8A-1P
Saturday 9/23/22 1P-6P, Saturday 11/18/22 1P-6P
Instructor: Clifford Winkel

February location: Fields Sweet School 8540 Root Rd North Ridgeville, Ohio 44039
March location: Jims Electric 39221 Center Ridge Rd North Ridgeville, Ohio 44039
April location: Net Electric 12925 Pearl Rd Strongsville, Ohio 44136
August Location Wink Electric Inc – 34400 Lorain Rd, North Ridgeville, Ohio 44039
September location: Wolff Brothers – 38777 Taylor Parkway North Ridgeville, Ohio 44039
November location: City of Elyria – 1194 Gulf Rd Elyria, Ohio 44035

ARTICLE 500.5 (D)(1)(A) – Combustible fibers/flyings. Discuss revision definition of combustible fibers.

ARTICLE 500.8 (D)(2) AND (D)(3) – Equipment temperature. Discuss revision in this section to align with the new definition of combustible fibers.

ARTICLE 505.9 (C) CHAPTER 9 TABLE 13 – Equipment suitable for hazardous locations. Discuss new table 13 in Chapter 9 and deletion of table 505.9 (C)(2)(4).

ARTICLE 512 – Cannabis oil equipment. Discuss new article 512 covering this kind of installation area.

ARTICLE 515.10 – Special equipment motor fuel. Discuss language change from gas dispenser to motor fuel dispenser.

ARTICLE 517 – Health care facilities. Discuss revision in definitions of Category 1-4 spaces.

ARTICLE 517.6 – Patient care related equipment. Discuss new language confirming reconditioning requirements in other areas of the code do not apply to patient care equipment.

ARTICLE 517.13 – EGC in patient care spaces. Discuss revision in language regarding installations in these areas.

ARTICLE 517.22 – Demand factors. Discuss new section regarding demand factors in heath care facilities.

ARTICLE 517.30 – Sources of power. Discuss revisions in terminology in this section.

ARTICLE 517 PART V – Diagnostic imaging and treatment equipment. Discuss revision in language from Xray installations to diagnostic imaging and treatment equipment.

10AM – 10:15 BREAK

10:15AM – 11:15AM

Wink Electric Class Syllabus
2023 NEC Code Changes Part II
5 hour continuing education class

Saturday 2/11/22 8A-1P, Saturday 3/11/22 8A-1P
Saturday 4/22/22 8A-1P, Tuesday 8/15/22 8A-1P
Saturday 9/23/22 1P-6P, Saturday 11/18/22 1P-6P
Instructor: Clifford Winkel

February location: Fields Sweet School 8540 Root Rd North Ridgeville, Ohio 44039
March location: Jims Electric 39221 Center Ridge Rd North Ridgeville, Ohio 44039
April location: Net Electric 12925 Pearl Rd Strongsville, Ohio 44136
August Location Wink Electric Inc – 34400 Lorain Rd, North Ridgeville, Ohio 44039
September location: Wolff Brothers – 38777 Taylor Parkway North Ridgeville, Ohio 44039
November location: City of Elyria – 1194 Gulf Rd Elyria, Ohio 44035

10:15 – 11:15

ARTICLE 518.2 – Casinos and gaming facilities. Discuss revision adding these areas to assembly examples.

ARTICLE 518.4 – Wiring methods. Discuss revision in language including POE cabling.

ARTICLE 518.5 – Supply. Discuss revision reorganizing assembly occupancies.

ARTICLE 547.26 – Physical protection. Discuss new section regarding nonmetallic cables.

ARTICLE 547.44 – Equipotential planes and bonding. Discuss new section clarifying indoor and outdoor locations of these areas.

ARTICLE 550.32 – Service equipment. Discuss revision for disconnect location.

ARTICLE 551.3 – Electrical datum plane. Discuss new section dealing with datum planes at RV areas.

ARTICLE 551.40 (D) – Loss of ground device. Discuss revision eliminating the requirement for reverse polarity devices.

ARTICLE 555.4 – Location of service equipment. Discuss revision modifying 555.4 and distances for docking services.

ARTICLE 555.6 – Load calculations for service and feeder conductors. Discuss relocation from 555.6 to 220.120 for calculations.

ARTICLE 555.14 – Equipotential planes and bonding. Discuss new section regarding installing equipotential planes in marinas and boatyards.

ARTICLE 555.15 – Replacement of equipment. Discuss new section requiring replacement devices to be installed to the new requirements of the NEC.

Wink Electric Class Syllabus
2023 NEC Code Changes Part II
5 hour continuing education class

Saturday 2/11/22 8A-1P, Saturday 3/11/22 8A-1P
Saturday 4/22/22 8A-1P, Tuesday 8/15/22 8A-1P
Saturday 9/23/22 1P-6P, Saturday 11/18/22 1P-6P
Instructor: Clifford Winkel

February location: Fields Sweet School 8540 Root Rd North Ridgeville, Ohio 44039
March location: Jims Electric 39221 Center Ridge Rd North Ridgeville, Ohio 44039
April location: Net Electric 12925 Pearl Rd Strongsville, Ohio 44136
August Location Wink Electric Inc – 34400 Lorain Rd, North Ridgeville, Ohio 44039
September location: Wolff Brothers – 38777 Taylor Parkway North Ridgeville, Ohio 44039
November location: City of Elyria – 1194 Gulf Rd Elyria, Ohio 44035

ARTICLE 555.35 (E) – Leakage current measurement device. Discuss new language requiring these devices to be listed by 1/1/26.

ARTICLE 555.36 (C) – Emergency electrical disconnect. Discuss new requirements mandating the emergency disconnect be located within sight of a marina power outlet.

ARTICLE 555.38 – Luminaires. Discuss new section dealing with luminaires in marinas and dockyards.

ARTICLE 590.4 (F) – Lamp protection. Discuss new revision requiring metal caged temp lighting.

ARTICLE 600.5 (A) – Exception. Discuss new exception relocation of timeclock language.

ARTICLE 600.35 – Retrofit kits. Discuss deletion of section 600.35.

ARTICLE 620.12 (A) – Traveling cables. Discuss new addition of class 2 cables to this section.

ARTICLE 620.22 (A) – Car light receptacles. Discuss revision to specify permissible loads on the car light circuit.

ARTICLE 620.36 – Different systems. Discuss revision specifying which cable types can be run.

ARTICLE 620.51 (A) TYPE EX NO. 2 – Stairway chair lift. Discuss revision determining where stairway chair lifts are allowed.

ARTICLE 625.6 – Listed. Discuss revision determining which EV systems are to be listed.

ARTICLE 625.44 (A) – Portable equipment. Discuss revision adding 60 amp receptacles to this section.

Wink Electric Class Syllabus
2023 NEC Code Changes Part II
5 hour continuing education class

Saturday 2/11/22 8A-1P, Saturday 3/11/22 8A-1P
Saturday 4/22/22 8A-1P, Tuesday 8/15/22 8A-1P
Saturday 9/23/22 1P-6P, Saturday 11/18/22 1P-6P
Instructor: Clifford Winkel

February location: Fields Sweet School 8540 Root Rd North Ridgeville, Ohio 44039
March location: Jims Electric 39221 Center Ridge Rd North Ridgeville, Ohio 44039
April location: Net Electric 12925 Pearl Rd Strongsville, Ohio 44136
August Location Wink Electric Inc – 34400 Lorain Rd, North Ridgeville, Ohio 44039
September location: Wolff Brothers – 38777 Taylor Parkway North Ridgeville, Ohio 44039
November location: City of Elyria – 1194 Gulf Rd Elyria, Ohio 44035

ARTICLE 625.49 – Island mode. Discuss new language dealing with island mode on EV's.

ARTICLE 630.8 – GFCI for welders. Discuss new section laying out when to install these.

ARTICLE 646.19 – Entrance to and egress from working space. Discuss revision regarding egress doors in modular areas.

ARTICLE 670.1 – Scope. Discuss revision requiring over voltage protection in these environments.

ARTICLE 680 – Swimming pools etc. Discuss reorganization to try to elevate usability of article 680.

ARTICLE 680.5 – GFCI and SPGFCI protection. Discuss revision requirements for these devices in article 680 areas.

ARTICLE 680.9 (A) – Power. Discuss revision clarifying open overhead wiring in raceways.

ARTICLE 680.10 – Electric pool water heaters. Discuss revision including electric pool water installations.

ARTICLE 680.21 (D) – Pool pump motor replacement. Discuss revision requiring GFCI for pumps replacement and reconditioned.

ARTICLE 680.12 – Equipment rooms. Discuss revision requiring drainage.

ARTICLE 680.23 (B)(2)(a) – Forming shell. Discuss revision requiring listing for rigid in certain pool areas.

ARTICLE 680.32 – GFCI and special purpose SPGFCI protection. Discuss revision regarding when to install these devices.

Wink Electric Class Syllabus
2023 NEC Code Changes Part II
5 hour continuing education class

Saturday 2/11/22 8A-1P, Saturday 3/11/22 8A-1P
Saturday 4/22/22 8A-1P, Tuesday 8/15/22 8A-1P
Saturday 9/23/22 1P-6P, Saturday 11/18/22 1P-6P
Instructor: Clifford Winkel

February location: Fields Sweet School 8540 Root Rd North Ridgeville, Ohio 44039
March location: Jims Electric 39221 Center Ridge Rd North Ridgeville, Ohio 44039
April location: Net Electric 12925 Pearl Rd Strongsville, Ohio 44136
August Location Wink Electric Inc – 34400 Lorain Rd, North Ridgeville, Ohio 44039
September location: Wolff Brothers – 38777 Taylor Parkway North Ridgeville, Ohio 44039
November location: City of Elyria – 1194 Gulf Rd Elyria, Ohio 44035

11:15 – 12:15

ARTICLE 680.41 (A) – Emergency switch for spas and hot tubs. Discuss revision excluding the need to these installations at single family dwellings.

ARTICLE 680.44 – GFCI and SPGFCI protection. Discuss revision regarding these devices installed in these areas.

ARTICLE 680.54 (C) – Equipotential bonding of splash pads. Discuss new section addressing bonding requirements in these areas.

ARTICLE 690 – Solar photovoltaic systems. Discuss removal of PV output circuit.

ARTICLE 700.2, 701.2, 702.2, AND 708.2 – Reconditioned equipment. Discuss reconditioning of transfer switches being prohibited.

ARTICLE 700.3 (F) – List items 4, 6, 7. Discuss new/revision requiring listing of devices.

ARTICLE 700.5 (D) – Redundant transfer equipment. Discuss revision pertaining to emergency loads supplied by single feeders.

ARTICLE 700.11 (C) – Wiring class 2 powered emergency lighting systems. Discuss new section citing requirements for the separation of class 2 circuits.

ARTICLE 700.12 (C) – Supply duration. Discuss new informational note to reference classification information for EPSS systems.

ARTICLE 700.12 (E) & 701.12 (E) – Stored energy power supply systems. Discuss revision in language from uninterruptible power supplies to stored energy power supply systems.

ARTICLE 700.12 (G) – Microgrid systems. Discuss revision to microgrid system management.

Wink Electric Class Syllabus
2023 NEC Code Changes Part II
5 hour continuing education class

Saturday 2/11/22 8A-1P, Saturday 3/11/22 8A-1P
Saturday 4/22/22 8A-1P, Tuesday 8/15/22 8A-1P
Saturday 9/23/22 1P-6P, Saturday 11/18/22 1P-6P
Instructor: Clifford Winkel

February location: Fields Sweet School 8540 Root Rd North Ridgeville, Ohio 44039
March location: Jims Electric 39221 Center Ridge Rd North Ridgeville, Ohio 44039
April location: Net Electric 12925 Pearl Rd Strongsville, Ohio 44136
August Location Wink Electric Inc – 34400 Lorain Rd, North Ridgeville, Ohio 44039
September location: Wolff Brothers – 38777 Taylor Parkway North Ridgeville, Ohio 44039
November location: City of Elyria – 1194 Gulf Rd Elyria, Ohio 44035

ARTICLE 701.4 (C) – Load management. Discuss revision to load management requirements.

ARTICLE 701.4 (D) – Parallel operation. Discuss new section adding language identifying two different types of parallel operations.

ARTICLE 701.10 – Wiring legally required standby systems. Discuss new section concerning wiring requirements for legally required standby systems.

ARTICLE 701.12 (C) – Supply duration. Discuss new informational note referencing classification information.

ARTICLE 705.11 – Source connections to a service. Discuss revision applying to systems interconnected with new or existing utility services.

ARTICLE 705.13 – EMS systems. Discuss relocation of much of the language from this article to article 750.

ARTICLE 705.20 – Source disconnecting means. Discuss deletion of requirements to lock and/or use tools to open.

ARTICLE 705.30 (F) – Transformers. Discuss new language addressing transformer requirements for interconnected systems.

ARTICLE 705.50 – System operation. Discuss revision discussing operational modes of microgrid systems.

ARTICLE 706.7 – Commissioning and maintenance (energy storage systems). Discuss new section regarding commissioning requirements.

ARTICLE 722 – Cables for power limited circuits. Discuss new article 722 covering general requirements for class 4 circuits.

Wink Electric Class Syllabus
2023 NEC Code Changes Part II
5 hour continuing education class

Saturday 2/11/22 8A-1P, Saturday 3/11/22 8A-1P
Saturday 4/22/22 8A-1P, Tuesday 8/15/22 8A-1P
Saturday 9/23/22 1P-6P, Saturday 11/18/22 1P-6P
Instructor: Clifford Winkel

February location: Fields Sweet School 8540 Root Rd North Ridgeville, Ohio 44039
March location: Jims Electric 39221 Center Ridge Rd North Ridgeville, Ohio 44039
April location: Net Electric 12925 Pearl Rd Strongsville, Ohio 44136
August Location Wink Electric Inc – 34400 Lorain Rd, North Ridgeville, Ohio 44039
September location: Wolff Brothers – 38777 Taylor Parkway North Ridgeville, Ohio 44039
November location: City of Elyria – 1194 Gulf Rd Elyria, Ohio 44035

ARTICLE 725.144 – Bundling of cables transmitting power and data. Discuss revision removing 4 pair from title section.

ARTICLE 726 – Class 4 power systems. Discuss new article 726 dealing with FMP systems.

ARTICLE 760 – Fire alarm systems. Discuss several section that were revised and reworded in article 760.

ARTICLE 800.179 – Wires and cables. Discuss relocation of hybrid power and comm systems to article 800.

ARTICLE 805.170 – Protectors. Discuss relocation of communications listing to article 800 from 805.

ARTICLE 840.160 – Powering circuits. Discuss relocation of communication cable wiring to article 800.

CHAPTER 9 TABLE 13 – Equipment suitable for hazardous locations. Discuss new table located in chapter 9.

ANNEX A – Discuss new table A.1(b).

ANNEX E – Fire resistance construction. Discuss changes to type IV construction.

Clifford Winkel
5640 Broad Blvd.
North Ridgeville, Ohio 44039
440-346-4125
winkelectric@hotmail.com

BIO

Hello, my name is Cliff Winkel and I am an electrical contractor operating out of North Ridgeville, Ohio. I have been an electrician since 1990 beginning with simple house remodels and rewiring working for various companies. In 1997 I started working for an outfit out of Cleveland, Ohio which dealt with commercial, residential, and industrial applications. In 2000 I applied, tested, passed, and received my Ohio Electrical Contractor's License (#23838) and started my own business, Winkelectric. In 2004 I applied, tested, passed and received my Ohio Electrical Safety Inspector's License (#1862). In 2005 I applied for, and received my Approved Training Agency License (#517). I also am licensed as a fire alarm contractor and am entry level NABCEP certified in photovoltaic installations. I also currently have a NICET level III fire alarm certification. In 2005, 2009 – 2022 I taught OCLIB electrical continuing education classes for electrical contractors (focused on 2005 2008 2011 and 2014/2017/2020 code changes and grounding). From 2000 to current I am continuing work as an electrical contractor. Some of the projects I have been involved in projects including residential buildings, commercial shopping centers, cellular tower land sites, and industrial high voltage maintenance and testing work. I have been registered and operated in numerous municipalities throughout Ohio.

Clifford Winkel

Wink Electric
11/14/22

Ohio | Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: CLIFFORD WINKER

Organization: WINK ELECTRIC

Address: 5640 BROAD N. RIDGEVILLE OH 44039

E-mail: WINKELECTRIC@HOTMAIL.COM Telephone: 440 346 4125

Website: WINKELECTRIC.NET

Conference Sponsor (if applicable)_____ Conference Email:_____

Check here if Course Renewal:_____ Prior course number _____ (*i.e. BBS2018-429*)

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: 2023 NEC CODE CHANGES PART II

Course instructor: CLIFFORD WINKER

Course description:

CODE CHANGES 2023 REVIEW

Instructional hours per session: 5 Number of Sessions: 1

Course Date(s) and Location:_____

Special Content:

Code Administration:_____ Conference Course: _____

Existing Buildings: _____ Conference Name: _____

Electrical Instruction: X Conference location:_____

Plumbing Instruction:_____

Course to be offered online? YES **On Demand** X **Webinar**_____

Course Website: WINKELECTRIC.NET

Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation)*:

_____

Course applicable for the following certifications

Residential Certifications Only: _____ Commercial Certifications: X

Administrative Course, All Certifications: _____

Application materials included:

_____ Course Outline or Course Learning Objectives

_____ Presentation Materials/Slides (not required for roundtable courses)

_____ Assessment Materials (for online courses)

_____ Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

File Attachments for Item:

EC-14 Certified Line Pressure Regulator Training (Maxitrol)

All certifications (1 hour)

APPLICATION FOR CONTINUING EDUCATION APPROVAL
COURSE CONDITIONS AND GUIDELINES

The Ohio Board of Building Standards is committed to the ongoing education and professional development of board-certified personnel through the delivery of high-quality, accurate and engaging professional continuing education content. To this end, the Board reviews and approves Continuing Education Courses for building department personnel.

Board approval is granted for course instruction on current codes and standards, including the OBC, OMC, OPC, and RCO, and any other content areas directly related to the responsibilities of the certification for which credit is being requested.

Promotion: Any person or organization promoting an approved course is required to make full and accurate disclosure regarding course title, course approval number, number of credit hours, categories for which the BBS has approved the class, and fees in promotion materials and advertising. ***The Board does not grant retroactive approval. It is recommended that courses be submitted for approval well in advance of any scheduling of classes and advertising***. Advertising may not falsely state BBS approval before approval is granted. Course providers may state that BBS approval is pending.

Application Submission: All Applications and associated materials shall be submitted by email in .pdf format. Instructions for completing the application are attached.

Certificate of Completion: Course providers shall provide participants a certificate of completion containing the following information:

- Name of participant
- Title of approved courses
- BBS approval #
- BBS approved certifications
- Date of the continuing education program
- Number of approved credit hours awarded, and
- Signature of authorized sponsor or instructor.

Any person or organization administering an approved course shall return a completed BBS Course Attendance form by email.

Participants: Participants must attend the complete course as presented by the instructor to receive credit hours approved by the Board. The organization or instructor of online courses shall plan and execute methods to verify the individual's attendance and completion of the course. No partial credit will be given to any participant who failed to complete the entire course as approved.

Board approval: All courses are approved for the calendar year in which application is made. Courses may be renewed so long as the referenced code is in effect, and the CEUs, certification and content remain unchanged. When the referenced code is updated, courses must be updated, and new approvals obtained.

Facility/training area: BBS Course may be delivered in person or online, or both, at the sponsor's option.
Course facilities shall include the following:

In Person Classes:
Sufficient seating capacity
ADA accessible facilities
Appropriate Audio/Visual devices for delivery
Writing surfaces for participants

Online Classes:
Web-accessible
ADA accessible delivery
Tech support available
Live and recorded courses permitted

In-person facilities shall comfortably and safely seat at least the number of attendees present in the room and shall be climate controlled, non-smoking, and sound controlled so that outside noise will not interfere with the training.

Ohio | Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: Bill Hanes

Organization: Maxitrol Company

Address: 23555 Telegraph Rd.

E-mail: bhanes@maxitrol.com Telephone: (248)894-0481

Website: maxitrol.com

Conference Sponsor (if applicable) _____ Conference Email: _____

Check here if Course Renewal: _____ Prior course number _____ (*i.e. BBS2018-429*)

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: Certified Line Pressure Regulator Training

Course instructor: Billl Hanes

Course description: This class will cover the ANSI standards involved with Certified Line Pressure along with sizing, how a regulator works, proper installation and correct Vent Limiter/Vent Prot

Instructional hours per session: 1 Number of Sessions: _____

Course Date(s) and Location: _____

Special Content:

Code Administration: ☑
Existing Buildings: ☑
Electrical Instruction: ☐
Plumbing Instruction: ☑

Conference Course: _____
Conference Name: _____
Conference location: _____

Course to be offered online? ☐ **On Demand** ☐ **Webinar** ☐

Course Website: _____

Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation)*:

Course applicable for the following certifications

Residential Certifications Only: ☐
Administrative Course, All Certifications: ☑
Commercial Certifications: ☑

Application materials included:

☐ Course Outline or Course Learning Objectives
☑ Presentation Materials/Slides (not required for roundtable courses)
☐ Assessment Materials (for online courses)
☑ Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

Instructions for new Continuing Education Approval form

Provider Information

1. Please include all contact information.
2. If course is not part of a conference, leave conference sponsor and email blank.

Course Renewal

1. Indicate if the course is being submitted for renewal. Include prior approval letter and write in prior course number.
2. Certification approval for courses has now changed: all existing courses being renewed will be approved within the new classification system.
    a. Courses previously approved for only residential certifications will be approved for all residential certifications.
    b. Courses previously approved for at least on commercial certification will now be approved for all commercial certifications and all residential certifications.
    c. Courses on required instruction topics, Ohio Ethics, Code Administration and Existing Buildings, will be noted as Administrative Courses and be approved for all certifications.
3. Courses being renewed should skip the New Course information section and are not required to submit outline, agenda, slides or other instructional materials for review. Skip to Special Content, and mark any item that applies to the course.

New Course Information

1. Enter course title, name of instructor, and a brief description of the course content. Learning objectives may be substituted for course description, if desired.
2. Number of instructional hours per session is the length of instructional time.
3. Number of sessions: can be 1 or the number of sessions planned.
4. Course date(s) and location: not necessary at this time, enter if known.

Special Content

1. Indicate if the course will meet instructional time in Code Administration or Existing Buildings.
2. Indicate if the course is a plumbing or electrical course, for ESIAC review and trainee course tracking.
3. If the course is associated with a conference, indicate the conference name and location, as this will allow BBS to coordinate approvals with the conference provider.
4. If the course will be offered online, specify whether it will be on demand or offered as a virtual webinar, or both. Include website where the course will be provided.

Course applicable for the following certifications

This section represents a major change from previous BBS course approval forms.

1. If the course is only for residential certifications, check 'Residential Certifications Only'. The course, if approved, will be approved for all residential certifications.
2. If the course is appropriate for any commercial certifications, check Commercial Certifications. The course, if approved, will be approved for all commercial certification **AND** all residential certifications.
3. If the course is intended to meet required instruction in Code Administration (Chapter 1) or Existing Buildings (commercial or residential) check 'Administrative Course, All Certifications'.

Application Materials Included

This is a checklist for the course submitter's use, to be sure all materials necessary for review are included with the application. All materials should be submitted in .pdf format, along with the application, via email to Michael.Lane@com.ohio.gov or BBS@com.ohio.gov

Headquarters
23555 Telegraph Road • P.O. Box 2230
Southfield, Michigan 48034-2230 U.S.A.
248.356.1400 • Fax 248.356.8388
www.maxitrol.com



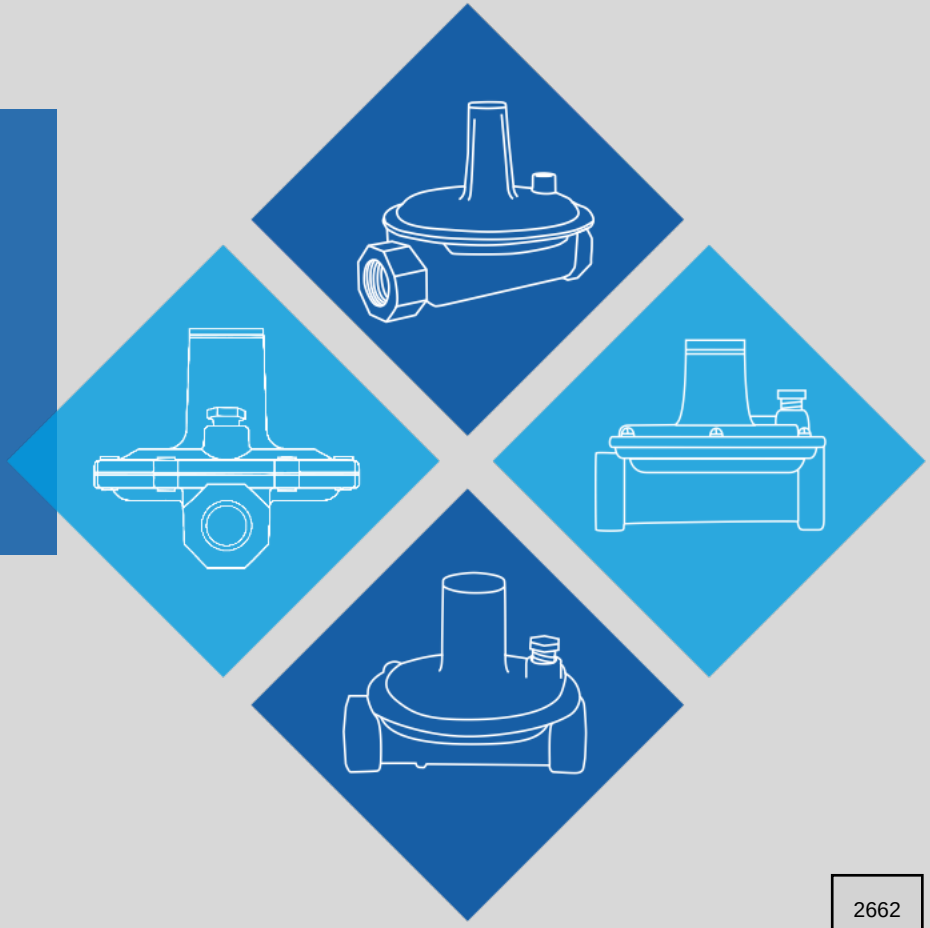
BILL HANES
BIOGRAPHY

Bill Hanes joined Maxitrol Company as a product specialist. He holds a bachelor's degree in education from Wayne State University which compliments his broad work experience in management and logistics. Bill's diverse background brings a unique perspective to Maxitrol's continuing education and product training programs for the HVAC industry, commercial/industrial burners, and boilers.

Bill is responsible for eastern North America territories and will be conducting training seminars for major OEMs, wholesalers/distributors, gas utilities, and building inspector groups.

When not sharing his knowledge of Maxitrol's line pressure regulators for 2 and 5 psi systems and the Line Regulator Standard, Mr. Hanes loves spending time with his wife and two kids.

CERTIFIED LINE PRESSURE REGULATOR TRAINING



MAXITROL®

© 2021 Maxitrol Company

2662

⚠ WARNING

Service and Installation must be performed by a trained/experienced service technician. All products used with combustible gas must be installed and used strictly in accordance with the instructions of the Original Equipment Manufacturer (OEM) and with all applicable government codes and regulations, e.g., plumbing, mechanical, and electrical codes and practices. These instructions do NOT supersede OEM's installation or operating instructions. All Maxitrol products should be installed and operated in accordance with Maxitrol Safety Warning Instructions.

Maxitrol Company is not responsible for any errors or omissions in reliance by anyone of any information set forth in this presentation without additional reference to local requirements and applicable ordinances or codes.

© 2021 Maxitrol Company| Certified Line Pressure Regulator Training

2 & 5 PSI PIPING SYSTEMS

- Street gas pressure is reduced to 2 or 5 psi using a utility supplied gas service regulator.
- The service regulator is located in an area where it can be vented to the outdoors.
- The gas is distributed throughout the structure using copper tubing or CSST to each gas appliance.
- The tubing or CSST can be sized to allow for significant pressure drop.
- The minimum operating inlet pressure to the line regulator should be approximately 1 psi when the appliance(s) is operating.



2664

© 2021 Maxitrol Company | Certified Line Pressure Regulator Training

2 & 5 PSI PIPING SYSTEMS

- The distribution pressure is greater than the rated inlet pressure of the gas appliance pressure regulator.
- An intermediate (line) pressure regulator reduces the pressure to within the appliance regulator's rated inlet pressure range while operating and maintains a reduced pressure during non-operating periods.
- Typical 2 and 5 psi piping systems use one line pressure regulator for each appliance or one line pressure regulator serving multiple appliances that are near one another.



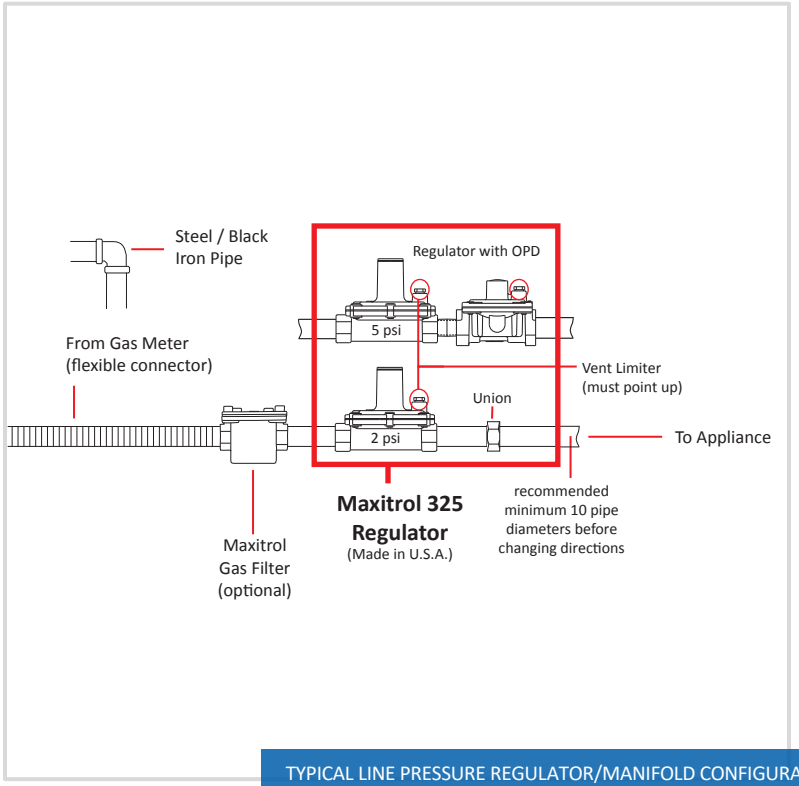
2665

© 2021 Maxitrol Company | Certified Line Pressure Regulator Training

CERTIFIED 325-L SERIES LINE PRESSURE REGULATORS

- Refer to National and Local Codes for Requirements.

NOTE: Install the regulator properly with gas flowing as indicated by the arrow on the casting



TYPICAL LINE PRESSURE REGULATOR/MANIFOLD CONFIGURATION

2666

CERTIFIED 325-L SERIES LINE PRESSURE REGULATORS

- ANSI Z21.80/CSA 6.22 is the standard for line pressure regulators suitable for application in natural, manufactured, mixed gases, liquefied petroleum gases and LP gas-air mixture piping systems.
- Maxitrol, in compliance with ANSI Z21.80/CSA 6.22, offers line pressure regulators for 2 psi and 5 psi piping systems.
- Maxitrol places a yellow sticker on the regulator stack identifying it as a certified gas line pressure regulator, and a yellow tag is attached to its vent limiter identifying it as a certified vent limiting device.

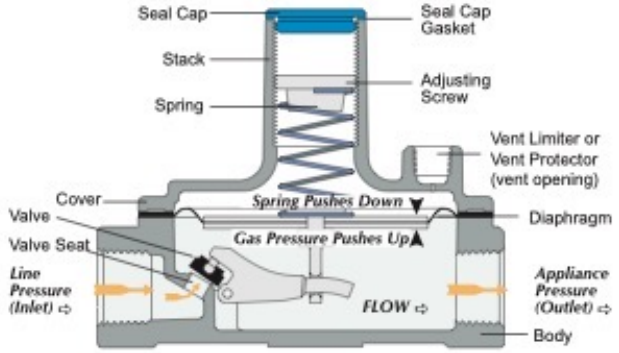


325-3L with 12A09 VENT LIMITING DEVICE

2667

CERTIFIED 325-L SERIES LINE PRESSURE REGULATORS

- Design certified for 2 or 5 psi inlet pressures, ANSI Z21.80/CSA 6.22.
- Designed for dead end lock up.
- Not constructed with internal relief.
- Approved with V-limiter vent limiting device (regulators up to 2” NPT).
- 325-L series is suitable for multi-positional mounting with the exception of the 325-11L, which must be mounted in an upright horizontal position only.



325 LINE PRESSURE REGULATOR CUTAWAY

2668

5 PSI PIPING SYSTEMS

- Maxitrol's 325-L series with overpressure protection devices (OPDs) are certified for 5 psi inlet pressure and 7 to 11 inches w.c. outlet pressure.
- 5 psi rated line pressure regulators require and OPD per ANSI Z21.80/CSA 6.22.
- The OPD must be integral or factory pre-assembled, approved and tested for use with the regulator to limit the downstream pressure to 2 psi maximum in the event of line regulator failure.

NOTE: Even though Maxitrol 5 psi line regulators with OPD are shipped as an assembly, it is important to check the pre-assembled pipe connection between the regulator and the OPD for leakage.

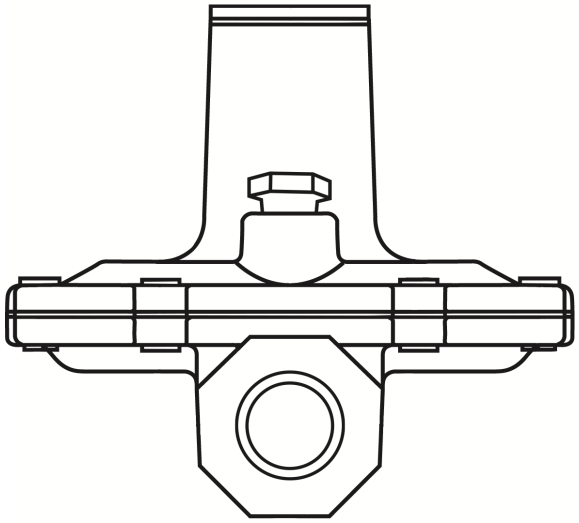


325-3L with OPD 48

2669

5 PSI PIPING SYSTEMS

- The 325-L with OPD series is suitable for limited horizontal mounting (less than or equal to 90° from upright) with the exception of 325-11L, which must be mounted in an upright horizontal position only.
- If a vent limiter or vent protector is installed, mount in an upright horizontal position only.



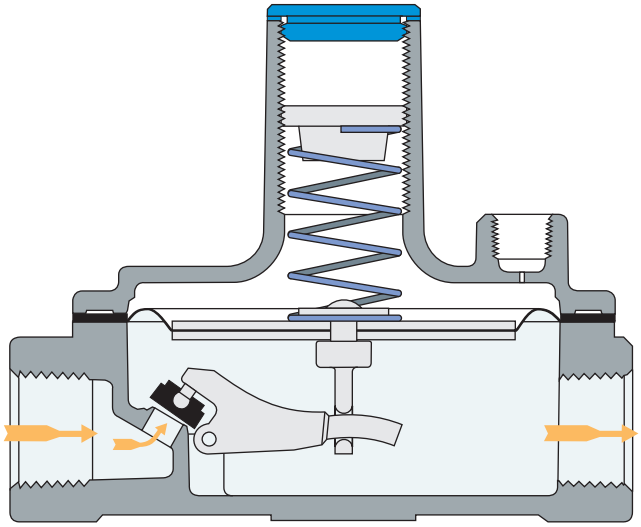
REGULATOR IN UPRIGHT POSITION

2670

© 2021 Maxitrol Company | Certified Line Pressure Regulator Training

DEAD END LOCKUP

- When an appliance shuts off, gas pressure downstream of the regulator attempts to equalize with upstream gas pressure.
- As the outlet pressure increases and begins to exceed the set point pressure, the regulator assumes its fully closed position (this is true for all Maxitrol regulators).
- Further increase in downstream pressure over set point pressure increases the valve-to-valve seat sealing force.



325 SERIES FEATURES A HIGH LEVERAGE LINKAGE ASSEMBLY

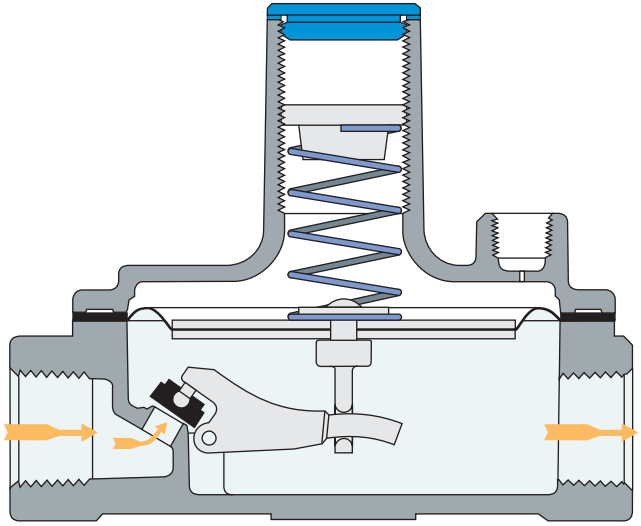
2671

© 2021 Maxitrol Company | Certified Line Pressure Regulator Training

DEAD END LOCKUP

- Regulators capable of dead end lockup stop inlet to outlet pressure equalization and maintain an outlet pressure slightly above set point pressure under static conditions.
- Per ANSI/CSA standards, the maximum allowable lockup pressure is 150% of operating outlet pressure or operating outlet pressure plus 5” w.c., whichever is greater.

NOTE: If the regulator is undersized, incorrectly placed into service, improperly oriented, or mounted too far from the appliance, a higher than desired lockup pressure can occur. When introducing or restoring the gas supply to the line pressure regulator, open the manual valve slowly in the line supplying the line pressure regulator.



325 SERIES FEATURES A HIGH LEVERAGE LINKAGE ASSEMBLY

2672

© 2021 Maxitrol Company | Certified Line Pressure Regulator Training

LINE PRESSURE REGULATOR VENTING - INDOORS

- Vent limiters are designed for use indoors to limit the amount of gas escapement in the unlikely event of a diaphragm failure. Gas escapement is limited to within the ANSI standard requirements.
- Maxitrol vent limiters used with Maxitrol regulators do NOT release or relieve gas into the environment during normal operation.
- Maxitrol's vent limiters should not be used outdoors if they are exposed to the elements.

NOTE: Maxitrol line pressure regulators DO NOT contain an internal relief function.



325-3L with 12A09 VENT LIMITING DEVICE

2673

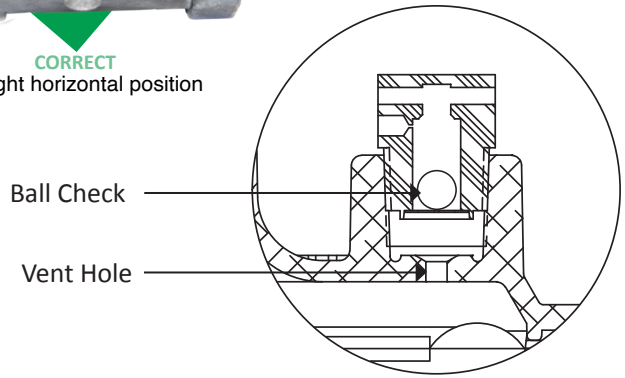
GAS PRESSURE REGULATOR VENTING - INDOORS

- When using a vent limiting device, the regulator must be mounted in an upright horizontal position only.

NOTE: A Maxitrol vent limiting device should only be installed in the Maxitrol regulator that it is certified with.



CORRECT
Upright horizontal position



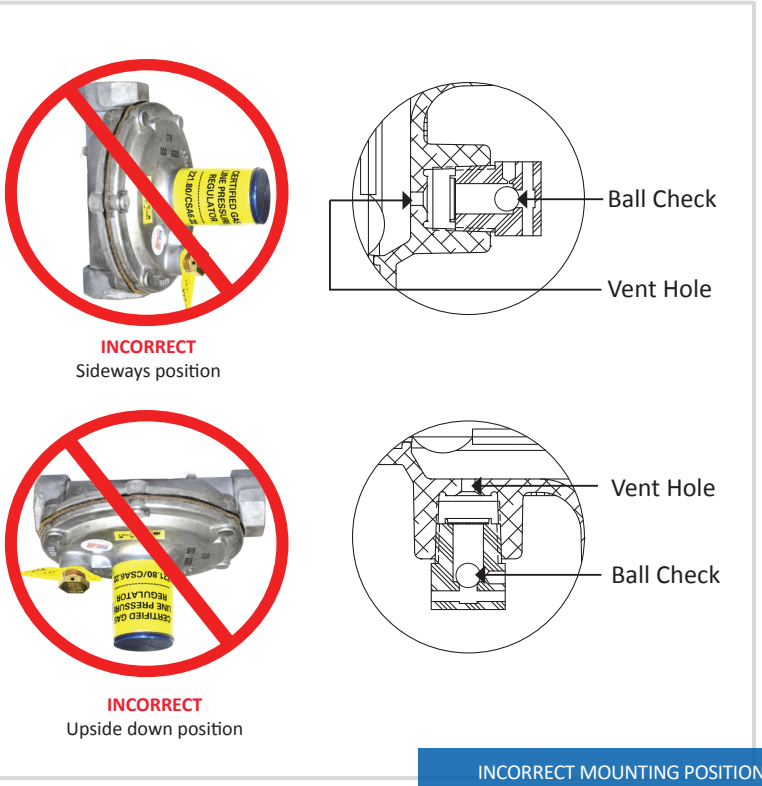
open/normal position

MOUNTING POSITION WHEN USING A VENT LIMITING DEVICE

2674

GAS PRESSURE REGULATOR VENTING - INDOORS

- Any orientation other than an upright horizontal position, will roll the ball check into the closed/limiting position.
- With the ball check in the closed/limiting position, the regulator may experience high lock-up and a sluggish response time and will not operate as designed.

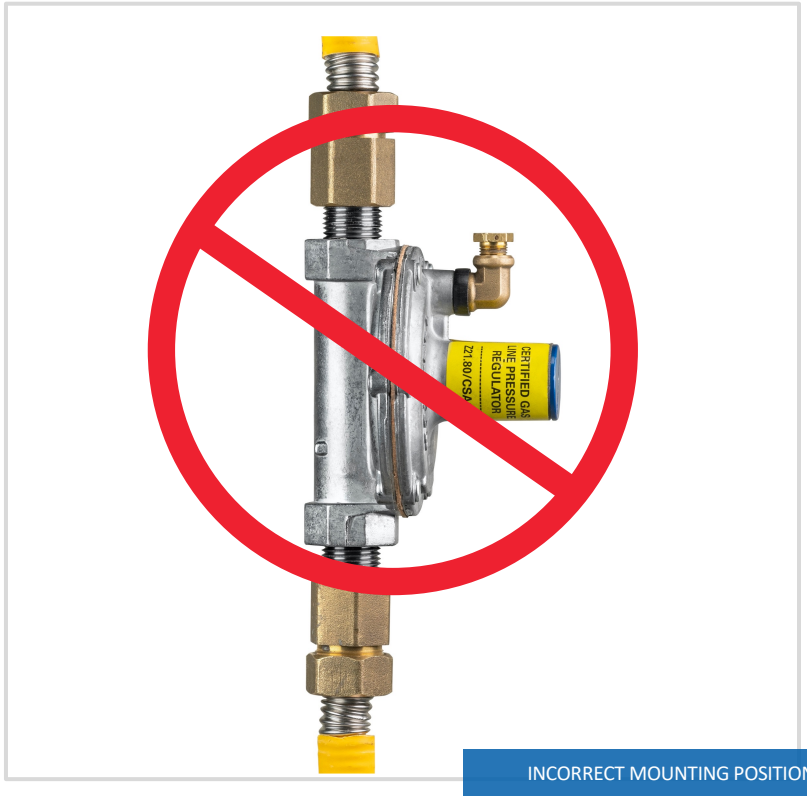


INCORRECT MOUNTING POSITIONS

2675

GAS PRESSURE REGULATOR VENTING - INDOORS

- Vent limiters must be threaded directly into the vent connection of the regulator without intermediate pipe or fittings.
- The Codes state you must follow the manufacturers' recommendations.



INCORRECT MOUNTING POSITION

2676

VENT LIMITER MAXIMUM ALLOWABLE VENTING RATE

REQUIREMENTS FOR VENT LIMITING DEVICE	SPECIFIC GRAVITY	MAXIMUM ALLOWABLE FLOW RATE, CUBIC FEET PER HOUR (cm^3/s)
Vent limiter for use only with natural, manufactured, mixed gases, and LP gas-air mixtures.	0.64	2.5 (19.6)
Vent limiter for use with liquefied petroleum gases.	1.53	1.0 (7.9)

NOTE: Maxitrol Vent limiting devices meet ANSI Z21.80/CSA 6.22. The requirements states “Vent Limiters shall be of materials having melting points of not less than 800°F (427° C).”

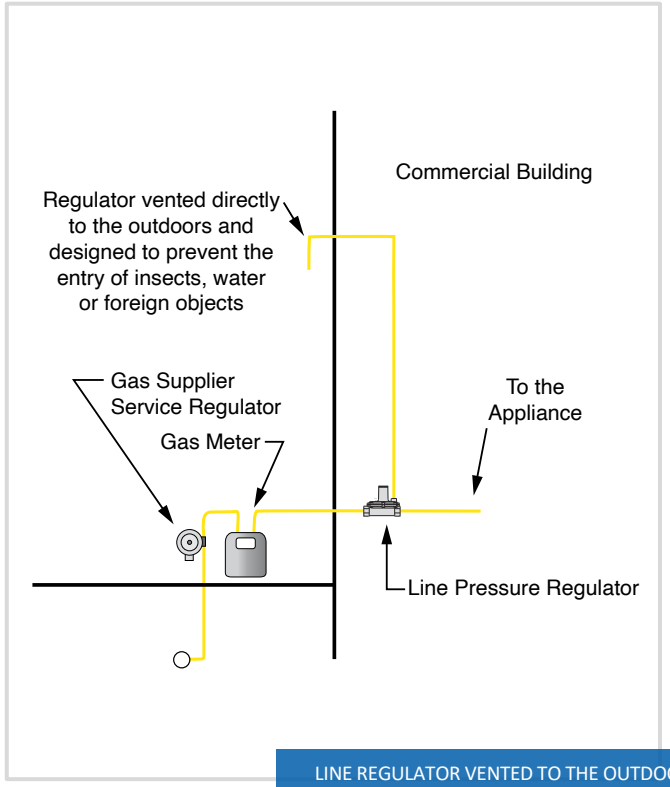
2677

© 2021 Maxitrol Company | Certified Line Pressure Regulator Training

LINE PRESSURE REGULATOR VENTING – TO THE OUTDOORS

- The diaphragm must be allowed to breathe to the atmosphere for unrestricted movement. The regulator vent opening should never be restricted.
- Vent lines should be installed directly into the vent port connection.

NOTE: Venting must be controlled in accordance with all applicable codes and regulations to avoid the danger of escaping gas should there be internal leakage. Venting systems are to be piped gas tight using approved thread joint compound. Be careful excess thread joint compound does not collect in or on the regulator vent, which could cause poor performance and interfere with lockup.



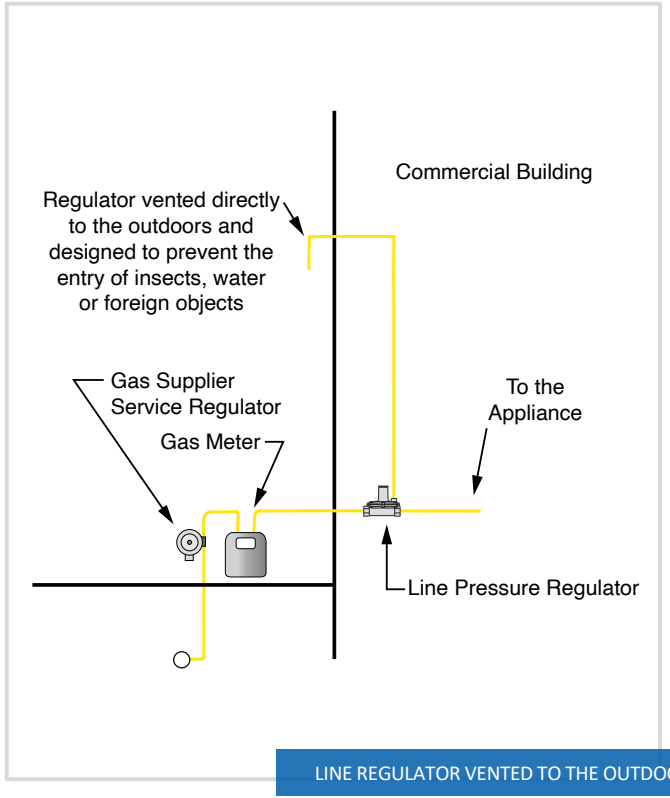
LINE REGULATOR VENTED TO THE OUTDOORS

2678

LINE PRESSURE REGULATOR VENTING – TO THE OUTDOORS

- Vent lines longer than 10 feet in length may require an increase to the next larger diameter to allow for free movement of air.
- Each regulator should have a separate vent line unless approved by code.
- Vent lines must remain open and protected against entry of foreign matter, including water.

NOTE: Venting must be controlled in accordance with all applicable codes and regulations to avoid the danger of escaping gas should there be internal leakage. Venting systems are to be piped gas tight using approved thread joint compound. Be careful excess thread joint compound does not collect in or on the regulator vent, which could cause poor performance and interfere with lockup.



LINE REGULATOR VENTED TO THE OUTDOORS

2679

LINE PRESSURE REGULATOR VENTING – OUTDOORS

- Maxitrol vent protectors are designed for outdoor applications to limit the entry of water, insects, or other foreign materials that could cause blockage or inhibit the vent function.
- Vent protectors must be mounted in an upright horizontal position only.
- Vent protectors are available for all regulators.

NOTE: Imblue® regulators have an anodized coating the increases corrosion resistance and provides extra protection against elements that cause aluminum to oxidize.



13A15 (1/8” NPT) 13A15-5 (3/8” NPT) 13A25 (1/2” NPT)

VENT PROTECTORS

2680

© 2021 Maxitrol Company | Certified Line Pressure Regulator Training

LINE PRESSURE REGULATOR SIZING

SYSTEM REQUIREMENTS

- Gas Type
- Pipe Size
- Inlet Pressure (Maximum Static Pressure, Minimum Operating Pressure)
- Desired Outlet Pressure
- Maximum Capacity (Total Load – All appliances combined)
- Maximum Individual Load Capacity

In most cases, the manifold pipe size has already been selected based on good engineering practice and the regulator pipe size should conform to this size.



REGULATOR MODELS

2681

LINE PRESSURE REGULATOR SIZING

CAPACITIES

Expressed in CFH (m^3/h) @ 0.64 sp gr gas

MODEL	PIPE SIZE	OUTLET PRESSURE SET POINT	OPERATING INLET PRESSURE				
			.5 psi (3.4 kPa)	.75 psi (5.2 kPa)	1 psi (6.9 kPa)	1.5 psi (10.3 kPa)	2 psi (13.8 kPa)
325-3L	3/8" x 3/8" 1/2" x 1/2"	7" w.c. (1.7 kPa)	145 (4.1)	200 (5.7)	250 (7.1)	250 (7.1)	250 (7.1)
		10" w.c. (2.5 kPa)	110 (3.1)	180 (5.1)	230 (6.5)	250 (7.1)	250 (7.1)
325-5L	1/2" x 1/2"	7" w.c. (1.7 kPa)	360 (10.2)	485 (13.7)	500 (14.2)	500 (14.2)	500 (14.2)
		10" w.c. (2.5 kPa)	275 (7.8)	475 (13.5)	500 (14.2)	500 (14.2)	500 (14.2)

PRESSURE DROP

Expressed in CFH (m^3/h) @ 0.64 sp gr gas

MODEL	7.0" w.c. (1.7 kPa)	.5 psi (3.4 kPa)	.75 psi (5.2 kPa)
325-3L	145 (4.0)	204 (5.8)	250 (7.0)
325-5L	400 (11.3)	550 (15.6)	670 (19.0)

2682

© 2021 Maxitrol Company | Certified Line Pressure Regulator Training

MAXITROL®

LINE PRESSURE REGULATOR SIZING

To select a 325-L series regulator

KNOWN

- Appliance with two 100,00 Btu/h burners
- Pipe Size ½”
- Inlet Pressure: 2 psi static, 1 psi Operating
- Desired Outlet Pressure: 7” w.c.
- Maximum Individual load: 100,000 Btu/h
- Total Appliance Load: 200,00 Btu/h

SOLUTION

The 325-3L’s capacity @ 1 psi operating inlet pressure is 250,000 Btu/h natural gas capacity. The maximum individual load for the 325-3L is 140,000 Btu/h.

The 325-3L (1/2”) is the correct regulator to use with this application.



325-3L with 12A09 VENT LIMITING DEVICE

2683

THANKS FOR LISTENING

Visit www.maxitrol.com for more information.





Maxitrol Company
23555 Telegraph Road
Southfield, MI 48033
USA

Phone: 248-356-1400
Fax: 248-356-0829
info.na@maxitrol.com

© 2021 Maxitrol Company | Certified Line Pressure Regulator Training

MAXITROL®

File Attachments for Item:

EC-15 Dry Sprinklers for Commercial and Residential Fire Protection (Victaulic)

All certifications (1 hour)

Victaulic® University Continuing Education
Dry Sprinklers For Commercial And Residential Fire Protection
Course Summary

Overview

Introduction

Upon completion of this course, each participant will be able to identify a dry sprinkler, explain how it works, and how it is installed. Participants will also be able to identify both properly and improperly installed dry sprinklers, according to applicable codes and standards.

Learning Objectives

- At the end of this course, learners will be able to:
  - Define what a dry sprinkler is and how it functions
  - Identify appropriate applications for dry sprinklers
  - Discuss code requirements associated with dry sprinklers
  - Identify the common issues associated with the application or installation of dry sprinklers
  - Recognize and inspect properly installed dry sprinklers

Lessons

	Time (minutes)
• **Dry Sprinklers**	**10**
– What Is A Dry Sprinkler?	3
– Anatomy Of A Dry Sprinkler	3
– How Does A Dry Sprinkler Work?	4
• **Code Requirements**	**10**
– Installation Requirements	3
– Commercial Exposed Barrel Lengths	3
– Residential Exposed Barrel Lengths	3
• **Applications**	**2**
– Where Are Dry Sprinklers Used?	2
• **Maintenance & Inspections**	**10**
– Maintenance	2
– Ice Build Up	1
– Installation Damage	2
– Conduction	1
– Damage Reports From The Field	2
– Installation Issues	2
• **Advancements**	**10**
– Freezer Applications	3
– Combining Technologies	3
– Installation	4
• **Review / Q&A**	**5**
• **Final Assessment**	**15**
TOTAL	**62**

Continued on next page

© 2020 VICTAULIC® COMPA
ALL RIGHTS RESERVED.

References

- This course references the following publications:
  - NFPA 13: Standard for the Installation of Sprinkler Systems, 2019 Edition
  - NFPA 13R: Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies, 2019 Edition
  - NFPA 13D: Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes, 2019 Edition
  - NFPA 25: Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems, 2020 Edition

© 2020 VICTAULIC® COMPA
ALL RIGHTS RESERVED.


Victaulic UNIVERSITY
CONTINUING EDUCATION
Victaulic® University Continuing Education
since 1919

1


DRY SPRINKLERS FOR COMMERCIAL & RESIDENTIAL FIRE PROTECTION

2


LEARNING OBJECTIVES:
Define A Dry Sprinkler And How It Functions
Identify Appropriate Applications For Dry Sprinklers
Discuss Code Requirements Associated With Dry Sprinklers
Identify The Common Issues Associated With The Application Or Installation Of Dry Sprinklers
Recognize And Inspect Properly Installed Dry Sprinklers
LESSONS:
The Dry Sprinkler
Code Requirements
Applications
Maintenance & Inspection
Advancements
Review Session / Q&A

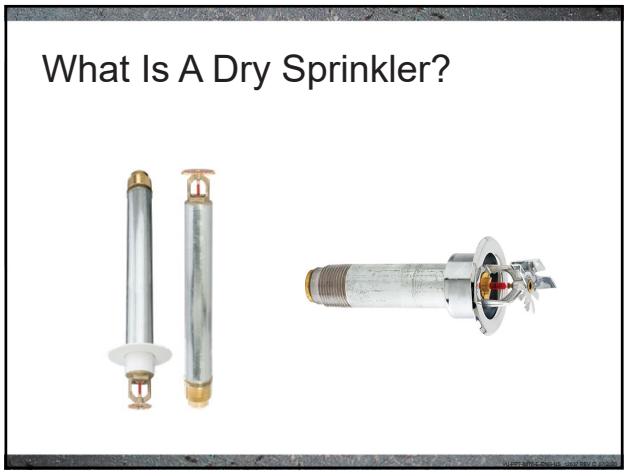
3


ACCREDITED IACET PROVIDER
IACET Accredited Provider: Victaulic® University Continuing Education has been awarded Accredited Provider status by the International Accreditors for Continuing Education and Training (IACET). In obtaining this approval, Victaulic University Continuing Education has demonstrated that it complies with the ANSI / IACET Standard, which is recognized internationally as a standard of good practice. As a result of their Accredited Provider accreditation status, Victaulic University Continuing Education is authorized to offer IACET CEUs for its programs that qualify under the ANSI / IACET Standard.
ICC PREFERRED EDUCATION PROVIDER
Course 11638
International Code Council (ICC) Preferred Provider: Victaulic University Continuing Education is a member of the ICC Preferred Provider Network. The Preferred Provider Program recognizes and promotes ICC-approved educational offerings by a variety of Providers, as they relate to codes, standards, and guidelines, as well as building construction materials, products, and methods.

4

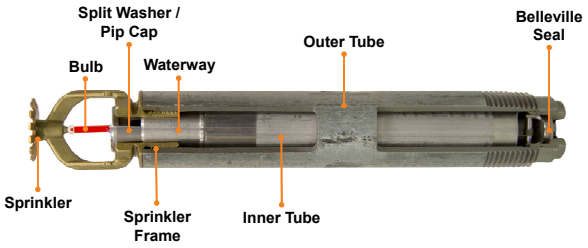

Dry Sprinklers For Commercial & Residential Fire Protection
The Dry Sprinkler

5


What Is A Dry Sprinkler?

6

Anatomy Of A Dry Sprinkler



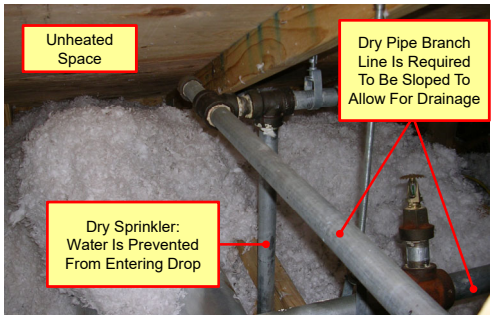
7

How Does A Dry Sprinkler Work?



8

Example



9

Dry Sprinklers For Commercial & Residential Fire Protection
Code Requirements

10

Installation Requirements

NFPA® INTERNATIONAL

NFPA Standards	
13	Commercial
13R	Residential
13D	Dwelling

11

Exposed Barrel Lengths

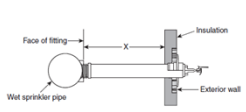


FIGURE A.15.3.1(a) Dry Sidewall Sprinkler Through Wall.

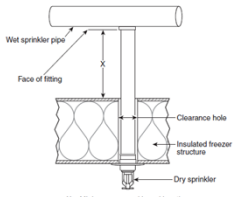


FIGURE A.15.3.1(b) Dry Pendent Sprinkler Through Ceiling or Top of Freezer.

X = Minimum Exposed Barrel Length

X Is Measured From the Face Of The Sprinkler Fitting To The Inside Surface Of The Exterior Wall Or Insulation – Whichever Is Closest To The Fitting

NFPA 13: Standard for the Installation of Sprinkler Systems, 2019 Edition

12

Determining Minimum Exposed Barrel Lengths

Table 15.3.1(a) Exposed Barrel Lengths for Dry Sprinklers (U.S. Customary Units)

Ambient Temperature Exposed to Discharge End of Sprinkler (°F)	Minimum Exposed Barrel Length when Exposed to 40°F (in.)	Minimum Exposed Barrel Length when Exposed to 50°F (in.)	Minimum Exposed Barrel Length when Exposed to 60°F (in.)
40	0	0	0
30	0	0	0
20	4	0	0
10	8	1	0
0	12	3	0
−10	14	4	1
−20	14	6	3
−30	16	8	4
−40	18	8	4
−50	20	10	6
−60	20	10	6

NFPA 13: Standard for the Installation of Sprinkler Systems, 2019 Edition

13

Dry Sprinklers For Commercial & Residential Fire Protection
Applications

14

Where Are Dry Sprinklers Used?

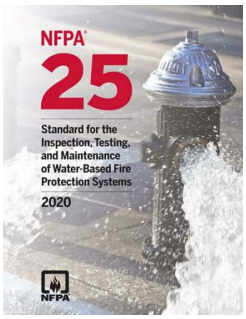


15

Dry Sprinklers For Commercial & Residential Fire Protection
Maintenance & Inspection

16

Maintenance



NFPA 25: Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems, 2020 Edition, National Fire Protection Association, copyright 2020

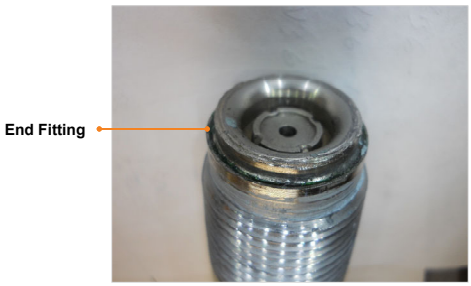
17

Ice Build Up



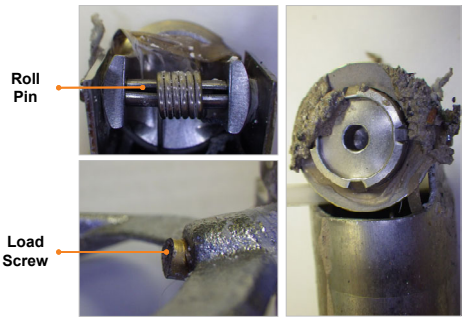
18

Installation Damage



19

Conduction



20

Damage Reports From The Field



21

Installation Issues

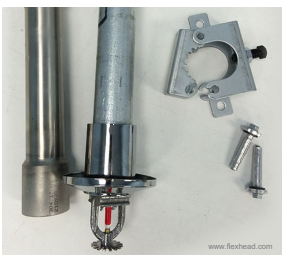


22

Dry Sprinklers For Commercial & Residential Fire Protection **Advancements**

23

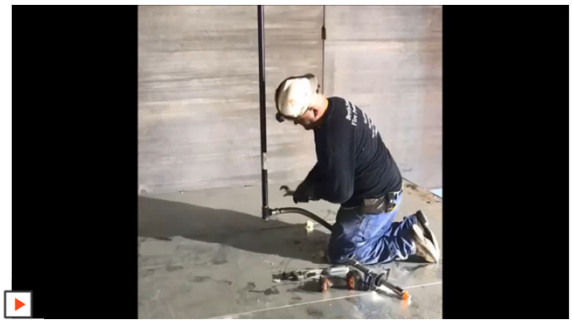
Freezer Applications





24

Installation Video



25

Combining Technologies



26

Installation



Pendent Orientation



Sidewall Orientation

27

Learn More

- Victaulic Website: **victaulic.com**
  - Product Submittals
  - Product / System Videos
  - Installation Manuals
  - Technical And Design Data
  - White Papers
  - Case Studies
- Approving Industry Organizations

28

Dry Sprinklers For Commercial & Residential Fire Protection

Review Session / Q&A

29

LEARNING OBJECTIVES:

- Define A Dry Sprinkler And How It Functions
- Identify Appropriate Applications For Dry Sprinklers
- Discuss Code Requirements Associated With Dry Sprinklers
- Identify The Common Issues Associated With The Application Or Installation Of Dry Sprinklers
- Recognize And Inspect Properly Installed Dry Sprinklers

LESSONS:

- The Dry Sprinkler
- Code Requirements
- Applications
- Maintenance & Inspection
- Advancements
- Review Session / Q&A

30

Dry Sprinklers For Residential & Commercial Fire Protection

Assessment & Course Close

31

Instructions

- Complete Final Assessment And Provide To Facilitator
- Complete Course Evaluation And Provide To Facilitator
- Verify You Have Signed The Attendance Book

32

Dry Sprinklers For Commercial & Residential Fire Protection

Thank You!

33

Victaulic UNIVERSITY | CONTINUING EDUCATION

Victaulic At A Glance

since 1919

34

Victaulic UNIVERSITY | CONTINUING EDUCATION since 1919

Victaulic History



35

Victaulic UNIVERSITY | CONTINUING EDUCATION since 1919

Grooved Mechanical Piping Products



- Over 10,000+ Products
- ½" - 144" | DN15 – DN3600 Diameter Solutions

36


Victaulic CONTINUING EDUCATION
since 1919
Diverse Material Solutions
• Metals
• Plastics
• Coatings / Linings

37


Victaulic CONTINUING EDUCATION
since 1919
Diversity In Market Solutions

38

Ohio | Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: Lyndsay Coyle

Organization: Victaulic

Address: 4901 Kesslersville Road Easton PA 18040

E-mail: lyndsay.coyle@victaulic.com Telephone: 484-541-1460

Website: www.victaulic.com | www.victaulicuniversity.com

Conference Sponsor (if applicable) NA Conference Email: NA

Check here if Course Renewal: _____ Prior course number BBS2020-527 (*i.e. BBS2018-429*)

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: Dry Sprinklers for Commercial & Residential Fire Protection

Course instructor: Michael Stamets, David Molnar, Colin Phelps

Course description: The purpose of this course is to help learners identify a dry sprinkler, explain how it works, and how it is installed. Learners will also be able to identify both properly and improperly installed dry sprinklers, according to applicable codes and standards.

Instructional hours per session: 1 hour Number of Sessions: TBD

Course Date(s) and Location: TBD

Special Content:

Code Administration: _____ Conference Course: _____

Existing Buildings: _____ Conference Name: _____

Electrical Instruction: _____ Conference location: _____

Plumbing Instruction: _____

Course to be offered online? Yes **On Demand** Yes **Webinar** Yes

Course Website: www.victaulicuniversity.com

Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation)*:

On Demand: Registration, Completion, & Assessment recorded on LMS. Webinar: Registration & Assessment recorded via LMS, attendance via Teams.

Course applicable for the following certifications

Residential Certifications Only: _____ Commercial Certifications: X

Administrative Course, All Certifications: X

Application materials included:

X Course Outline or Course Learning Objectives

X Presentation Materials/Slides (not required for roundtable courses)

X Assessment Materials (for online courses)

X Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

Victaulic® University Continuing Education Course Instructor Biography

Dave Molnar
Victaulic University Training Leader



Education

- Associates Degree – Mechanical Drafting and Design
  - Lincoln Technical Institute

Current Job Description

- Victaulic University course facilitator, specializing in:
  - Virtual Design & Construction
- Facilitating the following Victaulic University Continuing Education courses:
  - Victaulic Tools For Revit – Increasing Modeling Efficiency

Experience Relevant To Course Topic

- VDC/Special Projects Manager for Victaulic and
  - Managed a team of BIM project coordinators in the development and coordination of Fire Protection and Mechanical piping systems in accordance with design documents for prefabrication and construction shop drawing submissions
- Experience training on Revit and BIM best practices for Fire Protection and Mechanical contractors and engineers
- Over 25 years of experience in the construction design and drafting industry
  - Project management and senior BIM project coordinator positions with consulting engineering firms and mechanical contractors before joining Victaulic
- Member of NFPA and a certified designer under NFPA 13: Installation of Sprinkler Systems

VU-QRG-9110-E-ENG-GLB 15165 REV A 04/2020

© 2020 VICTAULIC COMPANY. ALL RIGHTS RESERVED.

Victaulic® University Continuing Education Course Instructor Biography

Colin Phelps
Manager of Sales & Customer Training



Education

- Associate of Applied Science – Welding Technology
  - Northampton Community College, Bethlehem, PA
- Bachelor of Science – Organizational Leadership
  - Pennsylvania State University, University City, PA
- Master of Education – Adult Education
  - Rutgers University, New Brunswick, NJ
  - Expected Date of Graduation: September of 2021

Current Job Description

- With a team of training professionals manage educating our customers and the industries we serve about Victaulic
- Manage a year-long new Sales hire onboarding training program
- Facilitating the following Victaulic University Continuing Education courses:
  - Basic Principles Of Grooved Mechanical Joints
  - Gasket Technology
  - Victaulic Certification Program
  - Victaulic Grooving And Installation Fundamentals
  - Victaulic Grooving And Installation Fundamentals For Copper Connections
  - Victaulic Grooving And Installation Fundamentals For Hydraulic Elevator Piping
  - Victaulic System Solution For HDPE Pipe Joining Certification

Experience Relevant To Course Topic

- Over 20 years of experience in welding industry
- Over 10 years of experience in education and training
- Over six years of experience in educating Victaulic employees and customers

VU-QRG-9110-E-ENG-GLB 15165 REV A 04/2020
© 2020 VICTAULIC COMPANY. ALL RIGHTS RESERVED.

Victaulic® University Continuing Education Course Instructor Biography

Michael Stamets
Victaulic University Technical Trainer



Education

- Associate Of Arts – Business Administration (Completion of 81 credits)
  - Northampton Community College, Bethlehem, PA
- Seven years of Professional Fire Service Experience & Certifications
  - NFPA Fire Instructor II
  - NFPA Fire Inspector II
  - NFPA Fire Officer III

Current Job Description

- Victaulic University course facilitator, specializing in:
  - Pipe joining and flow control solutions
  - Grooved mechanical joints engineering design principles
  - Fire protection valves and sprinklers
  - Flexible sprinkler systems
- Facilitating the following Victaulic University Continuing Education courses:
  - Basic Principles Of Grooved Mechanical Joints
  - Dry Sprinklers For Commercial And Residential Fire Protection
  - Flexible Sprinkler Hose Systems
  - Introduction To Victaulic Vortex™ Hybrid Fire Extinguishing Systems
  - Victaulic Fire Protection Workshop
  - Victaulic FireLock NXT™ Deluge System Check Valves
  - Victaulic FireLock NXT™ Dry System Check Valves
  - Victaulic FireLock NXT™ Preaction System Check Valves
  - Victaulic FireLock™ Products: Fire Protection Valves
  - Victaulic FireLock™ Valves For Wet Pipe Systems
  - Victaulic Grooving And Installation Fundamentals
  - Victaulic Small Diameter Fire Protection Solutions
  - Victaulic System Solution For HDPE Pipe Joining Certification
  - Victaulic Vortex™ Hybrid Fire Extinguishing Systems Integrator Training Courses

Experience Relevant To Course Topic

- Over five years of experience in the fire protection industry
  - Including the inspection, maintenance and installation of pre-engineered fire suppression systems
- Two years of experience in Application Engineering – Fire Protection
  - Providing technical expertise to Victaulic customers
  - Working closely with Product Development and Quality Assurance for design and manufacturing of fire protection products
- NFPA Member (2019 – Present)

VU-QRG-9110-E-ENG-GLB 15165 REV A 04/2020
© 2020 VICTAULIC COMPANY. ALL RIGHTS RESERVED.

File Attachments for Item:

EC-16 Enforcing NFPA 25: Deficiencies, Impairments, Observations (Fire Code Academy)

All certifications (1 hour)

Ohio | Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: Randy Hormann

Organization: Fire Code Academy

Address: 81 Mill Street - Suite 300 Gahanna, Ohio 43230

E-mail: RandyH@FireCodeAcademy.com Telephone: 614-416-8077

Website: www.FireCodeAcademy.com

Conference Sponsor (if applicable)_____ Conference Email:_____

Check here if Course Renewal:_____ Prior course number _____ (*i.e. BBS2018-429*)

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: 006. Enforcing NFPA 25: Deficiencies, Impairments, and Observations

Course instructor: John August Denhardt, Kevin Hall

Course description:

This seminar will focus on the enforcement of the requirements of NFPA 25. NFPA 25, Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems is referenced by the model fire codes.

Instructional hours per session: 1.0 Hours Number of Sessions:_____

Course Date(s) and Location:_____

Special Content:

Code Administration:_____ Conference Course: _____

Existing Buildings: _____ Conference Name: _____

Electrical Instruction: _____ Conference location:_____

Plumbing Instruction:_____

Course to be offered online? No **On Demand**_____ **Webinar**_____

Course Website: _____

Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation*):

_____

Course applicable for the following certifications

Residential Certifications Only: _____ Commercial Certifications: _____

Administrative Course, All Certifications: _____

Application materials included:

X Course Outline or Course Learning Objectives

X Presentation Materials/Slides (not required for roundtable courses)

_____ Assessment Materials (for online courses)

X Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

AHJ Webinar

Description: This seminar will focus on the enforcement of the requirements of NFPA 25. NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems* is referenced by the model fire codes. While NFPA 25 provides the required tasks and frequencies to perform ITM activities, enforcement lies within the fire code. This webinar will describe the differences in scope between the codes and standard, updates to NFPA 25 and the fire code involving enforcement, and how consistent enforcement will benefit the fire sprinkler industry.

Learning Objectives

Upon completion of this webinar attendees will be able to:

1. Identify the scope of NFPA 1 and NFPA 25
2. Determine the roles and responsibilities of the owner, the AHJ, and the ITM contractor
3. Identify a deficiency and impairment and the proper action for each
4. Determine the appropriate amount of time to correct a deficiency

AFSA Technical Services Seminar Instructor Information

John August Denhardt, P.E., ET, CWBSP, FSFPE • American Fire Sprinkler Association
1410 East Renner Rd, Suite 150 | Richardson, TX 75028 | 214-349-5965 | jdenhardt@firesprinkler.org

John August Denhardt, P.E., ET, CWBSP, FSFPE, is the vice president of engineering and technical services for the American Fire Sprinkler Association (AFSA). He is responsible for strengthening AFSA's engineering and technical approaches to meeting member, industry, and operational priorities, with an emphasis on service, quality, and integrity. Denhardt is a registered professional engineer (P.E.) in the District of Columbia as well as the states of Delaware, Maryland, Pennsylvania, and Virginia. He is NICET Level III certified in water-based systems layout, NICET Level III certified in inspection and testing of bater-based systems, and a certified water-based system professional through NFPA. Denhardt is a member of the NFPA 13 technical committee on sprinkler system discharge criteria, a fellow in the Society of Fire Protection Engineers (SFPE), a member of the SFPE Board of Directors, a member of the Board of Trustees for NFPA's Fire Protection Research Foundation and sits on the University of Maryland Department of Fire Protection Engineering's Board of Visitors. A native of Maryland, Denhardt holds a Bachelor of Science degree from the University of Maryland, College Park in fire protection engineering. Prior to this role, Denhardt was employed by Strickland Fire Protection in Forestville, Maryland since 1994, overseeing large-scale projects and assisting with design and installation technical issues.

Kevin Hall, M.Eng., P.E., ET, CWBSP, PMSFPE • American Fire Sprinkler Association
1410 East Renner Rd, Suite 150 | Richardson, TX 75028 | 214-349-5965 | khall@firesprinkler.org

Kevin Hall, M.Eng., P.E., ET, CWBSP, PMSFPE is the senior manager of engineering and technical services for the American Fire Sprinkler Association (AFSA). He is a member of several National Fire Protection Association (NFPA) technical committees responsible for developing the model codes and standards including, NFPA 1 *Fire Code*, NFPA 13/13R/13D *Installation of Sprinkler Systems*, NFPA 20 *Installation of Stationary Fire Pumps for Fire Protection*, NFPA 30 *Flammable and Combustible Liquids Code*, and NFPA 915 *Remote Inspections*. He also represents AFSA on numerous UL standard technical panels responsible for revising and maintaining the product standards used in the sprinkler industry. He is a registered professional engineer in Delaware and Maryland, NICET III certified in water-based system layout, a certified water-based system professional through NFPA, and a professional member of the Society of Fire Protection Engineers (SFPE). He earned his Bachelor of Science and Master of Engineering degrees from the University of Maryland, College Park in fire protection engineering. In 2021, he was recognized as one of SFPE's "5 Under 35" award recipients. Prior to his association and committee work, he worked for Reliance Fire Protection in Baltimore, Maryland as a project manager overseeing projects of various sizes and complexity for the Contracts Division.

Enforcing NFPA 25: Deficiencies, Impairments, and Observations

Instructors:
John August Denhardt, P.E., FSFPE
Kevin Hall, M.Eng., P.E., PMSFPE

AFSA
American Fire Sprinkler Association

No individual or entity - including a presenting author - may electronically record or broadcast any portion of this AFSA training without prior written consent of AFSA. Unauthorized recording (audio, video, still photographs, etc.) of this presentation without the express written consent of AFSA is strictly prohibited.

1



John August Denhardt, P.E., ET, CWBSP, FSFPE

AMERICAN FIRE SPRINKLER ASSOCIATION

John August Denhardt, P.E., ET, CWBSP, FSFPE, is the vice president of engineering and technical services for the American Fire Sprinkler Association (AFSA). He is responsible for strengthening AFSA's engineering and technical approaches to meeting member, industry, and operational priorities, with an emphasis on service, quality, and integrity. Denhardt is a registered professional engineer (P.E.) in the District of Columbia as well as the states of Delaware, Maryland, Pennsylvania, and Virginia. He is NICET Level III certified in water-based systems layout, NICET Level III certified in inspection and testing of water-based systems, and a certified water-based system professional through NFPA. Denhardt is a member of the NFPA 13 technical committee on sprinkler system discharge criteria, a fellow in the Society of Fire Protection Engineers (SFPE), a member of the SFPE Board of Directors, a member of the Board of Trustees for NFPA's Fire Protection Research Foundation and sits on the University of Maryland Department of Fire Protection Engineering's Board of Visitors. A native of Maryland, Denhardt holds a Bachelor of Science degree from the University of Maryland, College Park in fire protection engineering. Prior to this role, Denhardt was employed by Strickland Fire Protection in Forestville, Maryland since 1994, overseeing large-scale projects and assisting with design and installation technical issues.

jdenhardt@firesprinkler.org | 214-349-5965 | American Fire Sprinkler Association

2

2



Kevin Hall, M.Eng., P.E., ET, CWBSP, PMSFPE

AMERICAN FIRE SPRINKLER ASSOCIATION

Kevin Hall, M.Eng., P.E., ET, CWBSP, PMSFPE is the senior manager of engineering and technical services for the American Fire Sprinkler Association (AFSA). He is a member of several National Fire Protection Association (NFPA) technical committees responsible for developing the model codes and standards including, NFPA 1 *Fire Code*, NFPA 13/13R/13D *Installation of Sprinkler Systems*, NFPA 20 *Installation of Stationary Fire Pumps for Fire Protection*, NFPA 30 *Flammable and Combustible Liquids Code*, and NFPA 915 *Remote Inspections*. He also represents AFSA on numerous UL standard technical panels responsible for revising and maintaining the product standards used in the sprinkler industry. He is a registered professional engineer in Delaware and Maryland, NICET III certified in water-based system layout, a certified water-based system professional through NFPA, and a professional member of the Society of Fire Protection Engineers (SFPE). He earned his Bachelor of Science and Master of Engineering degrees from the University of Maryland, College Park in fire protection engineering. In 2021, he was recognized as one of SFPE's "5 Under 35" award recipients. Prior to his association and committee work, he worked for Reliance Fire Protection in Baltimore, Maryland as a project manager overseeing projects of various sizes and complexity for the Contracts Division.

khall@firesprinkler.org | 214-349-5965 | American Fire Sprinkler Association

3

3

IT'S A BIG WORLD.
LET'S PROTECT IT TOGETHER.

DISCLAIMER

This seminar and its content is not a formal interpretation issued pursuant to NFPA regulations. Any opinion expressed is the personal opinion of the author and presenter and does not necessarily present the official position of the NFPA and its Technical Committees.

4



Deficiencies and Impairments

5

5

NFPA 25 – Describe Findings

6

Non-critical Deficiency (3.3.8.2)

- No "material" effect on the functionality of the system
- System or unit will function in a fire event
- May be needed for proper ITM
- Examples:
  - Sprinklers lightly loaded
  - Loose hangers
  - Missing sign



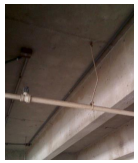
6

NFPA 25 – Describe Findings

7

Critical Deficiency (3.3.8.1)

- Can have a "material" effect on the functionality of the system
- Can have a "material" effect on the functionality of the unit
- Examples:
  - Leaking (dripping) sprinkler
  - Damaged or unattached hangers
  - Alarm device not functioning



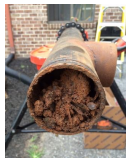
7

NFPA 25 – Describe Findings

8

Impairment (3.3.22)

- System or unit is "out-of-order" (service)
- Won't function in a fire event
- Two kinds:
  - Emergency
  - Preplanned
- Examples:
  - Caulked concealed sprinkler cover plates
  - Pipe or fitting spraying or running water
  - Obstructed pipes



8

Owner's Responsibilities

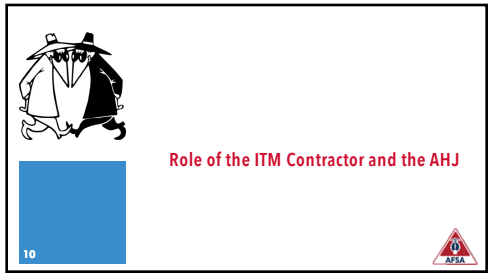
9



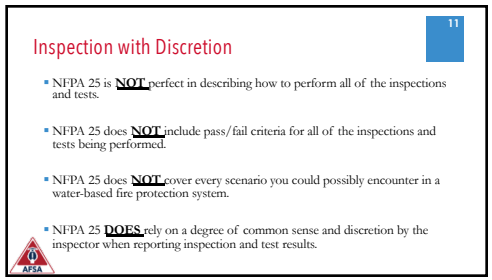
- Inspection, Testing, Maintenance, and Impairment
- Freeze Protection
- Accessibility
- Notification
- Corrections and Repairs
- Changes in Occupancy, Use, Process, or Materials
- Changes in Hazard
- Valve Locations/Information Signs

9

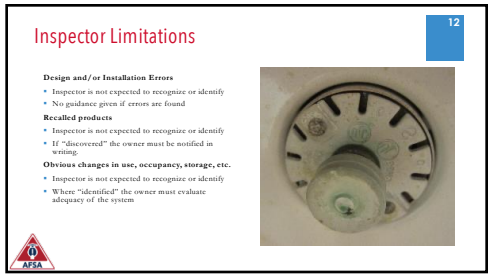
2705


Role of the ITM Contractor and the AHJ
10
AFSA

10


Inspection with Discretion
11
NFPA 25 is NOT perfect in describing how to perform all of the inspections and tests.
NFPA 25 does NOT include pass/fail criteria for all of the inspections and tests being performed.
NFPA 25 does NOT cover every scenario you could possibly encounter in a water-based fire protection system.
NFPA 25 DOES rely on a degree of common sense and discretion by the inspector when reporting inspection and test results.
AFSA

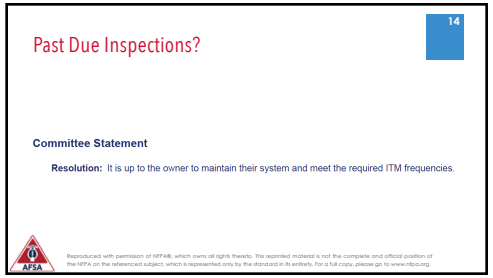
11


Inspector Limitations
12
Design and/or Installation Errors
Inspector is not expected to recognize or identify
No guidance given if errors are found
Recalled products
Inspector is not expected to recognize or identify
If "discovered" the owner must be notified in writing.
Obvious changes in use, occupancy, storage, etc.
Inspector is not expected to recognize or identify
Where "identified" the owner must evaluate adequacy of the system
AFSA

12


Past Due Inspections?
13
Public Input No.
after 4.1.1.1]
4.1.1\2 Testi
rdance with th
rd shall be considered a
non-critical
Statement of Pro
d Substan
Publ
To properly enforc
ements of NFPA
not performed should be
considered a non-c
ncy. Many AHJ
to perform requirements within the
standard documentin
not completed
ssist building owners and AHJ's in
having more compliant
Reproduced with permission of NFPA®, which owns all rights thereto. This reprinted material is not the complete and official position of
the NFPA on the referenced subject, which is represented only by the standard in its entirety. For a full copy, please go to www.nfpa.org.

13


Past Due Inspections?
14
Committee Statement
Resolution: It is up to the owner to maintain their system and meet the required ITM frequencies.
Reproduced with permission of NFPA®, which owns all rights thereto. This reprinted material is not the complete and official position of
the NFPA on the referenced subject, which is represented only by the standard in its entirety. For a full copy, please go to www.nfpa.org.

14


Past Due Inspections?
15
Public Comment
Section after 4.3.5]
ections and tests
e verified through
idered a non-cri
cy.
3.3.6
e term, ac
rs to inspec
ests with greater
ntervals than
ludes, fo
e 3-, 5-, 20-, 50-year
ts.
Statement of
nd Substantiati
nt
The AHJ relies
ntractor and owne
the correct intervals. If the owner
cannot provide
the
ded this should be considered a
non-critical deficie
ure the less frequent and
detrimental ITM requ
requirements.
Reproduced with permission of NFPA®, which owns all rights thereto. This reprinted material is not the complete and official position of
the NFPA on the referenced subject, which is represented only by the standard in its entirety. For a full copy, please go to www.nfpa.org.

15

Past Due Inspections?

16

Committee Statement

Committee Action: Rejected

Resolution: Where does the service provider draw the line? If the scope of one's contract is an annual test of the fire pump but a five-year standpipe flow test is not performed, does the service provider identify the lack of the standpipe flow test? This would be better addressed as an observation in an inspection report.

Reproduced with permission of NFPA®, which owns all rights thereto. This reprinted material is not the complete and official position of the NFPA on the referenced subject, which is represented only by the standard in its entirety. For a full copy, please go to www.nfpa.org.

16

What can you do?

17



- Ask for the records!
- Must be maintained by the owner
- Must be made available to the AHJ upon request
- Ask the owner, not the contractor
  - Unless specifically legislated in your jurisdiction

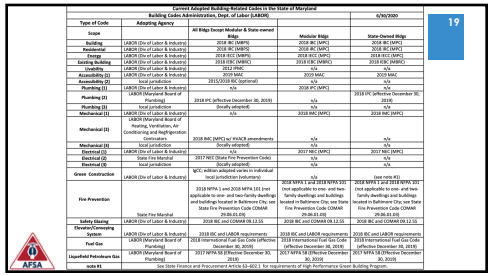
17

How should the requirements be enforced?

18



18



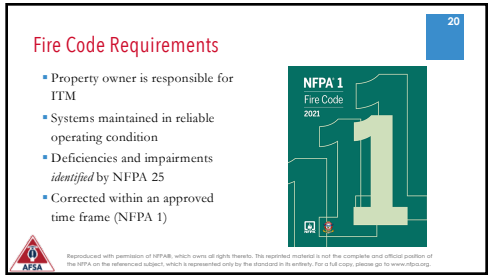
Current Adopted Building-Related Codes in the State of Maryland

Building Codes Administration, Dept. of Labor (LABOR) — 6/30/2020

Type of Code	Adopting Agency	All Bldgs Except Modular & State-owned		
Scope			Modular Bldgs	State-Owned Bldgs
Building	LABOR (Div of Labor & Industry)	2018 IBC (MBPS)	2018 IBC (MPC)	2018 IBC (MPC)
Residential	LABOR (Div of Labor & Industry)	2018 IRC (MBPS)	2018 IRC (MPC)	2018 IRC (MPC)
Energy	LABOR (Div of Labor & Industry)	2018 IECC (MBPS)	2018 IECC (MPC)	2018 IECC (MPC)
Existing Building	LABOR (Div of Labor & Industry)	2018 IEBC (MBRC)	2018 IEBC (MBRC)	2018 IEBC (MBRC)
Livability	LABOR (Div of Labor & Industry)	2012 IPMC	n/a	n/a
Accessibility (1)	LABOR (Div of Labor & Industry)	2009 MAC	2009 MAC	2009 MAC
Accessibility (2)	local jurisdiction	2012/2018 IBC (optional)	n/a	n/a
Plumbing (1)	LABOR (Div of Labor & Industry)	n/a	2018 IPC (MPC)	n/a
Plumbing (2)	LABOR (Maryland Board of Plumbing)	2018 IPC (effective December 30, 2019)	n/a	2018 IPC (effective December 30, 2019)
Plumbing (3)	local jurisdiction	(locally adopted)	n/a	n/a
Mechanical (1)	LABOR (Div of Labor & Industry)	n/a	2018 IMC (MPC)	2018 IMC (MPC)
Mechanical (2)	LABOR (Maryland Board of Heating, Ventilation, Air Conditioning and Refrigeration Contractors	2018 IMC (MPC) w/ WSACR amendments	n/a	n/a
Mechanical (3)	local jurisdiction	(locally adopted)	n/a	n/a
Electrical (1)	LABOR (Div of Labor & Industry)	n/a	2017 NEC (MPC)	2017 NEC (MPC)
Electrical (2)	State Fire Marshal	2017 NEC (State Fire Prevention Code)	n/a	n/a
Electrical (3)	local jurisdiction	(locally adopted)	n/a	n/a
Green Construction	LABOR (Div of Labor & Industry)	IgCC, edition adopted varies in individual local jurisdictions (voluntary)	n/a	(see note #1)
Fire Prevention	State Fire Marshal	2018 NFPA 1 and 2018 NFPA 101 (not applicable to one- and two-family dwellings and buildings located in Baltimore City; see State Fire Prevention Code COMAR 29.06.01.09)	2018 NFPA 1 and IRC&IRPA 101 (not applicable to one- and two-family dwellings and buildings located in Baltimore City; see State Fire Prevention Code COMAR 29.06.01.09)	2018 NFPA 1 and 2018 NFPA 101 (not applicable to one- and two-family dwellings and buildings located in Baltimore City; see State Fire Prevention Code COMAR 29.06.01.09)
Safety Glazing	LABOR (Div of Labor & Industry)	2018 IBC and COMAR 09.12.55	2018 IBC and COMAR 09.12.55	2018 IBC and COMAR 09.12.55
Elevator/Conveying System	LABOR (Div of Labor & Industry)	2018 IBC and LABOR requirements	2018 IBC and LABOR requirements	2018 IBC and LABOR requirements
Fuel Gas	LABOR (Maryland Board of Plumbing)	2018 International Fuel Gas Code (effective December 30, 2019)	2018 International Fuel Gas Code (effective December 30, 2019)	2018 International Fuel Gas Code (effective December 30, 2019)
Liquefied Petroleum Gas	LABOR (Maryland Board of Plumbing)	2017 NFPA 58 (Effective December 30, 2019)	2017 NFPA 58 (Effective December 30, 2019)	2017 NFPA 58 (Effective December 30, 2019)
note #1	See State Finance and Procurement Article §3-602.1 for requirements of High Performance Green Building Program.			

19

19



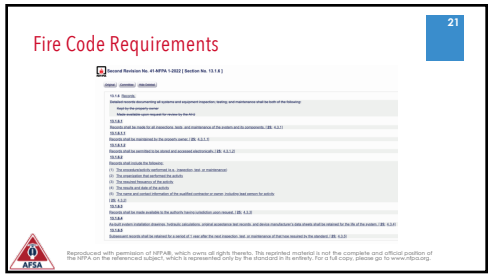
Fire Code Requirements

20

- Property owner is responsible for ITM
- Systems maintained in reliable operating condition
- Deficiencies and impairments *identified* by NFPA 25
- Corrected within an approved time frame (NFPA 1)

Reproduced with permission of NFPA®, which owns all rights thereto. This reprinted material is not the complete and official position of the NFPA on the referenced subject, which is represented only by the standard in its entirety. For a full copy, please go to www.nfpa.org.

20

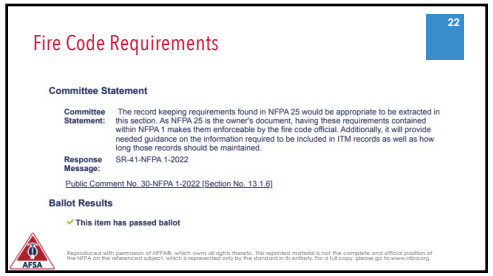


Fire Code Requirements

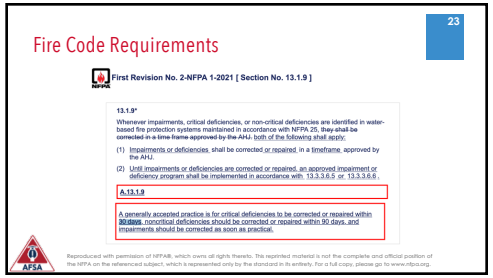
21

Reproduced with permission of NFPA®, which owns all rights thereto. This reprinted material is not the complete and official position of the NFPA on the referenced subject, which is represented only by the standard in its entirety. For a full copy, please go to www.nfpa.org.

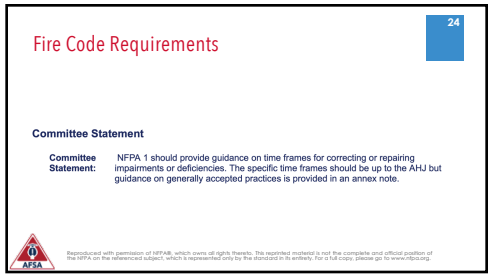
21


Fire Code Requirements
22
Committee Statement
Committee Statement:
The record keeping requirements found in NFPA 25 would be appropriate to be extracted in this section. As NFPA 25 is the owner's document, having these requirements contained within NFPA 1 makes them enforceable by the fire code official. Additionally, it will provide needed guidance on the information required to be included in ITM records as well as how long those records should be maintained.
Response Message:
SR-41-NFPA 1-2022
Public Comment No. 30-NFPA 1-2022 [Section No. 13.1.6]
Ballot Results
This item has passed ballot
AFSA
Reproduced with permission of NFPA®, which owns all rights thereto. This reprinted material is not the complete and official position of the NFPA on the referenced subject, which is represented only by the standard in its entirety. For a full copy, please go to www.nfpa.org.

22


Fire Code Requirements
23
First Revision No. 2-NFPA 1-2021 [Section No. 13.1.9]
13.1.9*
Whenever impairments, critical deficiencies, or non-critical deficiencies are identified in water-based fire protection systems maintained in accordance with NFPA 25, ~~they shall be corrected in a time frame approved by the AHJ.~~ both of the following shall apply:
(1) Impairments or deficiencies, shall be corrected or repaired, in a timeframe, approved by the AHJ.
(2) Until impairments or deficiencies are corrected or repaired, an approved impairment or deficiency program shall be implemented in accordance with 13.3.3.6.5 or 13.3.3.6.6 .
A.13.1.9
A generally accepted practice is for critical deficiencies to be corrected or repaired within ~~30 days~~, noncritical deficiencies should be corrected or repaired within 90 days, and impairments should be corrected as soon as practical.
AFSA
Reproduced with permission of NFPA®, which owns all rights thereto. This reprinted material is not the complete and official position of the NFPA on the referenced subject, which is represented only by the standard in its entirety. For a full copy, please go to www.nfpa.org.

23


Fire Code Requirements
24
Committee Statement
Committee Statement:
NFPA 1 should provide guidance on time frames for correcting or repairing impairments or deficiencies. The specific time frames should be up to the AHJ but guidance on generally accepted practices is provided in an annex note.
AFSA
Reproduced with permission of NFPA®, which owns all rights thereto. This reprinted material is not the complete and official position of the NFPA on the referenced subject, which is represented only by the standard in its entirety. For a full copy, please go to www.nfpa.org.

24

2710


25
For additional questions regarding the content in today's presentation, please contact:
John Denhardt, P.E., ET, CWBSP, FSFPE
Vice President of Engineering and Technical Services
American Fire Sprinkler Association
jdenhardt@firesprinkler.org
214-349-5965 x121
Kevin Hall, M.Eng., P.E., ET, CWBSP, PMSFPE
Sr. Manager of Engineering and Technical Services
American Fire Sprinkler Association
khall@firesprinkler.org
214-349-5965 x128
You can contact the AFSA Technical Services staff at technical@firesprinkler.org
AFSA

25

File Attachments for Item:

EC-17 Fire Pump Plan Review (Fire Code Academy)

All certifications (1 hour)

Ohio Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: Randy Hormann

Organization: Fire Code Academy

Address: 81 Mill Street - Suite 300 Gahanna, Ohio 43230

E-mail: RandyH@FireCodeAcademy.com Telephone: 614-416-8077

Website: www.FireCodeAcademy.com

Conference Sponsor (if applicable)_____ Conference Email:_____

Check here if Course Renewal:_____Prior course number _____ (*i.e. BBS2018-429*)

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: Fire Pump Plan Review

Course instructor: John August Denhardt

Course description:

While there is an ample amount of information available on what to include on working plans for sprinkler systems, the details necessary for a successful fire pump plan review are often overlooked. This seminar will discuss the specific items needed on fire pump plans as required by NFPA 20

Instructional hours per session: 1.0 Hours Number of Sessions:_____

Course Date(s) and Location:_____

Special Content:

Code Administration:_____ Conference Course: _____

Existing Buildings: _____ Conference Name: _____

Electrical Instruction: _____ Conference location:_____

Plumbing Instruction:_____

Course to be offered online? No **On Demand**_____ **Webinar**_____

Course Website: _____

Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation*):

_____

Course applicable for the following certifications

Residential Certifications Only: _____ Commercial Certifications: _____

Administrative Course, All Certifications: _____

Application materials included:

X Course Outline or Course Learning Objectives

X Presentation Materials/Slides (not required for roundtable courses)

_____ Assessment Materials (for online courses)

X Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

Seminar Description

Updates to the 2022 Edition of NFPA 13
0.1 CEU | 0.1 CPD | 1.0 Contact Hours
Standards Referenced: NFPA 13, 2022 edition

Description: This seminar will review the changes to the 2022 edition of NFPA 13. The content will summarize the actions of the four technical committees responsible for revising NFPA 13 and include topics on installation, discharge, hanging and bracing, and water supply requirements.

Learning Objectives:

Upon completion of this webinar, attendees will be able to:

1. Identify the scopes and applicable chapters of each technical committee
2. Identify new options for determining seismic protection requirements
3. Understand new definitions added for new technologies in the sprinkler industry
4. Identify new obstruction rules for Ordinary Hazard occupancies and ESFR systems
5. Apply single point density designs
6. Identify new requirements for the protection of rack storage
7. Apply the appropriate C Value when utilizing nitrogen
8. Apply appropriate flows and equivalent lengths in hydraulic calculation

AFSA Technical Services Seminar Instructor Information

John August Denhardt, P.E., ET, CWBSP, FSFPE • American Fire Sprinkler Association
1410 East Renner Rd, Suite 150 | Richardson, TX 75028 | 214-349-5965 | jdenhardt@firesprinkler.org

John August Denhardt, P.E., ET, CWBSP, FSFPE, is the vice president of engineering and technical services for the American Fire Sprinkler Association (AFSA). He is responsible for strengthening AFSA's engineering and technical approaches to meeting member, industry, and operational priorities, with an emphasis on service, quality, and integrity. Denhardt is a registered professional engineer (P.E.) in the District of Columbia as well as the states of Delaware, Maryland, Pennsylvania, and Virginia. He is NICET Level III certified in water-based systems layout, NICET Level III certified in inspection and testing of bater-based systems, and a certified water-based system professional through NFPA. Denhardt is a member of the NFPA 13 technical committee on sprinkler system discharge criteria, a fellow in the Society of Fire Protection Engineers (SFPE), a member of the SFPE Board of Directors, a member of the Board of Trustees for NFPA's Fire Protection Research Foundation and sits on the University of Maryland Department of Fire Protection Engineering's Board of Visitors. A native of Maryland, Denhardt holds a Bachelor of Science degree from the University of Maryland, College Park in fire protection engineering. Prior to this role, Denhardt was employed by Strickland Fire Protection in Forestville, Maryland since 1994, overseeing large-scale projects and assisting with design and installation technical issues.

Kevin Hall, M.Eng., P.E., ET, CWBSP, PMSFPE • American Fire Sprinkler Association
1410 East Renner Rd, Suite 150 | Richardson, TX 75028 | 214-349-5965 | khall@firesprinkler.org

Kevin Hall, M.Eng., P.E., ET, CWBSP, PMSFPE is the senior manager of engineering and technical services for the American Fire Sprinkler Association (AFSA). He is a member of several National Fire Protection Association (NFPA) technical committees responsible for developing the model codes and standards including, NFPA 1 *Fire Code*, NFPA 13/13R/13D *Installation of Sprinkler Systems*, NFPA 20 *Installation of Stationary Fire Pumps for Fire Protection*, NFPA 30 *Flammable and Combustible Liquids Code*, and NFPA 915 *Remote Inspections*. He also represents AFSA on numerous UL standard technical panels responsible for revising and maintaining the product standards used in the sprinkler industry. He is a registered professional engineer in Delaware and Maryland, NICET III certified in water-based system layout, a certified water-based system professional through NFPA, and a professional member of the Society of Fire Protection Engineers (SFPE). He earned his Bachelor of Science and Master of Engineering degrees from the University of Maryland, College Park in fire protection engineering. In 2021, he was recognized as one of SFPE's "5 Under 35" award recipients. Prior to his association and committee work, he worked for Reliance Fire Protection in Baltimore, Maryland as a project manager overseeing projects of various sizes and complexity for the Contracts Division.

Disable pop-up blocker on your browser to view/answer checkpoint questions during webinar.

Fire Pump Plan Review

Instructors:
John August Denhardt, P.E., FSFPE

AFSA
American Fire Sprinkler Association

No individual or entity - including a presenting author - may electronically record or broadcast any portion of this AFSA training without prior written consent of AFSA. Unauthorized recording (audio, video, still photography, etc.) of this presentation without the express written consent of AFSA is strictly prohibited.

1



John August Denhardt, P.E., ET, CWBSP, FSFPE

AMERICAN FIRE SPRINKLER ASSOCIATION

John August Denhardt, P.E., ET, CWBSP, FSFPE, is the vice president of engineering and technical services for the American Fire Sprinkler Association (AFSA). He is responsible for strengthening AFSA's engineering and technical approaches to meeting member, industry, and operational priorities, with an emphasis on service, quality, and integrity. Denhardt is a registered professional engineer (P.E.) in the District of Columbia as well as the states of Delaware, Maryland, Pennsylvania, and Virginia. He is NICET Level III certified in water-based systems layout, NICET Level III certified in inspection and testing of bater-based systems, and a certified water-based system professional through NFPA. Denhardt is a member of the NFPA 13 technical committee on sprinkler system discharge criteria, a fellow in the Society of Fire Protection Engineers (SFPE), a member of the SFPE Board of Directors, a member of the Board of Trustees for NFPA's Fire Protection Research Foundation and sits on the University of Maryland Department of Fire Protection Engineering's Board of Visitors. A native of Maryland, Denhardt holds a Bachelor of Science degree from the University of Maryland, College Park in fire protection engineering. Prior to this role, Denhardt was employed by Strickland Fire Protection in Forestville, Maryland since 1994, overseeing large-scale projects and assisting with design and installation technical issues.

2

jdenhardt@firesprinkler.org | 214-349-5965 | American Fire Sprinkler Association

2

3

NFPA
IT'S A BIG WORLD.
LET'S PROTECT IT TOGETHER.

DISCLAIMER

This seminar and its content is not a formal interpretation issued pursuant to NFPA regulations. Any opinion expressed is the personal opinion of the author and presenter and does not necessarily present the official position of the NFPA and its Technical Committees.

3

4

Fire Pump

- Not magic
- Cannot create flow
- Boost pressure



4

4

5



Approvals Required

Section 4.2

Reproduced with permission of NFPA®, which owns all rights thereto. This reprinted material is not the complete and official position of the NFPA on the referenced subject, which is represented only by the standard in its entirety. For a full copy, please go to www.nfpa.org.

5

5

6

Approvals Required

- Selection based on installation and use conditions
  - Maximum pressure
  - Minimum pressure
- Information provided to the pump manufacturer
  - Liquid supply/source
  - Power supply characteristics



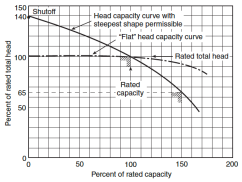
by Unknown Author is licensed under

6

6

7

How are they sized?



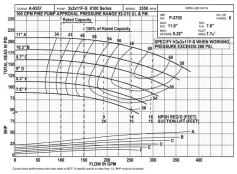
- For centrifugal pumps
  - Rated pressure
  - Rated flow
  - Max. 140% rated pressure at shutoff
  - Min. 65% rated pressure at 150% rated flow

Reproduced with permission of NFPA®, which owns all rights thereto. This reprinted material is not the complete and official position of the NFPA on the referenced subject, which is represented only by the standard in its entirety. For a full copy, please go to www.nfpa.org.

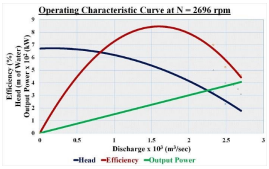
8

Product Data Submittals

Generic



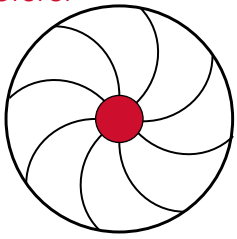
Certified



9

Fire Pump Manufacturer

- Not all fire pumps are the same
- Components can be modified to customize your curve
  - Eye size
  - Number of Vanes
  - Angle of Vanes
  - Width of Vanes



10

Technical Question

Is it acceptable for the fire pump on a combination system, automatic wet fire sprinkler system and a wet manual standpipe to be sized only for the fire sprinkler system and not the standpipe?

Yes, based on local requirements.



10

11



Plans

Section 4.2.3

Reproduced with permission of NFPA®, which owns all rights thereto. This reprinted material is not the complete and official position of the NFPA on the referenced subject, which is represented only by the standard in its entirety. For a full copy, please go to www.nfpa.org.

11

12

Plans



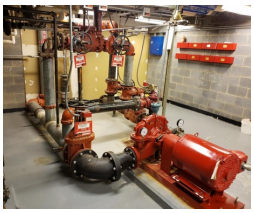
- Information required:
  1) Name(s) of owner and occupant
  2) Location, including street address
  3) Point of compass
  4) Name and address of installing contractor
  5) Pump make and model number
  6) Pump rating (gpm, psi, rpm)
  7) **Suction main size, length, location, type and class/schedule of material, and point of connection to water supply, as well as depth to top of pipe below grade**

12

13

Suction Main Sizing

- At 150% capacity
  - Minimum 0 psig at suction flange
  - -3 psig permitted when supply is a suction tank
- Pipe within 10 diameters of suction flange
  - Eg. 8 in. pipe □ 6 ft. 8 in. (80 in.)
  - Minimum prescribed by Table 4.28(a)



13

14

Technical Question

Does the 10 times diameter from the suction flange include the fitting?

Take the measurement from centerline of the fitting at the change in direction to the face of the suction flange.



14

15

Suction Main Sizing

Table 4.28(a) Summary of Centrifugal Fire Pump Data (U.S. Customary)

Pump Rating (gpm)	Minimum Pipe Sizes (Nominal) (in.)							
	Suction[a,b,c]	Discharge[a]	Relief Valve	Relief Valve Discharge	Meter Device	Number and Size of Hose Valves	Number and Size of Nonthreaded Connections	Hose Header Supply
25	1	1	$^{3}/_{4}$	1	$1^{1}/_{4}$	$1-1^{1}/_{2}$	$1-2^{1}/_{2}$	1
50	$1^{1}/_{2}$	$1^{1}/_{4}$	$1^{1}/_{4}$	$1^{1}/_{2}$	2	$1-1^{1}/_{2}$	$1-2^{1}/_{2}$	$1^{1}/_{2}$
100	2	2	$1^{1}/_{2}$	2	$2^{1}/_{2}$	$1-2^{1}/_{2}$	$1-2^{1}/_{2}$	$2^{1}/_{2}$
150	$2^{1}/_{2}$	$2^{1}/_{2}$	2	$2^{1}/_{2}$	3	$1-2^{1}/_{2}$	$1-2^{1}/_{2}$	$2^{1}/_{2}$
200	3	3	2	$2^{1}/_{2}$	3	$1-2^{1}/_{2}$	$1-2^{1}/_{2}$	$2^{1}/_{2}$
250	$3^{1}/_{2}$	3	2	$2^{1}/_{2}$	$3^{1}/_{2}$	$1-2^{1}/_{2}$	$1-2^{1}/_{2}$	3
300	4	4	$2^{1}/_{2}$	$3^{1}/_{2}$	$3^{1}/_{2}$	$1-2^{1}/_{2}$	$1-2^{1}/_{2}$	3
400	4	4	3	5	4	$2-2^{1}/_{2}$	$1-5$	4
450	5	5	3	5	4	$2-2^{1}/_{2}$	$1-5$	4
500	5	5	3	5	5	$2-2^{1}/_{2}$	$1-5$	4

Reproduced with permission of NFPA®, which owns all rights thereto. This reprinted material is not the complete and official position of the NFPA on the referenced subject, which is represented only by the standard in its entirety. For a full copy, please go to www.nfpa.org.

15

16

Technical Question

To comply with the requirement of avoiding having an elbow or tee with a centerline plane that is parallel to a horizontal split-case pump, contractors will often route the suction pipe near the pump room ceiling, which may be 8 to 12 feet above the pump centerline. Is this acceptable when the pump is taking suction from a gravity tank that is located at the same elevation as the pump room?

YES, but….



16

17

Plans



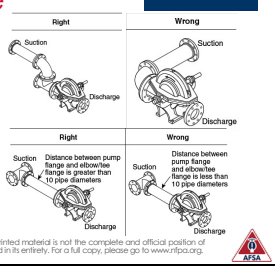
- Information required:
  8) Water storage tank, if applicable
  9) **Size and type of valves, regulators, meters, and valve pits, if applicable**
  10) Water supply information including the flow test information, if applicable:
  11) Pump driver details including manufacturer and horsepower
  12) Voltage for electric-motor-driven pumps

17

18

Devices in Suction Pipe

- Listed OS&Y must be installed
  - Other control valves permitted when 50 ft away
- Changes in direction
  - Vertical – OK
  - Horizontal – 10 pipe diameters away
    - Horizontal Split-Case ONLY



Reproduced with permission of NFPA®, which owns all rights thereto. This reprinted material is not the complete and official position of the NFPA on the referenced subject, which is represented only by the standard in its entirety. For a full copy, please go to www.nfpa.org.

18

19



Plans

- Information required:
  - **13)Fuel system details for diesel-driven pumps**
  - 14)Controller manufacturer, type, and rating
  - 15)Suction and discharge pipe, fitting, and valve types
  - **16)Test connection piping and valves**
  - 17)Flow meter details, if applicable
  - 18)Pressure maintenance pump and controller arrangement including sensing line details, if applicable

19

20

Technical Question

Reliable power. How do you verity?

Examples in the annex, ultimately up to the AHJ.

A.9.3.2

1) **No more than 10 continuous hours out of service**
2) **Power outages not routinely experienced**
3) **Other overcurrent or disconnect switches installed in normal power**



For more information on the determination of reliability, see the following publications:

(1) IEEE 493, *Recommended Practice for the Design of Reliable Industrial and Commercial Power Systems*

(2) "Reliability engineering applied to Critical Operations Power Systems (COPS)," a paper presented at the 2011 IEEE Industrial and Commercial Power Systems Conference (I&CPS)

(3) "Reliability analysis for power to fire pump using Fault Tree and RBD," in *IEEE Transactions on Industry Applications*

(4) "Risk analysis for NEC Article 708 Critical Operations Power Systems," paper presented at the 2009 Industry Applications Society Annual Meeting and published by IEEE

(5) "NEC Article 708," in IEEE *Industry Application Magazine*, Jan.-Feb. 2011



20

21

Diesel Fuel Tanks

Second Revision No. 29-NFPA 20-2020 [Section No. 11.4.1.3.1]

11.4.1.3.1*

Fuel supply tank(s) shall ~~have a capacity at least equal to 1 gal per hp (5.07 L per kW)~~ be sized for a minimum of 12 hours of engine run time based on the fuel supply rate requirements of the engine , plus 5 percent volume for expansion and 5 percent volume for sump.

See SR-63

Detail SR-64

11.4.1.3.1.1*

When the fuel supply rate requirements of the engine are not known, fuel supply tank(s) shall have a capacity at least equal to 1 gal per hp (5.07 L per kW), plus 5 percent volume for expansion and 5 percent volume for sump.

Reproduced with permission of NFPA®, which owns all rights thereto. This reprinted material is not the complete and official position of the NFPA on the referenced subject, which is represented only by the standard in its entirety. For a full copy, please go to www.nfpa.org.

21

Supply vs. Return vs. Consumption

22

CLARKE
Fire Protection Products, Inc.

JU6R-UFAAG7
INSTALLATION & OPERATION DATA (I&O Data)
USA Produced

Fuel System	1470	1760
Fuel Consumption - gal/hr (L/hr)	9.1 (34.4)	9.5 (36)
Fuel Return - gal/hr (L/hr)	4.9 (18.5)	5.1 (19.3)
Fuel Supply - gal/hr (L/hr)	14 (53)	14.6 (55.3)
Fuel Pressure - lb/in² (kPa)	3 (20.7) - 4 (27.6)	
Minimum Line Size - Supply - in.	.50 Schedule 40 Steel Pipe	
Pipe Outer Diameter - in (mm)	0.848 (21.5)	
Minimum Line Size - Return - in.	.375 Schedule 40 Steel Pipe	
Pipe Outer Diameter - in (mm)	0.675 (17.1)	
Maximum Allowable Fuel Pump Suction Lift with clean Filter - in H_2O (mH_2O)	31 (0.8)	
Maximum Allowable Fuel Head above Fuel pump, Supply or Return - ft (m)	4.5 (1.4)	
Fuel Filter Micron Size	5	

22

Diesel Fuel Tanks

23

NFPA 20-2022 Edition
Standard for the Installation of Stationary Pumps for Fire Protection
TIA Log No.: 1611
Reference: 11.4.1.3.1.1
Comment Closing Date: October 29, 2021
Submitter: John Denhardt, American Fire Sprinkler Association
www.nfpa.org/20

1. Revise 11.4.1.3.1.1 to read as follows:

11.4.1.3.1.1* When the fuel ~~supply~~ consumption rate requirements of the engine are not known, fuel supply tank(s) shall have a capacity at least equal to 1 gal per hp (5.07 L per kW), plus 5 percent volume for expansion and 5 percent volume for sump.

Reproduced with permission of NFPA®, which owns all rights thereto. This reprinted material is not the complete and official position of the NFPA on the referenced subject, which is represented only by the standard in its entirety. For a full copy, please go to www.nfpa.org.

23

Test Headers

24

- Is a test header required?

NO!

- Options for testing
  - Test Header (Table 4.28(a))
  - Closed loop metering
    - 3 years – flow water
  - Standpipe system
  - Hose outlets



24


25
For additional questions regarding the content in today's presentation, please contact:
John Denhardt, P.E., ET, CWBSP, FSFPE
Vice President of Engineering and Technical Services
American Fire Sprinkler Association
jdenhardt@firesprinkler.org
214-349-5965 x121
You can contact the AFSA Technical Services staff at technical@firesprinkler.org

25

File Attachments for Item:

EC-18 General Gas Pressure Regulator Training (Maxitrol)

All certifications (1 hour)

APPLICATION FOR CONTINUING EDUCATION APPROVAL
COURSE CONDITIONS AND GUIDELINES

The Ohio Board of Building Standards is committed to the ongoing education and professional development of board-certified personnel through the delivery of high-quality, accurate and engaging professional continuing education content. To this end, the Board reviews and approves Continuing Education Courses for building department personnel.

Board approval is granted for course instruction on current codes and standards, including the OBC, OMC, OPC, and RCO, and any other content areas directly related to the responsibilities of the certification for which credit is being requested.

Promotion: Any person or organization promoting an approved course is required to make full and accurate disclosure regarding course title, course approval number, number of credit hours, categories for which the BBS has approved the class, and fees in promotion materials and advertising. ***The Board does not grant retroactive approval. It is recommended that courses be submitted for approval well in advance of any scheduling of classes and advertising***. Advertising may not falsely state BBS approval before approval is granted. Course providers may state that BBS approval is pending.

Application Submission: All Applications and associated materials shall be submitted by email in .pdf format. Instructions for completing the application are attached.

Certificate of Completion: Course providers shall provide participants a certificate of completion containing the following information:

- Name of participant
- Title of approved courses
- BBS approval #
- BBS approved certifications
- Date of the continuing education program
- Number of approved credit hours awarded, and
- Signature of authorized sponsor or instructor.

Any person or organization administering an approved course shall return a completed BBS Course Attendance form by email.

Participants: Participants must attend the complete course as presented by the instructor to receive credit hours approved by the Board. The organization or instructor of online courses shall plan and execute methods to verify the individual's attendance and completion of the course. No partial credit will be given to any participant who failed to complete the entire course as approved.

Board approval: All courses are approved for the calendar year in which application is made. Courses may be renewed so long as the referenced code is in effect, and the CEUs, certification and content remain unchanged. When the referenced code is updated, courses must be updated, and new approvals obtained.

Facility/training area: BBS Course may be delivered in person or online, or both, at the sponsor's option.
Course facilities shall include the following:

In Person Classes:
Sufficient seating capacity
ADA accessible facilities
Appropriate Audio/Visual devices for delivery
Writing surfaces for participants

Online Classes:
Web-accessible
ADA accessible delivery
Tech support available
Live and recorded courses permitted

In-person facilities shall comfortably and safely seat at least the number of attendees present in the room and shall be climate controlled, non-smoking, and sound controlled so that outside noise will not interfere with the training.

Ohio Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: Bill Hanes

Organization: Maxitrol Company

Address: 23555 Telegraph Rd.

E-mail: bhanes@maxitrol.com Telephone: (248)894-0481

Website: maxitrol.com

Conference Sponsor (if applicable) _____ Conference Email: _____

Check here if Course Renewal: _____ Prior course number _____ (*i.e. BBS2018-429*)

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: General Gas Pressure Regulator Training

Course instructor: Bill Hanes

Course description: This class will talk about the different gas regulators and making sure to choos
The class will also talk about how regulators operate, proper venting and the correct use of Ve

Instructional hours per session: 1 Number of Sessions: _____

Course Date(s) and Location: _____

Special Content:

Code Administration: ☑ Conference Course: _____

Existing Buildings: ☑ Conference Name: _____

Electrical Instruction: ☐ Conference location: _____

Plumbing Instruction: ☑

Course to be offered online? ☐ **On Demand** ☐ **Webinar** ☐

Course Website: _____

Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation)*:

Course applicable for the following certifications

Residential Certifications Only: ☐ Commercial Certifications: ☑

Administrative Course, All Certifications: ☑

Application materials included:

☐ Course Outline or Course Learning Objectives

☐ Presentation Materials/Slides (not required for roundtable courses)

☐ Assessment Materials (for online courses)

☐ Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

Instructions for new Continuing Education Approval form

Provider Information

1. Please include all contact information.
2. If course is not part of a conference, leave conference sponsor and email blank.

Course Renewal

1. Indicate if the course is being submitted for renewal. Include prior approval letter and write in prior course number.
2. Certification approval for courses has now changed: all existing courses being renewed will be approved within the new classification system.
    a. Courses previously approved for only residential certifications will be approved for all residential certifications.
    b. Courses previously approved for at least on commercial certification will now be approved for all commercial certifications and all residential certifications.
    c. Courses on required instruction topics, Ohio Ethics, Code Administration and Existing Buildings, will be noted as Administrative Courses and be approved for all certifications.
3. Courses being renewed should skip the New Course information section and are not required to submit outline, agenda, slides or other instructional materials for review. Skip to Special Content, and mark any item that applies to the course.

New Course Information

1. Enter course title, name of instructor, and a brief description of the course content. Learning objectives may be substituted for course description, if desired.
2. Number of instructional hours per session is the length of instructional time.
3. Number of sessions: can be 1 or the number of sessions planned.
4. Course date(s) and location: not necessary at this time, enter if known.

Special Content

1. Indicate if the course will meet instructional time in Code Administration or Existing Buildings.
2. Indicate if the course is a plumbing or electrical course, for ESIAC review and trainee course tracking.
3. If the course is associated with a conference, indicate the conference name and location, as this will allow BBS to coordinate approvals with the conference provider.
4. If the course will be offered online, specify whether it will be on demand or offered as a virtual webinar, or both. Include website where the course will be provided.

Course applicable for the following certifications

This section represents a major change from previous BBS course approval forms.

1. If the course is only for residential certifications, check 'Residential Certifications Only'. The course, if approved, will be approved for all residential certifications.
2. If the course is appropriate for any commercial certifications, check Commercial Certifications. The course, if approved, will be approved for all commercial certification **AND** all residential certifications.
3. If the course is intended to meet required instruction in Code Administration (Chapter 1) or Existing Buildings (commercial or residential) check 'Administrative Course, All Certifications'.

Application Materials Included

This is a checklist for the course submitter's use, to be sure all materials necessary for review are included with the application. All materials should be submitted in .pdf format, along with the application, via email to Michael.Lane@com.ohio.gov or BBS@com.ohio.gov

Headquarters
23555 Telegraph Road • P.O. Box 2230
Southfield, Michigan 48034-2230 U.S.A.
248.356.1400 • Fax 248.356.8388
www.maxitrol.com



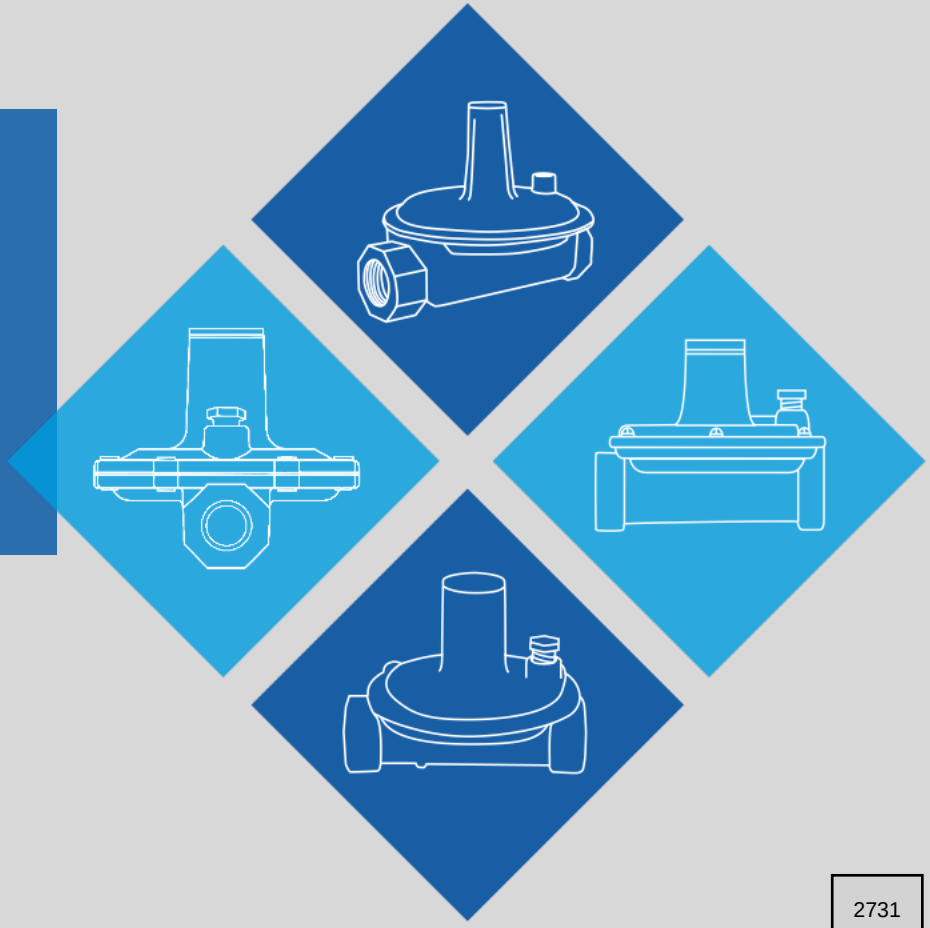
BILL HANES
BIOGRAPHY

Bill Hanes joined Maxitrol Company as a product specialist. He holds a bachelor's degree in education from Wayne State University which compliments his broad work experience in management and logistics. Bill's diverse background brings a unique perspective to Maxitrol's continuing education and product training programs for the HVAC industry, commercial/industrial burners, and boilers.

Bill is responsible for eastern North America territories and will be conducting training seminars for major OEMs, wholesalers/distributors, gas utilities, and building inspector groups.

When not sharing his knowledge of Maxitrol's line pressure regulators for 2 and 5 psi systems and the Line Regulator Standard, Mr. Hanes loves spending time with his wife and two kids.

GAS PRESSURE REGULATOR TRAINING



MAXITROL®

© 2021 Maxitrol GmbH & Co. KG

GAS APPLIANCE REGULATORS

- Rubber Seat Poppet Design
- Straight-Thru-Flow Design
- Lever Acting Design
- Balanced Valve Design



RV47



RV52



325-3



R400

GAS APPLIANCE REGULATORS

2732

⚠ WARNING

Service and Installation must be performed by a trained/experienced service technician. All products used with combustible gas must be installed and used strictly in accordance with the instructions of the Original Equipment Manufacturer (OEM) and with all applicable government codes and regulations, e.g., plumbing, mechanical, and electrical codes and practices. These instructions do NOT supersede OEM's installation or operating instructions. All Maxitrol products should be installed and operated in accordance with Maxitrol Safety Warning Instructions.

Maxitrol Company is not responsible for any errors or omissions in reliance by anyone of any information set forth in this presentation without additional reference to local requirements and applicable ordinances or codes.

© 2021 Maxitrol Company| Gas Pressure Regulator Training

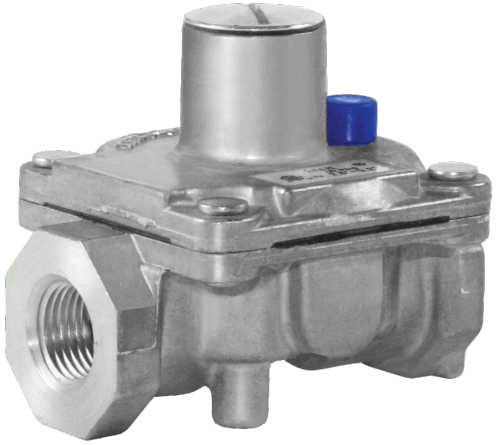
RUBBER SEAT POPPET DESIGN

RV SERIES – Rubber Seat Poppet Design

- Rubber Seat Poppet models offer low cost, compact design.
- Integral vent limiter

Typical Applications

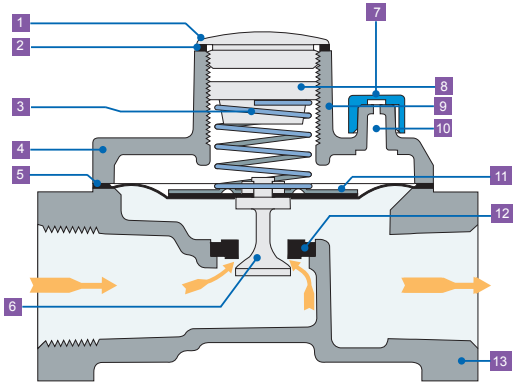
- Residential and commercial cooking
- Hearth products
- Pilot lines
- Used on ½ psi gas supplies



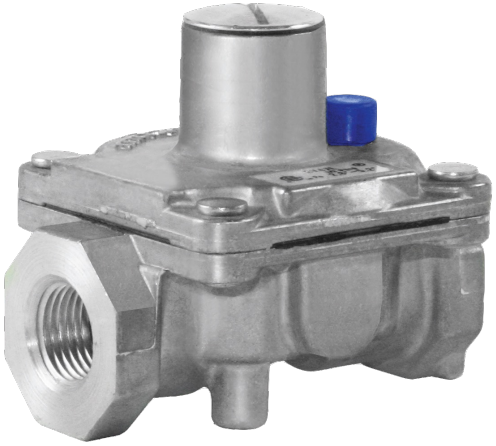
RV47

2734

RUBBER SEAT POPPET DESIGN



1	Welch Plug or Seal Cap
2	Seal Cap Gasket
3	Spring
4	Top Housing
5	Diaphragm
6	Stem & Valve
7	Dust Cap
8	Adjusting Screw
9	Stack
10	Vent
11	Diaphragm Plate
12	Rubber Seat
13	Bottom Housing



RV47

NOTE: Diagrams are graphical representations only and may differ from actual product.

2735

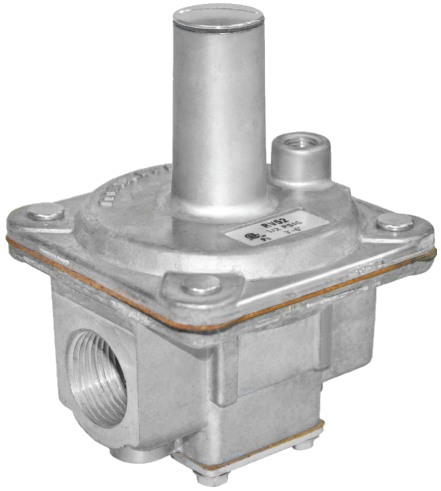
STRAIGHT-THRU-FLOW DESIGN

RV SERIES – Straight-Thru-Flow Design

- Design developed by Maxitrol
- High capacity at low supply pressure

Typical Applications

- Residential, commercial, and industrial gas-fired appliances and equipment
- Used on ½ psi, up to 1 psi gas supplies
- Several models available with vent limiters.

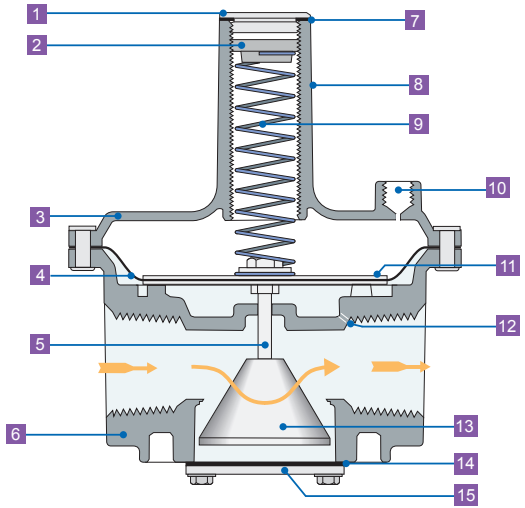


RV52

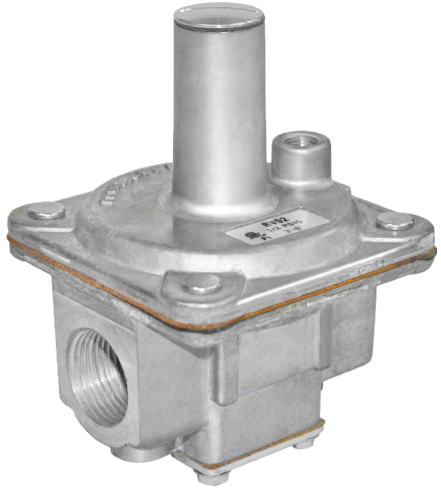
2736

© 2021 Maxitrol Company|

STRAIGHT-THRU-FLOW DESIGN



1	Welch Plug or Seal Cap
2	Vibration Resistant Adjusting Screw
3	Top Housing
4	Diaphragm
5	Stem
6	Bottom Housing
7	Seal Cap Gasket
8	Stack
9	Spring
10	Vent Connection
11	Diaphragm Plates
12	Sensing Hole
13	Valve
14	Bottom Plate Gasket
15	Bottom Plate



RV52

NOTE: Diagrams are graphical representations only and may differ from actual product.

2737

LEVER ACTING DESIGN

325 SERIES – Lever Acting Design

- PSI to inches w.c. regulator
- High leverage valve linkage delivers positive dead end lock up
- Controls main burner and pilot flow

Typical Applications

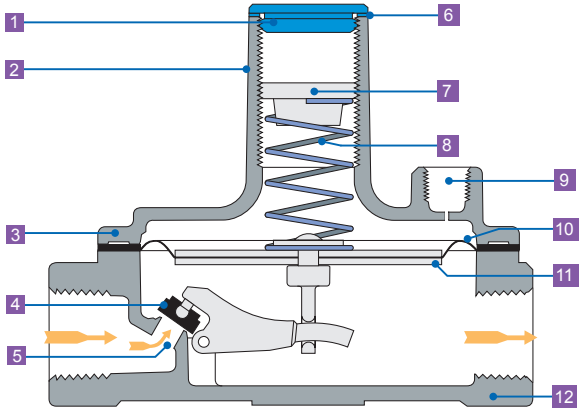
- Industrial pilots
- Higher pressure appliances
- Used on 2 – 10 psi gas supplies



325-3

2738

LEVER ACTING DESIGN



1	Seal Cap
2	Stack
3	Top Housing
4	Rubber Valve
5	Valve Seat
6	Seal Cap Gasket
7	Adjusting Screw
8	Spring
9	Vent Connection
10	Diaphragm
11	Diaphragm Plates
12	Bottom Housing



325-3

NOTE: Diagrams are graphical representations only and may differ from actual product.

2739

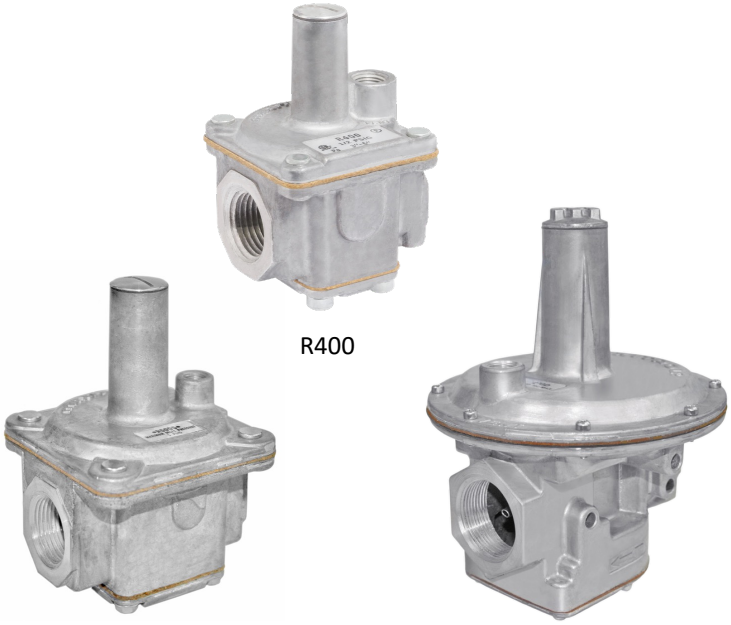
BALANCED VALVE DESIGN

R/RS and 210 SERIES - Balanced Valve Design

- The balanced valve design maintains constant outlet pressure control over wide range of inlet pressures.
- R/RS series used on both main burner and pilot load applications.

Typical Applications

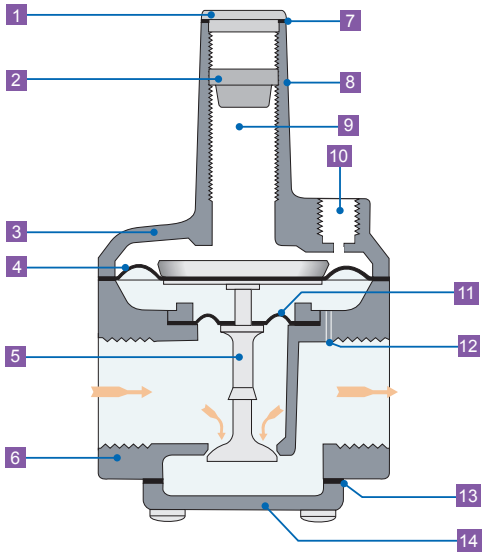
- R/RS Series: For pilot lines of large industrial heaters and boilers, and appliances with higher rated inlet pressures.
- 210 Series: Gas-fired boilers, steam generators, industrial furnaces, and ovens.
- Used on 1/2 – 10 psi gas supplies.



BALANCED VALVES

2740

BALANCED VALVE DESIGN



1	Welch Plug or Seal Cap
2	Vibration Resistant Adjusting Screw
3	Top Housing
4	Regulating Diaphragm
5	Stem & Valve
6	Bottom Housing
7	Seal Cap Gasket
8	Stack
9	Spring
10	Vent Connection
11	Balancing Diaphragm
12	Sensing Hole
13	Bottom Plate Gasket
14	Bottom Plate

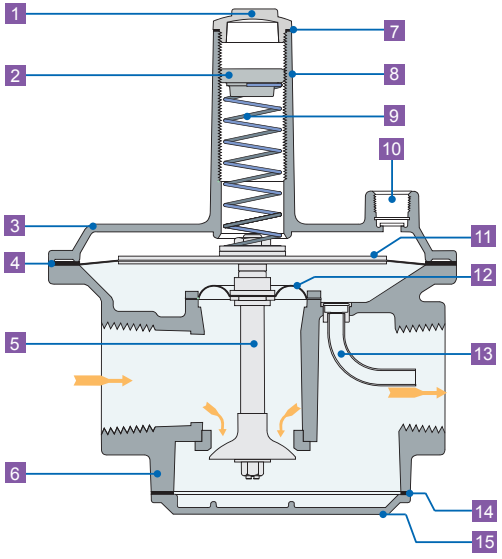


R400

NOTE: Diagrams are graphical representations only and may differ from actual product.

2741

BALANCED VALVE DESIGN



1	Welch Plug or Seal Cap
2	Vibration Resistant Adjusting Screw
3	Top Housing
4	Regulating Diaphragm
5	Stem & Valve
6	Bottom Housing
7	Seal Cap Gasket
8	Stack
9	Spring
10	Vent Connection
11	Diaphragm Plates
12	Balancing Diaphragm
13	Sensing Tube
14	Bottom Plate Gasket
15	Bottom Plate



210D

NOTE: Diagrams are graphical representations only and may differ from actual product.

2742

GAS APPLIANCE REGULATORS

SR SERIES – Two-Stage Regulator Valves

- Gas pressure regulating and flame staging in a single unit.

220 SERIES – Pilot Loaded Design

- A servo-operated design delivers higher outlet pressures for industrial applications.

RZ and 210Z SERIES – Zero Governor Design

- Typically used with gas-air mixing devices.



SR400



220D



210Z

APPLIANCE REGULATORS

2743

GAS PRESSURE REGULATOR VENTING - INDOORS

- Vent limiters are designed for use indoors to limit the amount of gas escapement in the unlikely event of a diaphragm failure. Gas escapement is limited to within the ANSI standard requirements.
- Maxitrol vent Limiters used with Maxitrol regulators do NOT release or relieve gas into the environment during normal operation.
- Maxitrol's vent limiters should not be used outdoors if they are exposed to the elements.

NOTE: Maxitrol line pressure regulators DO NOT contain an internal relief function.



325-3 W/ VENT LIMITER 12A49

2744

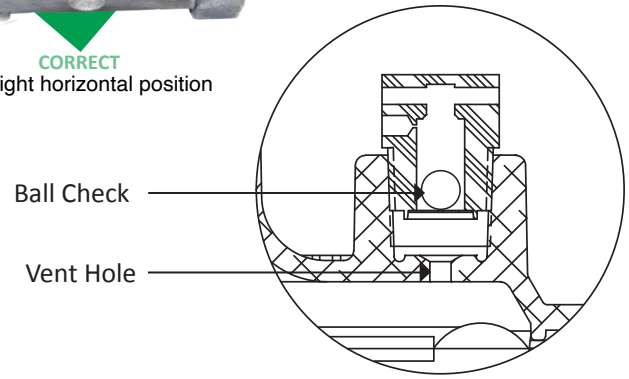
GAS PRESSURE REGULATOR VENTING - INDOORS

- When using a vent limiting device, the regulator must be mounted in an upright horizontal position only.

NOTE: A Maxitrol vent limiting device should only be installed in the Maxitrol regulator that it is certified with.



CORRECT
Upright horizontal position



open/normal position

MOUNTING POSITION WHEN USING A VENT LIMITING DEVICE

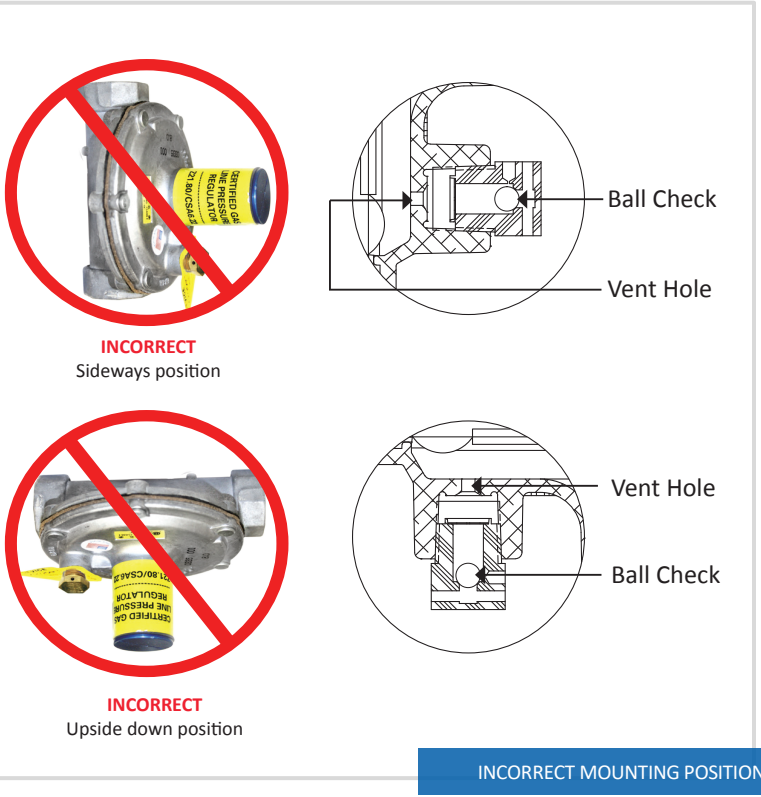
2745

© 2021 Maxitrol Company

MAXITROL®

GAS PRESSURE REGULATOR VENTING - INDOORS

- Any orientation other than an upright horizontal position, will roll the ball check into the closed/limiting position.
- With the ball check in the closed/limiting position, the regulator will experience a sluggish response time and will not operate as designed.

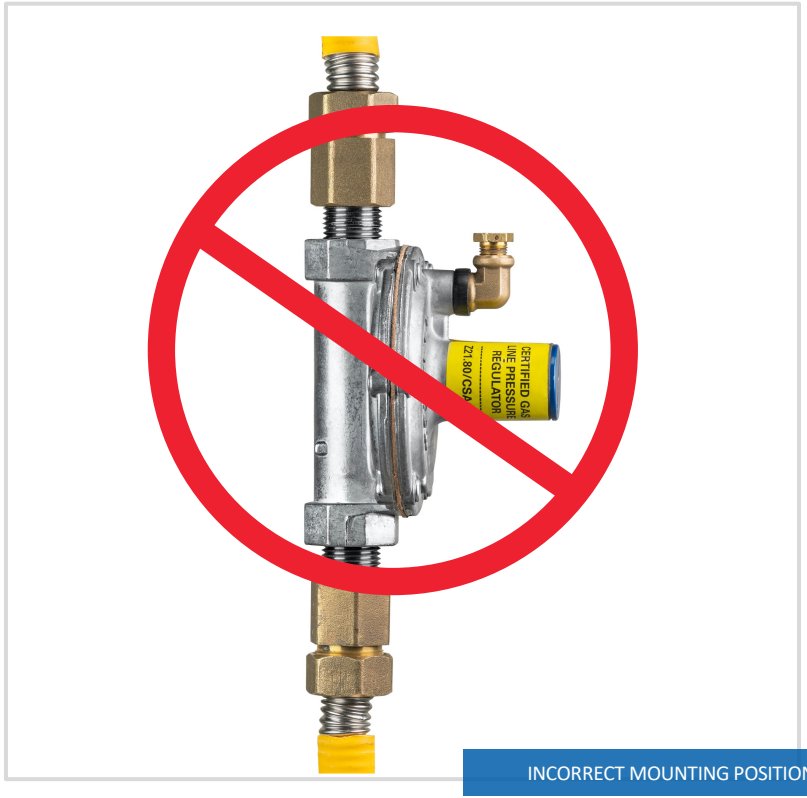


INCORRECT MOUNTING POSITIONS

2746

GAS PRESSURE REGULATOR VENTING - INDOORS

- Vent limiters must be threaded directly into the vent connection of the regulator without intermediate pipe or fittings. The Codes state you must follow the manufacturers' recommendations.



INCORRECT MOUNTING POSITION

2747

VENT LIMITER MAXIMUM ALLOWABLE VENTING RATE

REQUIREMENTS FOR VENT LIMITING DEVICE	SPECIFIC GRAVITY	MAXIMUM ALLOWABLE FLOW RATE, CUBIC FEET PER HOUR (cm^3/s)
Vent limiter for use only with natural, manufactured, mixed gases, and LP gas-air mixtures.	0.64	2.5 (19.6)
Vent limiter for use with liquefied petroleum gases.	1.53	1.0 (7.9)

NOTE: Maxitrol Vent limiting devices meet ANSI Z21.80/CSA 6.22. The requirements states “Vent Limiters shall be of materials having melting points of not less than 800°F (427° C).”

2748

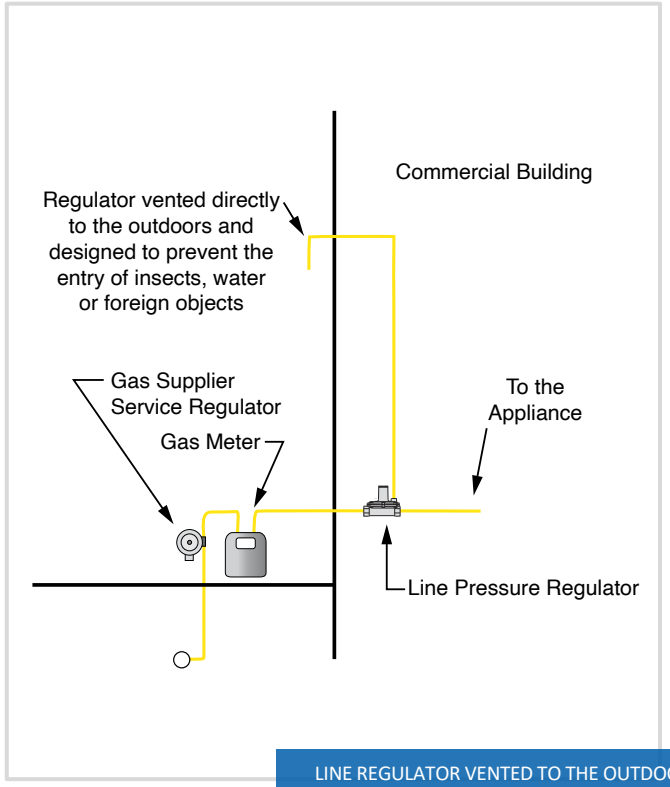
© 2021 Maxitrol Company|

MAXITROL®

GAS PRESSURE REGULATOR VENTING – TO THE OUTDOORS

- The diaphragm must be allowed to breathe to the atmosphere for unrestricted movement. The regulator vent opening should never be restricted.
- Vent lines should be installed directly into the vent port connection.

NOTE: Venting must be controlled in accordance with all applicable codes and regulations to avoid the danger of escaping gas should there be internal leakage. Venting systems are to be piped gas tight using approved thread joint compound. Be careful excess thread joint compound does not collect in or on the regulator vent, which could cause poor performance and interfere with lockup.



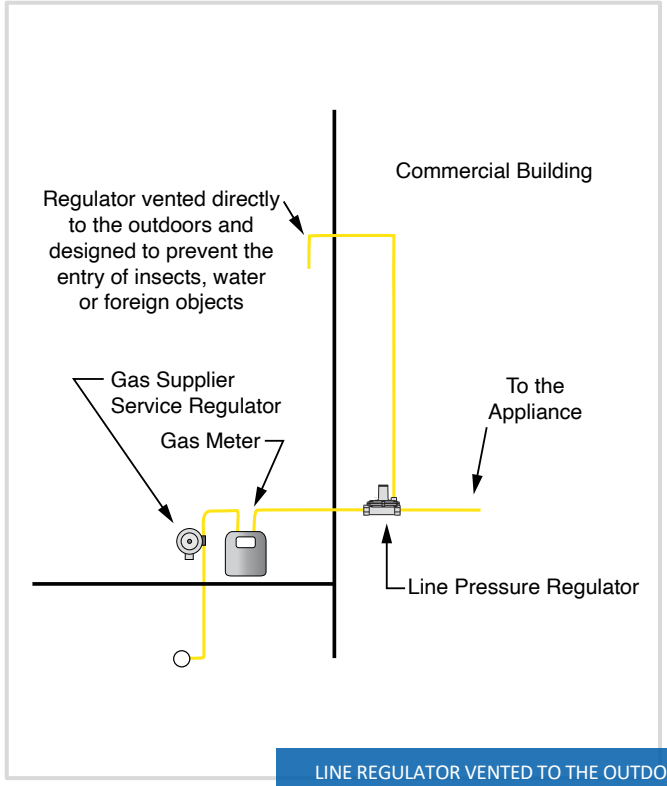
LINE REGULATOR VENTED TO THE OUTDOORS

2749

GAS PRESSURE REGULATOR VENTING – TO THE OUTDOORS

- Vent lines longer than 10 feet in length may require an increase to the next larger diameter to allow for free movement of air.
- Each regulator should have a separate vent line unless approved by code.
- Vent lines must remain open and protected against entry of foreign matter, including water.

NOTE: Venting must be controlled in accordance with all applicable codes and regulations to avoid the danger of escaping gas should there be internal leakage. Venting systems are to be piped gas tight using approved thread joint compound. Be careful excess thread joint compound does not collect in or on the regulator vent, which could cause poor performance and interfere with lockup.



LINE REGULATOR VENTED TO THE OUTDOORS

2750

© 2021 Maxitrol GmbH & Co. KG | Gas Pressure Regulator Training

GAS PRESSURE REGULATOR VENTING – OUTDOORS

- Maxitrol vent protectors are designed for outdoor applications to limit the entry of water, insects, or other foreign materials that could cause blockage or inhibit the vent function.
- Vent protectors must be mounted in an upright horizontal position only.
- Vent protectors are available for all regulators.

NOTE: Imblue® regulators have an anodized coating the increases corrosion resistance and provides extra protection against elements that cause aluminum to oxidize.



13A15 (1/8” NPT) 13A15-5 (3/8” NPT) 13A25 (1/2” NPT)

VENT PROTECTORS

2751

© 2021 Maxitrol GmbH & Co. KG | Gas Pressure Regulator Training

THANKS FOR LISTENING

Visit www.maxitrol.com for more information.





Maxitrol Company
23555 Telegraph Road
Southfield, MI 48033
USA

Phone: 248-356-1400
Fax: 248-356-0829
info.na@maxitrol.com

File Attachments for Item:

EC-19 Key Changes to the 2022 Edition of NFPA 72 (Fire Code Academy)

All certifications (1 hour)

Ohio Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: Randy Hormann

Organization: Fire Code Academy

Address: 81 Mill Street - Suite 300 Gahanna, Ohio 43230

E-mail: RandyH@FireCodeAcademy.com Telephone: 614-416-8077

Website: www.FireCodeAcademy.com

Conference Sponsor (if applicable)_____ Conference Email:_____

Check here if Course Renewal:_____ Prior course number _____ (*i.e. BBS2018-429*)

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: Key Changes to the 2022 Edition of the NFPA 72® National Fire Alarm and Signaling Code

Course instructor: Richard Roberts

Course description: An informative and unbiased presentation covering key changes to the 2022 edition of the NFPA 72® National Fire Alarm and Signaling Code as well as providing the reasons for the changes and how they will impact public life safety.

Instructional hours per session: 1.0 Hours Number of Sessions:_____

Course Date(s) and Location:_____

Special Content:

Code Administration:_____ Conference Course: _____

Existing Buildings: _____ Conference Name: _____

Electrical Instruction: _____ Conference location:_____

Plumbing Instruction:_____

Course to be offered online? No **On Demand**_____ **Webinar**_____

Course Website: _____

Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation*):

_____

Course applicable for the following certifications

Residential Certifications Only: _____ Commercial Certifications: _____

Administrative Course, All Certifications: _____

Application materials included:

X Course Outline or Course Learning Objectives

X Presentation Materials/Slides (not required for roundtable courses)

_____ Assessment Materials (for online courses)

X Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

Richard Roberts
Senior Industry Affairs Manager
Honeywell Fire Safety
3825 Ohio Avenue
St. Charles, IL 60174
1-630-338-7025
richard.roberts@systemsensor.com

Summary of Key Changes to the 2022 Edition of the NFPA 72® *National Fire Alarm and Signaling Code*

An informative and unbiased presentation covering key changes to the 2022 edition of the NFPA 72® *National Fire Alarm and Signaling Code* as well as providing the reasons for the changes and how they will impact public life safety.

This will be a 60 minute presentation by Richard Roberts.

Learning Ojectives: Attendees will learn about the new requirements for batteries, abandoned fire alarm equipment, carbon monoxide detection, low frequency audible alarm signal, remote access to systems, wireless pathways and supervising stations.

Presentor: Richard Roberts is Senior Industry Affairs Manager at Honeywell Security and Fire with over 35 years in the fire alarm and life safety markets. His experience spans the installation, sales, and the development of products/systems. Currently, Mr. Roberts is a member of thirten NFPA Technical Committees, member of several ICC Fire Code Action Committee (FCAC) Working Groups and a member of two Underwriters Laboratories (UL) Standards Technical Panel (STP). He serves on the Board of Directors for the Fire and Life safety Section (FLSS) of the International Association of Fire Chiefs (IAFC), Safer Buildings Coalition (SBC), Center for Campus Fire Safety (CCFS) and is the Chair of NEMA's Building Codes Committee as well as a member of the Model Codes Committee of the National Assocation of State Fire Marshals (NASFM).

Presentor:

Richard Roberts
Senior Industry Affairs Manager
Honeywell Fire Safety
richard.roberts@systemsensor.com
1-630-338-7025

Bio:

Over thirty-five years of experience in the installation, sales, commissioning and product management of code compliant commercial fire alarm, carbon monoxide detection, emergency communication and security systems. Mr. Roberts is responsible for codes & standards development at the federal, state, and local level as well as legislation.

Currently Mr, Roberts is serving on:

- 14 National Fire Protection Association (NFPA) Technical Committees
- 2 Underwriters Laboratories (UL) Standards Technical Panels for carbon monoxide detection
- Member of numerous ICC Fire Code Action Committee (FCAC) working groups
- Board member of the International Association of Fire Chiefs (IAFC) Fire and Life Safety Section (FLSS)
- Member of the National Association of State Fire Marshals (NASFM) Model Codes Committee (MCC)
- Board member of the Center for Campus Fire Safety (CCFS)
- Board member of the Safer Buildings Coalition (SBC)
- Chair of the Safer Buildings Coalition (SBC) Government Affairs Committee
- Chair of the National Electrical Manufacturers Association (NEMA) Building Codes Committee (BCC)
- Chair of the U.S. TAG to the International Organization for Standardization (ISO) TC 21/SC 3 (Fire Detection and Alarm Systems)

SNEAK PEAK:
CHANGES TO THE 2022 EDITION OF THE NFPA 72® NATIONAL FIRE ALARM & SIGNALING CODE + WHAT IT MEANS FOR YOU



RICHARD ROBERTS
GLOBAL SENIOR INDUSTRY AFFAIRS MANAGER

Honeywell

2757

AGENDA

Chapter 7:	Documentation
Chapter 10:	Fundamentals
Chapter 14:	Inspection, Testing, and Maintenance
Chapter 17:	Initiating Devices
Chapter 18:	Notification Appliances
Chapter 23:	Protected Premises Fire Alarm Systems
Chapter 24:	Emergency Communications Systems
Chapter 26:	Supervising Station Alarm Systems



2758

Honeywell Confidential - ©2020 by Honeywell International Inc. All rights reserved.

INTRODUCTION

Comments and opinions during the presentation are exclusively the presenter and do not reflect an official position of the National Fire Protection Association (NFPA), its employees, or any of the Technical Committees



All changes in presentation will be referenced using legislative text.

~~Red strike through~~ means text is being removed

Blue underline means text is being added

Black text means no changes

2759

Honeywell Confidential - ©2020 by Honeywell International Inc. All rights reserved.

INTRODUCTION

Development of the 2022 Edition of NFPA 72®

- 597 Public Inputs
- 258 First Revisions
- 284 Public Comments
- 151 Second Revisions

This presentation will not cover all the revisions, details, requirements or exceptions

Highly recommend purchasing a copy of NFPA 72® or the Handbook for all the changes, requirements and details

2760

Honeywell Confidential - ©2020 by Honeywell International Inc. All rights reserved.

CHAPTER 7 - DOCUMENTATION

7.3.3.6 Design documents shall indicate the pathway class designations in accordance with Section 12.3 .

7.3.3.7 Design documents shall indicate the pathway survivability level designations in accordance with Section 12.4 .

7.4.5 Floor plan drawings shall comply with both of the following:

1) Be drawn to an indicated scale
2) Include the following information, where applicable for the particular system:
   p) Pathway class designations in accordance with Section 12.3 , including the location of any end of-line supervisory or power devices that are required by the pathway class
   q) Pathway survivability level designations in accordance with Section 12.4

2761

Honeywell Confidential - ©2020 by Honeywell International Inc. All rights reserved.

CHAPTER 7 - DOCUMENTATION

7.3.5.5 Carbon Monoxide Detectors. Carbon monoxide detector design documentation shall be provided in accordance with Section 17.12 .

7.4.6 System riser diagrams shall comply with both of the following:

(1) Be coordinated with the floor plans

(2) Include the following information, where applicable for the particular system:

f) Pathway class designation in accordance with Section 12.3 , including the location of any end of-line supervisory or power devices that are required by the pathway class

g) Pathway survivability level designations in accordance with Section 12.4

Honeywell Confidential - ©2020 by Honeywell International Inc. All rights reserved.

CHAPTER 10 - FUNDAMENTALS

10.4.7 Abandoned Fire Alarm Equipment.

10.4.7.1 Abandoned fire alarm equipment shall be removed.

10.4.7.2 Abandoned fire alarm equipment shall be marked “not in service” until removed.

~~**10.6.7.2.1.1*** Battery calculations shall include a minimum 20 percent safety margin above the calculated amp-hour capacity required.~~

10.6.7.2.14* As a minimum, battery calculations shall apply a correction factor of 1.25 for aging to ensure the battery can meet its current demand at the end of service life.

2763

Honeywell Confidential - ©2020 by Honeywell International Inc. All rights reserved.

CHAPTER 10 - FUNDAMENTALS

10.6.7.2.11 The secondary power supply for communications equipment at the protected premises that is used to transmit signals to a supervising station shall have sufficient capacity to operate the system under quiescent load (system operating in a nonalarm condition) for a minimum of 24 hours.

10.6.7.2.12 At the end of that period in 10.6.7.2.11, shall be capable of transmitting signals for a period of 5 minutes.

2764

Honeywell Confidential - ©2020 by Honeywell International Inc. All rights reserved.

CHAPTER 10 - FUNDAMENTALS

10.6.10* Storage Batteries.

10.6.10.1 Marking.

10.6.10.1.1 Batteries shall be marked with the month and year of manufacture using the month/year format.

10.6.10.1.2 Where the battery is not marked with the month/year by the manufacturer, the installer shall obtain the date code and mark the battery with the month/year of battery manufacture.

10.6.10.1.3* Effective January 1, 2024, rechargeable batteries for the secondary power supply used in control units, devices, and accessories shall be listed or component recognized by a nationally recognized testing laboratory.

A.10.6.10.1.5 Examples of listing standards are: UL 1989 Standard for Standby Batteries and UL 2054 Standard for Household and Commercial Batteries.

2765

Honeywell Confidential - ©2020 by Honeywell International Inc. All rights reserved.

CHAPTER 10 - FUNDAMENTALS

3.3.300 Supervised Notification Appliance Control Circuit. An output circuit that is monitored for integrity and used exclusively to activate control equipment for notification appliance circuits.

10.17 Notification Appliance Circuits and Supervised Notification Appliance Control Circuits.

10.17.1 An open, ground-fault, or short-circuit fault on the installation conductors of one alarm notification appliance circuit shall not affect the operation of any other alarm notification appliance circuit for more than 200 seconds regardless of whether the short-circuit fault is present during the normal or activated circuit state.

~~**10.17.2*** Notification appliance circuits that do not have notification appliances connected directly to the circuit shall be considered control circuits~~

2766

Honeywell Confidential - ©2020 by Honeywell International Inc. All rights reserved.

CHAPTER 10 - FUNDAMENTALS

10.17.2 Supervised notification appliance control circuits shall comply with all of the following:

1. A supervised notification appliance control circuit shall not serve more than one notification zone.
2. The supervised notification appliance control circuit shall be monitored for integrity in accordance with Section 12.6.
3. A fault in the supervised notification appliance control circuit installation conductors shall result in a trouble signal in accordance with Section 10.15.

2767

Honeywell Confidential - ©2020 by Honeywell International Inc. All rights reserved.

CHAPTER 14 - INSPECTION, TESTING, MAINTENANCE

3.3.193* Observation. A suggested correction, improvement, or enhancement to the fire alarm or signaling system that is not considered to be an impairment or deficiency.

14.2.2.4 Observations.

14.2.2.4.1 If observations are noted, they shall be permitted to be communicated to the system owner.

14.2.2.4.2 The system owner shall not be required to address such observations unless the observations become an impairment or deficiency.

14.4.4.3.3 After the second required calibration test, if sensitivity tests indicate that the device has remained within its listed and marked sensitivity range, ~~(or 4 percent obscuration light gray smoke, if not marked),~~ the length of time between calibration tests shall be permitted to be extended to a maximum of 5 years.

2768

Honeywell Confidential - ©2020 by Honeywell International Inc. All rights reserved.

CHAPTER 14 - INSPECTION, TESTING, MAINTENANCE

14.4.2.6 Where changes are made to system executive software or site-specific software for control equipment or transmitting equipment from a remote location not on the protected premises, such changes shall not be made without an individual, meeting the qualifications of 10.5.3.2, 10.5.3.3, or 10.5.3.5, being at the protected premises to verify that testing is accomplished in accordance with 14.4.2.

Table 14.4.3.2

Section 29. Low-power radio (wireless systems)

(b) For initial and reacceptance testing, confirm the introduction of a fault in any Class A or B radio-frequency-specified pathway results in a trouble indication at fire alarm control unit

(c) For periodic testing, test each Class A and B radio frequency initiating device circuit radio pathway, notification appliance circuit radio pathway, and signaling line circuit radio pathway for correct indication at the control unit

2769

Honeywell Confidential - ©2020 by Honeywell International Inc. All rights reserved.

CHAPTER 14 - INSPECTION, TESTING, MAINTENANCE

New Annex I Color-Coded Tagging Program

Many AHJs adopt color-coded system status tagging programs to provide a readily accessible means of determining the status of a system following its most current inspection or test. NFPA 72 does not mandate system status tagging, it is desirable that a certain level of consistency exist between programs.

I.1.1 Installation Tagging.

I.1.2 Service Tagging.

I.1.3 Inspection and Testing Tagging.

I.1.4 Yellow Tags.

I.1.5 Red Tags.

Honeywell Confidential - ©2020 by Honeywell International Inc. All rights reserved.

CHAPTER 17 - INITIATING DEVICES

17.12.3 Carbon monoxide detectors that are installed in air duct systems shall not be used as a substitute for open area protection.



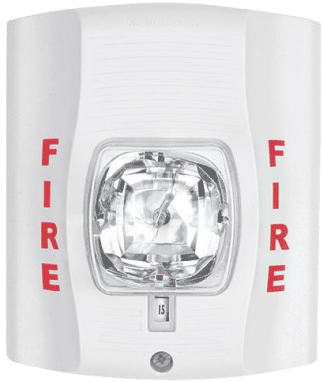
A.17.12.3 At present there is no product performance listing for duct-mounted carbon monoxide detectors because there is no peer-reviewed research to determine what the alarm thresholds for duct-mounted carbon monoxide detectors should be. There are considerable differences between the operation of a spot-type carbon monoxide detector and a duct-mounted carbon monoxide detector. The environment in ducts can be very harsh and could impact the carbon monoxide detector's sensing element. Furthermore, in most buildings, there are periods when the HVAC system is not moving significant quantities of air from the compartments it serves. As a result, the carbon monoxide detection system cannot be designed to rely on the HVAC system operation for the transport of carbon monoxide to the carbon monoxide detectors.

Honeywell Confidential - ©2020 by Honeywell International Inc. All rights reserved.

CHAPTER 18 - NOTIFICATION APPLIANCES

18.3.3.4 In situations where existing notification appliances previously used exclusively for fire alarm signaling and marked with the word ‘FIRE’ are to be used for signaling other than fire, field modification to the marking shall be permitted provided that it is accomplished by one of the following methods:

1. In accordance with manufacturers' published instructions
2. Installation of a permanent sign directly adjacent or below the notification appliance indicating that it is multipurpose and will operate for fire and other emergency conditions





2772

Honeywell Confidential - ©2020 by Honeywell International Inc. All rights reserved.

CHAPTER 18 - NOTIFICATION APPLIANCES

A.18.4.6.1 The intent of this section is to require the use of the low frequency signal in areas intended for sleeping and in areas that might reasonably be used for sleeping. Some of these rooms/areas include the following:

1) Hotel guest rooms
2) Common spaces of a hotel suite, such as living rooms, etc. that have couches, beds, or sleeping furniture.
3) Common spaces within dwelling units, such as living rooms, dens, etc. that have couches, beds, or sleeping furniture.
4) Areas and rooms with “Murphy” beds
5) Doctor’s/Staff sleeping rooms
6) Nap rooms or sleeping areas in any occupancy

Honeywell Confidential - ©2020 by Honeywell International Inc. All rights reserved.

CHAPTER 23 - PROTECTED PREMISES ALARM SYSTEMS

23.8.1.1.2 A pre-signal feature shall meet the following conditions:

3) Subsequent system operation is by either of the following means:
   a) Human action that actuates the general fire alarm evacuation alarm signal or other response per the emergency response plan
   b) A feature that allows the control equipment unit to delay the general alarm by more than 1 minute after the start of the alarm processing
4) Investigation of a pre-signal alarm is performed by qualified personnel.
5) The emergency response plan of a pre-signal facility includes details of the alarm receipt, investigation, and alarm activation procedures and is approved by the authority having jurisdiction.

23.8.1.2.1.3 Manually actuated alarm-initiating devices shall be permitted to be included in a positive alarm sequence where specifically approved by the authority having jurisdiction.

2774

Honeywell Confidential - ©2020 by Honeywell International Inc. All rights reserved.

CHAPTER 23 - PROTECTED PREMISES ALARM SYSTEMS

3.3.252* Remote Access. Communications between a remote device and a component of a fire alarm or signaling system.



A.3.3.252 Remote devices include but are not limited to laptop computers, cellular handheld devices, cloud-based systems, applications, and other similar equipment or software. Remote access communications are not intended to be used for supervising station alarm reporting systems.

23.8.2.11 Remote Access.

23.8.2.11.1* Remote access to fire alarm or signaling systems control units shall be permitted in accordance with 23.8.2.11.

2775

Honeywell Confidential - ©2020 by Honeywell International Inc. All rights reserved.

CHAPTER 23 - PROTECTED PREMISES ALARM SYSTEMS

23.8.2.11.2 Remote access shall not affect the operation or response of the fire alarm or signaling systems unless permitted by 23.8.2.11.3 or 23.8.2.11.5.

23.8.2.11.3 Remote access shall be permitted for testing and maintenance activities, including resetting, silencing, or operation of emergency control functions provided all of the following are met:

1) *The system shall provide a means to manually terminate the remote access connection at the remote device and at the fire alarm or signaling system control unit at any time.
2) *Remote access shall be automatically terminated within a maximum of 1 hour of inactivity in the remote access mode.
3) Resetting, silencing, or operation of emergency control functions shall be limited to portion(s) of the system taken out of service.
4) Qualified personnel shall be on-site to enable resetting, silencing, and operation of emergency control functions at the affected system(s) by password or limited access.

2776

Honeywell Confidential - ©2020 by Honeywell International Inc. All rights reserved.

CHAPTER 23 - PROTECTED PREMISES ALARM SYSTEMS

23.8.2.11.4* Remote access shall be permitted to be enabled remotely for the purposes of performing remote diagnostics when both of the following are met:

1) *The system shall provide a means to manually terminate the remote access connection at the remote device and at the fire alarm or signaling system control unit at any time.
2) *Remote access shall be automatically terminated within a maximum of 1 hour of inactivity in the remote access mode.



2777

Honeywell Confidential - ©2020 by Honeywell International Inc. All rights reserved.

CHAPTER 23 - PROTECTED PREMISES ALARM SYSTEMS

23.8.2.11.5 Remote access for the purposes of software updating shall be permitted when all of the following are met:

1) *The system shall provide a means to manually terminate the remote access connection at the remote device and at the fire alarm or signaling system control unit at any time.
2) *Remote access shall be automatically terminated within a maximum of 1 hour of inactivity in the remote access mode.
3) Qualified personnel shall be on-site to enable software updating at the affected fire alarm or signaling system control unit by password or limited access.
4) All software changes shall be tested in accordance with Section 14.4.

2778

Honeywell Confidential - ©2020 by Honeywell International Inc. All rights reserved.

CHAPTER 23 - PROTECTED PREMISES ALARM SYSTEMS

23.16.4.8 Operation of Class A Radio Pathways.

23.16.4.8.1 Radio frequency pathways designated as Class A shall operate as follows:

1) A redundant pathway is included.
2) Operational capability is verified via end-to-end communication.
3) Conditions that affect the intended operation of the required pathways are annunciated as a trouble signal when two pathways are no longer available to each transceiver/device.
4) Operational capability in a radio frequency pathway/channel continues during conditions that affect the intended operation of one of the two remaining pathways.
5) Each transceiver or repeater in a radio frequency or wireless pathway is powered by one of the following means:
   a) Both a primary and a secondary source meeting Section 10.6
   b) Multiple primary batteries meeting 23.16.2.2

23.16.4.8.2 Where operational capability is to be maintained during a fault, the operational capability shall be restored within 200 seconds of the application of the fault.

Honeywell Confidential - ©2020 by Honeywell International Inc. All rights reserved.

CHAPTER 23 - PROTECTED PREMISES ALARM SYSTEMS

23.16.4.9 Operation of Class B Radio Pathways.

23.16.4.9.1 Radio frequency pathways designated as Class B shall operate as follows:

1) A redundant path is not included.
2) Operational capability is verified via end-to-end communication.
3) Conditions that affect the intended operation of the pathway are annunciated as a trouble signal.
4) Operational capability stops at the affected portion of the pathway.
5) Each transceiver and/or repeater in a radio frequency pathway is powered by one of the following means:
   a) Both a primary and a secondary source meeting Section 10.7
   b) Multiple primary batteries meeting 23.16.2.2

23.16.4.9.2 Where operational capability is to be maintained during a fault, the operational capability shall be restored within 200 seconds of the application of the fault.

Honeywell Confidential - ©2020 by Honeywell International Inc. All rights reserved.

CHAPTER 24 - EMERGENCY COMMUNICATION SYSTEMS

24.3.10* Control Unit Listing for Mass Notification Systems. Control units installed as part of a mass notification system shall be listed in ~~compliance with this Code and~~ accordance with applicable standards such as UL 2572, *Mass Notification Systems* ~~at least one of the following applicable standards~~:

~~1) ANSI/UL 864, *Standard for Control Units and Accessories for Fire Alarm Systems*~~

~~2) ANSI/UL 2572, *Mass Notification Systems*~~

A. 24.3.10 Fire emergency voice/alarm communications systems (EVACS) that are listed in accordance with ~~ANSI/~~ UL 864, *Standard for Control Units and Accessories for Fire Alarm Systems*, can be used for MNS only if they are also listed in accordance with UL 2572, *Mass Notification Systems* . A control unit only listed in accordance with ~~ANSI/~~ UL 2572~~, *Mass Notification Systems* ,~~ cannot be used as a fire alarm control unit

2781

Honeywell Confidential - ©2020 by Honeywell International Inc. All rights reserved.

CHAPTER 26 - SUPERVISING STATION ALARM SYSTEMS

26.2.1.4 Retransmission of subsequent signals shall comply with 26.2.1.4.1 and 26.2.1.4.2.

26.2.1.4.1 The supervising station shall continue to retransmit subsequent signals from a protected premises to the communications center until advised otherwise by the communications center.

26.2.1.4.2 Subsequent signals that are suppressed by the supervising station as directed by the communications center shall be permitted to be suppressed for a maximum of one hour.



2782

Honeywell Confidential - ©2020 by Honeywell International Inc. All rights reserved.

CHAPTER 26 - SUPERVISING STATION ALARM SYSTEMS

26.6.2.3 Remote Programming of Transmitting Technologies. Remote programming of protected premises transmission technologies covered by 26.6.3, 26.6.4, and 26.6.5 shall be permitted when all the conditions in 26.6.2.3.1 through 26.6.2.3.8 are met.

26.6.2.3.1 A qualified person in accordance with 14.4.2.6 shall be at the protected premises at all times during the remote programming.

26.6.2.3.2 Before remote programming of protected premises transmission technologies occurs, notifications shall be made in accordance with 14.2.4.1.

26.6.2.3.3 A test plan shall be developed in accordance with 14.2.10.

Honeywell Confidential - ©2020 by Honeywell International Inc. All rights reserved.

CHAPTER 26 - SUPERVISING STATION ALARM SYSTEMS

26.6.2.3.4 A mitigation plan shall be initiated by the responsible party for the alarm system, which assigns an individual, or individuals, who will be charged with contacting the communications center in the event that an actual alarm occurs during the remote programming of the transmitting equipment.

26.6.2.3.5 Where the transmission technology is integral to the control unit, reacceptance testing shall occur in accordance with 14.4.2.5 and item 4, Supervising station alarm systems transmission equipment, in Table 14.4.3.2 when executive software for the transmission technology is changed.

26.6.2.3.6 Where the transmission technology is integral to the control unit, reacceptance testing shall occur in accordance with 14.4.2.4 and item 4, Supervising station alarm systems transmission equipment, in Table 14.4.3.2 when site-specific software for the transmission technology is changed.

2784

Honeywell Confidential - ©2020 by Honeywell International Inc. All rights reserved.

CHAPTER 26 - SUPERVISING STATION ALARM SYSTEMS

26.6.2.3.7 Where the transmission technology is not integral to the control unit, testing shall occur in accordance with item 4, Supervising station alarm systems transmission equipment, in Table 14.4.3.2.

26.6.2.3.8 At the conclusion of testing, notifications shall be in accordance with 14.2.4.2.



2785

Honeywell Confidential - ©2020 by Honeywell International Inc. All rights reserved.

QUESTIONS?

RICHARD ROBERTS
GLOBAL SENIOR INDUSTRY AFFAIRS MANAGER
HONEYWELL FIRE SAFETY
RICHARD.ROBERTS@SYSTEMSENSOR.COM
630.338.7025

Honeywell Confidential - ©2020 by Honeywell International Inc. All rights reserved.

THANK YOU

Honeywell

RICHARD ROBERTS
GLOBAL SENIOR INDUSTRY AFFAIRS MANAGER
HONEYWELL FIRE SAFETY
RICHARD.ROBERTS@SYSTEMSENSOR.COM
630.338.702

File Attachments for Item:

EC-20 Mass Timber and Type IV Construction (3-hour version) (American Wood Council)

All certifications (3 hours)

Edward J. Lisinski

Phone: (414) 412-6096
Email: elisinski@awc.org

QUALIFICATIONS:

In my current position as Regional Manager for the American Wood Council, I monitor and participate in local, state and national building codes processes, as they relate to wood construction, in my region. I am responsible to provide training (both in-person and virtual) and resources for building and fire officials, inspectors and plan reviewers in my region. I am a State of Wisconsin licensed Professional Engineer, Master Plumber and have commercial and residential building and plumbing inspection certifications from the State of Wisconsin. I currently serve on the ICC Governing Committee for the Building Membership Council as Chair, the IBC-Structural Committee as Chair, and numerous other boards and committees. I am currently serving as the Immediate Past-President and Treasurer of the Wisconsin Code Officials Alliance.

EDUCATION:

Bachelor of Science in Architectural Engineering, Milwaukee School of Engineering

EMPLOYMENT:

12/2021-Present Regional Manager, American Wood Council.
My responsibilities include monitoring and participating in the local, state and national building codes processes, as they relate to wood construction; providing training (both in-person and virtual) for building and fire officials, inspectors and plan reviewers; and being a resource for the design, construction, review and inspection of wood construction in my region.

8/2005-11/2021 Plan Reviewer (8/05-6/11)/Assistant Director (6/11-12/14)/Director (12/14-11/21), City of West Allis Department of Building Inspection and Neighborhood Services

My responsibilities included directing a team of 16 building inspectors and staff; reviewing building plans for local, state and national building codes; writing building permits; meeting with contractors, architects and home owners to discuss projects; budgeting; hiring and disciplining my staff; being the primary contact for other departments in City Hall; writing municipal codes and ordinances; managing and updating department policies and procedures.

4/2019-5/2022 Co-Owner, E-Plan Exam
E-Plan Exam is a third party plan review company which provides municipal plan reviews for four municipalities in Wisconsin, and growing. We provide plan reviews for building, plumbing, mechanical, fire alarm and fire sprinkler systems. We also provide building code consulting services for architects, developers and contractors.

3/2000-8/2005 Architectural Designer, Anderson Ashton, Inc.
My responsibilities included drafting building plans, creating 3D models and renderings, designing structural systems for buildings, preparing all construction documents, drawings, and structural calculations, and performing code reviews.

9/2003-5/2006 Adjunct Instructor, ITT Technical Institute, Greenfield Campus
My responsibilities included teaching classes such as: Architectural Drafting I & II, Engineering Graphics I, Digital Information Management, Physical & Computer Aided 3D Modeling, and aid students in their design projects.

1994-2000 Laborer, Leppin Services, Inc.
My responsibilities included work in the construction field installing drywall, insulation, and steel and wood studs.

CERTIFICATIONS, LICENSES, AWARDS:

Professional Engineer, State of Wisconsin, No. 41154
Master Plumber, State of Wisconsin, No. 997556
Commercial and Residential Building and Plumbing Inspector, No. 997556
Gold Certificate in Supervision, Cities and Villages Mutual Insurance Company, August 2013
Silver Certificate in Management, Cities and Villages Mutual Insurance Company, December 2013
2014 West Allis/West Milwaukee Chamber of Commerce "Young Professional of the Year Award"
2020 NARI Milwaukee "Bill Bobrowitz Image Award"

PROFESSIONAL BOARDS AND COMMITTEES:

International Code Council (ICC), Building Membership Council
- Governing Committee Member, elected to first term, 2017-2021
  - Elected to second term 2022-2025
  - Elected as Vice Chairman for 2020-2021
  - Elected as Chairman for 2022 and 2023
- Chairman, Continuity and Outreach subcommittee, 2020-2021
- Raising the Profile subcommittee, Member 2016-Present, Chairman 2019
- Preparing for the Future Task Group Member, 2016-2018
- Higher Education Task Group Member, 2016-2018

ICC Structural Code Development Committee,
- Member 2015-Present
- Vice Chairman 2017-2019
- Chairman 2020-Present

ICC Building Code Interpretation Committee, Chairman 2017-2019
ICC Region III Code Development Committee Member, 2016-Present
Wisconsin Code Officials Alliance
- Member, 2013-Present
- Vice President, 2016
- President, 2017-2020
- Immediate Past-President 2020-Present
- Treasurer 2021-Present
- Board Liaison of Strategic Planning Committee, 2015-Present
- Member of Government Relations/Code Development Committee, 2015-Present

Building Inspectors Association of Southeastern Wisconsin;
- Member, 2005-Present
- Code Development Committee, Member 2015-Present, Chairman 2017-2021

COMMUNITY BOARDS AND COMMITTEES:

City of West Allis Plan Commission, 2002-2005
City of West Allis Historical Conservation Commission, 2004-2005; 2022-Present
West Allis Community Gala Planning Committee 2011-Present
West Allis Crime Stoppers Board of Directors, 2017-Present, Treasurer 2019-Present
West Allis Historical Society
- Board of Directors, 2009-Present
- Vice President, 2013-Present

West Allis Little League
- Volunteer Coach, 2010-2015
- Board of Directors, 2012-2015

West Allis Old Timers Baseball Association
- Board of Directors, 2010-Present
- Vice President 2014-2016
- President 2017-Present

Mass Timber and Type IV Construction

Course Description:

This presentation will provide an overview of mass timber which includes any product currently permitted for use in Type IV (heavy timber) construction such as cross-laminated timber (CLT), structural composite lumber (SCL), glued laminated timber (glulam), mechanically laminated decking (aka nail-laminated timber, NLT), and large section sawn timbers. Structural and fire protection characteristics of mass timber will be discussed as well as IBC code provisions that allow their specification in both residential and commercial applications for a wide variety of occupancies. This presentation will provide an overview of changes to the 2015, 2018 and 2021 International Building Code (IBC) related to mass timber construction. Changes to the 2021 IBC allow for construction of mass timber buildings with larger heights and areas than is currently permitted in Types III, IV, and V construction. This presentation will provide an overview of the allowable heights and areas for the three new types of mass timber construction: Types IV-A, IV-B, and IV-C. Construction fire safety requirements and owner responsibilities related to the fire resistance elements of the building will also be discussed. An overview of fire design of mass timber building elements and assemblies and protection of connections will be discussed. New code provisions for special inspection of tall mass timber structures will also be discussed.

Learning Objectives:

- Identify code acceptance of mass timber products.
- Describe technology advances and standards related to mass timber products.
- Recognize the unique fire resistive characteristics of mass timber as it influences the use of wood in building construction.
- Describe the application of NDS Chapter 16 which can be utilized to design up to 2-hours of fire-resistance for exposed wood members.

Note: The presentation slides are provided for the full 4-hour presentation. The 3-hour presentation will end after Slide 306. I would like to receive approval of both the three and four hour versions so that I can have some flexibility when scheduling the class with local organizations.

Ohio Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: Ed Lisinski

Organization: American Wood Council

Address: 50 Catoctin Cir NE, Suite 201, Leesburg, VA 20176

E-mail: elisinski@awc.org Telephone: 414-412-6096

Website: www.awc.org

Conference Sponsor (if applicable) None Conference Email: None

Check here if Course Renewal: No Prior course number _____ (*i.e. BBS2018-429*)

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: Mass Timber and Type IV Construction

Course instructor: Ed Lisinski

Course description: See attached documents.

Instructional hours per session: 3 Number of Sessions: 1

Course Date(s) and Location: TBD

Special Content:

Code Administration:_____ Conference Course: _____

Existing Buildings: _____ Conference Name: _____

Electrical Instruction: _____ Conference location: _____

Plumbing Instruction:_____

Course to be offered online? No **On Demand**_____ **Webinar**_____

Course Website: _____

Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation)*:

Course applicable for the following certifications

Residential Certifications Only: _____ Commercial Certifications: Yes

Administrative Course, All Certifications: _____

Application materials included:

X Course Outline or Course Learning Objectives

X Presentation Materials/Slides (not required for roundtable courses)

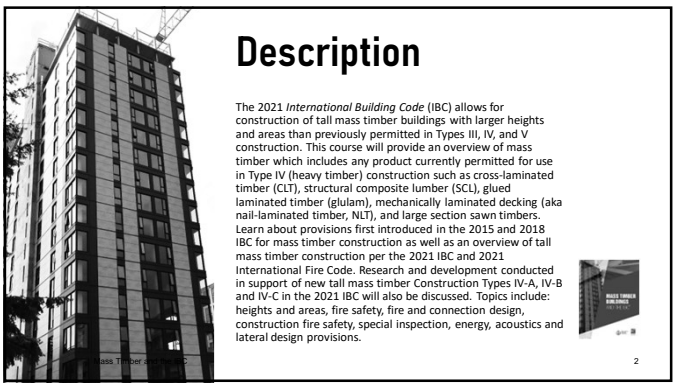
N/A Assessment Materials (for online courses)

X Presenter Bio

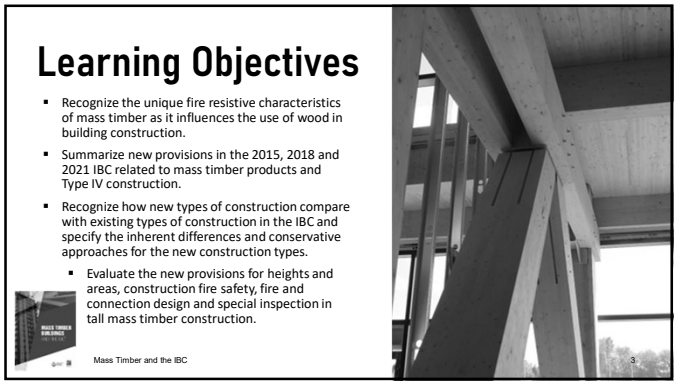
Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov



1



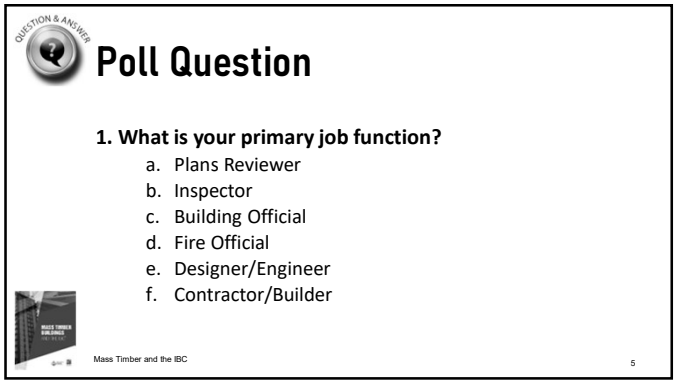
2



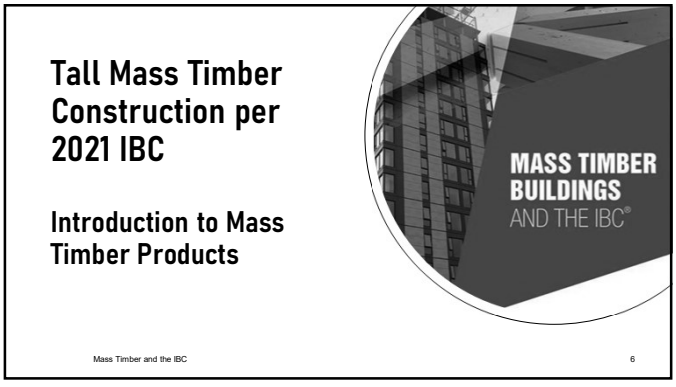
3



4



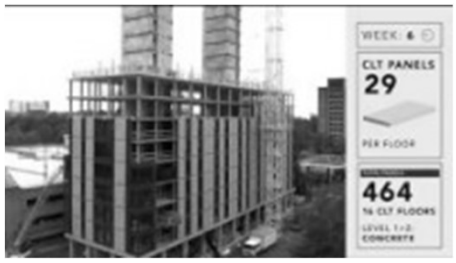
5



6

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

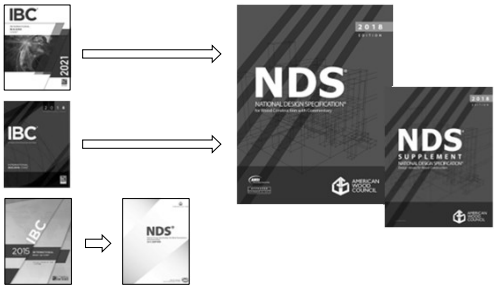
Why do we need mass timber buildings?



Mass Timber and the IBC 7

7

Standard for Engineered Wood Design



Mass Timber and the IBC 8

8

Sub-Outline

- Introduction to Mass Timber Products
- Types of Mass Timber Products
  - Code Acceptance
  - Technology
  - Application



Mass Timber and the IBC 9

9

Introduction to Mass Timber Products

What are all these acronyms?

- Sawn Lumber
  - Heavy Timber – HT
- Glued Laminated Timber
  - Beam or column – Glulam
  - Floor or roof slab – GLT
- Mechanically Laminated Decking
  - Nail-Laminated Timber – NLT
  - Dowel-Laminated Timber – DLT
- Structural Composite Lumber – SCL
  - Laminated Veneer Lumber – LVL
  - Parallel Strand Lumber – PSL
  - Laminated Strand Lumber – LSL
  - Oriented Strand Lumber – OSL
- Cross-Laminated Timber – CLT
- Mass Plywood Panels – MPP



This Photo by Unknown Author is licensed under CC BY-ND

Mass Timber and the IBC 10

10

Traditional Stick Frame Construction



Mass Timber and the IBC 11

11

Mass Timber is NOT Light-Frame



… but Mass Timber elements can be used in all construction types

Mass Timber and the IBC 12

12

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Where is Mass Timber Allowed in the IBC?

- Types I & II – generally noncombustible inside and out
  - Heavy Timber allowed for limited roof applications in Type I-B & Type II
- Type III – noncombustible exterior walls, but interior any material
- Types IV & V – generally combustible
  - Type V includes any material permitted



LeMay – America's Auto Museum – Tacoma, WA
Courtesy of APA-The Engineered Wood Association

13

Mass timber elements are the ONLY combustible elements allowed for tall mass timber buildings



IV-A IV-B IV-C

14

Minimum Sizes for Mass Timber

Spelled out in 602.4 and 2304.11

Table 2304.11 MINIMUM DIMENSIONS OF HEAVY TIMBER STRUCTURAL MEMBERS

Supporting	Min. Nom. Solid Sawn Size		Min. Glulam Net Size		Min. SCL Net Size	
	Width (in.)	Depth (in.)	Width (in.)	Depth (in.)	Width (in.)	Depth (in.)
Floor or Floor/Roof	8	8	6¾	8¾	7	7½
	6	10	5	10½	5¼	9½
Roof Only	6	8	5	8¾	5¼	7½
	6	6	5	6	5¼	5½
	4	6	3	$6^{7}/_{8}$	3½	5½

- CLT minimum thicknesses
  - Floors – 4″ actual
  - Roofs – 3″ nominal
  - Exterior Walls in Type IV – 6″ with limitations (see 602.4.2)

15

Sub-Outline

- Introduction to Mass Timber Products
- Types of Mass Timber Products
  - Code Acceptance
  - Technology
  - Application



16

Types of Mass Timber Products

- Sawn Lumber (Timbers)
- Glued Laminated Timber
- Mechanically Laminated
  - Nail-Laminated Timber (NLT)
  - Dowel-Laminated Timber (DLT)
- Structural Composite Lumber (SCL)
  - Laminated Veneer Lumber (LVL)
  - Parallel Strand Lumber (PSL)
  - Laminated Strand Lumber (LSL)
  - Oriented Strand Lumber (OSL)
- Cross-Laminated Timber (CLT)
  - Mass Plywood Panels (MPP)



17

Sawn Lumber (Timbers)

- Beams and Stringers
- Posts and Timbers
- Mechanically Laminated Decking
- Glulam
- 500,000 SF, 300 lbs./SF Design Load
- 24″ x 24″ columns on ground floor
- 9″ x 9″ columns on the 9th floor
- https://www.butlersquare.com/history



Butler Building – Minneapolis
Courtesy of WoodWorks

18

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Code Acceptance

- Grading practices and identification shall comply with rules published by an agency approved in accordance with the procedures of DOC PS 20 or equivalent
  - IBC 2301.1.1
  - Adobe version pdf version on NIST

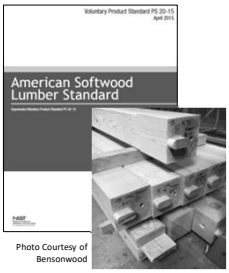


Photo Courtesy of Bensonwood

Mass Timber and the IBC 19

19

Code-referenced Standard

- National Design Specification for Wood Construction
  - Design Values Supplement

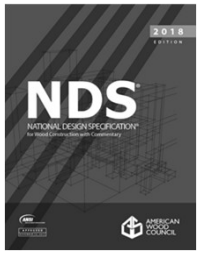


Mass Timber and the IBC 20

20

Sawn Lumber Design: 2018 NDS

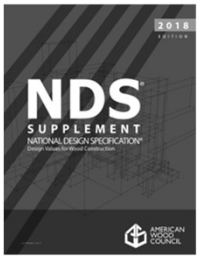
1. General Requirements for Building Design
2. Design Values for Structural Members
3. Design Provisions and Equations
4. **Sawn Lumber**
5. Structural Glued Laminated Timber
6. Round Timber Poles and Piles
7. Prefabricated Wood I-Joists
8. Structural Composite Lumber
9. Wood Structural Panels
10. Cross-laminated Timber
11. Mechanical Connections
12. Dowel-Type Fasteners
13. Split Ring and Shear Plate Connectors
14. Timber Rivets
15. Special Loading Conditions
16. Fire Design of Wood Members



Mass Timber and the IBC 21

21

2018 NDS Supplement



1. **Sawn Lumber Grading Agencies**
2. **Species Combinations**
3. **Section Properties**
4. **Reference Design Values**
   - Sawn Lumber and Timber
   - MSR and MEL
   - Decking
   - Non-North American Sawn Lumber
   - Structural Glued Laminated Timber
   - Timber Poles and Piles

Mass Timber and the IBC 22

22

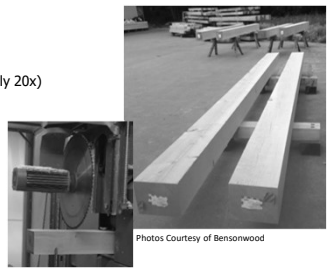
Sawn Lumber (Timbers)

Beams and Stringers

Posts and Timbers

- Readily available
- Western species 4x, 6x and 8x (possibly 20x)
- Southern Pine 2x (built-up)
- 8′ to 20′ lengths (2′ increments)

NOTE: always check for local availability



Photos Courtesy of Bensonwood

Mass Timber and the IBC 23

23

Sawn Lumber (Timbers)

- Manufacturing sizes
  - Nominal vs. Actual
  - Dry vs. Green



Photos Courtesy of Fraserwood

Mass Timber and the IBC 24

24

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Types of Mass Timber Products

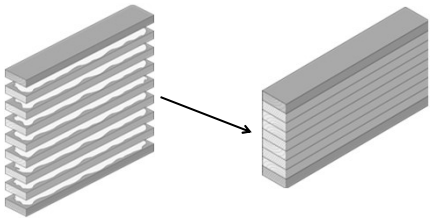
- Sawn Lumber (Timbers)
- Glued Laminated Timber
- Mechanically Laminated
  - Nail-Laminated Timber (NLT)
  - Dowel-Laminated Timber (DLT)
- Structural Composite Lumber (SCL)
  - Laminated Veneer Lumber (LVL)
  - Parallel Strand Lumber (PSL)
  - Laminated Strand Lumber (LSL)
  - Oriented Strand Lumber (OSL)
- Cross-Laminated Timber (CLT)
  - Mass Plywood Panels (MPP)



25

Glued Laminated Timber

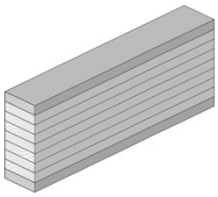
- STRUCTURAL GLUED LAMINATED TIMBER = Glued laminated timber = Glulam
  - composite of lumber laminations bonded with adhesives



26

Glulam – Characteristics

- Wood laminations bonded together
- Wood grain runs parallel to length



- Typical Widths
  - 3-1/8", 3-1/2", 5-1/8", 5-1/2" and 6-3/4" (possibly to 10-3/4")
  - Widths vary by species
- Laminations
  - 1-3/8" for Southern Pine
  - 1-1/2" for Douglas Fir

27

Glued Laminated Timber - Glulam

- Glulam – when used as a beam or column



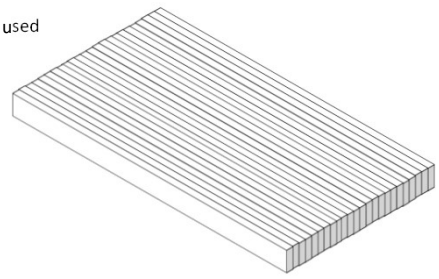
Photo courtesy of naturallywood.com. Photo - Steven Errico



28

Glued Laminated Timber - GLT

- GLT – when used as a panel



29

Code Acceptance

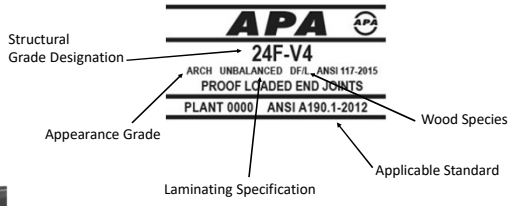
- IBC 2303.1.3 - Structural glued laminated timber manufactured and identified as required
  - Qualification and quality assurance
  - On-going third-party inspection
  - Grademark meeting ANSI A190.1
  - *D 3737: Practice for Establishing Allowable Properties for Structural Glued Laminated Timber (Glulam)*
  - Commonly uses sawn lumber - DOC PS 20



30

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Marking per ANSI/APA A190.1

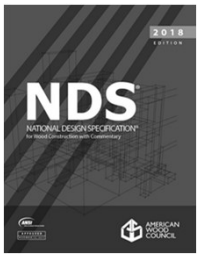


Mass Timber and the IBC 31

31

Glulam Design: 2018 NDS

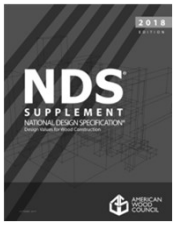
1. General Requirements for Building Design
2. Design Values for Structural Members
3. Design Provisions and Equations
4. Sawn Lumber
5. **Structural Glued Laminated Timber**
6. Round Timber Poles and Piles
7. Prefabricated Wood I-Joists
8. Structural Composite Lumber
9. Wood Structural Panels
10. Cross-laminated Timber
11. Mechanical Connections
12. Dowel-Type Fasteners
13. Split Ring and Shear Plate Connectors
14. Timber Rivets
15. Special Loading Conditions
16. Fire Design of Wood Members



Mass Timber and the IBC 32

32

2018 NDS Supplement

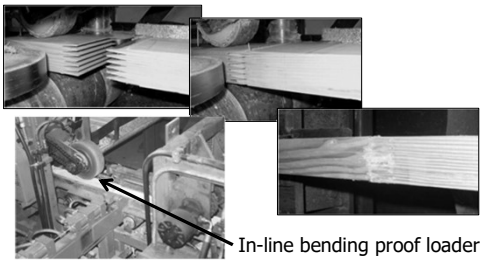


1. **Sawn Lumber Grading Agencies**
2. **Species Combinations**
3. **Section Properties**
4. **Reference Design Values**
   - Sawn Lumber and Timber
   - MSR and MEL
   - Decking
   - Non-North American Sawn Lumber
   - Structural Glued Laminated Timber
   - Timber Poles and Piles

Mass Timber and the IBC 33

33

Finger Jointing Using RF Curing



Mass Timber and the IBC 34

34

Pre-Adhesive Layup

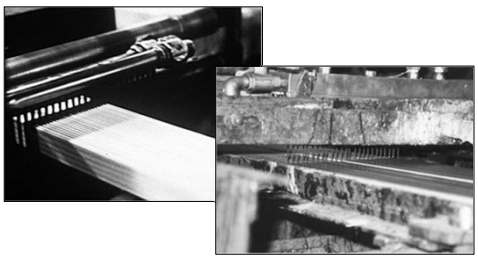


Lumber typically color-coded by grade

Mass Timber and the IBC 35

35

Face Bonding

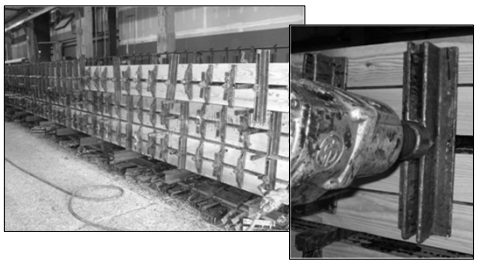


Mass Timber and the IBC 36

36

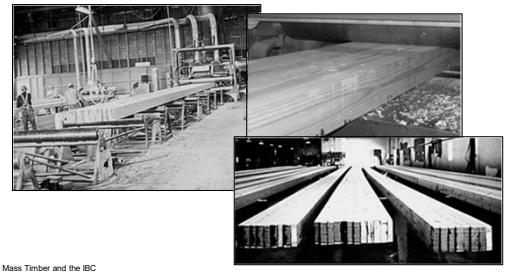
Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Clamping and Curing



37

Fabrication & Finishing



38

Church in Louisville, KY





12-1/4" x 84"
140' clear span

39

Bullitt Center – Seattle, WA



250 YEAR STRUCTURE
HEAVY TIMBER, CONCRETE & STEEL





Architect: Miller Hull Partnership
Structural Engineer: DCI Engineers
Photo Credit: Miller Hull Partnership

40

Bullitt Center – Seattle, WA



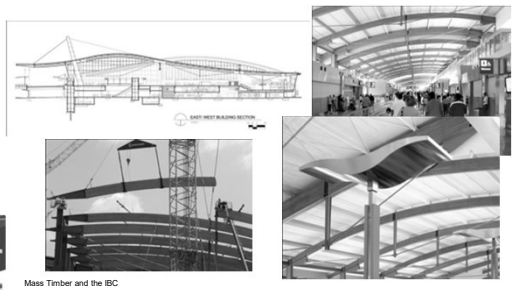
- Glulam beams and columns
- Nail-laminated timber floors



Architect: Miller Hull Partnership
Structural Engineer: DCI Engineers
Photo Credit: Miller Hull Partnership

41

Raleigh Durham Airport



42

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Cathedral of Christ the Light - Oakland





43

Cathedral of Christ the Light - Oakland

Design Team: Skidmore Owings & Merrill, Craig W. Harman
Webcore Builders
Glulam Manufacturer: Western Wood Structures
Photo Credit: Timothy Hursley, Cesar Rubio, and John Blaustein





44

Fire House - Multnomah County, OR



Owner: Multnomah County Rural Fire Protection District 10. Oregon
Architect: Hennebery Eddy Architects, Inc
Photo by Josh Partee

45

Denver – Platte15



46

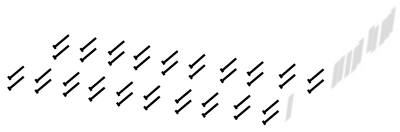
Types of Mass Timber Products

- Sawn Lumber (Timbers)
- Glued Laminated Timber
- Mechanically Laminated
  - Nail-Laminated Timber (NLT)
  - Dowel-Laminated Timber (DLT)
- Structural Composite Lumber (SCL)
  - Laminated Veneer Lumber (LVL)
  - Parallel Strand Lumber (PSL)
  - Laminated Strand Lumber (LSL)
  - Oriented Strand Lumber (OSL)
- Cross-Laminated Timber (CLT)
  - Mass Plywood Panels (MPP)



47

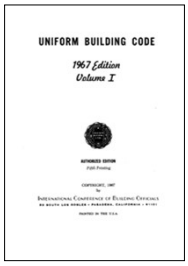
What is Nail-Laminated Timber?



48

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Code Acceptance


UNIFORM BUILDING CODE

1967 Edition
Volume I

(g) **Mechanically Laminated Floors and Decks.** A laminated lumber floor or deck built up of wood members set on edge, when meeting the following requirements, may be designed as a solid floor or roof deck of the same thickness, and continuous spans may be designed on the basis of the full cross section using the simple span moment coefficient.

Laminations shall be driven up and spiked closely together with a row of nails near each edge at spaced intervals and staggered vertically. Nail spacing in each row shall not exceed eighteen inches (18") for two-inch by eight-inch (2" x 8") nominal width and be proportional for other plank widths. Nail length shall be not less than two and one-half times the net thickness of each lamination.

A single span deck shall have all laminations full length.

A continuous deck of two spans shall have not more than every fourth lamination spliced within quarter points adjoining supports.

A continuous deck of more than two spans shall have not more than every third lamination spliced within quarter points adjoining supports.

Joints shall be closely butted over supports or staggered across the deck but within the adjoining quarter spans.

No lamination shall be spliced more than twice in any span.



49

Code Acceptance

- 2304.9.3 Mechanically laminated decking. Mechanically laminated decking shall comply with Sections 2304.9.3.1 through 2304.9.3.3.
- 2304.9.3.1 General. Mechanically laminated decking consists of square-edged dimension lumber laminations set on edge and nailed to the adjacent pieces and to the supports.
- 2304.9.3.2 Nailing. The length of nails connecting laminations shall not be less than two and one-half times the net thickness of each lamination. Where decking supports are 48 inches (1219 mm) on center (o.c.) or less, side nails shall be installed not more than 30 inches (762 mm) o.c. alternating between top and bottom edges and staggered one-third of the spacing in adjacent laminations. Where supports are spaced more than 48 inches (1219 mm) o.c., side nails shall be installed not more than 18 inches (457 mm) o.c. alternating between top and bottom edges and staggered one-third of the spacing in adjacent laminations. Two side nails shall be installed at each end of butt-jointed pieces.

  Laminations shall be toenailed to supports with 20d or larger common nails. Where the supports are 48 inches (1219 mm) o.c. or less, alternate laminations shall be toenailed to alternate supports; where supports are spaced more than 48 inches (1219 mm) o.c., alternate laminations shall be toenailed to every support.
- 2304.9.3.3 Controlled random pattern. There shall be a minimum distance of 24 inches (610 mm) between end joints in adjacent courses. The pieces in the first and second courses shall bear on at least two supports with end joints in these two courses occurring on alternate supports. A maximum of seven intervening courses shall be permitted before this pattern is repeated.

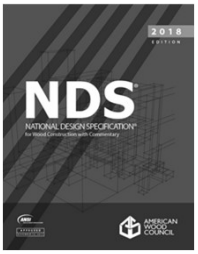




50

Sawn Lumber Design: 2018 NDS

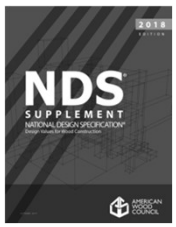
1. General Requirements for Building Design
2. Design Values for Structural Members
3. Design Provisions and Equations
4. **Sawn Lumber**
5. Structural Glued Laminated Timber
6. Round Timber Poles and Piles
7. Prefabricated Wood I-Joists
8. Structural Composite Lumber
9. Wood Structural Panels
10. Cross-laminated Timber
11. Mechanical Connections
12. Dowel-Type Fasteners
13. Split Ring and Shear Plate Connectors
14. Timber Rivets
15. Special Loading Conditions
16. Fire Design of Wood Members





51

2018 NDS Supplement



1. **Sawn Lumber Grading Agencies**
2. **Species Combinations**
3. **Section Properties**
4. **Reference Design Values**
   - Sawn Lumber and Timber
   - MSR and MEL
   - Decking
   - Non-North American Sawn Lumber
   - Structural Glued Laminated Timber
   - Timber Poles and Piles



52

Nail-Laminated Timber







Courtesy: StructureCraft



53

Nail-Laminated Timber



Courtesy : StructureCraft



54

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Nail-Laminated Timber



Courtesy : StructureCraft

55

Nail-Laminated Timber





- Nail-Laminated Timber – 2x12 vertical
- Mechanically connected w/nails
- NDS principles of mechanics



Architect: Profeta Royalty Architecture
Structural Engineer: Structural Focus 2011

56

Nail-Laminated Timber

- Samuel Brighouse Elementary School (Richmond, BC)



Design Team: Perkins + Will Canada, Fast + Epp
Photo Credit: Stephan Pasche





Courtesy : StructureCraft

57

Nail-Laminated Timber



Architect: DLR Group
https://vimeo.com/162580838

- T3 – Minneapolis
  - Glued & Nail-laminated Timber – vertical 2x sawn lumber mechanically connected w/nails
  - Engineered with NDS principles of mechanics
  - **7 Stories total**
  - **6 Stories Type IV Construction**
  - **1 Story Type 1-A Podium**
  - **IBC Section 510**

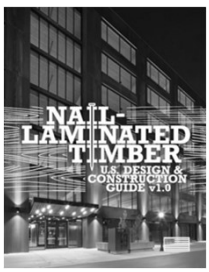


58

Nail-Laminated Timber Handbook

- Architecture
- Fire
- Structure
- Enclosures
- Supply & Fabrication
- Construction & Installation
- Erection Engineering

https://www.thinkwood.com/products-and-systems/mass-timber/nltguide



59

Dowel-Laminated Timber

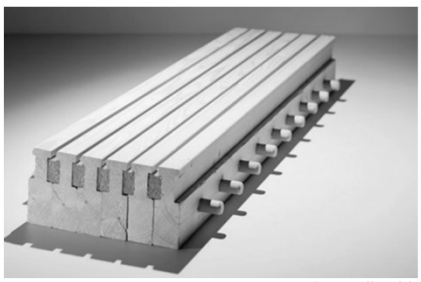


Photo courtesy of StructureCraft

60

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Dowel-Laminated Timber



Mass Timber and the IBC 61

61

Dowel-Laminated Timber



Photo provided by B.Bishop

Mass Timber and the IBC 62

62

Dowel-Laminated Timber

ICC-ES Evaluation Report

ESR-4069

Issued November 2019
Revised November 8, 2019
This report is subject to renewal November 2020.

www.icc-es.org | (800) 423-6587 | (562) 699-0543 *A Subsidiary of the International Code Council®*

DIVISION: 06 00 00 —WOOD, PLASTICS AND COMPOSITES
Section: 06 17 21—Dowel-Laminated Timber

REPORT HOLDER:

STRUCTURECRAFT BUILDERS INC.

EVALUATION SUBJECT:

DOWEL-LAMINATED TIMBER (DLT)

1.0 EVALUATION SCOPE

Compliance with the following codes:

- 2018, 2015, 2012 and 2009 *International Building Code®*

time of manufacture does not exceed 19 percent, and the dowels are dried to 5 to 9 percent moisture content prior to insertion. Once inserted, the dowels swell as they come into equilibrium with the higher moisture content of the surrounding lumber, providing additional friction for a tight fit of the dowel in the laminations.

The StructureCraft Dowel-Laminated Timber panels are available in thicknesses of 4 inches nominal (89 mm) to 12 inches nominal (286 mm), widths of 12 inches (305 mm) to 14 feet (4.3 m) and lengths up to 60.7 feet (18.5 m).

3.2 Material:

3.2.1 Wood Laminations: Wood laminations used in manufacturing StructureCraft Dowel-Laminated Timber are

Mass Timber and the IBC 63

63

Types of Mass Timber Products

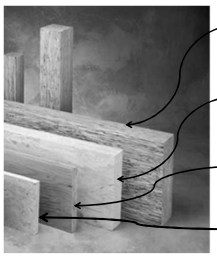
- Sawn Lumber (Timbers)
- Glued Laminated Timber
- Mechanically Laminated
  - Nail-Laminated Timber (NLT)
  - Dowel-Laminated Timber (DLT)
- Structural Composite Lumber (SCL)
  - Laminated Veneer Lumber (LVL)
  - Parallel Strand Lumber (PSL)
  - Laminated Strand Lumber (LSL)
  - Oriented Strand Lumber (OSL)
- Cross-Laminated Timber (CLT)
  - Mass Plywood Panels (MPP)



Mass Timber and the IBC 64

64

Structural Composite Lumber (SCL)

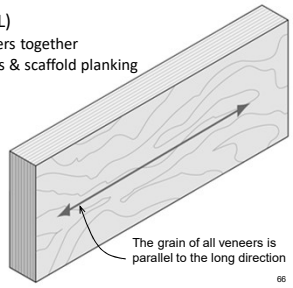


Mass Timber and the IBC 65

65

SCL – Features & Applications

- Laminated Veneer Lumber (LVL)
  - Produced by bonding thin veneers together
  - Used for beams, headers, rafters & scaffold planking
- Common Thicknesses
  - 1-3/4" to 7"
- Depths
  - 5-1/2" – 24"
- Lengths
  - Up to 60'



Mass Timber and the IBC 66

66

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Code Acceptance

- **2303.1.10 Structural composite lumber.** Structural capacities…in accordance with ASTM D 5456
- D 5456: *Specification for Evaluation of Structural Composite Lumber Products*


Designation: D5456 – 14b

Standard Specification for Evaluation of Structural Composite Lumber Products[1]

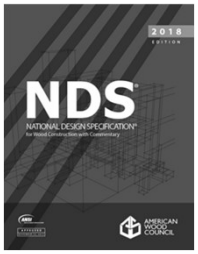
INTRODUCTION

Mass Timber and the IBC 67

67

SCL Design: 2018 NDS

1. General Requirements for Building Design
2. Design Values for Structural Members
3. Design Provisions and Equations
4. Sawn Lumber
5. Structural Glued Laminated Timber
6. Round Timber Poles and Piles
7. Prefabricated Wood I-Joists
8. **Structural Composite Lumber**
9. Wood Structural Panels
10. Cross-laminated Timber
11. Mechanical Connections
12. Dowel-Type Fasteners
13. Split Ring and Shear Plate Connectors
14. Timber Rivets
15. Special Loading Conditions
16. Fire Design of Wood Members



Mass Timber and the IBC 68

68

SCL – Features & Applications

- Features
  - Wood veneers or strands primarily oriented in the same direction
  - Strong when face- or edge-loaded
  - Milled (sawn) to consistent sizes
- Strength Properties
  - APA publishes strength properties
  - See manufacturer criteria


Photo Courtesy of www.naturallywood.com

Mass Timber and the IBC 69

69

Types of Mass Timber Products

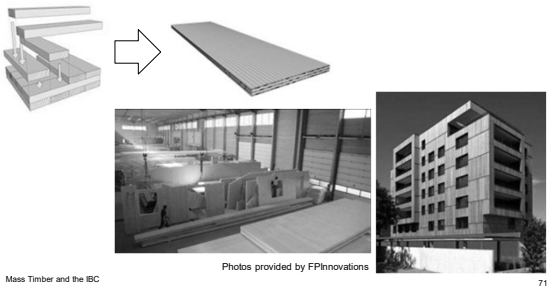
- Sawn Lumber (Timbers)
- Glued Laminated Timber
- Mechanically Laminated
  - Nail-Laminated Timber (NLT)
  - Dowel-Laminated Timber (DLT)
- Structural Composite Lumber (SCL)
  - Laminated Veneer Lumber (LVL)
  - Parallel Strand Lumber (PSL)
  - Laminated Strand Lumber (LSL)
  - Oriented Strand Lumber (OSL)
- Cross-Laminated Timber (CLT)
  - Mass Plywood Panels (MPP)



Mass Timber and the IBC 70

70

Cross-Laminated Timber


Photos provided by FPInnovations

Mass Timber and the IBC 71

71

Code Acceptance

- 2303.1.4 Structural glued cross-laminated timber is to be manufactured and identified in accordance with ANSI/APA PRG 320



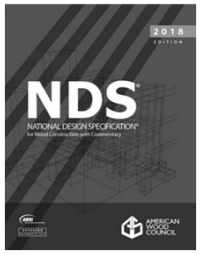
Mass Timber and the IBC 72

72

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

CLT Design: 2018 NDS

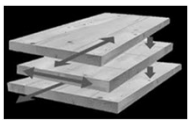
1. General Requirements for Building Design
2. Design Values for Structural Members
3. Design Provisions and Equations
4. Sawn Lumber
5. Structural Glued Laminated Timber
6. Round Timber Poles and Piles
7. Prefabricated Wood I-Joists
8. Structural Composite Lumber
9. Wood Structural Panels
10. **Cross-laminated Timber**
11. Mechanical Connections
12. Dowel-Type Fasteners
13. Split Ring and Shear Plate Connectors
14. Timber Rivets
15. Special Loading Conditions
16. Fire Design of Wood Members



73

History of CLT

- 1985 1st CLT patent - France
- 1993 1st CLT projects - Switzerland and Germany
- 1995-1996 Improved press technology
- 1998 1st multi-story res building - Austria
- Early 2000's
  - CLT use (Europe) increased significantly
  - Green building movement driven
  - Better efficiencies, product approvals, improved marketing and distribution channels
  - Over 500 CLT buildings in England
- Recent - US and Canadian use of CLT





74

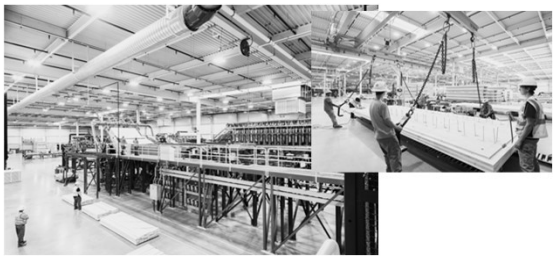
CLT Press & Assembly Line



Photos Courtesy of Katerra

75

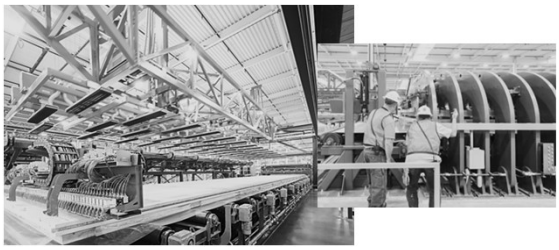
CLT Manufacturing Process



Photos Courtesy of Katerra

76

CLT Manufacturing Process



Photos Courtesy of Katerra

77

Ready to Ship

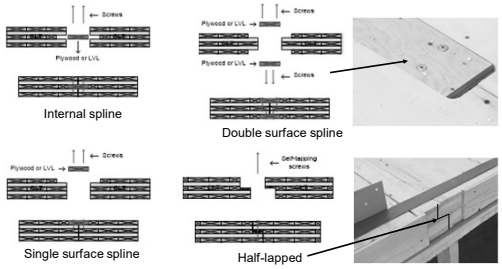


Photo Courtesy of Katerra

78

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

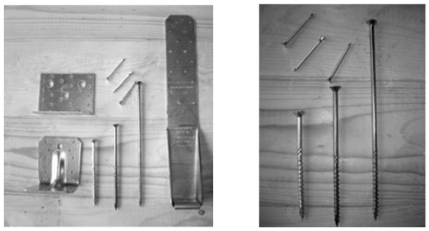
Typical Construction Details



Mass Timber and the IBC 79

79

Typical Panel Connectors



Mass Timber and the IBC 80

80

Typical Panel Connectors



Mass Timber and the IBC 81

81

CLT – Fitchburg, WI

- Factory
- Promega Feynman Center
- Fitchburg, WI



Owner: Promega Corporation
Architect: Uihlein-Wilson
Photos by J.B. Smith

Mass Timber and the IBC 82

82

CLT – Huntsville, AL

- Private Army Hotel – Redstone Arsenal
- Four stories and 58,000 sq ft



Owner/GC: Lendlease (US) Public Partnerships LLC
Architect: Leidos (now Benham)
Structural Engineer: Schaefer Structural Engineers
Photo: Lendlease

Mass Timber and the IBC 83

83

CLT – Huntsville, AL



Mass Timber and the IBC 84

84

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

CLT – Huntsville, AL



85

CLT – Huntsville, AL



86

CLT – Huntsville, AL



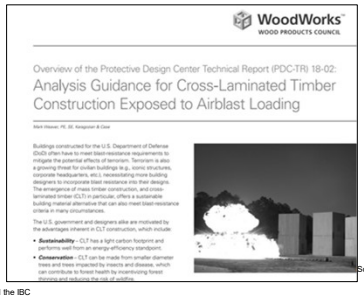
87

CLT – Huntsville, AL



88

CLT – Blast Testing



Source: WoodWorks

89

CLT – WV Elementary School

- 46,200 sq. ft.
- 8-week assembly
- Architect: MSES Architects Fairmont, WV



Source: LignaTerra

90

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

CLT – WV Elementary School



Photos: LignaTerra

Mass Timber and the IBC 91

91

CLT – Clemson University



Courtesy of Clemson University

Mass Timber and the IBC 92

92

CLT – Boston



Courtesy of Generate Architecture and Technologies

Mass Timber and the IBC 93

93

CLT – Canadian Projects

- The Arbora
- Québec, Canada
  - 8 Stories
  - 434 Residential condos, townhouses and rentals



Mass Timber and the IBC 94

94

CLT and Glulam – Vancouver, BC

- Brock Commons
  - 18 Stories
  - Mixed use student housing
  - Glulam columns
  - CLT floors

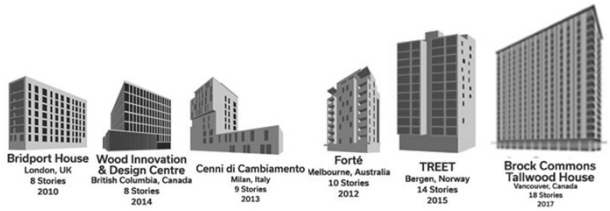




Mass Timber and the IBC 95

95

Mass Timber Worldwide



www.Thinkwood.com/tallerwood

Source: ThinkWood

Mass Timber and the IBC 96

96

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Mass Plywood Panel - MPP

- SCL-based "panel" or slab
- Alternative to CLT
- Like LVL – parallel laminations



Photo Courtesy
Freres Lumber



97

Mass Plywood Panel



Photos Courtesy
of Freres Lumber



Photo courtesy of
Stephen A. Miller
and Skylab



98

Q&A





99



Outline

- Introduction to Mass Timber Products
- 2015/2018 IBC for Mass Timber Construction
- Break – 15 minutes
- 2021 IBC for Tall Mass Timber Construction
  - Part 1: Background and Overview
  - Lunch – 1 hour
  - Part 2: New Construction Types and Heights & Areas
  - Part 3: Fire Safety
  - Break – 15 minutes
  - Part 4: Fire & Connection Design and Special Inspection
  - Part 5: Acoustics, Energy, and Lateral Resistance
  - Part 6: Construction Fire Safety



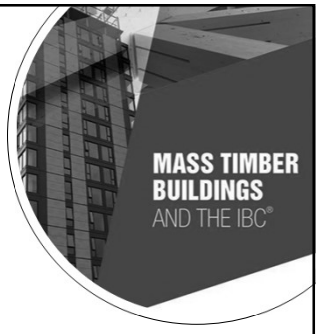




100

2015/2018 IBC for Mass Timber Construction





101

Sub-Outline

- 2015 IBC Related to CLT and SCL
- 2018 IBC Related to Heavy Timber





102

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

2015 IBC: SCL in Type IV

- Structural Composite Lumber (SCL) defined as heavy timber

Minimum Nominal Solid Sawn Size		Minimum Glued Laminated Timber Net Size		Minimum Structural Composite Lumber Net Size	
Width, inch	Depth, inch	Width, inch	Depth, inch	Width, inch	Depth, inch
8	8	6¾	8¼	7	7½
6	10	5	10½	5¼	9½
6	8	5	8¼	5¼	7½
6	6	5	6	5¼	5½
4	6	3	6⅞	3½	5½

103

2015 IBC: CLT in Type IV

- Cross Laminated Timber (CLT) defined as heavy timber
  - Ext/Int Walls
  - Floors
  - Roofs



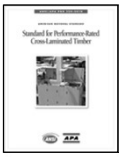
Photo provided by FPInnovations

104

2015 IBC: Definition and Standard

[BS] CROSS-LAMINATED TIMBER. A prefabricated engineered wood product consisting of not less than three layers of solid-sawn lumber or *structural composite lumber* where the adjacent layers are cross oriented and bonded with structural adhesive to form a solid wood element.

2303.1.4 Structural glued cross-laminated timber. Cross-laminated timbers shall be manufactured and identified in accordance with ANSI/APA PRG 320.



105

Supporting Data: CLT Fire Test



Fire Testing Laboratory

NGC Testing Services

ACCREDITED Testing Laboratory TL-216

TEST REPORT Page 1 of 53

for

American Wood Council

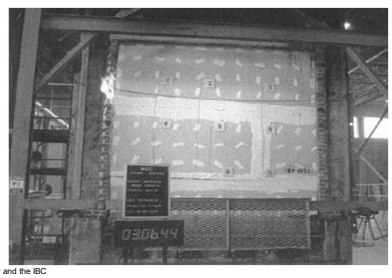
222 Catoctin Circle SE, Suite 201
Leesburg, VA 20175

Standard Methods of
Fire Tests of Building Construction and Materials
ASTM E 119 – 11a

Test Report No: WP-1950

106

Supporting Data: CLT Fire Test



107

2015 IBC: CLT Permitted Uses

- Types I and II – balcony and canopy or roof construction
- Type III – interior building elements
  - Roof-ceiling assemblies
  - Floor-ceiling assemblies
  - Interior walls
- Types IV or V – any



108

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

2015 IBC: CLT in Type IV

- Heavy Timber Family

602.4 Type IV. Type IV construction (Heavy Timber, HT) is that type of construction in which the exterior walls are of noncombustible materials and the interior building elements are of solid or laminated wood without concealed spaces. The details of Type IV construction shall comply with the provisions of this section and Section 2304.11. Exterior walls complying with Section 602.4.1 or 602.4.2 shall be permitted. Minimum solid sawn nominal dimensions are required for structures built using Type IV construction (HT). For glued-laminated members and structural composite lumber (SCL) members, the equivalent net finished width and depths corresponding to the minimum nominal width and depths of solid sawn lumber are required as specified in Table 602.4. Cross-laminated timber (CLT) dimensions used in this section are actual dimensions.

Mass Timber and the IBC 109

109

2015 IBC: CLT in Type IV

- Exterior Walls (2 hours or less)

602.4.2 Cross-laminated timber in exterior walls. Cross-laminated timber complying with Section 2303.1.4 shall be permitted within exterior wall assemblies with a 2-hour rating or less, provided the exterior surface of the cross-laminated timber is protected by one the following:

1. Fire-retardant-treated wood sheathing complying with Section 2303.2 and not less than $^{15}/_{32}$ inch (12 mm) thick;
2. Gypsum board not less than $^{1}/_{2}$ inch (12.7 mm) thick; or
3. A noncombustible material.

Mass Timber and the IBC 110

110

2015 IBC: Plank Floors in Type IV

- Floors

602.4.6.1 Sawn or glued-laminated plank floors. Sawn or glued-laminated plank floors shall be one of the following:

1. Sawn or glued-laminated planks, splined or tongue-and-groove, of not less than 3 inches (76 mm) nominal in thickness covered with 1-inch (25 mm) nominal dimension tongue-and-groove flooring, laid crosswise or diagonally, $^{15}/_{32}$-inch (12 mm) wood structural panel or $^{1}/_{2}$-inch (12.7 mm) particleboard.

Mass Timber and the IBC 111

111

2015 IBC: CLT Floors in Type IV

- Floors

602.4.6.2 Cross-laminated timber floors. Cross-laminated timber shall be not less than 4 inches (102 mm) in thickness. Cross-laminated timber shall be continuous from support to support and mechanically fastened to one another. Cross-laminated timber shall be permitted to be connected to walls without a shrinkage gap providing swelling or shrinking is considered in the design. Corbelling of masonry walls under the floor shall be permitted to be used.

Mass Timber and the IBC 112

112

2015 IBC: CLT in Type IV

- Roofs

602.4.7 Roofs. Roofs shall be without concealed spaces and wood roof decks shall be sawn or glued laminated, splined or tongue-and-groove plank, not less than 2 inches (51 mm) nominal in thickness; $1^{1}/_{8}$-inch-thick (32 mm) wood structural panel (exterior glue); planks not less than 3 inches (76 mm) nominal in width, set on edge close together and laid as required for floors; or of cross-laminated timber. Other types of decking shall be permitted to be used if providing equivalent fire resistance and structural properties.

Cross-laminated timber roofs shall be not less than 3 inches (76 mm) nominal in thickness and shall be continuous from support to support and mechanically fastened to one another.

Mass Timber and the IBC 113

113

2015 IBC: CLT in Type IV

- Interior Walls

602.4.8 Partitions and walls. Partitions and walls shall comply with Section 602.4.8.1 or 602.4.8.2.

602.4.8.1 Interior walls and partitions. Interior walls and partitions shall be of solid wood construction formed by not less than two layers of 1-inch (25 mm) matched boards or laminated construction 4 inches (102 mm) thick, or of 1-hour fire-resistance-rated construction.

Mass Timber and the IBC 114

114

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

2015 IBC: CLT in Type IV

- Exterior walls – assembly must be 6" thick

602.4.8.2 Exterior walls. Exterior walls shall be of one of the following:

1. Noncombustible materials.
2. Not less than 6 inches (152 mm) in thickness and constructed of one of the following:
   - 2.1. Fire-retardant-treated wood in accordance with Section 2303.2 and complying with Section 602.4.1.
   - 2.2. Cross-laminated timber complying with Section 602.4.2.

Mass Timber and the IBC 115

115

Sub-Outline

- 2015 IBC Related to CLT and SCL
- 2018 IBC Related to Heavy Timber



Mass Timber and the IBC 116

116

2018 IBC: Heavy Timber Reorg

2018 IBC	2015 IBC	Provision
602.4	602.4	Type IV construction
602.4.1, 602.4.2	602.4.1	Wall assembly thickness
602.4.3	602.4.9	Exterior structural members
2304.11	2304.11	Heavy timber construction
Table 2304.11	Table 602.4	Minimum dimensions
2304.11.1	New	Details of heavy timber structural members
2304.11.1.1	602.4.3, 2304.11.1	Columns
2304.11.1.2	602.4.4, 2304.11.2	Floor framing
2304.11.1.3	602.4.5, 2304.11.3	Roof framing
2304.11.2.1	602.4.8.2	Exterior walls
2304.11.2.2	602.4.8.1	Partitions and interior walls
2304.11.3	602.4.6	Floors
2304.11.3.1	602.4.6.2	CLT floors
2304.11.3.2	602.4.6.1, 2304.11.4	Sawn or glued-laminated plank floors
2304.11.4	2304.11.5	Roof decks

Mass Timber and the IBC 117

117

2018 IBC: Mech Laminated Decking

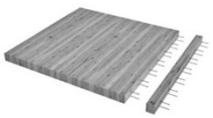
2304.11 Heavy timber construction. Where a structure, portion thereof or individual structural elements are required by provisions of this code to be of heavy timber, the building elements therein shall comply with the applicable provisions of Sections 2304.11.1 through 2304.11.4. Minimum dimensions of heavy timber shall comply with the applicable requirements in Table 2304.11 based on roofs or floors supported and the configuration of each structural element, or in Sections 2304.11.2 through 2304.11.4. Lumber decking shall be in accordance with Section 2304.9.

Mass Timber and the IBC 118

118

2018 IBC: Mech Laminated Decking

- Nail-laminated timber



2304.9.3.2 Nailing. The length of nails connecting laminations shall be not less than two and one-half times the net thickness of each lamination. Where decking supports are 48 inches (1219 mm) on center or less, side nails shall be installed not more than 30 inches (762 mm) on center alternating between top and bottom edges, and staggered one-third of the spacing in adjacent laminations. Where supports are spaced more than 48 inches (1219 mm) on center, side nails shall be installed not more than 18 inches (457 mm) on center alternating between top and bottom edges and staggered one-third of the spacing in adjacent laminations. For mechanically laminated decking constructed with laminations of 2-inch (51 mm) nominal thickness, nailing in accordance with Table 2304.9.3.2 shall be permitted. Two side nails shall be installed at each end of butt-jointed pieces.

Laminations shall be toenailed to supports with 20d or larger common nails. Where the supports are 48 inches (1219 mm) on center or less, alternate laminations shall be toenailed to alternate supports; where supports are spaced more than 48 inches (1219 mm) on center, alternate laminations shall be toenailed to every support. For mechanically laminated decking constructed with laminations of 2-inch (51 mm) nominal thickness, toenailing in accordance with Table 2304.9.3.2 shall be permitted.

Mass Timber and the IBC 119

119

2018 IBC: Mech Laminated Decking

TABLE 2304.9.3.2
FASTENING SCHEDULE FOR MECHANICALLY LAMINATED DECKING USING LAMINATIONS OF 2-INCH NOMINAL THICKNESS

MINIMUM NAIL SIZE (Length x Diameter) (inches)	MAXIMUM SPACING BETWEEN FACE NAILS [a,b] (inches)		NUMBER OF TOENAILS INTO SUPPORTS[c]
	Decking Supports ≤ 48 inches o.c.	Decking Supports > 48 inches o.c.	
4 × 0.192	30	18	1
4 × 0.162	24	14	2
4 × 0.148	22	13	2
3½ × 0.162	20	12	2
3½ × 0.148	19	11	2
3½ × 0.135	17	10	2
3 × 0.148	11	7	2
3 × 0.128	9	5	2
2½ × 0.148	10	6	2
2½ × 0.131	9	6	3
2½ × 0.120	8	5	3

Mass Timber and the IBC 120

120

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

2018 IBC: CLT Exterior Walls – Type IV

602.4.2 Cross-laminated timber in exterior walls. *Cross-laminated timber* complying with Section 2303.1.4 shall be permitted within exterior wall assemblies not less than 6 inches (152 mm) in thickness with a 2-hour rating or less, provided the exterior surface of the cross-laminated timber is protected by one the following:

1. *Fire-retardant-treated wood* sheathing complying with Section 2303.2 and not less than $^{15}/_{32}$ inch (12 mm) thick;
2. *Gypsum board* not less than $^{1}/_{2}$ inch (12.7 mm) thick; or
3. A noncombustible material.

Mass Timber and the IBC 121

121

2018 IBC: Flame Spread

803.3 Heavy timber exemption. Exposed portions of building elements complying with the requirements for buildings of ~~Type IV~~ heavy timber construction in Section 602.4 or Section 2304.11 shall not be subject to interior finish requirements except in interior exit stairways, interior exit ramps, and exit passageways.



Mass Timber and the IBC 122

122

2018 IBC: SCL Dimensions

602.4 Type IV. Type IV construction ~~(Heavy Timber, HT)~~ is that type of construction in which the exterior walls are of noncombustible materials and the interior building elements are of solid ~~or~~ wood, laminated wood, heavy timber (HT) or structural composite lumber (SCL) without concealed spaces. The minimum dimensions for permitted materials including solid timber, glued-laminated timber, structural composite lumber (SCL), and cross-laminated timber and details of Type IV construction shall comply with the provisions of this section and Section 2304.11. Exterior walls complying with Section 602.4.1 or 602.4.2 shall be permitted. Interior walls and partitions not less than 1-hour fire-resistance rating or heavy timber complying with Section 2304.11.2.2 shall be permitted.



Mass Timber and the IBC 123

123

2018 IBC: Heights & Areas

- IBC Chapter 5 – Heights & Areas
- IBC Chapter 6 – Types of Construction
- Addressed in Sections 5 and 6 of CCWD

Free at awc.org



Mass Timber and the IBC 124

124

2018 IBC: Types of Construction

- IBC Chapter 6
  - Defines types of construction
  - Wood frame construction is typical in Types III, IV and V
  - Specific applications permitting use of wood in Types I and II



Mass Timber and the IBC 125

125

2018 IBC: Type V

- Permits use of wood or other approved materials for loadbearing and nonloadbearing structural elements
  - Including heavy timber



Mass Timber and the IBC 126

126

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

2018 IBC: Type IV – Heavy Timber

- Exterior walls of noncombustible materials, FRTW or protected CLT
- Interior elements of solid or laminated wood without concealed spaces



Mass Timber and the IBC 127

127

2018 IBC: Type IV – Column/Beam

- Columns
  - Minimum 6″ × 8″ supporting roof/ceiling
  - Minimum 8″ × 8″ supporting floors
- Beams and Girders
  - Minimum 6″ × 10″ for floors
  - Minimum 4″ × 6″ for roofs



Old Faithful Inn, Yellowstone National Park

Mass Timber and the IBC 128

128

2018 IBC: Type IV – Floor/Roof

- Floors
  - Minimum 3-inch thickness covered with 1-inch nominal dimension T&G flooring or 4-inch thick CLT
- Roof decking
  - Minimum 2-inch thickness, 1-1/8-inch wood structural panels, or 3-inch thick CLT
- Partitions
  - 1-hour-fire-resistance-rated; or
  - Minimum 2 layers of 1-inch nominal board; or
  - Laminated construction 4-inches thick



Free at awc.org

Mass Timber and the IBC 129

129

2018 IBC: Type III

- Requires noncombustible or FRTW exterior bearing walls with minimum 2-hr FRR
  - Type IIIA – 1-hr FRR for building elements other than nonbearing walls
  - Type IIIB does not require any FRR other than exterior bearing walls



Mass Timber and the IBC 130

130

2018 IBC: Types I and II

- Requires most structural loadbearing elements to be noncombustible
  - Heavy timber permitted in roof
    - Table 601 footnote c (Type IB, IIA & IIB)
    - Alternate to 1-hr FRR noncombustible roof elements



Mass Timber and the IBC 131

131

2018 IBC: Heights & Areas

- IBC Chapter 5
  - Size thresholds for wood frame structures often determined by structural rather than code limitations
  - CLT and developments in mass timber technology are changing structural limitations for wood



Mass Timber and the IBC 132

132

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

2018 IBC: Heights & Areas

Table 504.3: Allowable Building Height (ft above grade)

	Occupancy Classification		Type of Construction				
			Type III		Type IV	Type V	
			A	B	HT	A	B
TABLE 504.3: Allowable Building Height (ft above Grade)	A, B, E, F, M, S, U	NS	65	55	65	50	40
		S	85	75	85	70	60
	I-1 Condition 1, I-3	NS	65	55	65	50	40
		S	85	75	85	70	60
	I-1 Condition 2, I-2	NS	65	55	65	50	40
		S					
	I-4	NS	65	55	65	50	40
		S	85	75	85	70	60
	R	NS	65	55	65	50	40
		S13R	60	60	60	60	60
		S	85	75	85	70	60

133

2018 IBC: Heights & Areas

Table 504.4: Allowable Number of Stories above Grade

	Occupancy Classification		Type of Construction				
			Type III		Type IV	Type V	
			A	B	HT	A	B
TABLE 504.4: Allowable Number of Stories above Grade	A-1, A-2, A-3, A-4	NS	3	2	3	2	1
		S	4	3	4	3	2
	B	NS	5	3	5	3	2
		S	6	4	6	4	3
	E	NS	3	2	3	1	1
		S	4	3	4	2	2
	M	NS	4	2	4	3	1
		S	5	3	5	4	2
	S-2	NS	4	3	4	4	2
		S	5	4	5	5	3
	R-1	NS	4	4	4	3	2
		S13R				4	3
		S	5	5	5	4	3
	R-2	NS	4	4	4	3	2
		S13R				4	3
		S	5	5	5	4	3

134

2018 IBC: Heights & Areas

Table 506.2: Allowable Area Factor

	Occupancy Classification		Type of Construction				
			Type III		Type IV	Type V	
			A	B	HT	A	B
TABLE 506.2: Allowable Area Factor	A-2, A-3	NS	14,000	9,500	15,000	11,500	6,000
		S1	56,000	38,000	60,000	46,000	24,000
		SM	42,000	28,500	45,000	34,500	18,000
	B	NS	28,500	19,000	36,000	18,000	9,000
		S1	114,000	76,000	144,000	72,000	36,000
		SM	85,500	57,000	108,000	54,000	27,000
	E	NS	23,500	14,500	25,500	18,500	9,500
		S1	94,000	58,000	102,000	74,000	38,000
		SM	70,500	43,500	76,500	55,500	28,500
	M	NS	18,500	12,500	20,500	14,000	9,000
		S1	74,000	50,000	82,000	56,000	36,000
		SM	55,500	37,500	61,500	42,000	27,000
	S-2	NS	39,000	26,000	38,500	21,000	13,500
		S1	156,000	104,000	154,000	84,000	54,000
		SM	117,000	78,000	115,500	63,000	40,500
	R-1, R-2	NS	24,000	16,000	20,500	12,000	7,000
		S13R					
		S1	96,000	64,000	82,000	48,000	28,000
		SM	72,000	48,000	61,500	36,000	21,000

135

2018 IBC: Allowable Increases

- Automatic Sprinkler Systems
- Building equipped with NFPA 13 automatic sprinkler system, allowable floor area can be increased
  - Single-story building – 3x
  - Multi-story building – 2x



136

2018 IBC: Single Occupancy

- IBC 506.2.3 – Buildings 3+ stories above grade have a total building area per story (A_a) calculated by Equation 5-2 with $S_a = 3$

$A_a = A_t + (NS \times I_f)$ Equation 5-1
$A_a = [A_t + (NS \times I_f)] \times S_a$ Equation 5-2

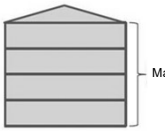
S_a = Actual number of building stories above grade plane, not to exceed three. For buildings equipped throughout with an automatic sprinkler system installed in accordance with Section 903.3.1.2, use the actual number of building stories above grade plane, not to exceed four



137

2018 IBC: Building Area

- **4 and 4+ Story Building**
  - Total Allowable Building Area
  - $A_a = 3 \times A_t$ (single story)
- **where**
  - A_a = allowable building area
  - A_t = allowable building area per story



- **Type IV (HT) Business**
  - Sprinklered
  - SM = 108,000 ft²
  - No frontage increase
- Stories of equal area
  - Each story may not exceed 324,000/4 = 81,000 ft²
- Stories of unequal area
  - No single story can exceed 108,000 ft²

138

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

2018 IBC: Wood Interior Finish

- Exceptions
  - Traditional wood floor covering exempt from interior floor finish requirements (804.1)
  - Exposed portions of Type IV structural members also exempt, except in exit elements (803.3)



Butler Building – Minneapolis
Courtesy of WoodWorks

Mass Timber and the IBC 139

139

2018 IBC: Fire Walls

- Fire walls define separate buildings for allowable building size (706)
  - Not fire barriers (707)
  - Not fire partitions (708)
  - Not smoke barriers, smoke partitions or horizontal assemblies
  - Table 706.4 gives required ratings based on occupancies separated

TABLE 706.4
FIRE WALL FIRE-RESISTANCE RATINGS

GROUP	FIRE-RESISTANCE RATING (hours)
A, B, E, H-4, I, R-1, R-2, U	3[a]
F-1, H-3[b], H-5, M, S-1	3
H-1, H-2	4[b]
F-2, S-2, R-3, R-4	2

Mass Timber and the IBC 140

140

2018 IBC: Fire Walls

- Type V construction
  - May be wood frame

706.3 Materials. *Fire walls* shall be of any *approved* noncombustible materials.
Exception: Buildings of Type V construction.

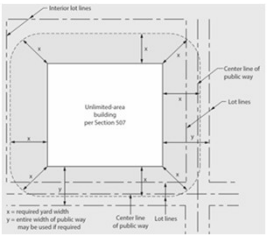
- Types III and IV construction
  - Must be noncombustible in accordance with IBC 706.3

Mass Timber and the IBC 141

141

2018 IBC: Unlimited Area

- One-Story – NFPA 13 Sprinklers
  - Public ways or yards not less than 60 feet wide – all sides
  - Group B, F, M and S
  - Limits in IBC 507.4

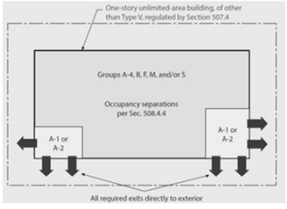


Mass Timber and the IBC 142

142

2018 IBC: Unlimited Area

- One-Story – NFPA 13 Sprinklers
- Group A-1 and A-2 allowed in unlimited area mixed occupancy containing Group B, F, M or S
  - Limits in IBC 507.4.1
  - Type III or IV construction
  - Occupancies separated per IBC 508.4.4
  - A-1 and A-2 portions shall not exceed max areas permitted by IBC 503.1
  - Group A-1 and A-2 exit doors must discharge directly to building exterior



Mass Timber and the IBC 143

143

2018 IBC: Unlimited Area

- One-Story – NFPA 13 Sprinkler System
- Group A-3
  - Limits in IBC 507.7
  - Types III or IV
  - Religious worship, community hall, dance hall, exhibition hall, gymnasium, lecture hall, indoor swimming pool or tennis
- Group A-4
  - Limits in IBC 507.4
  - Types IIIA, IIIB and IV
  - Tennis, swimming, skating and equestrian venues



Mass Timber and the IBC 144

144

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

2018 IBC: Unlimited Area

- One-Story – NFPA 13 Sprinkler System
- Group E
  - Limits in Section 507.11
  - Type IIIA or IV
  - Each classroom must have 2 means of egress, with one outside exit
  - Public ways or yards not less than 60 feet wide – all sides



Exit sign licensed under CC0 Public Domain

145

2018 IBC: Unlimited Area

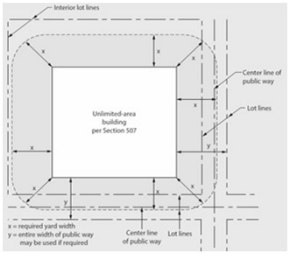
- One-Story – Non-sprinklered Buildings
- Group F-2 or S-2
  - Limits in IBC 507.3
  - Public ways or yards not less than 60 feet wide – all sides



146

2018 IBC: Unlimited Area

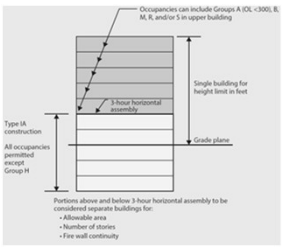
- Two-Story – NFPA 13 Sprinkler System
- Group B, F, M or S
  - Limits in Section 507.5
  - Public ways or yards not less than 60 feet wide – all sides



147

2018 IBC: Stacked Buildings – 510.2

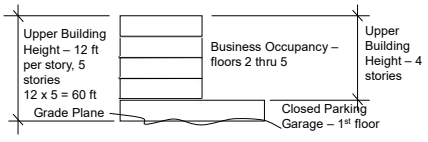
- 3-hour FRR Horizontal Assembly between upper & lower buildings
  - Upper Building
    - Group B, M and R
    - Group S-2 open & enclosed parking
    - Group A's (occupant load < 300)
  - Lower Building
    - Any occupancy except Group H



148

2018 IBC: Stacked Buildings – 510.2

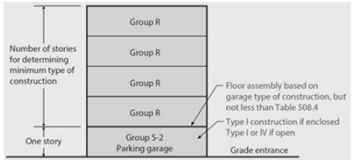
- Upper Building Height – in feet
  - Measured from grade plane
- Upper Building Height – in stories
  - Measured from top of lower building



149

2018 IBC: Stacked Buildings – 510.4

- Parking Beneath Group R
- Single-story Group S-2 parking garage
  - Grade entrance to parking
  - Type I if enclosed
  - Type I or IV if open



150

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

2018 IBC: Stacked Buildings – 510.7

- Open Parking Garage
- Beneath Groups A, B, I, M and R
- Height of upper building measured from grade plane and includes open parking garage level
- Open parking garage of Type IV construction permitted



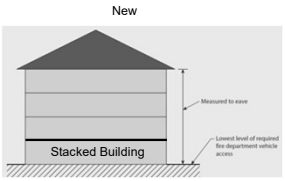
Image courtesy of SRG Partnership

Mass Timber and the IBC 151

151

2018 IBC: Stacked Buildings

- Attic Protection per IBC 903.3.1.2.3 (NFPA 13R)
- Types III, IV, and V when using IBC 510.2 and 510.4
  - Alternatives are attic sprinklers, noncombustible construction, FRTW, or filling entire space with noncombustible insulation
  - Protection applies when roof assembly > 55 feet above lowest level of required fire department access
  - Additional requirements for living or storage use, when fuel-fire equipment is present, and in R-4 Condition 2



Mass Timber and the IBC 152

152

Q&A



Mass Timber and the IBC 153

153

Outline

- Introduction to Mass Timber Products
- 2015/2018 IBC for Mass Timber Construction
- Break – 15 minutes
- 2021 IBC for Tall Mass Timber Construction
  - Part 1: Background and Overview
  - Lunch – 1 hour
  - Part 2: New Construction Types and Heights & Areas
  - Part 3: Fire Safety
  - Break – 15 minutes
  - Part 4: Fire & Connection Design and Special Inspection
  - Part 5: Acoustics, Energy, and Lateral Resistance
  - Part 6: Construction Fire Safety

Mass Timber and the IBC 154

154

Tall Mass Timber Construction per 2021 IBC

Part 1: Background and Overview

MASS TIMBER BUILDINGS AND THE IBC®

Mass Timber and the IBC 155

155

Mass Timber vs Traditional

Mass Timber		Conventional Light-Frame
	<-->	

Mass Timber and the IBC 156

156

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Mass Timber vs Traditional

Type IV-A, IV-B, IV-C <--> **Type IV-HT**





Mass Timber and the IBC 157

157

Sub-Outline

- TWB Ad Hoc Committee
- Consensus Process



Mass Timber and the IBC 158

158

ICC Tall Wood Ad Hoc Committee

- ICC Board Established ICC Ad Hoc Committee on Tall Wood Buildings - December 2015
  - Explore science of tall wood buildings
  - Investigate feasibility
  - Take action on developing code changes for tall wood buildings



Mass Timber and the IBC 159

159

ICC Tall Wood Ad Hoc Committee

- Consensus committee with necessary balance of stakeholders
- Building and Fire Officials
- Architects and engineers
- Fire protection experts
- Representatives from building construction material industries
- Other construction-related professionals



Photo courtesy of Susan Jones, atelierjones

Mass Timber and the IBC 160

160

ICC Tall Wood Ad Hoc Committee

- Four Work Groups appointed
  - Definitions and Standards
  - Fire
  - Structural
  - Codes
- 82 major issues investigated
- Hundreds of reports reviewed
- Performance Objectives discussed



Mass Timber and the IBC 161

161

ICC Tall Wood Ad Hoc Objectives

- TWB identified performance objectives
  - No collapse under reasonable scenarios of complete burn-out of fuel without automatic sprinkler protection considered
  - No unusually high radiation exposure from the subject building to adjoining properties to present a risk of ignition under reasonably severe fire scenarios
  - No unusual response from typical radiation exposure from adjacent properties to present a risk of ignition of the subject building under reasonably severe fire scenarios



Mass Timber and the IBC 162

162

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

ICC Tall Wood Ad Hoc Objectives

- TWB identified performance objectives (cont.)
  - No unusual fire department access issues
  - Egress systems designed to protect building occupants during design escape time, plus a safety factor
  - Highly reliable fire suppression systems to reduce risk of failure during reasonably expected fire scenarios – degree of reliability proportional to evacuation time (height) and collapse risk



163

ICC Tall Wood Ad Hoc Objectives

TWB determined that its comprehensive package of proposals met all performance objectives



164

ICC Tall Wood Ad Hoc Committee

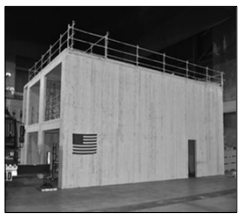
- Fire Work Group created fire test scenarios to study and validate TWB code change proposals
  - 2-story condo situation
  - 30 ft x 30 ft interior dimensions
  - Corridor and stair included in the structure
  - UL "modern furnishings" fuel load imposed → 570 MJ/m²
    - Fuel load was approximately 85th percentile of Group R fuel loads from survey of Group R's



165

Multi-Story Fire Tests

- Purpose: Perform tests of realistic fire scenarios applicable to tall wood construction in order to evaluate occupant and firefighter tenability for egress and suppression efforts, and provide data necessary to guide further development of relevant code and standard provisions
  - Conducted at U.S. government facilities (ATF)
  - Supervised by U.S. Forest Product Laboratory staff



166



167

ATF Fire Test Plan

- **Tests 1 through 3:** unlikely scenario in which automatic sprinklers fail to activate and fire service unable to respond
- **Test 4:** normal sprinkler activation
- **Test 5:** automatic sprinklers fail to activate, but are later manually charged by fire service



168

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

ATF Fire Test Scenarios

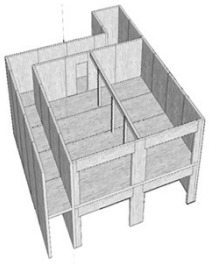
Test	Description	Date	Duration
1	All mass timber surfaces protected with 2-layers of 5/8" Type X GWB – establishes baseline	5/23/17	3 hours
2	30% of CLT ceiling area in living room and bedroom exposed – represents maximum exposure in Type IV-B	5/31/17	4 hours
3	Two opposing CLT walls exposed – one in bedroom and one in living room (there is a partition wall) – Type IV-B	6/20/17	4 hours
4	All mass timber surfaces fully exposed in bedroom and living room. Sprinklered – normal activation	6/27/17	6 minutes
5	All mass timber surfaces fully exposed in bedroom and living room (except bathroom). Sprinklered – 23 min delayed activation	6/29/17	30 minutes

Mass Timber and the IBC 169

169

Two-Story Structure

- Two stories, one apartment per level
- Each apartment: 30 ft x 30 ft
- Ceiling height: 9 ft
- 5-ply CLT
  - Douglas Fir-Larch species group
  - Lamination Thickness: 1.375 inches
  - CLT Thickness: 6.875 inches
  - Polyurethane Adhesive
- Corridor around each apartment
- Stairwell

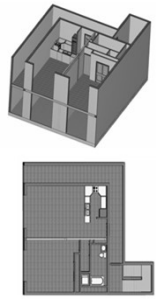


Mass Timber and the IBC 170

170

Apartment Layout

- Partitions used unrated ½" gypsum wallboard
- Kitchen & Living Room: 15 ft x 30 ft
- Bedroom & Bath: 15 ft x 30 ft
- 20-min rated door between compartment and corridor
- 90-min rated door between corridor and stairwell
- Fuel load ~570 MJ/m^2 (23 MW)



Mass Timber and the IBC 171

171

Apartment Furnishings – Bedroom & Bath



Photos provided by U.S. Forest Products Laboratory, USDA

Mass Timber and the IBC 172

172

Apartment Furnishings – Kitchen & Living Room



Photos provided by U.S. Forest Products Laboratory, USDA

Mass Timber and the IBC 173

173

ATF Fire Tests

Fire Test #1

All mass timber surfaces protected with **2 layers of 5/8" Type X GWB**

awc.org/codes-and-standards
Link to Youtube videos available on this page



Mass Timber and the IBC 174

174

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

ATF Fire Test #1 – All Mass Timber Protected



Video

175

ATF Fire Tests

Fire Test #2

30% of CLT ceiling area in living room and bedroom **exposed**

awc.org/codes-and-standards
Link to Youtube videos available on this page



176

ATF Fire Test #2 – 30% CLT



Photos provided by U.S. Forest Products Laboratory, USDA

Video

177

ATF Fire Test #2 – 30% CLT Ceilings Exposed

Results and Post-Fire Condition of Glulam and CLT After Gypsum Removal

- Fire intensity **decreased** subsequent to consumption of furnishings and contents (known as *decay phase*)
- Exposed mass timber surfaces **self-extinguished** in the decay phase
- Mass timber surfaces protected with 2 layers of 5/8" Type X GWB **remained mostly uncharred**



178

Section of Exposed CLT



179

ATF Fire Tests

Fire Test #3

Two **opposing CLT walls exposed** one in bedroom and one in living room

awc.org/codes-and-standards
Link to Youtube videos available on this page

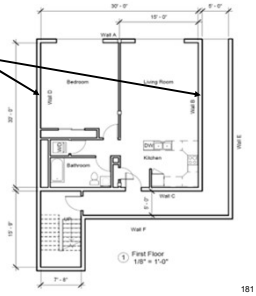


180

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

ATF Fire Test #3 – Exposed Walls

- Two opposing CLT walls exposed
  - Bedroom (D) and living room (B)
  - Results comparable to Test #2



181

ATF Fire Test #3 – Exposed Walls



Video

182

ATF Fire Tests

Fire Test #4

All mass timber surfaces fully exposed
in bedroom and living room

Sprinklered – normal activation

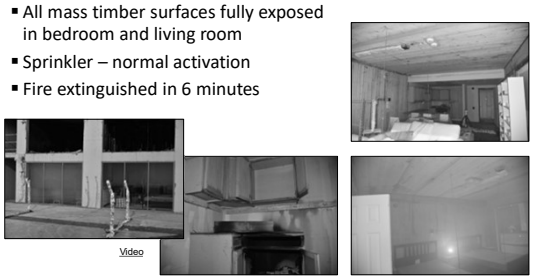
awc.org/codes-and-standards
Link to Youtube videos available on this page



183

ATF Fire Test #4 – Sprinklers, Exposed

- All mass timber surfaces fully exposed in bedroom and living room
- Sprinkler – normal activation
- Fire extinguished in 6 minutes



Video

184

ATF Fire Tests

Fire Test #5

All mass timber surfaces fully exposed
in bedroom and living room

Sprinklered
- activation delayed for 20 minutes after first head activation in Test #4
- …approximately 23 minutes from ignition…

awc.org/codes-and-standards
Link to Youtube videos available on this page



185

ATF Test #5 – Delayed Sprinklers, Exposed

- All mass timber surfaces fully exposed in bedroom and living room
- Sprinkler – water delayed 20 minutes after Test #4 sprinkler activation…approximately 23 minutes from ignition
- Flashover conditions reached in kitchen
- Bedroom nearly reached flashover
- Sprinkler system effectively suppressed fire



Video

186

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

ATF Fire Test Results – Event Log

Test No.	Flashover (600°C) Living Room	Flashover (600°C) Bedroom	Time After Ignition (mm:ss) Flames in Hallway	Compartment door Fails	Sprinkler Activation
1 1st floor	13:27	17:20	26:51	57:46	N/A
2 2nd floor	11:42	17:20	30:38	63:59	N/A
3 2nd floor	12:37	17:00	13:06 (door frame installation error)	29:42 (door frame installation error)	N/A
4 1st floor	-	-	-	-	2:37
5 1st floor	-	-	-	-	23:00

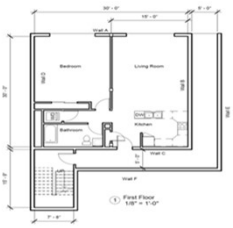
Tests 2 and 3 terminated at 4 hours with no re-growth

Mass Timber and the IBC 187

187

ATF Fire Test Results – Event Log

- Tests 2 and 3 terminated at 4 hours with no re-growth
- Flashover in living room consistent around 12-13 minutes
- Time to flashover in bedroom consistent at around 17 minutes
- Flames breach 20-minute hallway door about 27-30 minutes
- Test 3: 20-minute door failed early – improperly installed

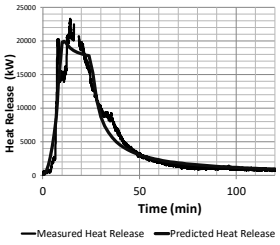


Mass Timber and the IBC 188

188

Comparison of Modeling & Measured Data

- Heat Release Data Comparison
  - Modeling conducted by Research Institutes of Sweden (RISE)
  - Measured data from ATF #2 with 30% Ceiling exposed

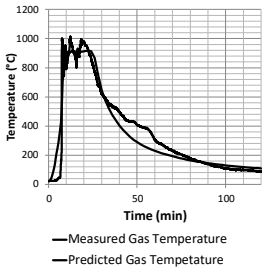


Mass Timber and the IBC 189

189

Comparison of Modeling & Measured Data

- Comparison of Ceiling Gas Temperature
  - Modeling conducted by Research Institutes of Sweden (RISE)
  - Measured data from ATF #2 with 30% Ceiling exposed



Mass Timber and the IBC 190

190

Research Justification

- Each new Construction Type based on conditions in at least 1 of 5 ATF fire tests
- Fire Test Plan developed by TWB Fire Work Group
- Test Plan included testing various "generic" connections as recommended by Structural Work Group
- Both mass timber (CLT) panels and other mass timber (glulam beams and columns) tested



Mass Timber and the IBC 191

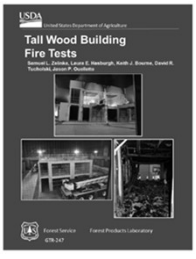
191

ATF Tall Mass Timber Fire Tests

Full Report on AWC Website

awc.org/codes-and-standards

Link to Youtube videos available on this page



Mass Timber and the IBC 192

192

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Sub-Outline

- TWB Ad Hoc Committee
- Consensus Process



Mass Timber and the IBC 193

193

TWB Committee Proposals

- 17 code change proposals under Group A and Group B
- 3 new types of construction approved
- New entries in Height & Area
- Multiple new requirements for safety during construction
- Exterior wall test standard still required (NFPA 285)



ALL 17 PROPOSALS APPROVED AS RECOMMENDED

Mass Timber and the IBC 194

194

TWB Group A Proposals

ALL APPROVED AS SUBMITTED OR APPROVED AS MODIFIED

- G108 New types of construction (602.4)
- G75 Height in feet (Table 504.3)
- G80 Height in stories (Table 504.4)
- G84 Allowable area per floor (Table 506.2)
- G89 Fire barriers (508.4 & 509.4)
- G146 MT Membrane/Special Const. (3102)
- G152 Appendix D-Fire Districts (G152)
- G28 Redundant water supply (403.3.2)
- FS5 Performance-based noncom protection (703.8)
- FS6 Sealing of Splices and intersections (703.9)
- FS73 Mass timber as fire blocking (718.2.1)
- FS81 Prescriptive noncom protection (722.7)
- IFC
  - F88 Owner responsibility (701.6)
  - F266 Fire safety during construction (3308.4)



Mass Timber and the IBC 195

195

TWB Group B Proposals

ALL APPROVED AS SUBMITTED OR APPROVED AS MODIFIED

- S170 Fire resistance of connections (2304.10.1)
- S100 Special inspection provisions (1705.5.3)
- ADM35 Inspection of connection protection (110.3.5)



Mass Timber and the IBC 196

196

Q&A



Mass Timber and the IBC 197

197



Outline

- Introduction to Mass Timber Products
- 2015/2018 IBC for Mass Timber Construction
- Break – 15 minutes
- 2021 IBC for Tall Mass Timber Construction
  - Part 1: Background and Overview
  - Lunch – 1 hour
  - Part 2: New Construction Types and Heights & Areas
  - Part 3: Fire Safety
  - Break – 15 minutes
  - Part 4: Fire & Connection Design and Special Inspection
  - Part 5: Acoustics, Energy, and Lateral Resistance
  - Part 6: Construction Fire Safety

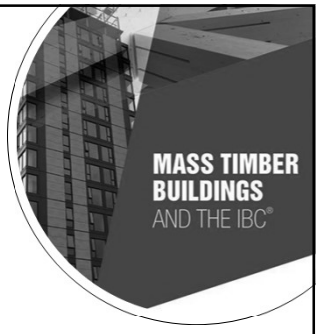
198

198

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Tall Mass Timber Construction per 2021 IBC

Part 2: New Construction Types and Heights & Areas



Mass Timber and the IBC 199

199

Sub-Outline

- Noncombustible Protection
- New Construction Types
- Heights and Areas



Mass Timber and the IBC 200

200

Definitions

DEFINITIONS FOR NEW IBC TERMS

- Mass Timber: Structural elements of Type IV construction primarily of solid, built-up, panelized or engineered wood products that meet minimum cross section dimensions of Type IV construction.
- Noncombustible Protection (FOR MASS TIMBER): Noncombustible material, in accordance with Section 703.6, designed to increase the fire-resistance rating and delay the combustion of mass timber.

Mass Timber and the IBC 201

201

Definitions

DEFINITIONS FOR NEW IBC TERMS

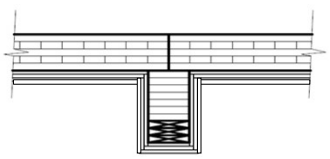
- Mass Timber: Structural elements of Type IV construction primarily of solid, built-up, panelized or engineered wood products that meet minimum cross section dimensions of Type IV construction.
- Noncombustible Protection (FOR MASS TIMBER): Noncombustible material, in accordance with Section 703.6, designed to increase the fire-resistance rating and delay the combustion of mass timber.

Mass Timber and the IBC 202

202

Noncombustible Time Contribution

722.7 Fire-resistance rating of mass timber. The required fire resistance of mass timber elements in Section 602.4 shall be determined in accordance with Section 703.2. The fire resistance rating of building elements shall be as required in Tables 601 and 705.5 and as specified elsewhere in this code. The fire-resistance rating of the mass timber elements shall consist of the fire resistance of the unprotected element added to the protection time of the noncombustible protection.



IV-A

IV-B

IV-C

Mass Timber and the IBC 203

203

Noncombustible Time Contribution

Protection Required

722.7.1 Minimum required protection. Where required by Section 602.4.1 through 602.4.3, *noncombustible protection* shall be provided for *mass timber* building elements in accordance with Table 722.7.1(1). The rating, in minutes, contributed by the *noncombustible protection* of *mass timber* building elements, components, or assemblies, shall be established in accordance with Section 703.6. The protection contributions indicated in Table 722.7.1(2) shall be deemed to comply with this requirement when installed and fastened in accordance with Section 722.7.2.

IV-A

IV-B

IV-C

Mass Timber and the IBC 204

204

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Noncombustible Time Contribution



Protection Required

TABLE 722.7.1(1)
PROTECTION REQUIRED FROM NONCOMBUSTIBLE COVERING MATERIAL

Required Fire-Resistance Rating of Building Element per Tables 601 and 705.5 (hours	Minimum Protection Required from Noncombustible Protection (minutes)
1	40
2	80
3 or more	120

IV-A IV-B IV-C



205

Noncombustible Time Contribution



Protection Required

722.7.1 Minimum required protection. Where required by Section 602.4.1 through 602.4.3, *noncombustible protection* shall be provided for *mass timber* building elements in accordance with Table 722.7.1(1). The rating, in minutes, contributed by the *noncombustible protection* of *mass timber* building elements, components, or assemblies, shall be established in accordance with Section 703.6. The protection contributions indicated in Table 722.7.1(2) shall be deemed to comply with this requirement when installed and fastened in accordance with Section 722.7.2.

IV-A IV-B IV-C



206

Noncombustible Time Contribution



Performance Method

703.6 Determination of noncombustible protection time contribution. The time, in minutes, contributed to the fire-resistance rating by the noncombustible protection of mass timber building elements, components, or assemblies, shall be established through a comparison of assemblies tested using procedures set forth in ASTM E119 or UL 263. The test assemblies shall be identical in construction, loading, and materials, other than the noncombustible protection. The two test assemblies shall be tested to the same criteria of structural failure.

1. Test Assembly 1 shall be without protection.
2. Test Assembly 2 shall include the representative noncombustible protection. The protection shall be fully defined in terms of configuration details, attachment details, joint sealing details, accessories and all other relevant details.

The noncombustible protection time contribution shall be determined by subtracting the fire-resistance time, in minutes, of Test Assembly 1 from the fire-resistance time, in minutes, of Test Assembly 2.

IV-A IV-B IV-C



207

Noncombustible Time Contribution



Protection Required

722.7.1 Minimum required protection. Where required by Section 602.4.1 through 602.4.3, *noncombustible protection* shall be provided for *mass timber* building elements in accordance with Table 722.7.1(1). The rating, in minutes, contributed by the *noncombustible protection* of *mass timber* building elements, components, or assemblies, shall be established in accordance with Section 703.6. The protection contributions indicated in Table 722.7.1(2) shall be deemed to comply with this requirement when installed and fastened in accordance with Section 722.7.2.

IV-A IV-B IV-C



208

Noncombustible Time Contribution



Prescriptive Method

TABLE 722.7.1(2)
PROTECTION PROVIDED BY NONCOMBUSTIBLE COVERING MATERIAL

Noncombustible Protection	Protection Contribution (minutes)
1/2 inch Type X Gypsum Board	25
5/8 inch Type X Gypsum Board	40

IV-A IV-B IV-C



209

Noncombustible Protection –722.7.2



- Type X Gypsum Board Used as Noncombustible Protection
  - Screws shall penetrate ≥ 1" into mass timber
  - Screws shall be spaced no more than 12" o.c. in each direction
  - Screws at panel edges shall be between 1" and 2" from the edge
  - Panel edges shall be offset 18" from those of adjacent layers
  - Stair-step profile required at wall-to-wall & wall-to-ceiling intersections
  - Screw heads and panel joints shall be covered with joint compound

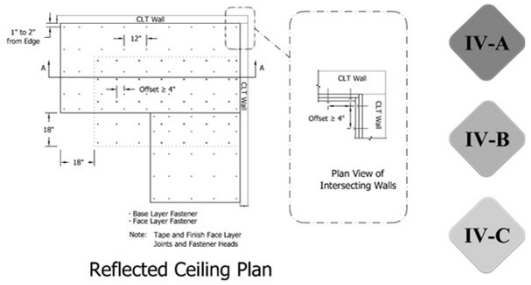
IV-A IV-B IV-C



210

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Noncombustible Protection –722.7.2

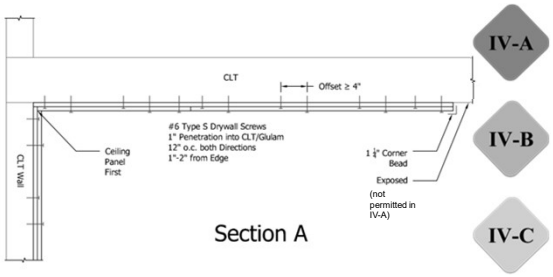


Reflected Ceiling Plan

IV-A IV-B IV-C

211

Noncombustible Protection –722.7.2



Section A

IV-A IV-B IV-C

212

Exterior Surfaces

722.7.2.2 Exterior surfaces. Layers of Type X gypsum board serving as noncombustible protection for the outside of the exterior heavy timber walls determined in accordance with Table 722.7.1(a) shall be fastened 12 inches on center each way and 6 inches on center at all joints or ends. All panel edges shall be attached with fasteners located at least 1 inch but not more than 2 inches from the panel edge. Fasteners shall comply with one of the following:

1. Galvanized nails of minimum 12 Gage with a 7/16-inch head of sufficient length to penetrate the mass timber a minimum of 1 inch.
2. Screws which comply with ASTM C 1002 (Type S, Type W, or Type G) of sufficient length to penetrate the mass timber a minimum of 1 inch.

IV-A IV-B IV-C

213

Sub-Outline

- Noncombustible Protection
- New Construction Types
- Heights and Areas



214

Building Element Fire-Resistance Ratings

TABLE 601
FIRE-RESISTANCE RATING REQUIREMENTS FOR BUILDING ELEMENTS (HOURS)

BUILDING ELEMENT	TYPE I		TYPE II		TYPE III		TYPE IV			HT	TYPE V	
	A	B	A	B	A	B	A	B	C		A	B
Primary structural frame[2] (see Section 202)	3[a, b]	2[a, b]	1[b, c]	0	1[b, c]	0	3[c]	2	2	HT	1[b, c]	0
Bearing walls												
Exterior[e, f]	3	2	1	0	2	2	3	2	2	2	1	0
Interior	3[c]	2[c]	1	0	1	0	3	2	2	1/HT[g]	1	0
Nonbearing walls and partitions Exterior	See Table 705.5											
Nonbearing walls and partitions Interior[d]	0	0	0	0	0	0	0	0	0	See Section 2304.11.2	0	0
Floor construction and associated secondary structural members (see Section 202)	2	2	1	0	1	0	2	2	2	HT	1	0
Roof construction and associated secondary structural members (see Section 202)	1½[c]	1[b, c]	1[b, c]	0[c]	1[b, c]	0	1½[c]	1[c]	1[c]	HT	1[b, c]	0

215

Building Element Fire-Resistance Ratings

TABLE 705.5 (formerly Table 602)
FIRE-RESISTANCE RATING REQUIREMENTS FOR EXTERIOR WALLS BASED ON FIRE SEPARATION DISTANCE[a, d, g]

FIRE SEPARATION DISTANCE = X (feet)	TYPE OF CONSTRUCTION	OCCUPANCY GROUP H[e]	OCCUPANCY GROUP F-1, M, S-1[f]	OCCUPANCY GROUP A, B, E, F-2, I, R[c], S-2, U[b]
X < 5[b]	All	3	2	1
5 ≤ X < 10	IA, IVA	3	2	1
	Others	2	1	1
10 ≤ X < 30	IA, IB, IVA, IVB	2	1	1[c]
	IIB, VB	1	0	0
	Others	1	1	1[c]
X ≥ 30	All	0	0	0

216

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

2021 IBC Construction Types

- Revise IBC 602.4 to reflect 3 new construction types

IV-A IV-B IV-C

- No changes to existing heavy timber provisions (formerly Type IV)
- Rename heavy timber to IV-HT (throughout code where referring to heavy timber as a construction type)
- Indicate heavy timber in sections where building elements are permitted to be "heavy timber" (e.g. Types I & II roofs)

IV-HT

Mass Timber and the IBC 217

217

2021 IBC Construction Types

Type of Construction -- Comparison			
Feature	**Type IV-A**	**Type IV-B**	**Type IV-C**
Description of New Construction Types	100% Noncombustible (NC) protection on all surfaces of Mass Timber (MT)	100% NC protection on all surfaces of mass timber (MT) except for limited exposed mass timber (MT) elements	100% exposed mass timber (MT) except: shafts, concealed spaces, and outside of exterior walls
Permitted Materials			
Structural Building Elements	MT or NC	MT or NC	MT or NC
Non-loadbearing Exterior Walls	MT or NC	MT or NC	MT or NC
Non-loadbearing Interior Walls	MT or NC	MT or NC	MT or NC
Shaft and Exit Enclosures			
Highrise* to 12 stories or 180 ft: *see IBC definition of highrise	NC or MT protected with 2 (or 3 when 3 hr FRR) layers of 5/8" type X	NC or MT protected with 2 layers of 5/8" type X gypsum or equiv each side of enclosure	NC or MT protected with one layer of 5/8" type X gypsum each side of shaft or enclosure
Above 12 stories or 180 feet:	NC	Not Permitted	Not Permitted

Mass Timber and the IBC 218

218

2021 IBC Construction Types

Type of Construction -- Comparison			
Feature	**Type IV-A**	**Type IV-B**	**Type IV-C**
Description of New Construction Types	100% Noncombustible (NC) protection on all surfaces of Mass Timber (MT)	100% NC protection on all surfaces of mass timber (MT) except for limited exposed mass timber (MT) elements	100% exposed mass timber (MT) except: shafts, concealed spaces, and outside of exterior walls
Permitted Materials			
Structural Building Elements	MT or NC	MT or NC	MT or NC
Non-loadbearing Exterior Walls	MT or NC	MT or NC	MT or NC
Non-loadbearing Interior Walls	MT or NC	MT or NC	MT or NC
Shaft and Exit Enclosures			
Highrise* to 12 stories or 180 ft: *see IBC definition of highrise	NC or MT protected with 2 (or 3 when 3 hr FRR) layers of 5/8" type X	NC or MT protected with 2 layers of 5/8" type X gypsum or equiv each side of enclosure	NC or MT protected with one layer of 5/8" type X gypsum each side of shaft or enclosure
Above 12 stories or 180 feet:	NC	Not Permitted	Not Permitted

Mass Timber and the IBC 219

219

2021 IBC Construction Types

Type of Construction -- Comparison			
Feature	**Type IV-A**	**Type IV-B**	**Type IV-C**
Description of New Construction Types	100% Noncombustible (NC) protection on all surfaces of Mass Timber (MT)	100% NC protection on all surfaces of mass timber (MT) except for limited exposed mass timber (MT) elements	100% exposed mass timber (MT) except: shafts, concealed spaces, and outside of exterior walls
Permitted Materials			
Structural Building Elements	MT or NC	MT or NC	MT or NC
Non-loadbearing Exterior Walls	MT or NC	MT or NC	MT or NC
Non-loadbearing Interior Walls	MT or NC	MT or NC	MT or NC
Shaft and Exit Enclosures			
Highrise* to 12 stories or 180 ft: *see IBC definition of highrise	NC or MT protected with 2 (or 3 when 3 hr FRR) layers of 5/8" type X	NC or MT protected with 2 layers of 5/8" type X gypsum or equiv each side of enclosure	NC or MT protected with one layer of 5/8" type X gypsum each side of shaft or enclosure
Above 12 stories or 180 feet:	NC	Not Permitted	Not Permitted

Mass Timber and the IBC 220

220

2021 IBC Construction Types

Type of Construction -- Comparison			
Feature	**Type IV-A**	**Type IV-B**	**Type IV-C**
Description of New Construction Types	100% Noncombustible (NC) protection on all surfaces of Mass Timber (MT)	100% NC protection on all surfaces of mass timber (MT) except for limited exposed mass timber (MT) elements	100% exposed mass timber (MT) except: shafts, concealed spaces, and outside of exterior walls
Permitted Materials			
Structural Building Elements	MT or NC	MT or NC	MT or NC
Non-loadbearing Exterior Walls	MT or NC	MT or NC	MT or NC
Non-loadbearing Interior Walls	MT or NC	MT or NC	MT or NC
Shaft and Exit Enclosures			
Highrise* to 12 stories or 180 ft: *see IBC definition of highrise	NC or MT protected with 2 (or 3 when 3 hr FRR) layers of 5/8" type X	NC or MT protected with 2 layers of 5/8" type X gypsum or equiv each side of enclosure	NC or MT protected with one layer of 5/8" type X gypsum each side of shaft or enclosure
Above 12 stories or 180 feet:	NC	Not Permitted	Not Permitted

Mass Timber and the IBC 221

221

2021 IBC Construction Types

- TYPE IV-A – Mass Timber with noncombustible protection
  - Noncombustible protection at least 2/3 FRR for Building Elements (Table 601, 705.5)
  - Taller buildings – no exposed mass timber
- TYPE IV-B – Mass Timber with limited exposed MT
  - Limits how much mass timber can be exposed
  - Limits how close exposed areas can be to one another
- TYPE IV-C – Mass Timber with no requirement for noncombustible protection, except certain features

IV-A IV-B IV-C

Mass Timber and the IBC 222

222

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

2021 IBC Construction Types

- TYPE IV-A – Mass Timber with noncombustible protection
  - Noncombustible protection at least 2/3 FRR for Building Elements (Table 601, 602)
  - Taller buildings – no exposed mass timber
- TYPE IV-B – Mass Timber with limited exposed MT
  - Limits how much mass timber can be exposed
  - Limits how close exposed areas can be to one another
- TYPE IV-C – Mass Timber with no requirement for noncombustible protection, except certain features

IV-A

Mass Timber and the IBC 223

223

2021 IBC Construction Types

- TYPE IV-A – Mass Timber with noncombustible protection
  - Noncombustible protection at least 2/3 FRR for Building Elements (Table 601, 602)
  - Taller buildings – no exposed mass timber
- TYPE IV-B – Mass Timber with limited exposed MT
  - Limits how much mass timber can be exposed
  - Limits how close exposed areas can be to one another
- TYPE IV-C – Mass Timber with no requirement for noncombustible protection, except certain features

IV-B

Mass Timber and the IBC 224

224

2021 IBC Construction Types

- TYPE IV-A – Mass Timber with noncombustible protection
  - Noncombustible protection at least 2/3 FRR for Building Elements (Table 601, 602)
  - Taller buildings – no exposed mass timber
- TYPE IV-B – Mass Timber with limited exposed MT
  - Limits how much mass timber can be exposed
  - Limits how close exposed areas can be to one another
- TYPE IV-C – Mass Timber with no requirement for noncombustible protection, except certain features

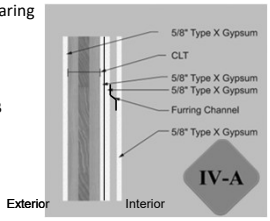
IV-C

Mass Timber and the IBC 225

225

2021 IBC Type IV-A Exterior Wall

- 3-hr FRR for exterior and interior bearing walls (Table 601)
- 2/3 FRR noncombustible protection
- 2-hr FRR noncombustible protection
- 2-hr FRR = 3 layers 5/8" Type X GWB
  - 40-min x 3 layers = 120-min
- Furring channel per AISI S220



Mass Timber and the IBC 226

226

2021 IBC Type IV-A

- Fire research
- Full-scale, multi-story
- Simulated new construction types
- ATF Fire Test Lab



IV-A

Mass Timber and the IBC 227

227

2021 IBC 602.4.1 Type IV-A

- All mass timber must have noncombustible protection – interior and exterior
- Floors must have minimum 1-inch noncombustible material above the mass timber



IV-A

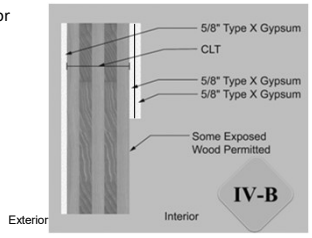
Mass Timber and the IBC 228

228

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

2021 IBC Type IV-B Exterior Wall

- 2-hr FRR for exterior and interior bearing walls (Table 601)
- 2/3 FRR noncom protection = 2 layers 5/8" GB @ 40-min
- 2-hr x 2/3 = 80-min
- 40-min x 2 = 80-min



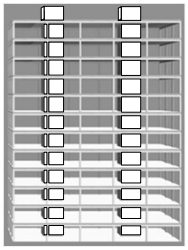
Mass Timber and the IBC 229

229

2021 IBC 602.4.2 Type IV-B

- Interior MT can be partially exposed
- Noncombustible protection certain areas
  - Exterior of exterior walls protected 40 min noncom
  - MT in concealed spaces protected
  - Shafts protected inside and room-side with 80 min noncom
  - Floors must have minimum 1-inch noncombustible material above the mass timber

IV-B



Mass Timber and the IBC 230

230

2021 IBC 602.4.2 Type IV-B

602.4.2.2.2 Protected Area. Interior faces of mass timber elements shall be protected in accordance with Section 602.4.2.2.1, including the inside faces of exterior mass timber walls and mass timber roofs.

Exceptions: Unprotected portions of mass timber ceilings and walls complying with Section 602.4.2.2.4 and the following:

1. Unprotected portions of mass timber ceilings and walls complying with one of the following:
   - 1.1 Unprotected portions of mass timber ceilings, including attached beams, shall be permitted and shall be limited to an area equal to 20% of the floor area in any dwelling unit or fire area.
   - 1.2 Unprotected portions of mass timber walls, including attached columns, shall be permitted and shall be limited to an area equal to 40% of the floor area in any dwelling unit or fire area.
   - 1.3 Unprotected portions of both walls and ceilings of mass timber, including attached columns and beams, in any dwelling unit or fire area shall be permitted in accordance with section 602.4.2.2.3.

IV-B

Mass Timber and the IBC 231

231

2021 IBC 602.4.2 Type IV-B

602.4.2.2.2 Protected Area

Exceptions (continued)

2. Mass timber columns and beams that are not an integral portion of walls or ceilings, respectively, shall be permitted to be unprotected without restriction of either aggregate area or separation from one another.

Exception 2 may be applied simultaneously with Exception 1.1, 1.2 or 1.3

IV-B

Mass Timber and the IBC 232

232

2021 IBC 602.4.2 Type IV-B

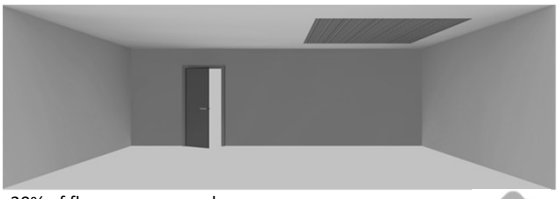


IV-B

Mass Timber and the IBC 233

233

2021 IBC 602.4.2 Type IV-B



20% of floor area exposed

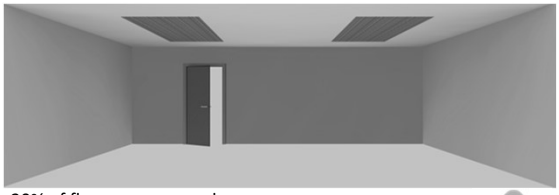
IV-B

Mass Timber and the IBC 234

234

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

2021 IBC 602.4.2 Type IV-B



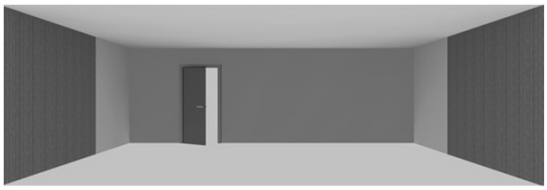
20% of floor area exposed

IV-B

Mass Timber and the IBC 235

235

2021 IBC 602.4.2 Type IV-B



40% of floor area exposed

IV-B

Mass Timber and the IBC 236

236

2021 IBC 602.4.2 Type IV-B

602.4.2.2.3 Mixed Unprotected Areas. In each dwelling unit or fire area, where both portions of ceilings and portions of walls are unprotected, the total allowable unprotected area shall be determined in accordance with Equation 6-1.

$$(U_{tc}/U_{ac}) + (U_{tw}/U_{aw}) \leq 1 \qquad \text{(Equation 6-1)}$$

IV-B

where:

U_{tc} = Total unprotected mass timber ceiling areas

U_{ac} = Allowable unprotected mass timber ceiling area conforming to Exception 1.1 of Section 602.4.2.2.2

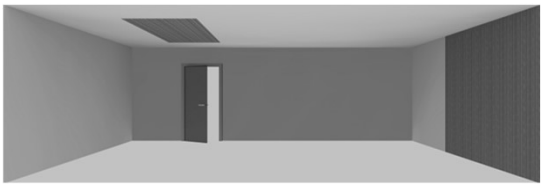
U_{tw} = Total unprotected mass timber wall areas

U_{aw} = Allowable unprotected mass timber wall area conforming to Exception 1.2 of Section 602.4.2.2.2

Mass Timber and the IBC 237

237

2021 IBC 602.4.2 Type IV-B

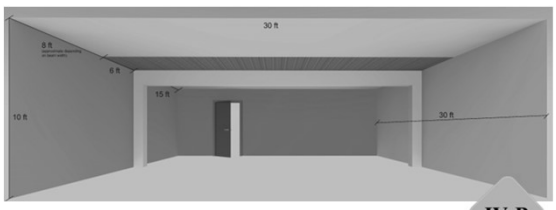


IV-B

Mass Timber and the IBC 238

238

2021 IBC 602.4.2 Type IV-B

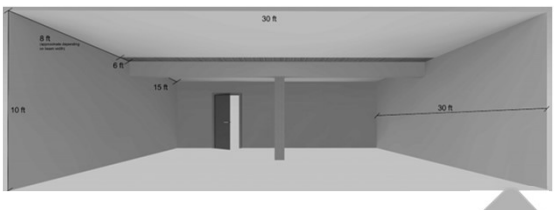


IV-B

Mass Timber and the IBC 239

239

2021 IBC 602.4.2 Type IV-B



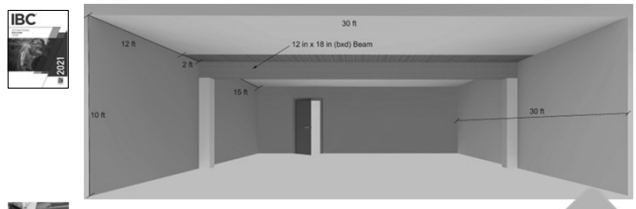
IV-B

Mass Timber and the IBC 240

240

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

2021 IBC 602.4.2 Type IV-B

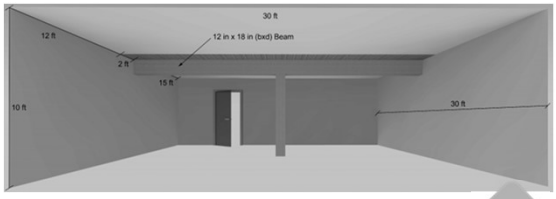


IV-B

Mass Timber and the IBC 241

241

2021 IBC 602.4.2 Type IV-B



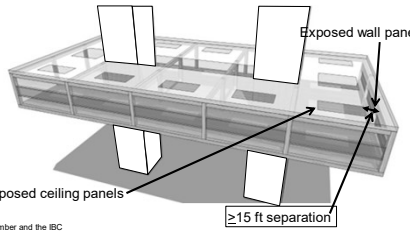
IV-B

Mass Timber and the IBC 242

242

Separation of Unprotected MT

602.4.2.2.4 Separation Distance Between Unprotected Mass Timber Elements. In each *dwelling unit* or *fire area*, unprotected portions of mass timber walls and ceilings shall be not less than 15 feet from unprotected portions of other walls and ceilings, measured horizontally along the ceiling and from other unprotected portions of walls measured horizontally along the floor.

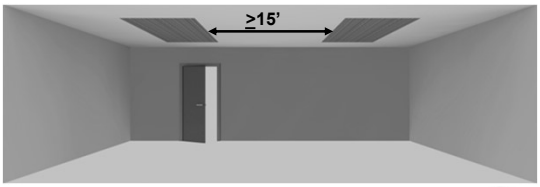


IV-B

Mass Timber and the IBC 243

243

2021 IBC 602.4.2 Type IV-B

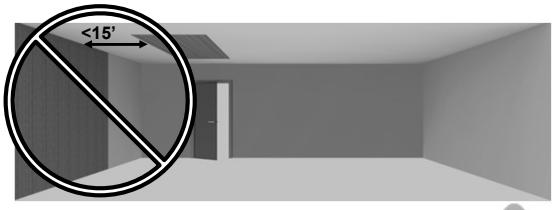


IV-B

Mass Timber and the IBC 244

244

2021 IBC 602.4.2 Type IV-B

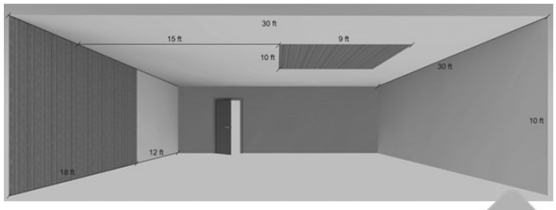


IV-B

Mass Timber and the IBC 245

245

2021 IBC 602.4.2 Type IV-B



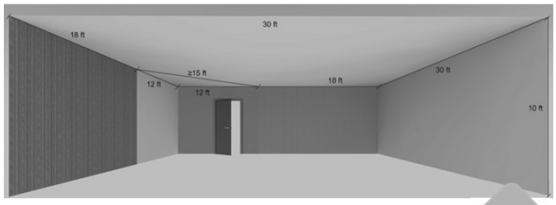
IV-B

Mass Timber and the IBC 246

246

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

2021 IBC 602.4.2 Type IV-B

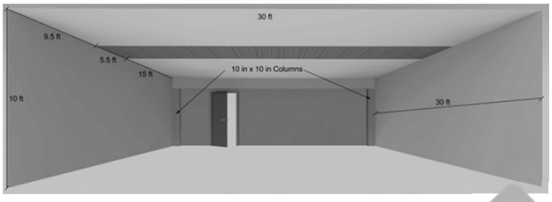


IV-B

Mass Timber and the IBC 247

247

2021 IBC 602.4.2 Type IV-B



IV-B

Mass Timber and the IBC 248

248

2021 IBC Type IV-C



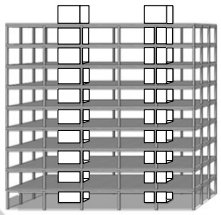
IV-C

Mass Timber and the IBC 249

249

2021 IBC 602.4.3 Type IV-C

- Interior MT can be exposed
- Noncombustible protection certain areas
  - Exterior of exterior walls protected 40 min noncom
  - Floors must meet IBC 804
  - MT in concealed spaces protected
    - No combustibles other than plenum
  - Shafts protected inside and room-side with 40 min noncom



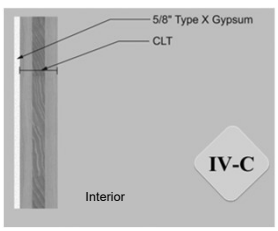
IV-C

Mass Timber and the IBC 250

250

2021 IBC Type IV-C Exterior Wall

- 2-hr FRR for exterior and interior bearing walls (Table 601)
- CLT must be designed for 2-hr FRR if exposed



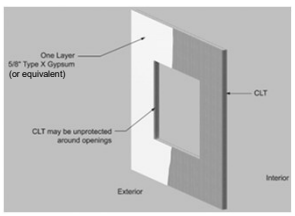
IV-C

Mass Timber and the IBC 251

251

Exterior Wall Section

All material outboard of Mass Timber MUST BE NONCOMBUSTIBLE
Except: water resistive barrier



IV-A
IV-B
IV-C

Mass Timber and the IBC 252

252

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

NFPA 285 Fire Tests

1402.5 ~~Vertical and lateral flame propagation~~ Water-resistive Barriers. *Exterior walls* on buildings of Type I, II, III or IV construction that are greater than 40 feet in height above grade plane and contain a combustible *water-resistive barrier* shall be tested in accordance with and comply with the acceptance criteria of NFPA 285…



Mass Timber and the IBC 253

253

Outline

- Noncombustible Protection
- New Construction Types
- Heights and Areas



Mass Timber and the IBC 254

254

Allowable Heights – Table 504.3

TABLE 504.3
ALLOWABLE BUILDING HEIGHT IN FEET ABOVE GRADE PLANE[a]

OCCUPANCY CLASSIFICATION	SEE FOOTNOTES	TYPE OF CONSTRUCTION: TYPE I A	TYPE I B	TYPE II A	TYPE II B	TYPE III A	TYPE III B	TYPE IV A	TYPE IV B	TYPE IV C	TYPE IV HT	TYPE V A	TYPE V B
A, B, E, F, M, S, U	NS[b]	UL	160	65	55	65	55	65	65	65	65	50	40
	S	UL	180	85	75	85	75	270	180	85	85	70	60
H-1, H-2, H-3, H-5	NS[c,d]	UL	160	65	55	65	55	120	90	65	65	50	40
	S												
H-4	NS[c,d]	UL	160	65	55	65	55	65	65	65	65	50	40
	S	UL	180	85	75	85	75	140	100	85	85	70	60
I-1 Condition 1, I-3	NS[d,e]	UL	160	65	55	65	55	65	65	65	65	50	40
	S	UL	180	85	75	85	75	180	120	85	85	70	60
I-1 Condition 2, I-2	NS[d,e,f]	UL	160	65	55	65	55	65	65	65	65	50	40
	S	UL	180	85									
I-4	NS[d,e]	UL	160	65	55	65	55	65	65	65	65	50	40
	S	UL	180	85	75	85	75	180	120	85	85	70	60
R[h]	NS[d]	UL	160	65	55	65	55	65	65	65	65	50	40
	S13D	60	60	60	60	60	60	60	60	60	60	50	40
	S13R	60	60	60	60	60	60	60	60	60	60	60	60
	S	UL	180	85	75	85	75	270	180	85	85	70	60

No changes to footnotes.

Sprinklered: IV-B = I-B & IV-A = 1.5 x IV-B with exceptions

IV-A IV-B IV-C

Mass Timber and the IBC 255

255

Allowable Stories – Table 504.4

ALLOWABLE NUMBER OF STORIES ABOVE GRADE PLANE[a,b]

OCCUPANCY CLASSIFICATION	SEE FOOTNOTES	TYPE OF CONSTRUCTION: TYPE I A	TYPE I B	TYPE II A	TYPE II B	TYPE III A	TYPE III B	TYPE IV A	TYPE IV B	TYPE IV C	TYPE IV HT	TYPE V A	TYPE V B
A-1	NS	UL	5	3	2	3	2	3	3	3	3	2	1
	S	UL	6	4	3	4	3	9	6	4	4	3	2
A-2	NS	UL	11	3	2	3	2	3	3	3	3	2	1
	S	UL	12	4	3	4	3	18	12	6	4	3	2
A-3	NS	UL	11	3	2	3	2	3	3	3	3	2	1
	S	UL	12	4	3	4	3	18	12	6	4	3	2
A-4	NS	UL	11	3	2	3	2	3	3	3	3	2	1
	S	UL	12	4	3	4	3	18	12	6	4	3	2
A-5	NS	UL	UL	UL	UL	UL	UL	1	1	1	UL	UL	UL
	S	UL	UL	UL	UL	UL	UL	UL	UL	UL	UL	UL	UL
B	NS	UL	11	5	3	5	3	5	5	5	5	3	2
	S	UL	12	6	4	6	4	18	12	9	6	4	3
E	NS	UL	5	3	2	3	2	3	3	3	3	1	1
	S	UL	6	4	3	4	3	9	6	4	4	2	2
F-1	NS	UL	11	4	2	3	2	3	3	3	4	2	1
	S	UL	12	5	3	4	3	10	7	5	5	3	2
F-2	NS	UL	11	5	3	4	3	5	5	5	5	3	2
	S	UL	12	6	4	5	4	12	8	6	6	4	3

Sprinklered: IV-B = I-B & IV-A = 1.5 x IV-B with exceptions

IV-A IV-B IV-C

Mass Timber and the IBC 256

256

Allowable Stories – Table 504.4 (cont'd)

ALLOWABLE NUMBER OF STORIES ABOVE GRADE PLANE[a,b]

OCCUPANCY CLASSIFICATION	SEE FOOTNOTES	TYPE OF CONSTRUCTION: TYPE I A	TYPE I B	TYPE II A	TYPE II B	TYPE III A	TYPE III B	TYPE IV A	TYPE IV B	TYPE IV C	TYPE IV HT	TYPE V A	TYPE V B
H-1	NS[c,d]	1	1	1	1	1	1	NP	NP	NP	1	1	NP
	S							1	1	1			
H-2	NS[c,d]	UL	3	2	1	2	1	1	1	1	2	1	1
	S							2	2	2			
H-3	NS[c,d]	UL	6	4	2	4	2	3	3	3	4	2	1
	S							4	4	4			
H-4	NS[c,d]	UL	7	5	3	5	3	5	5	5	5	3	2
	S	UL	8	6	4	6	4	8	7	6	6	4	3
H-5	NS[c,d]	4	4	3	3	3	3	2	2	2	3	3	2
	S							3	3	3			
I-1 Condition 1	NS[d,e]	UL	9	4	3	4	3	4	4	4	4	3	2
	S	UL	10	5	4	5	4	10	7	5	5	4	3
I-1 Condition 2	NS[d,e]	UL	9	4	3	4	3	3	3	3	4	3	2
	S	UL	10	5				10	6	4			
I-2	NS[d,e]	UL	4	2	1	1	NP	NP	NP	NP	1	1	NP
	S	UL	5	3				7	5	2			
I-3	NS[d,e]	UL	4	2	1	2	1	2	2	2	2	2	1
	S	UL	5	3	2	3	2	7	5	3	3	3	2
I-4	NS[d,g]	UL	5	3	2	3	2	3	3	3	3	1	1
	S	UL	6	4	3	4	3	9	6	4	4	2	2

IV-C = IV-HT with exceptions

IV-A IV-B IV-C

Mass Timber and the IBC 257

257

Allowable Stories – Table 504.4 (cont'd)

ALLOWABLE NUMBER OF STORIES ABOVE GRADE PLANE[a,b]

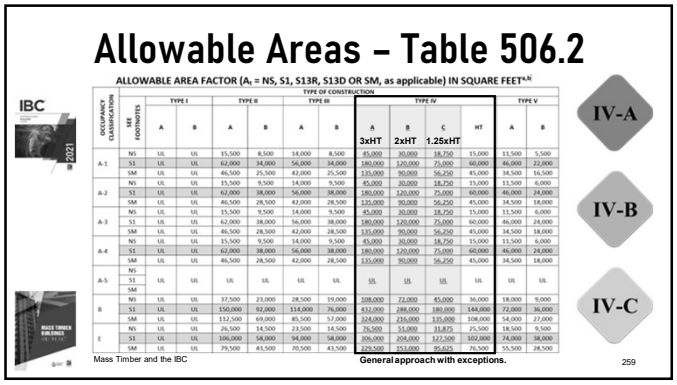
OCCUPANCY CLASSIFICATION	SEE FOOTNOTES	TYPE OF CONSTRUCTION: TYPE I A	TYPE I B	TYPE II A	TYPE II B	TYPE III A	TYPE III B	TYPE IV A	TYPE IV B	TYPE IV C	TYPE IV HT	TYPE V A	TYPE V B
M	NS	UL	11	4	2	4	2	4	4	4	4	3	1
	S	UL	12	5	3	5	3	12	8	6	5	4	2
R-1	NS[c]	UL	11					4	4	4	4	3	2
	S13R	4	4	4	4	4	4					4	3
	S	UL	12	5	5	5	5	18	12	8	5	4	3
R-2	NS[c]	UL	11	4	4	4	4	4	4	4	4	3	2
	S13R	4	4	4								4	3
	S	UL	12	5	5	5	5	18	12	8	5	4	3
R-3[h]	NS[c]	UL	11									3	3
	S13D	4	4	4	4	4	4	4	4	4	4	3	3
	S13R	4	4									4	4
	S	UL	12	5	5	5	5	18	12	8	5	4	4
R-4[h]	NS[c]	UL	11									3	2
	S13D	4	4	4	4	4	4	4	4	4	4	3	2
	S13R	4	4									4	3
	S	UL	12	5	5	5	5	18	12	8	5	4	3
S-1	NS	UL	11	4	2	3	2	4	4	4	4	3	1
	S	UL	12	5	3	4	3	10	7	5	5	4	2
S-2	NS	UL	11	5	3	4	3	4	4	4	4	3	2
	S	UL	12	6	4	5	4	12	8	5	5	4	3
U	NS	UL	5	4	2	3	2	4	4	4	4	2	1
	S	UL	6	5	3	4	3	9	6	5	5	3	2

IV-A IV-B IV-C

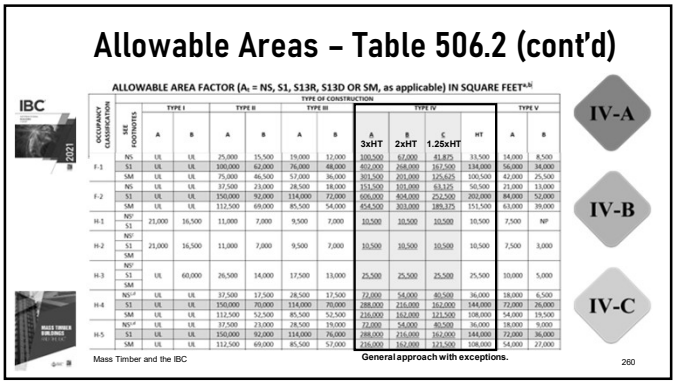
Mass Timber and the IBC 258

258

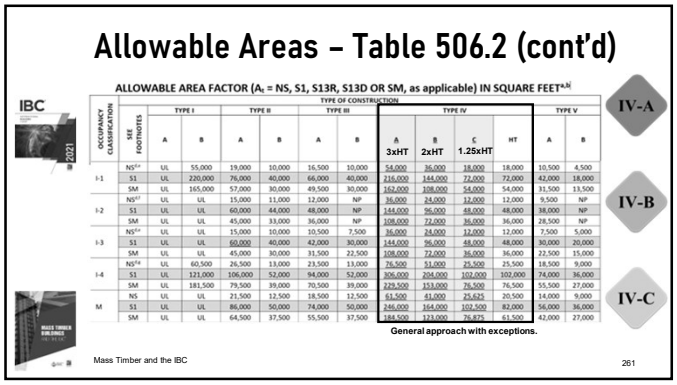
Copyright © 2021 American Wood Council and International Code Council. All rights reserved.



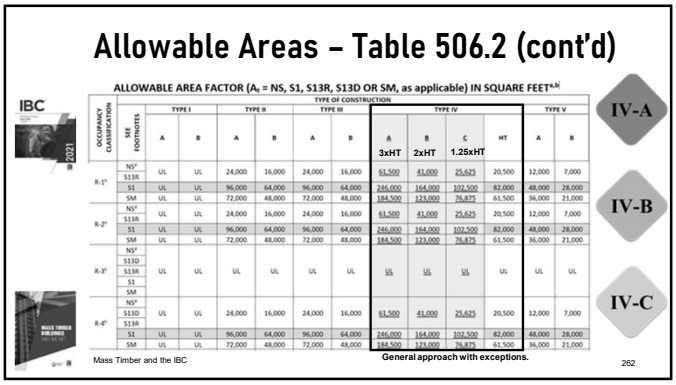
259



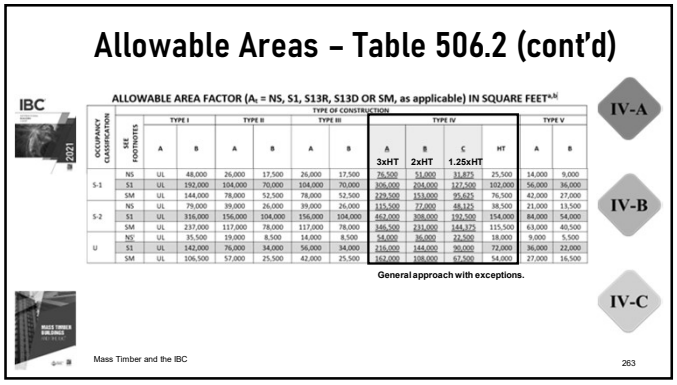
260



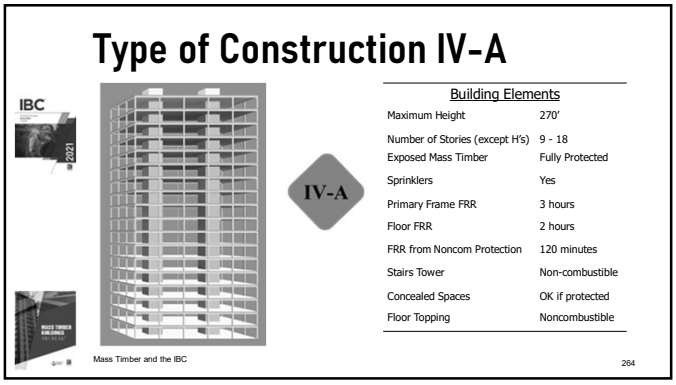
261



262



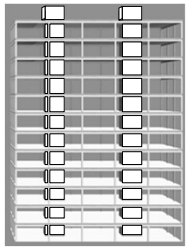
263



264

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Type of Construction IV-B



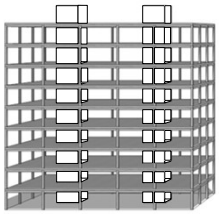
IV-B

Building Elements	
Maximum Height	180′
Number of Stories (except H's)	6 - 12
Exposed Mass Timber	Partially
Sprinklers	Yes
Primary Frame FRR	2 hours
Floor FRR	2 hours
FRR from Noncom Protection	80 minutes
Stairs Tower	Protected mass timber
Concealed Spaces	OK if protected
Floor Topping	Noncombustible

Mass Timber and the IBC 265

265

Type of Construction IV-C

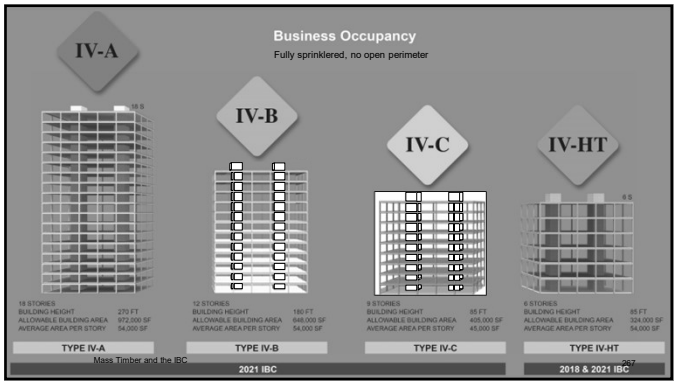


IV-C

Building Element	
Maximum Height	85′
Number of Stories	4 - 9
Exposed Mass Timber	Fully Exposed
Sprinklers	Yes
Primary Frame FRR	2 hours
Floor FRR	2 hours
Stairs Tower	Protected mass timber
FRR from Non-com Protection	0 hours
Concealed Spaces	OK if Protected
Floor Topping	No requirement

Mass Timber and the IBC 266

266



Mass Timber and the IBC 267

267

Q&A



Mass Timber and the IBC 268

268

Outline

- Introduction to Mass Timber Products
- 2015/2018 IBC for Mass Timber Construction
- Break – 15 minutes
- 2021 IBC for Tall Mass Timber Construction
  - Part 1: Background and Overview
  - Lunch – 1 hour
  - Part 2: New Construction Types and Heights & Areas
  - Part 3: Fire Safety
  - Break – 15 minutes
  - Part 4: Fire & Connection Design and Special Inspection
  - Part 5: Acoustics, Energy, and Lateral Resistance
  - Part 6: Construction Fire Safety

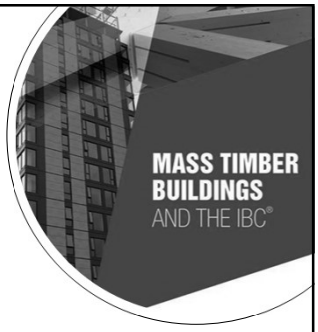


Mass Timber and the IBC 269

269

Tall Mass Timber Construction per 2021 IBC

Part 3: Fire Safety



Mass Timber and the IBC 270

270

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Sub-Outline

- Fire Barriers
- Shaft Walls
- Sealing Abutting Edges/Intersections and Fire Blocking Material
- New Redundant Sprinkler Water Supply Systems
- Concealed Spaces and Heavy Timber
- Owner's Responsibilities



Mass Timber and the IBC 271

271

Occupancy Separation

508.4.4.1 Construction. Required separations shall be *fire barriers* constructed in accordance with Section 707 or *horizontal assemblies* constructed in accordance with Section 711, or both, so as to completely separate adjacent occupancies. Mass timber elements serving as fire barriers or horizontal assemblies to separate occupancies in Type IV-B or IV-C construction shall be separated from the interior of the building with an approved thermal barrier consisting of a minimum of ½ gypsum board or a material that is tested in accordance with and meets the acceptance criteria of both the Temperature Transmission Fire Test and the Integrity Fire Test of NFPA 275.

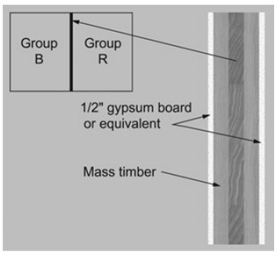
IV-B

IV-C

Mass Timber and the IBC 272

272

Separated Mixed Use



IV-B

IV-C

Mass Timber and the IBC 273

273

Incidental Use Separation

509.4.1.1 Type IV-B and IV-C construction. Where Table 509 specifies a fire-resistance-rated separation, mass timber elements serving as fire barriers or a horizontal assembly in Type IV-B or IV-C construction shall be separated from the interior of the incidental use with an approved thermal barrier consisting of a minimum of ½ inch gypsum board or a material that is tested in accordance with and meets the acceptance criteria of both the Temperature Transmission Fire Test and the Integrity Fire Test of NFPA 275.

IV-B

IV-C

Mass Timber and the IBC 274

274

Sub-Outline

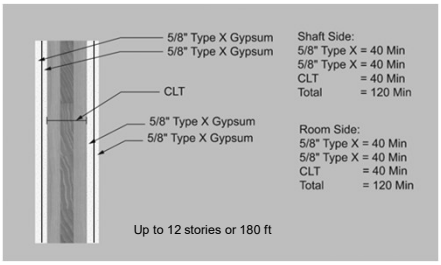
- Fire Barriers
- Shaft Walls
- Sealing Abutting Edges/Intersections and Fire Blocking Material
- New Redundant Sprinkler Water Supply Systems
- Concealed Spaces and Heavy Timber
- Owner's Responsibilities



Mass Timber and the IBC 275

275

Shaft Walls



IV-A

Height restricted

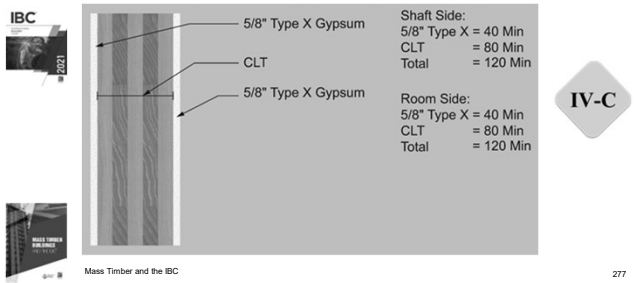
IV-B

Mass Timber and the IBC 276

276

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Shaft Walls



IV-C

Mass Timber and the IBC 277

277

Sub-Outline

- Fire Barriers
- Shaft Walls
- Sealing Abutting Edges/Intersections and Fire Blocking Material
- New Redundant Sprinkler Water Supply Systems
- Concealed Spaces and Heavy Timber
- Owner's Responsibilities



Mass Timber and the IBC 278

278

Sealing Intersections

- Mandatory sealing of adjacent mass timber elements in Section 703.7
  - Mass timber to mass timber
  - Mass timber to other materials

IV-A IV-B IV-C



Mass Timber and the IBC 279

279

Sealing Intersections (cont'd)

703.7 Sealing of adjacent mass timber elements. In buildings of Type IV-A, IV-B, and IV-C construction, sealant or adhesive shall be provided to resist the passage of air in the following locations:

1. At abutting edges and intersections of *mass timber* building elements required to be fire resistance-rated.

2. At abutting intersections of *mass timber* building elements and building elements of other materials where both are required to be fire resistance-rated.

Sealants shall meet the requirements of ASTM C920. Adhesives shall meet the requirements of ASTM D3498.

Exception: Sealants or adhesives need not be provided where they are not a required component of a tested fire resistance-rated assembly.

IV-A IV-B IV-C

Mass Timber and the IBC 280

280

Sealing Intersections (cont'd)

1705.20 Sealing of mass timber
Periodic special inspections of sealants or adhesives shall be conducted where sealant or adhesive required by Section 703.7 is applied to *mass timber* building elements as designated in the *approved* construction documents.

IV-A IV-B IV-C



Mass Timber and the IBC 281

281

Fireblocking

718.2.1 Fireblocking materials. *Fireblocking* shall consist of the following materials:

1. Two-inch nominal lumber.

…laundry list continues with existing unchanged Items 2 through 8…

9. *Mass timber* complying with Section 2304.11.



Mass Timber and the IBC 282

282

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Penetrations

Through penetrations

- Tested in ATF research

Not Specific to Tall Mass Timber



283

Sub-Outline

- Fire Barriers
- Shaft Walls
- Sealing Abutting Edges/Intersections and Fire Blocking Material
- New Redundant Sprinkler Water Supply Systems
- Concealed Spaces and Heavy Timber
- Owner's Responsibilities



284

Water Supply to Required Fire Pumps

403.3.2 Water supply to required fire pumps. In all buildings that are more than 420 feet in building *height,* and buildings of Type IV-A and IV-B that are more than 120' in building height, required fire pumps shall be supplied by connections to not fewer than two water mains located in different streets. Separate supply piping shall be provided between each connection to the water main and the pumps. Each connection and the supply piping between the connection and the pumps shall be sized to supply the flow and pressure required for the pumps to operate.

IV-A

IV-B

285

Sub-Outline

- Fire Barriers
- Shaft Walls
- Sealing Abutting Edges/Intersections and Fire Blocking Material
- New Redundant Sprinkler Water Supply Systems
- Concealed Spaces and Heavy Timber
- Owner's Responsibilities



286

Concealed Spaces

Type IV-A & IV-B…at least 80 minutes of protection

602.4.1.5 & 602.4.2.5 Concealed spaces…Combustible construction forming concealed spaces shall be protected in accordance with Section 602.4.1.2.

602.4.1.2 Interior protection. Interior faces of all *mass timber* elements, including the inside faces of exterior *mass timber* walls and *mass timber* roofs, shall be protected…

602.4.1.2.1 Protection time. *Noncombustible protection* shall contribute a time equal to or greater than times assigned in Table 722.7.1(1), but not less than 80 minutes. The use of materials and their respective protection contributions listed in Table 722.7.1(2) shall be permitted to be used for compliance with Section 722.7.1.

TABLE 722.7.1(2)
PROTECTION PROVIDED BY NONCOMBUSTIBLE COVERING MATERIAL

Noncombustible Protection	Protection Contribution (minutes)
1/2 inch Type X Gypsum Board	25
5/8 inch Type X Gypsum Board	40

IV-A IV-B

287

Concealed Spaces

Type IV-C…40 minutes of protection

602.4.3.5 Concealed spaces…Combustible construction forming concealed spaces shall be protected with *noncombustible protection* with a minimum assigned time of 40 minutes as determined in Section 722.7.1.

TABLE 722.7.1(2)
PROTECTION PROVIDED BY NONCOMBUSTIBLE COVERING MATERIAL

Noncombustible Protection	Protection Contribution (minutes)
1/2 inch Type X Gypsum Board	25
5/8 inch Type X Gypsum Board	40

IV-C



288

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Concealed Spaces

IBC

Type IV-HT (only)

602.4.4.3 Concealed spaces…Concealed spaces shall be protected in accordance with one or more of the following:

1. The building shall be sprinklered throughout in accordance with Section 903.3.1.1 and automatic sprinklers shall also be provided in the concealed space.
2. The concealed space shall be completely filled with noncombustible insulation.
3. Surfaces within the concealed space shall be fully sheathed with not less than 5/8-inch Type X gypsum board.

Exception: Concealed spaces within interior walls and partitions with a one-hour or greater fire resistance rating complying Section 2304.11.2.2 shall not require additional protection.



IV-HT

289

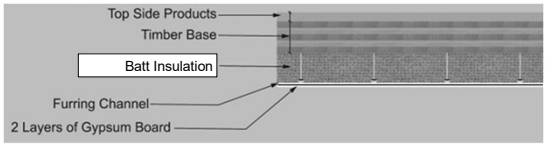
Concealed Spaces

IBC

2304.11.3 Floors. Floors shall be without concealed spaces or with concealed spaces complying with Section 602.4.4.3…

2304.11.4 Roof decks. Roofs shall be without concealed spaces ~~and roof~~ or with concealed spaces complying with Section 602.4.4.3…

IV-HT



290

Concealed Spaces

IBC

IV-A, IV-B } Assigned NC Protection (at least 80-min)

IV-C 40-min protection

IV-HT 3 options (NFPA 13)

291

Concealed Spaces

IBC





Photos provided by ATF Fire Research Laboratory

292

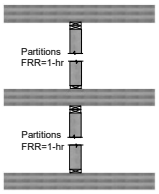
Concealed Space Exception

IBC

602.4 Type IV…

Combustible concealed spaces are not permitted except as otherwise indicated in Sections 602.4.1 through 602.4.4. Combustible stud spaces within light-frame walls of Type IV-HT construction shall not be considered concealed spaces but shall comply with Section 718.

IV-HT



293

CLT Wall Thickness

IBC

- Clarify min CLT thickness in Type IV-HT exterior walls
  - Requires min actual 4-inch CLT thickness rather than overall 6-inch wall thickness

IV-HT

602.4.4.2 Cross-laminated timber in exterior walls. *Cross-laminated timber* (CLT) not less than 4 inches in thickness complying with Section 2303.1.4 shall be permitted within exterior wall assemblies ~~not less than 6 inches in thickness~~ with a 2-hour rating or less. ~~provided the~~ Heavy timber structural members appurtenant to the CLT exterior wall shall meet the requirements of Table 2304.11 and be fire-resistance rated as required for the exterior wall. The exterior surface of the *cross-laminated timber* and heavy timber elements shall be ~~is~~ protected by one of the following:

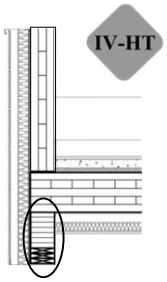
294

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

HT in Exterior Walls

- Provides for glulam and SCL in CLT exterior walls of Type IV-HT construction

602.4.4.2 Cross-laminated timber in exterior walls. *Cross-laminated timber* (CLT) not less than 4 inches in thickness complying with Section 2303.1.4 shall be permitted within exterior wall assemblies ~~not less than 6 inches in thickness~~ with a 2-hour rating or less. ~~provided the~~ Heavy timber structural members appurtenant to the CLT exterior wall shall meet the requirements of Table 2304.11 and be fire-resistance rated as required for the exterior wall. The exterior surface of the *cross-laminated timber* and heavy timber elements shall be ~~is~~ protected by one of the following:



295

HT Roof Beams/Frames

TABLE 601

FIRE-RESISTANCE RATING REQUIREMENTS FOR BUILDING ELEMENTS (HOURS)

BUILDING ELEMENT	TYPE I		TYPE II		TYPE III		TYPE IV				TYPE V	
	A	B	A	B	A	B	A	B	C	HT	A	B
Primary structural frame[f] (see Section 202)	3[a,b]	2[a,b,c]	1[b,c]	0[c]	1[b,c]	0	3[a]	2[a]	2[a]	HT	1[b,c]	0
Bearing walls												
Exterior[e,f]	3	2	1	0	2	2	3	2	2	2	1	0
Interior	3[a]	2[a]	1	0	1	0	3	2	2	1/HT[a]	1	0

c. In all occupancies, heavy timber complying with Section 2304.11 shall be allowed for roof construction, including primary structural frame members, where a 1-hour or less fire-resistance rating is required.
g. Heavy timber bearing walls supporting more than two floors or more than a floor and a roof shall have a fire resistance rating of not less than 1 hour.

IV-HT

296

HT Interior Bearing Walls

TABLE 601

FIRE-RESISTANCE RATING REQUIREMENTS FOR BUILDING ELEMENTS (HOURS)

BUILDING ELEMENT	TYPE I		TYPE II		TYPE III		TYPE IV				TYPE V	
	A	B	A	B	A	B	A	B	C	HT	A	B
Primary structural frame[f] (see Section 202)	3[a,b]	2[a,b,c]	1[b,c]	0[c]	1[b,c]	0	3[a]	2[a]	2[a]	HT	1[b,c]	0
Bearing walls												
Exterior[e,f]	3	2	1	0	2	2	3	2	2	2	1	0
Interior	3[a]	2[a]	1	0	1	0	3	2	2	1/HT[a]	1	0

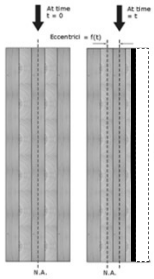
c. In all occupancies, heavy timber complying with Section 2304.11 shall be allowed for roof construction, including primary structural frame members, where a 1-hour or less fire-resistance rating is required.
g. Heavy timber bearing walls supporting more than two floors or more than a floor and a roof shall have a fire resistance rating of not less than 1 hour.

IV-HT

297

HT Interior Bearing Walls

- Table 601 Type IV-HT
  - Footnote g. Heavy timber bearing walls supporting more than two floors or more than a floor and a roof shall have a fire resistance rating of not less than 1 hour.
  - Calculated or protected



IV-HT

298

Primary vs. Secondary Frame

TABLE 601
FIRE-RESISTANCE RATING REQUIREMENTS FOR BUILDING ELEMENTS (HOURS)

BUILDING ELEMENT	TYPE I		TYPE II		TYPE III		TYPE IV				TYPE V	
	A	B	A	B	A	B	A	B	C	HT	A	B
Primary structural frame [f] (see Section 202)	3[a,b]	2[a,b,c]	1[b,c]	0[c]	1[b,c]	0	3[a]	2[a]	2[a]	HT	1[b,c]	0
Bearing walls												
Exterior [e, f]	3	2	1	0	2	2	3	2	2	2	1	0
Interior	3[a]	2[a]	1	0	1	0	3	2	2	1/HT[a]	1	0
Nonbearing walls and partitions – Exterior	See Table 705.5											
Nonbearing walls and partitions – Interior [d]	0	0	0	0	0	0	0	0	0	See Section 2304.11.2	0	0
Floor construction and associated secondary structural members (see Section 202)	2	2	1	0	1	0	2	2	2	HT	1	0
Roof construction and associated secondary structural members (see Section 202)	1 ½[b]	1[b,c]	1[b,c]	0[c]	1[b,c]	0	1 ½	1	1	HT	1[b,c]	0

299

Primary vs. Secondary Frame

Primary Structural Frame. The primary structural frame shall include all of the following structural members:
- The columns.
- Structural members having direct connections to the columns, including girders, beams, trusses and spandrels.
- Members of the floor construction and roof construction having direct connections to the columns.
- Bracing Members that are essential to the vertical stability of the primary structural frame under gravity loading. ~~shall be considered part of the primary structural frame whether or not the bracing member carries gravity *loads*.~~

Secondary Structural Members. The following structural members shall be considered secondary members and not part of the primary structural frame:
- Structural members not having direct connections to the columns.
- Members of the floor construction and roof construction not having direct connections to the columns.
- Bracing members ~~other than those that are part of the *primary structural frame*~~ that are not designated as part of a primary structural frame or bearing wall.

300

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Primary vs. Secondary Frame

IBC 2021

Primary
- Columns and Beams

Secondary
- Floor Panels



Mass Timber and the IBC 301

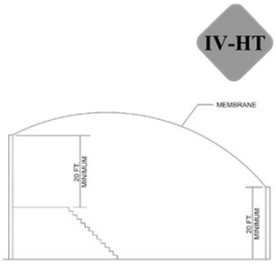
301

Membrane Structures

IBC 2021

3102.3 Type of construction…
Heavy timber frame-supported structures covered by an *approved* membrane in accordance with Section 3102.3.1 shall be classified as Type IV-HT construction.

Note: The Exception to 3102.3 remains unchanged.



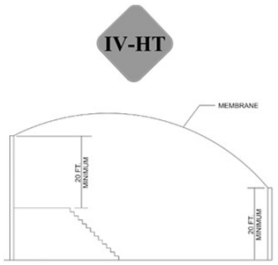
Mass Timber and the IBC 302

302

Membrane Structures

IBC 2021

3102.6.1.1 Membrane.
A membrane meeting the fire propagation performance criteria of Test Method 1 or Test Method 2, as appropriate, of NFPA 710 shall be permitted to be used as the roof or as a skylight on buildings of Type II B, III, IV-HT and V construction, provided that the membrane is not less than 20 feet above and floor, balcony or gallery.



Mass Timber and the IBC 303

303

Sub-Outline

- Fire Barriers
- Shaft Walls
- Sealing Abutting Edges/Intersections and Fire Blocking Material
- New Redundant Sprinkler Water Supply Systems
- Concealed Spaces and Heavy Timber
- Owner's Responsibilities



Mass Timber and the IBC 304

304

Owner's Responsibility

IFC 2021

IFC 701.6 Owner's responsibility. The owner shall maintain an inventory of all required fire-resistance-rated construction, construction installed to resist the passage of smoke and the construction included in Sections 703 through 707 and Sections 602.4.1 and 602.4.2 of the *International Building Code*. Such construction shall be visually inspected by the owner annually and properly repaired, restored or replaced where damaged, altered, breached or penetrated. Records of inspections and repairs shall be maintained…

IV-A

IV-B

Mass Timber and the IBC 305

305

Q&A



Mass Timber and the IBC 306

306

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.



Outline

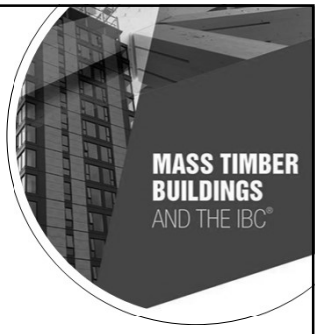
- Introduction to Mass Timber Products
- 2015/2018 IBC for Mass Timber Construction
- Break – 15 minutes
- 2021 IBC for Tall Mass Timber Construction
  - Part 1: Background and Overview
  - Lunch – 1 hour
  - Part 2: New Construction Types and Heights & Areas
  - Part 3: Fire Safety
  - Break – 15 minutes
  - Part 4: Fire & Connection Design and Special Inspection
  - Part 5: Acoustics, Energy, and Lateral Resistance
  - Part 6: Construction Fire Safety



307

Tall Mass Timber Construction per 2021 IBC

Part 4: Principles of Fire Resistance Design, Protection of Connections and Special Inspections



308

Sub-Outline

- Principles of Fire-resistance Design for New Construction Types IV-A, IV-B, and IV-C
- Design of Fire-resistance Protection for Mass Timber Connections
- Special Inspection of Tall Mass Timber Structures





309

Mass Timber Fire-Resistance Design



TABLE 601
FIRE-RESISTANCE RATING REQUIREMENTS FOR BUILDING ELEMENTS (HOURS)

BUILDING ELEMENT	TYPE I		TYPE II		TYPE III		TYPE IV			TYPE V	
	A	B	A	B	A	B	A	B	C	HT	A	B
Primary structural frame [f] (see Section 202)	3[a,b]	2[a,b,c]	1[b,c]	0[c]	1[b,c]	0	3[a]	2[a]	2[a]	HT	1[a,c]	0
Bearing walls												
Exterior [e, f]	3	2	1	0	2	2	3	2	2	2	1	0
Interior	3[a]	2[a]	1	0	1	0	3	2	2	1/HT[a]	1	0
Nonbearing walls and partitions – Exterior	See Table 705.5											
Nonbearing walls and partitions – Interior [d]	0	0	0	0	0	0	0	0	0	See Section 2304.11.2	0	0
Floor construction and associated secondary structural members (see Section 202)	2	2	1	0	1	0	2	2	2	HT	1	0
Roof construction and associated secondary structural members (see Section 202)	1 ½[a]	1[b,c]	1[b,c]	0[c]	1[b,c]	0	1 ½	1	1	HT	1[b,c]	0



310

Mass Timber Fire-Resistance Design

Noncombustible

(703.3)

≠

Fire-resistant

(703.2)



311

Mass Timber Fire-Resistance Design

Heavy timber inherent fire resistance

⇕

minimum prescriptive dimensions

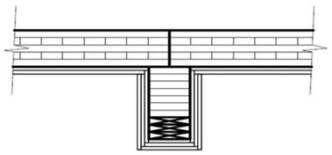


312

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Noncombustible Time Contribution

722.7 Fire-resistance rating of mass timber. The required fire resistance of mass timber elements in Section 602.4 shall be determined in accordance with Section 703.2. The fire resistance rating of building elements shall be as required in Tables 601 and 705.5 and as specified elsewhere in this code. The fire-resistance rating of the mass timber elements shall consist of the fire resistance of the unprotected element added to the protection time of the noncombustible protection.



IV-A

IV-B

IV-C

313

Noncombustible Time Contribution

Protection Required

TABLE 722.7.1(1)
PROTECTION REQUIRED FROM NONCOMBUSTIBLE COVERING MATERIAL

Required Fire-Resistance Rating of Building Element per Tables 601 and 705.5 (hours)	Minimum Protection Required from Noncombustible Protection (minutes)
1	40
2	80
3 or more	120

IV-A

IV-B

IV-C

314

Noncombustible Time Contribution

Prescriptive Method

TABLE 722.7.1(2)
PROTECTION PROVIDED BY NONCOMBUSTIBLE COVERING MATERIAL

Noncombustible Protection	Protection Contribution (minutes)
1/2 inch Type X Gypsum Board	25
5/8 inch Type X Gypsum Board	40

IV-A

IV-B

IV-C

315

Mass Timber Fire-Resistance Design

Methods for establishing fire resistance (703.2.2)

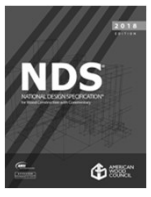
1. Tested fire assembly (ASTM E119 or UL 263)
2. Fire-resistance designs documented in approved sources
3. Prescriptive assemblies using fire-resistance rated designs in Section 721
4. **Calculation of fire-resistance per Section 722**
5. Engineering analysis based on a comparison of building element, component or assembly designs that have been tested
6. Fire-resistance designs certified by an approved agency

703.2.3 Alternative protection methods per Section 104.11

316

Mass Timber Fire-Resistance Design







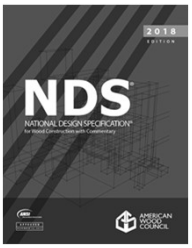
IBC 722.1 | **NDS Chapter 16** | **TR-10**

317

Mass Timber Fire-Resistance Design

SECTION 722
CALCULATED FIRE RESISTANCE

722.1 General. The provisions of this section contain procedures by which the *fire resistance* of specific materials or combinations of materials is established by calculations. These procedures apply only to the information contained in this section and shall not be otherwise used…The calculated *fire resistance* of exposed wood members and wood decking shall be permitted in accordance with Chapter 16 of ANSI/AWC *National Design Specification for Wood Construction (NDS)*.



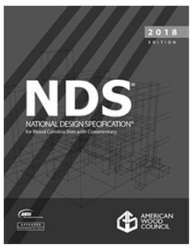
318

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Mass Timber Fire-Resistance Design

NDS Section 16.2

- Fire design up to 2 hours
- Beams, columns, walls, floors/roofs
- Products
  - Sawn lumber
  - Glulam (softwood)
  - LVL
  - PSL
  - LSL
  - CLT



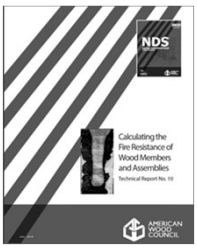
Mass Timber and the IBC 319

319

Mass Timber Fire-Resistance Design

AWC Technical Report 10

- NDS Chapter 16 basis
  - Background
  - Commentary
  - Examples



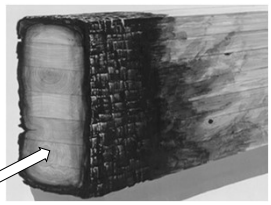
Mass Timber and the IBC 320

320

Mass Timber Fire-Resistance Design

Wood at high temperature

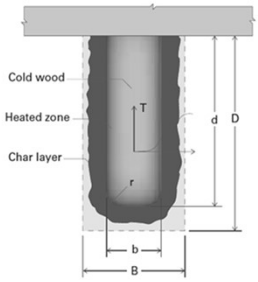
- **Low thermal conductivity**
- Dimensionally stable
- Predictable char rate
- **Inner portion remains cool**
  - Does not lose strength



Mass Timber and the IBC 321

321

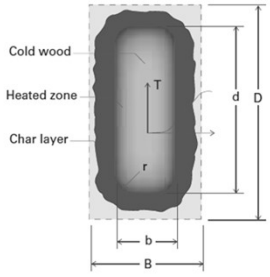
Mass Timber Fire-Resistance Design



Mass Timber and the IBC 322

322

Mass Timber Fire-Resistance Design



Mass Timber and the IBC 323

323

Mass Timber Fire-Resistance Design

Table 16.2.1A Char Depth and Effective Char Depth (for β_n = 1.5 in./hr.)

Required Fire Resistance (hr.)	Char Depth, a_{char} (in.)	Effective Char Depth, a_{eff} (in.)
1-Hour	1.5	1.8
1½-Hour	2.1	2.5
2-Hour	2.6	3.2

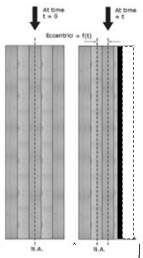
Mass Timber and the IBC 324

324

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Mass Timber Fire-Resistance Design





CLT: modified char depth model

Mass Timber and the IBC 325

325

Mass Timber Fire-Resistance Design

Table 16.2.1B Effective Char Depths (for CLT with β_n = 1.5in./hr.)

Required Fire Resistance (hr.)	Effective Char Depths, a_{eff} (in.) lamination thicknesses, h_{lam} (in.)								
	5/8	3/4	7/8	1	1-1/4	1-3/8	1-1/2	1-3/4	2
1-Hour	2.2	2.2	2.1	2.0	2.0	1.9	1.8	1.8	1.8
1½-Hour	3.4	3.2	3.1	3.0	2.9	2.8	2.8	2.8	2.6
2-Hour	4.4	4.3	4.1	4.0	3.9	3.8	3.6	3.6	3.6

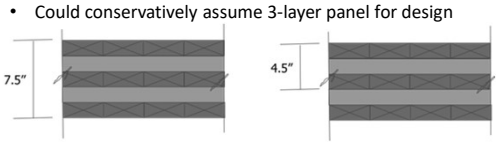
Mass Timber and the IBC 326

326

Mass Timber Fire-Resistance Design

Determination of effective CLT floor cross-section

- Assume 5-layers @ 1.5" (total = 7.5")
- Determine thickness for 1-hr FRR
- a_{char} = 1.8" (NDS Table 16.2.1B)
- d = 7.5" – 1.8" = 5.7"
- Could conservatively assume 3-layer panel for design

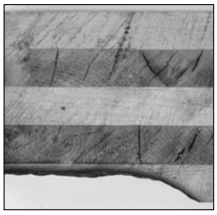


Mass Timber and the IBC 327

327

Mass Timber Fire-Resistance Design

- Fire-resistance of exposed mass timber
  - Cross-sectional dimensions
  - Load ratio



Mass Timber and the IBC 328

328

Mass Timber Fire-Resistance Design

- Fire-resistance of protected mass timber
  - Cross-sectional dimensions
  - Load ratio

- plus -

- Noncombustible protection



Mass Timber and the IBC 329

329

Mass Timber Fire-Resistance Design



Waugh Thistleton Architects (Stradthaus – Murry Grove)

Mass Timber and the IBC 330

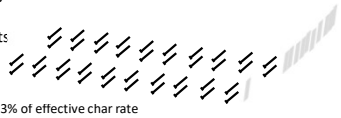
330

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Mass Timber Fire-Resistance Design

Nail-Laminated Timber (NLT)

- NDS 16.2.5. Timber Decks
  - ≥ 2" thick (actual)
  - Clear-span between supports
  - Assembly of wood beams
    - Exposed partially on sides
    - Exposed fully on one face
    - Char rate on sides reduced to 33% of effective char rate
    - Does not address thermal separation
    - Typically requires one layer of Type X gypsum



331

Mass Timber Fire-Resistance Design

16.2.4 Special Provisions for Structural Glued Laminated Timber Beams

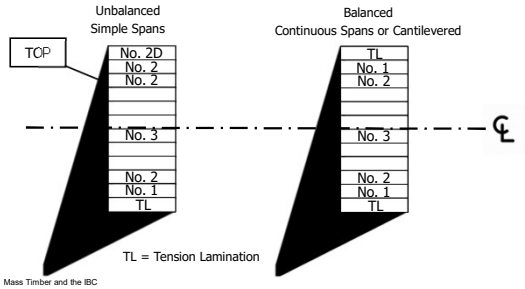
For structural glued laminated timber bending members given in Table 5A and rated for 1-hour fire endurance, an outer tension lamination shall be substituted for a core lamination on the tension side for unbalanced beams and on both sides for balanced beams. For structural glued laminated timber bending members given in Table 5A and rated for 1½- or 2-hour fire endurance, 2 outer tension laminations shall be substituted for 2 core laminations on the tension side for unbalanced beams and on both sides for balanced beams.



Glulam column caps at the Bullitt Center

332

Glulam - Engineered Layups



333

Tension Lams - Unbalanced

3-sided exposure only (protected compression side)

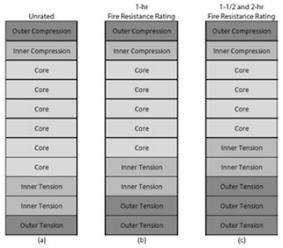


Figure 3-1 Typical glulam unbalanced beam layups

334

Tension Lams - Balanced

3- or 4-sided beam (or column) exposure

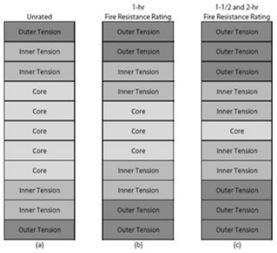


Figure 3-2 Typical glulam balanced beam layups

335

Sub-Outline

- Principles of Fire-resistance Design for New Construction Types IV-A, IV-B, and IV-C
- Design of Fire-resistance Protection for Mass Timber Connections
- Special Inspection of Tall Mass Timber Structures



336

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Fire-Resistive Connection Protection

IBC 2021

IV-A IV-B IV-C

704.2 Column protection. Where columns are required to have protection to achieve a *fire-resistance rating*, the entire column shall be provided individual encasement protection by protecting it on all sides for the full column height, including connections to other structural members, with materials having the required *fire-resistance rating*. Where the column extends through a ceiling, the encasement protection shall be continuous from the top of the foundation or floor/ceiling assembly below through the ceiling space to the top of the column.

704.3 Protection of the primary structural frame other than columns. Members of the primary structural frame other than columns that are required to have protection to achieve a *fire-resistance rating* and support more than two floors or one floor and roof, or support a load-bearing wall or a nonload-bearing wall more than two stories high, shall be provided individual encasement protection by protecting them on all sides for the full length, including connections to other structural members, with materials having the required *fire-resistance rating*.



Mass Timber and the IBC 337

337

Fire-Resistive Connection Protection

IBC 2021

2304.10.1 Connection fire-resistance rating. Fire-resistance ratings for connections in Type IV-A, IV-B or IV-C shall be determined by one of the following:

IV-A IV-B IV-C

1. Testing in accordance with Section 703.2 where the connection is a part of the fire-resistance test.
2. Engineering analysis that demonstrates that the temperature rise at any portion of the connection is limited to an average temperature rise of 250°F, and a maximum temperature rise of 325°F, for a time corresponding to the required fire-resistance rating of the structural element being connected. For the purposes of this analysis, the connection includes connectors, fasteners, and portions of wood members included in the structural design of the connection.



Beam-to-column connection tested at ATF Fire Research Lab.



Mass Timber and the IBC 338

338

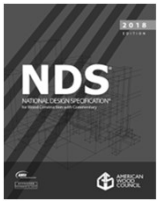
Fire-Resistive Connection Protection

IBC 2021

But we can't test every connection!

2304.10.1 Connection fire resistance rating. Fire-resistance ratings for connections in Type IV-A, IV-B or IV-C shall be determined by one of the following:

1. Testing in accordance with Section 703.2 where the connection is a part of the fire resistance test.
2. Engineering analysis that demonstrates . . .



IV-A IV-B IV-C



Mass Timber and the IBC 339

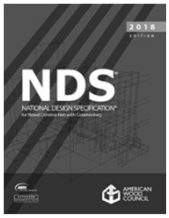
339

Fire-Resistive Connection Protection

NDS 16.3 Wood Connections

Where fire resistance is required, connectors and fasteners shall be protected from fire exposure

- Additional wood cover
- Fire-rated gypsum board
- Other approved materials like coatings or insulation (approved for required endurance time)
- OR a combination thereof





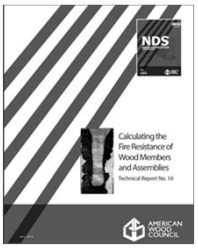
Mass Timber and the IBC 340

340

Fire-Resistive Connection Protection

AWC *Technical Report 10*

- NDS Chapter 16 basis
  - Protecting connections
    - Background
    - Commentary
    - Examples





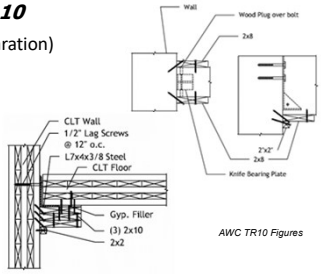
Mass Timber and the IBC 341

341

Fire-Resistive Connection Protection

AWC *Technical Report 10*

- Thermal protection (separation)
- Example details
- Common fasteners and connectors



AWC TR10 Figures



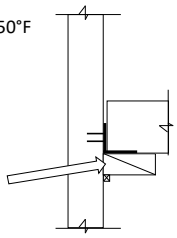
Mass Timber and the IBC 342

342

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Fire-Resistive Connection Protection

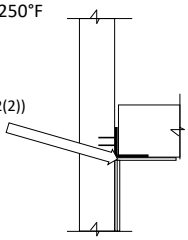
- Thermal Separation – limit avg temp rise ≤ 250°F
- 2-hr Example
  - 3 inches of wood protection
  - $t_p = 60\left(\frac{3.0}{1.5}\right)^{1.23} = 141\ minutes$
  - Wood protecting a connection
  - 0.85 x (calculated protection time)
  - $0.85\ t_p = (0.85)\ 141\ minutes = 120\ minutes$



343

Fire-Resistive Connection Protection

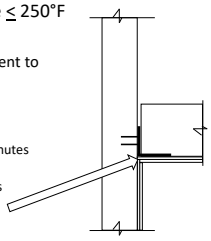
- Thermal Separation – limit avg temp rise ≤ 250°F
- 1-hr Example
  - Gypsum Board
  - 0.5 x (NC Protection Time)
  - 5/8" Type X GB = 40 minutes (IBC Table 722.7.2(2))
  - $0.5\ t_p = (0.5)\ 40\ minutes = 20\ minutes$ NG



344

Fire-Resistive Connection Protection

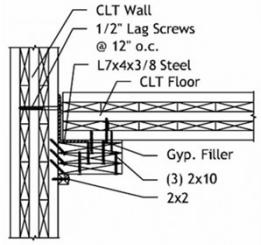
- Thermal Separation – limit avg temp rise ≤ 250°F
- Multiple layers of protection
  - Reduction factor only applies to layer adjacent to connection
- 1-hr Example
  - 2 layers of 5/8" Type X GB
    - Layer adjacent to connection = 40 (0.5) = 20 minutes
    - Second layer = 40 minutes
    - Total thermal separation = 40 + 20 = 60 minutes



345

Fire-Resistive Connection Protection

- Char contraction
  - Abutting edges
  - Char layer < char depth
  - Wedge-shaped gap
  - Additional wood cover protects abutting edges
  - Fasteners attaching cover do not require protection

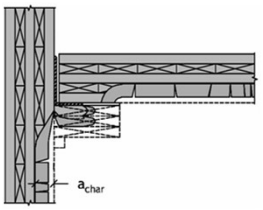


AWC TR10 Figure 8-4. Example connection protection

346

Fire-Resistive Connection Protection

- Char contraction
  - Abutting edges
  - Char layer < char depth
  - Wedge-shaped gap
  - Additional wood cover or blocking to protect abutting edges
  - Fasteners attaching cover do not require protection



AWC TR10 Figure 8-3. Char pattern with wood strip added

347

Fire-Resistive Connection Protection

Code Official Inspection

110.3.5 Type IV-A, IV-B and IV-C connection protection inspection. In buildings of Type IV-A, IV-B and IV-C Construction, where connection fire-resistance ratings are provided by wood cover calculated to meet the requirements of Section 2304.10.1, inspection of the wood cover shall be made after the cover is installed, but before any other coverings or finishes are installed.



348

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Sub-Outline

- Principles of Fire-resistance Design for New Construction Types IV-A, IV-B, and IV-C
- Design of Fire-resistance Protection for Mass Timber Connections
- Special Inspection of Tall Mass Timber Structures



Mass Timber and the IBC 349

349

Special Inspection

- New Section 1705.5.3 on Tall Mass Timber Construction
- New Table 1705.5.3
  - Required special inspections for new mass timber types
    - IV-A, IV-B & IV-C
- NOT Type IV-HT



IV-A IV-B IV-C

Mass Timber and the IBC 350

350

Special Inspection

Table 1705.5.3. Required Special Inspections of Mass Timber Construction

	Type		Continuous Special Inspection	Periodic Special Inspection
1.	Inspection of anchorage and connections of mass timber construction to timber deep foundation systems.			X
2.	Inspect erection of mass timber construction.			X
3.	Inspection of connections where installation methods are required to meet design loads.			
	Threaded fasteners	Verify use of proper installation equipment.		
		Verify use of pre-drilled holes where required.		X
		Inspect screws, including diameter, length, head type, spacing, installation angle, and depth.		X
	Adhesive anchors installed in horizontal or upwardly inclined orientation to resist sustained tension loads.		X	
	Adhesive anchors not defined in preceding cell.			X
	Bolted connections.			X
	Concealed connections.			X

IV-A IV-B IV-C

Mass Timber and the IBC 351

351

Special Inspection

- Connections for TMT can be designed with common connectors
  - Screws, bolts, etc.
  - Thus, periodic
- Continuous inspection
  - Adhesive anchors under sustained tension
  - Similar to precast



IV-A IV-B IV-C

Mass Timber and the IBC 352

352

Special Inspection

1705.20 Sealing of mass timber
Periodic special inspections of sealants or adhesives shall be conducted where sealant or adhesive required by Section 703.7 is applied to *mass timber* building elements as designated in the *approved* construction documents.

IV-A IV-B IV-C



Mass Timber and the IBC 353

353

Special Inspection

703.7 Sealing of adjacent mass timber elements…

- Sealants per ASTM C920

or

- Adhesives per ASTM D3498

Exception: Sealants or adhesives need not be provided where they are not a required component of a tested fire-resistance-rated assembly.



IV-A IV-B IV-C

Mass Timber and the IBC 354

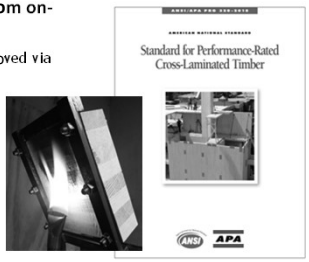
354

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Special Inspection

Fabricated items exempt from on-site special inspection

- IBC 1704.2.5 – fabricator approved via QC/QA and third-party audit
  - CLT
  - SCL
  - Glulam
  - Sawn Timber



Mass Timber and the IBC 355

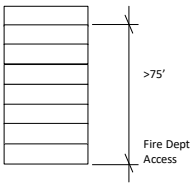
355

Structural Observation

1704.6.1 Structural observations for structures. Structural observations shall be provided for those structures where one or more of the following conditions exist:

1. The structure is classified as Risk Category III or IV.
2. The structure is a high-rise building.
3. The structure is assigned to Seismic Design Category E and is greater than two stories above the grade plane.
4. Such observation is required by the registered design professional responsible for the structural design.
5. Such observation is specifically required by the building official.

Not Specific to Tall Mass Timber



Mass Timber and the IBC 356

356

Q&A



Mass Timber and the IBC 357

357



Outline

- Introduction to Mass Timber Products
- 2015/2018 IBC for Mass Timber Construction
- Break – 15 minutes
- 2021 IBC for Tall Mass Timber Construction
  - Part 1: Background and Overview
  - Lunch – 1 hour
  - Part 2: New Construction Types and Heights & Areas
  - Part 3: Fire Safety
  - Break – 15 minutes
  - Part 4: Fire & Connection Design and Special Inspection
  - Part 5: Acoustics, Energy, and Lateral Resistance
  - Part 6: Construction Fire Safety

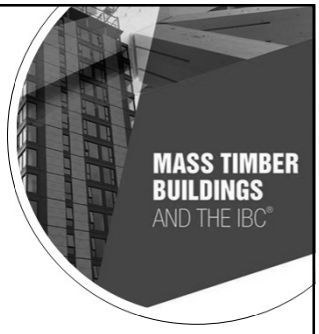


Mass Timber and the IBC 358

358

Tall Mass Timber Construction per 2021 IBC

Part 5: Acoustics, Energy and Lateral Load Performance



Mass Timber and the IBC 359

359

Sub-Outline

- Acoustics
- Energy
- Lateral Resistance



Mass Timber and the IBC 360

360

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Acoustics

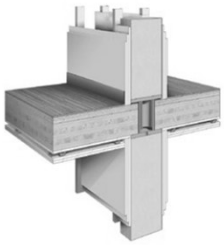
- IBC 1206
  - Airborne sound – STC
  - Structure-borne sound – IIC



361

Acoustics

- Multi-family
  - STC minimum = 50
  - IIC minimum = 50
  - Field-test = 45



362

Acoustics

Sound Transmission Ratings of Selected Mass Timber Panels

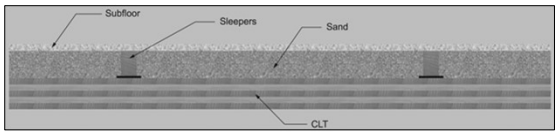
Mass Timber Panel	Thickness	STC Rating	IIC Rating
3-ply CLT wall	3"	33	N/A
5-ply CLT wall	$6^{7}/_{8}$"	38	N/A
5-ply CLT floor	$5^{1}/_{16}$"	39	22
5-ply CLT floor	$6^{7}/_{8}$"	41	25
7-ply CLT floor	$9^{5}/_{8}$"	44	30
2x4 NLT wall	3-1/2" bare NLT 3-1/2" with 3/4" plywood	24 bare NLT 29 with 3/4" plywood	N/A
2x6 NLT wall	5-1/2" bare NLT 5-1/2" with 3/4" plywood	22 bare NLT 31 with 3/4" plywood	N/A
2x6 NLT floor + 1/2" plywood	5-1/2" with 1/2" plywood	34	33

Source: Inventory of Acoustically-Tested Mass Timber Assemblies, WoodWorks

363

Acoustics

- Example – floor with exposed mass timber

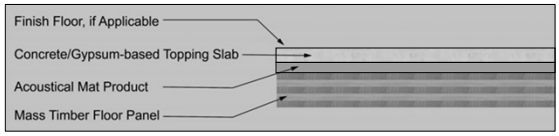


IV-HT

364

Acoustics

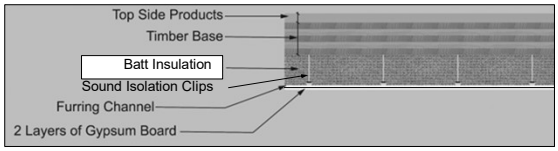
- Example – floor with exposed mass timber



365

Acoustics

- Examples – floors with ceiling concealed



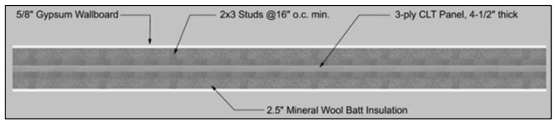
IV-HT

366

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Acoustics

- Example – walls

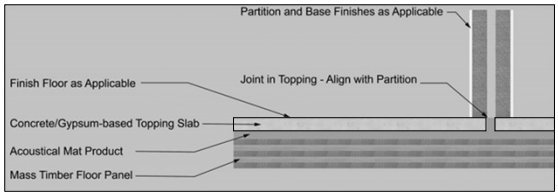


IV-HT

367

Acoustics

- Example – flanking control



368

Sub-Outline

- Acoustics
- Energy
- Lateral Resistance



369

Energy Performance

- Exterior walls
  - Mass timber panels (e.g. CLT)
  - Curtain walls
- IBC Chapter 13
  - IECC compliance paths
    - ANSI/ASHRAE/IES Standard 90.1
    - Prescriptive design per IECC C402 through C405
    - Performance design per IECC C407



370

Energy Performance

IECC TABLE C402.1.4
OPAQUE THERMAL ENVELOPE ASSEMBLY MAXIMUM REQUIREMENTS, U-FACTOR METHOD

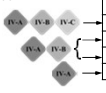
CLIMATE ZONE	1		2		3		4 EXCEPT MARINE		5 AND MARINE 4		6		7		8	
	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R
Walls, above grade																
Mass	U-0.151	U-0.151	U-0.151	U-0.123	U-0.123	U-0.104	U-0.104	U-0.090	U-0.090	U-0.080	U-0.080	U-0.071	U-0.071	U-0.071	U-0.037	U-0.037
Wood framed and other	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.051	U-0.051	U-0.051	U-0.051	U-0.051	U-0.051	U-0.032	U-0.032
Floors																
Mass	U-0.322	U-0.322	U-0.107	U-0.087	U-0.074	U-0.074	U-0.057	U-0.051	U-0.057	U-0.051	U-0.051	U-0.051	U-0.042	U-0.042	U-0.038	U-0.038

R-value method does not account for the mass effect

371

Energy Performance

- Does a CLT wall qualify as a "mass" wall?
  - Assume 1-3/8" lamination thickness
    - 3 layers = 4.125"
    - 5 layers = 6.875"
    - 7 layers = 9.625"
- Exterior fire protection required
  - All new construction types



Required Mass Timber Thickness for Minimum Heat Capacity of 5 Btu/ft²•°F	
Layers of 5/8" Type X Gypsum	Minimum Thickness of Mass Timber (in.)
0[1]	6.36 (5 layers)
1	5.53 (5 layers)
2	4.71 (5 layers)
3	3.88 (3 layers)
4	3.05 (3 layers)

372

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Energy Performance

Required Minimum Thickness of Mass Wall to Meet IECC U-Factors

CZ	Req. U-Factor	All Except Residential			
		Layers of 5/8" Gypsum			
		0[1]	1	2	3
1	0.151	4.62	4.23	3.85	3.47
2	0.151	4.62	4.23	3.85	3.47
3	0.123	5.82	5.44	5.06	4.67
4	0.104	7.01	6.63	6.24	5.86
5	0.090	8.21	7.82	7.44	7.06
6	0.080	9.32	8.94	8.55	8.17
7	0.071	10.59	10.20	9.82	9.44
8	0.037	20.94	20.56	20.17	19.79

IV-A IV-B IV-C IV-A IV-B

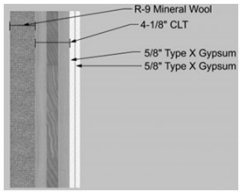
CLT
3 layers = 4.125"
5 layers = 6.875"
7 layers = 9.625"

373

Energy Performance

Additional Minimum R-value for a Non-mass 4-1/8-inch-thick Wall under IECC

CZ	Req. U-Factor	All Except Residential			
		Layers of 5/8" Gypsum			
		0[1]	1	2	3
		Additional required R-value			
1	0.064	9.62	9.14	8.66	8.18
2	0.064	9.62	9.14	8.66	8.18
3	0.064	9.62	9.14	8.66	8.18
4[2]	0.064	9.62	9.14	8.66	8.18
5[3]	0.051	13.60	13.12	12.64	12.16
6	0.051	13.60	13.12	12.64	12.16
7	0.051	13.60	13.12	12.64	12.16
8	0.032	25.24	24.76	24.28	23.80



IV-A IV-B IV-C IV-A IV-B

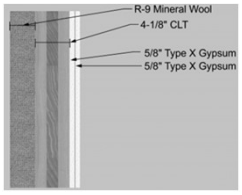
R-9 mineral wool works

374

Energy Performance

Additional Minimum R-value for a Mass 4-1/8-inch-thick Wall under IECC

CZ	Req. U-Factor	All Except Residential			
		Layers of 5/8" Gypsum			
		0[1]	1	2	3
		Additional required R-value			
1	0.151	0.62	0.14	0.00	0.00
2	0.151	0.62	0.14	0.00	0.00
3	0.123	2.12	1.64	1.16	0.68
4[2]	0.104	3.61	3.13	2.65	2.17
5[3]	0.090	5.10	4.62	4.14	3.66
6	0.080	6.49	6.01	5.53	5.05
7	0.071	8.08	7.60	7.12	6.64
8	0.037	21.02	20.54	20.06	19.58



IV-A IV-B IV-C IV-A IV-B

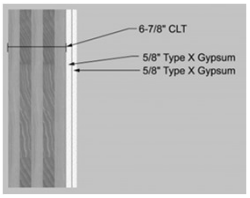
R-9 mineral wool works

375

Energy Performance

Additional Minimum R-value for a Mass 6-7/8-inch-thick Wall under IECC

CZ	Req. U-Factor	All Except Residential			
		Layers of 5/8" Gypsum			
		0[1]	1	2	3
		Additional required R-value			
1	0.151	0.00	0.00	0.00	0.00
2	0.151	0.00	0.00	0.00	0.00
3	0.123	0.00	0.00	0.00	0.00
4	0.104	0.17	0.00	0.00	0.00
5	0.090	1.67	1.19	0.71	0.23
6	0.080	3.06	2.58	2.10	1.62
7	0.071	4.64	4.16	3.68	3.20
8	0.037	17.58	17.10	16.62	16.14



IV-A IV-B IV-C IV-A IV-B

376

Sub-Outline

- Acoustics
- Energy
- Lateral Resistance



377

Seismic Design Options

- *ASCE 7 Minimum Design Loads for Buildings and Other Structures*
- Response Modification Coefficient (R)
  - CLT not recognized vertical SFRS in ASCE 7-16
  - Options
    - Performance-based design procedure per ASCE 7
    - Demonstrating equivalence to an existing ASCE 7 system
    - ASCE 7, FEMA P695, and FEMA P795 Quantification of Building Seismic Performance Factors; Component Equivalency Methodology
- R-factor anticipated in ASCE 7-22



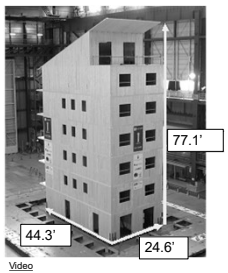
378

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Shake Table Test

7-story CLT Building – 2007

- Conducted at E-Defense
- Building weight 270t
  - Self-weight 120t
  - Added weight 150t
- Panel thickness
  - 5.5" floors 1 and 2
  - 4.9" floors 3 and 4
  - 3.3" top 3 floors
- Wall panels length 7.5'



Video

379

Lateral Design Options

- Horizontal diaphragm example
  - Wood structural panels over CLT
  - Acceptable under current codes





Photo courtesy of StructureCraft

www.structurlam.com

380

Current Research

- Colorado State University
  - CLT shear wall testing (P695) to determine seismic R factor
- Colorado School of Mines
  - NEES project on rocking CLT shear wall
- Arup
  - Heavy timber buckling-restrained braced frame system
- Oregon State University
  - CLT diaphragm testing



photo courtesy of Robert Beckley



photo courtesy of Shiling Pei

381

Current Standards

- *2021 Special Design Provisions for Wind and Seismic*
  - CLT Diaphragms
  - CLT shear walls
  - Ductility via nailed metal connectors
  - Referenced in 2021 IBC

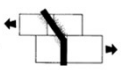


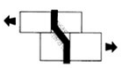
382

CLT Diaphragms

- Cross-laminated Timber (CLT) Diaphragm Design
  - Deflection per engineering
  - Unit shear capacity
    - Nominal dowel fastener shear capacities
      - 4.5 x Z*
      - Z* = Z x NDS adjustments except C_D, K_θ, ϕ, and λ
      - Mode III_s or IV
    - Wood, steel, and chord splices
      - 2 x diaphragm forces – seismic
      - 1.5 x diaphragm forces – wind
    - Chord splice fasteners – Mode III_s and IV
      - 1.5 x diaphragm forces – seismic
      - 1.0 x diaphragm forces – wind

§ 4.5





Ductile connections

383

CLT Shear Walls

- CLT Shear Wall Design
  - Deflection per engineering
  - Shear capacity
    - Nominal capacities per SDPWS Appendix B or
    - Approved alternative (by AHJ) CLT shear wall
  - NOT permitted
    - FTAO
    - PSW
    - ASCE 7 light-frame seismic

§ 4.6 & App. B



384

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

CLT Shear Walls

- Aspect Ratio Limit
  - $2 \leq h/b_s \leq 4$
- Hold-downs
  - 2 x v_s – seismic
  - 1.5 x v_s – wind
  - NDS App. E net section
- Dowel-type fasteners
  - Mode III_s or IV (ductile)
  - NDS App. E net section
- Deflection – 5-part equation

§ 4.6 & App. B



Mass Timber and the IBC 385

385

CLT Shear Walls

$$v_s = n\left(\frac{2605}{b_s}\right)C_G$$

§ 4.6 & App. B

where:

n = number of angle connectors along bottom of panel face

2605 = NDS connector nominal shear capacity (lbs)

b_s = individual CLT panel length (ft)

C_G = CLT panel specific gravity adjustment factor.

- C_G = 1.0 for G ≥ 0.42
- C_G = 0.86 for G = 0.35
- Linear interpolation permitted for G of 0.35 to 0.42

CLT Shear Wall Capacities* (ASD)

		Seismic		Wind	
Panel b_s x h (ft)	No. of Angles (n)	Shear (plf)	Hold-down (lbs)	Shear (plf)	Hold-down (lbs)
4 x 8	2	465	7443	651	7815
4 x 8	3	698	11,164	977	11,723
4 x 8	4	930	14,886	1303	15,630
4 x 8	5	1163	18,607	1628	19,538

*Capacity based on angles on one face

Mass Timber and the IBC 386

386

Q&A



Mass Timber and the IBC 387

387



Outline

- Introduction to Mass Timber Products
- 2015/2018 IBC for Mass Timber Construction
- Break – 15 minutes
- 2021 IBC for Tall Mass Timber Construction
  - Part 1: Background and Overview
  - Lunch – 1 hour
  - Part 2: New Construction Types and Heights & Areas
  - Part 3: Fire Safety
  - Break – 15 minutes
  - Part 4: Fire & Connection Design and Special Inspection
  - Part 5: Acoustics, Energy, and Lateral Resistance
  - Part 6: Construction Fire Safety

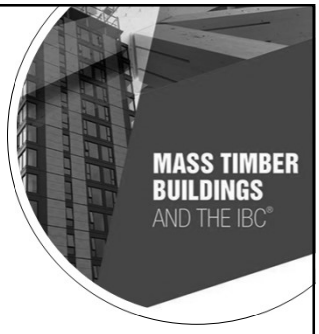


Mass Timber and the IBC 388

388

Tall Mass Timber Construction per 2021 IBC

Part 6: Construction Fire Safety



Mass Timber and the IBC 389

389

Construction Fire Safety





- Standpipes
- Water Supply
- Noncombustible Protection
- Exterior Wall Coverings
- Owner's Responsibility



Mass Timber and the IBC 390

390

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Construction Fire Safety

IFC 3308.4 Fire safety requirements for buildings of Types IV-A, IV-B, and IV-C construction. Buildings of Types IV-A, IV-B, and IV-C construction designed to be greater than six stories above grade plane shall meet the following requirements during construction unless otherwise approved by the *fire code official.*

1. Standpipes shall be provided during construction in accordance with Section 3313.
2. A water supply . . .



391

Standpipes

3313.1 Where required. In buildings required to have standpipes by Section 905.3.1, not less than one standpipe shall be provided for use during construction. Such standpipes shall be . . .

- Installed prior to construction exceeding 40 feet in height above lowest level of FD apparatus access.
- Have FD hose connection at locations adjacent to stairways complying with Section 3311.1
- Keep extending to stay within one floor of the highest construction having secured decking or flooring

Not 2021 IBC change



392

Water Supply

3312.1 When required. An approved water supply for fire protection, either temporary or permanent, shall be made available as soon as combustible building materials arrive on the site, upon commencement of vertical combustible construction, and upon installation of a standpipe system in buildings under construction, in accordance with Sections 3312.2 through 3312.5.

Exception: The fire code official is authorized to reduce the fire-flow requirements for isolated buildings or a group of buildings in rural areas or small communities where the development of full fire-flow requirements is impractical.

Not Specific to Tall Mass Timber



393

Water Supply

3312.2 Combustible building materials. When combustible building materials of the building under construction are delivered to a site, a minimum fire flow of 500 gpm shall be provided. The fire hydrant used to provide this fire flow supply shall be within 500 feet of the combustible building materials, as measured along an approved fire apparatus access lane. Where the site configuration is such that one fire hydrant cannot be located within 500 feet of all combustible building materials, additional fire hydrants shall be required to provide coverage in accordance with this section.

Not Specific to Tall Mass Timber



394

Water Supply

3312.3 Vertical construction of Types III, IV, and V construction. Prior to commencement of vertical construction of Type III, IV, or V buildings that utilize any combustible building materials, the fire flow required by Sections 3312.3.1 through 3312.3.3 shall be provided, accompanied by fire hydrants in sufficient quantity to deliver the required fire flow and proper coverage.

- 3312.3.1 Fire separation up to 30 ft
- 3312.3.2 Fire separation 30-60 ft
- 3312.3.3 Fire separation over 60 ft

Not Specific to Tall Mass Timber



395

Water Supply

3312.5 Standpipe supply. Regardless of the presence of combustible building materials, the construction type or the fire separation distance, where a standpipe is required in accordance with Section 3313, a water supply providing a minimum flow of 500 gpm shall be provided. The fire hydrant used for this water supply shall be located within 100 feet of the Fire Department Connection supplying the standpipe.

Not Specific to Tall Mass Timber



396

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Fire Safety Reqmt's - Water Supply

IV-A IV-B IV-C

IFC 3308.4 Fire safety requirements for buildings of Types IV-A, IV-B, and IV-C construction…(cont'd)

1. Standpipes . . .

2. A water supply for fire department operations, as approved by the fire code official and the fire chief.



Mass Timber and the IBC 397

397

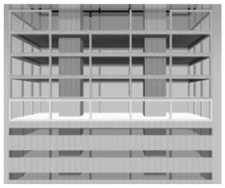
Noncombustible Protection

IV-A IV-B

IFC 3308.4 Fire safety requirements for buildings of Types IV-A, IV-B, and IV-C construction…(cont'd)

3. Where building construction exceeds six stories above grade plane, at least one layer of noncombustible protection where required by Section 602.4 of the International Building Code shall be installed on all building elements more than 4 floor levels, including mezzanines, below active mass timber construction before erecting additional floor levels.

Exception: Shafts and vertical exit enclosures…

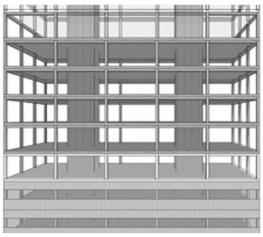


Mass Timber and the IBC 398

398

Noncombustible Protection

Protection (gray) applied to mass timber on all levels more than 4 stories below active construction floor



IV-A

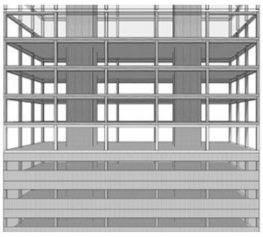
IV-B

Mass Timber and the IBC 399

399

Noncombustible Protection

Work can only proceed on 9th floor after mass timber protection is applied as required on 4th floor



IV-A

IV-B

Mass Timber and the IBC 400

400

Noncombustible Protection



18-story Brock Commons Example

IV-A IV-B

Mass Timber and the IBC 401

401

Exterior Wall Coverings

IV-A IV-B IV-C

IFC 3308.4 Fire safety requirements for buildings of Types IV-A, IV-B, and IV-C construction…(cont'd)

4. Where building construction exceeds six stories above grade plane required exterior wall coverings shall be installed on all floor levels more than 4 floor levels, including mezzanines, below active mass timber construction before erecting additional floor level.

Exception: Shafts and vertical exit enclosures…



Mass Timber and the IBC 402

402

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Owner's Responsibility

3303.3 Daily fire safety inspection. The site safety director shall be responsible for completion of a daily fire safety inspection at the project site. Each day, all building and outdoor areas shall be inspected to ensure compliance with the inspection list in this section. The results of each inspection shall be documented and maintained on site until a certificate of occupancy has been issued. Documentation shall be immediately available on site for presentation to the fire code official upon request…

3rd offense → stop work

Not Specific to Tall Mass



403

Owner's Responsibility

3303.3 Daily fire safety inspection…(cont'd)

- Inspect hot work areas
- Inspect all temporary heating equipment
- Ensure trash/debris removed
- No exposed conductors on temporary wiring
- Flammable/hazardous materials stored properly
- Hydrants unobstructed and "clearly visible"
- Fire access roads obstruction-free
- Standpipes/sprinklers identifiable from access road
- Standpipes within 1 floor of highest construction
- Portable fire extinguishers in-service and properly spaced

Not Specific to Tall Mass Timber



404

Q&A



405

Conclusion

This concludes *Mass Timber Buildings & the IBC*. You should now be able to:

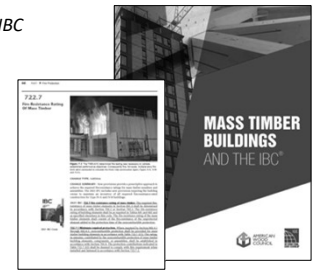
- Recognize unique fire-resistive characteristics of mass timber
- Summarize new provisions in 2015, 2018 and 2021 IBC related to mass timber products and Type IV construction
- Compare new and existing construction types and recognize inherent differences and conservative approaches for new construction types
- Evaluate new provisions for heights and areas, construction fire safety, fire and connection design and special inspection in tall mass timber construction

406

Resources

Mass Timber Buildings & the IBC

- AWC & ICC publication
- Available PDF and Print



407

Resources

Tall Mass Timber Special Inspector

- Exam now available
- PRONTO



408

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

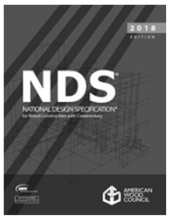
2021 I-Codes



Mass Timber and the IBC 409

409

AWC Standards





Mass Timber and the IBC 410

410

AWC Tall Mass Timber Webpage

www.awc.org



Mass Timber and the IBC 411

411

AIA

American Wood Council and International Code Council are a Registered Providers with The American Institute of Architects Continuing Education Systems. Credit earned on completion of this program will be reported to CES Records for AIA members. Certificates of Completion for non-AIA members are available on request.

This program is registered with the AIA/CES for continuing professional education. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the AIA of any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product. Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

Mass Timber and the IBC 412

412

Copyright Materials

This presentation is protected by U.S. and International Copyright laws. Reproduction, distribution, display and use of the presentation without written permission of the speaker is prohibited.

© American Wood Council 2021

© International Code Council 2021

Mass Timber and the IBC 413

413

Thank you for participating!

To schedule a seminar, contact:
The Learning Center™
1-888-ICC-SAFE (422-7233) Ext. 33821
learn@iccsafe.org

or

AWC Education
202-463-2766
education@awc.org

Mass Timber Buildings
and the IBC

Mass Timber and the IBC 414

414

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

File Attachments for Item:

EC-21 Mass Timber and Type IV Construction (4-hour version) (American Wood Council)

All certifications (4 hours)

Edward J. Lisinski

Phone: (414) 412-6096
Email: elisinski@awc.org

QUALIFICATIONS:

In my current position as Regional Manager for the American Wood Council, I monitor and participate in local, state and national building codes processes, as they relate to wood construction, in my region. I am responsible to provide training (both in-person and virtual) and resources for building and fire officials, inspectors and plan reviewers in my region. I am a State of Wisconsin licensed Professional Engineer, Master Plumber and have commercial and residential building and plumbing inspection certifications from the State of Wisconsin. I currently serve on the ICC Governing Committee for the Building Membership Council as Chair, the IBC-Structural Committee as Chair, and numerous other boards and committees. I am currently serving as the Immediate Past-President and Treasurer of the Wisconsin Code Officials Alliance.

EDUCATION:

Bachelor of Science in Architectural Engineering, Milwaukee School of Engineering

EMPLOYMENT:

12/2021-Present Regional Manager, American Wood Council.
My responsibilities include monitoring and participating in the local, state and national building codes processes, as they relate to wood construction; providing training (both in-person and virtual) for building and fire officials, inspectors and plan reviewers; and being a resource for the design, construction, review and inspection of wood construction in my region.

8/2005-11/2021 Plan Reviewer (8/05-6/11)/Assistant Director (6/11-12/14)/Director (12/14-11/21), City of West Allis Department of Building Inspection and Neighborhood Services

My responsibilities included directing a team of 16 building inspectors and staff; reviewing building plans for local, state and national building codes; writing building permits; meeting with contractors, architects and home owners to discuss projects; budgeting; hiring and disciplining my staff; being the primary contact for other departments in City Hall; writing municipal codes and ordinances; managing and updating department policies and procedures.

4/2019-5/2022 Co-Owner, E-Plan Exam
E-Plan Exam is a third party plan review company which provides municipal plan reviews for four municipalities in Wisconsin, and growing. We provide plan reviews for building, plumbing, mechanical, fire alarm and fire sprinkler systems. We also provide building code consulting services for architects, developers and contractors.

3/2000-8/2005 Architectural Designer, Anderson Ashton, Inc.
My responsibilities included drafting building plans, creating 3D models and renderings, designing structural systems for buildings, preparing all construction documents, drawings, and structural calculations, and performing code reviews.

9/2003-5/2006 Adjunct Instructor, ITT Technical Institute, Greenfield Campus
My responsibilities included teaching classes such as: Architectural Drafting I & II, Engineering Graphics I, Digital Information Management, Physical & Computer Aided 3D Modeling, and aid students in their design projects.

1994-2000 Laborer, Leppin Services, Inc.
My responsibilities included work in the construction field installing drywall, insulation, and steel and wood studs.

CERTIFICATIONS, LICENSES, AWARDS:

Professional Engineer, State of Wisconsin, No. 41154
Master Plumber, State of Wisconsin, No. 997556
Commercial and Residential Building and Plumbing Inspector, No. 997556
Gold Certificate in Supervision, Cities and Villages Mutual Insurance Company, August 2013
Silver Certificate in Management, Cities and Villages Mutual Insurance Company, December 2013
2014 West Allis/West Milwaukee Chamber of Commerce "Young Professional of the Year Award"
2020 NARI Milwaukee "Bill Bobrowitz Image Award"

PROFESSIONAL BOARDS AND COMMITTEES:

International Code Council (ICC), Building Membership Council
- Governing Committee Member, elected to first term, 2017-2021
  - Elected to second term 2022-2025
  - Elected as Vice Chairman for 2020-2021
  - Elected as Chairman for 2022 and 2023
- Chairman, Continuity and Outreach subcommittee, 2020-2021
- Raising the Profile subcommittee, Member 2016-Present, Chairman 2019
- Preparing for the Future Task Group Member, 2016-2018
- Higher Education Task Group Member, 2016-2018

ICC Structural Code Development Committee,
- Member 2015-Present
- Vice Chairman 2017-2019
- Chairman 2020-Present

ICC Building Code Interpretation Committee, Chairman 2017-2019
ICC Region III Code Development Committee Member, 2016-Present
Wisconsin Code Officials Alliance
- Member, 2013-Present
- Vice President, 2016
- President, 2017-2020
- Immediate Past-President 2020-Present
- Treasurer 2021-Present
- Board Liaison of Strategic Planning Committee, 2015-Present
- Member of Government Relations/Code Development Committee, 2015-Present

Building Inspectors Association of Southeastern Wisconsin;
- Member, 2005-Present
- Code Development Committee, Member 2015-Present, Chairman 2017-2021

COMMUNITY BOARDS AND COMMITTEES:

City of West Allis Plan Commission, 2002-2005
City of West Allis Historical Conservation Commission, 2004-2005; 2022-Present
West Allis Community Gala Planning Committee 2011-Present
West Allis Crime Stoppers Board of Directors, 2017-Present, Treasurer 2019-Present
West Allis Historical Society
- Board of Directors, 2009-Present
- Vice President, 2013-Present

West Allis Little League
- Volunteer Coach, 2010-2015
- Board of Directors, 2012-2015

West Allis Old Timers Baseball Association
- Board of Directors, 2010-Present
- Vice President 2014-2016
- President 2017-Present

Mass Timber and Type IV Construction

Course Description:

This presentation will provide an overview of mass timber which includes any product currently permitted for use in Type IV (heavy timber) construction such as cross-laminated timber (CLT), structural composite lumber (SCL), glued laminated timber (glulam), mechanically laminated decking (aka nail-laminated timber, NLT), and large section sawn timbers. Structural and fire protection characteristics of mass timber will be discussed as well as IBC code provisions that allow their specification in both residential and commercial applications for a wide variety of occupancies. This presentation will provide an overview of changes to the 2015, 2018 and 2021 International Building Code (IBC) related to mass timber construction. Changes to the 2021 IBC allow for construction of mass timber buildings with larger heights and areas than is currently permitted in Types III, IV, and V construction. This presentation will provide an overview of the allowable heights and areas for the three new types of mass timber construction: Types IV-A, IV-B, and IV-C. Construction fire safety requirements and owner responsibilities related to the fire resistance elements of the building will also be discussed. An overview of fire design of mass timber building elements and assemblies and protection of connections will be discussed. New code provisions for special inspection of tall mass timber structures will also be discussed.

Learning Objectives:

- Identify code acceptance of mass timber products.
- Describe technology advances and standards related to mass timber products.
- Recognize the unique fire resistive characteristics of mass timber as it influences the use of wood in building construction.
- Describe the application of NDS Chapter 16 which can be utilized to design up to 2-hours of fire-resistance for exposed wood members.

Note: The presentation slides are provided for the full 4-hour presentation. The 3-hour presentation will end after Slide 306. I would like to receive approval of both the three and four hour versions so that I can have some flexibility when scheduling the class with local organizations.

Ohio Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: Ed Lisinski

Organization: American Wood Council

Address: 50 Catoctin Cir NE, Suite 201, Leesburg, VA 20176

E-mail: elisinski@awc.org Telephone: 414-412-6096

Website: www.awc.org

Conference Sponsor (if applicable) None Conference Email: None

Check here if Course Renewal: No Prior course number _____ (*i.e. BBS2018-429*)

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: Mass Timber and Type IV Construction

Course instructor: Ed Lisinski

Course description: See attached documents.

Instructional hours per session: 4 Number of Sessions: 1

Course Date(s) and Location: TBD

Special Content:

Code Administration:_____ Conference Course: _____

Existing Buildings: _____ Conference Name: _____

Electrical Instruction: _____ Conference location: _____

Plumbing Instruction:_____

Course to be offered online? No **On Demand**_____ **Webinar**_____

Course Website: _____

Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation)*:

Course applicable for the following certifications

Residential Certifications Only: _____ Commercial Certifications: Yes

Administrative Course, All Certifications: _____

Application materials included:

X Course Outline or Course Learning Objectives

X Presentation Materials/Slides (not required for roundtable courses)

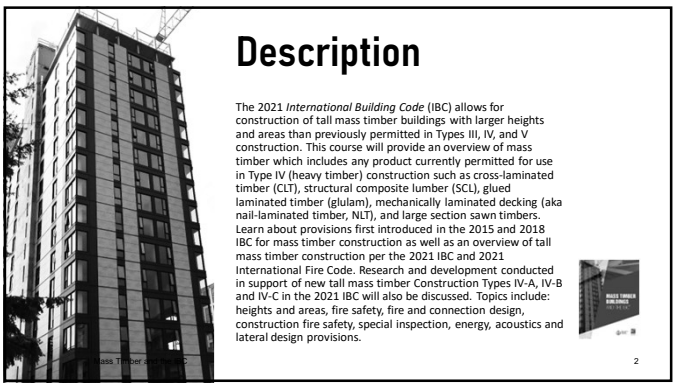
N/A Assessment Materials (for online courses)

X Presenter Bio

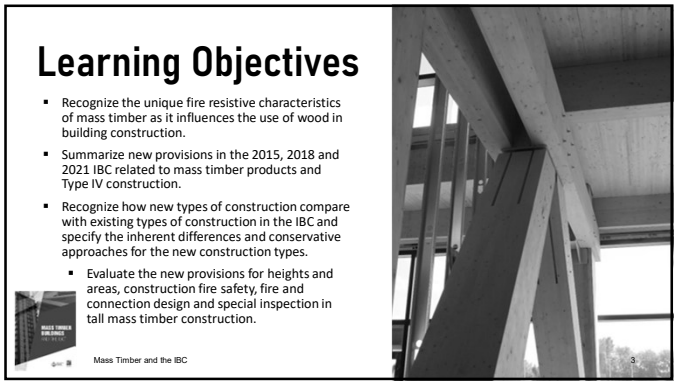
Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov



1



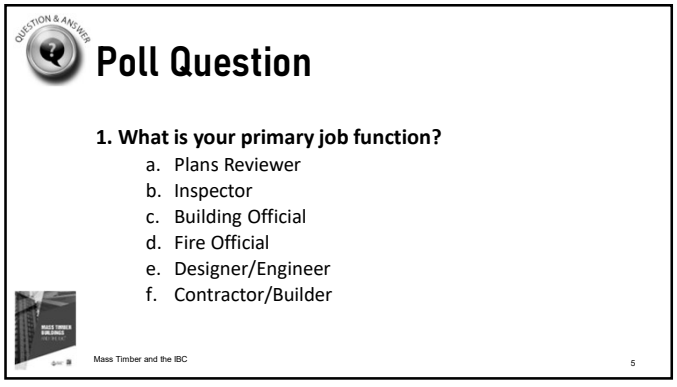
2



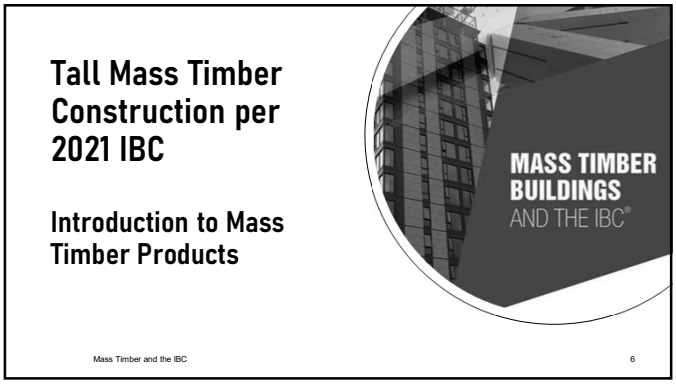
3



4



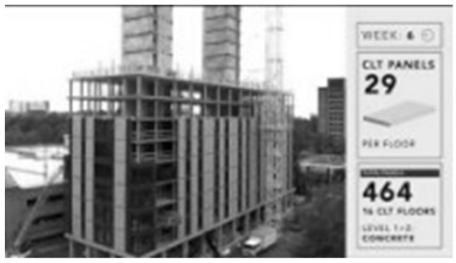
5



6

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

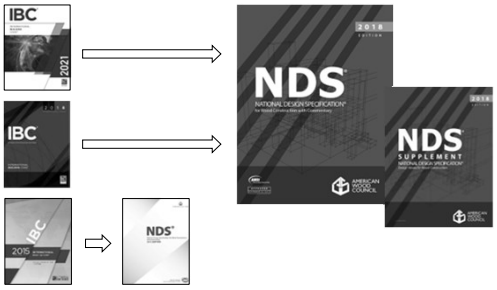
Why do we need mass timber buildings?



Mass Timber and the IBC 7

7

Standard for Engineered Wood Design



Mass Timber and the IBC 8

8

Sub-Outline

- Introduction to Mass Timber Products
- Types of Mass Timber Products
  - Code Acceptance
  - Technology
  - Application



Mass Timber and the IBC 9

9

Introduction to Mass Timber Products

What are all these acronyms?

- Sawn Lumber
  - Heavy Timber – HT
- Glued Laminated Timber
  - Beam or column – Glulam
  - Floor or roof slab – GLT
- Mechanically Laminated Decking
  - Nail-Laminated Timber – NLT
  - Dowel-Laminated Timber – DLT
- Structural Composite Lumber – SCL
  - Laminated Veneer Lumber – LVL
  - Parallel Strand Lumber – PSL
  - Laminated Strand Lumber – LSL
  - Oriented Strand Lumber – OSL
- Cross-Laminated Timber – CLT
- Mass Plywood Panels – MPP

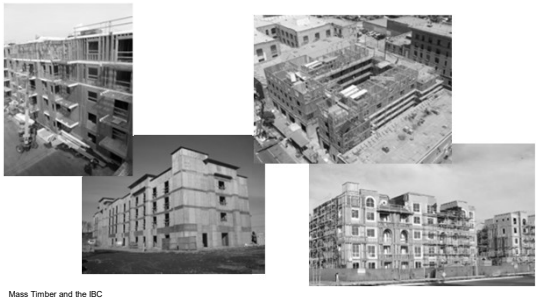


This Photo by Unknown Author is licensed under CC BY-ND

Mass Timber and the IBC 10

10

Traditional Stick Frame Construction



Mass Timber and the IBC 11

11

Mass Timber is NOT Light-Frame



… but Mass Timber elements can be used in all construction types

Mass Timber and the IBC 12

12

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Where is Mass Timber Allowed in the IBC?

- Types I & II – generally noncombustible inside and out
  - Heavy Timber allowed for limited roof applications in Type I-B & Type II
- Type III – noncombustible exterior walls, but interior any material
- Types IV & V – generally combustible
  - Type V includes any material permitted



LeMay – America's Auto Museum – Tacoma, WA
Courtesy of APA-The Engineered Wood Association

13

Mass timber elements are the ONLY combustible elements allowed for tall mass timber buildings





14

Minimum Sizes for Mass Timber

Spelled out in 602.4 and 2304.11

Table 2304.11 MINIMUM DIMENSIONS OF HEAVY TIMBER STRUCTURAL MEMBERS

Supporting	Min. Nom. Solid Sawn Size		Min. Glulam Net Size		Min. SCL Net Size	
	Width (in.)	Depth (in.)	Width (in.)	Depth (in.)	Width (in.)	Depth (in.)
Floor or Floor/Roof	8	8	6¾	8¼	7	7½
	6	10	5	10½	5¼	9½
Roof Only	6	8	5	8¼	5¼	7½
	6	6	5	6	5¼	5½
	4	6	3	$6^{7}/_{8}$	3½	5½

- CLT minimum thicknesses
  - Floors – 4″ actual
  - Roofs – 3″ nominal
  - Exterior Walls in Type IV – 6″ with limitations (see 602.4.2)



15

Sub-Outline

- Introduction to Mass Timber Products
- Types of Mass Timber Products
  - Code Acceptance
  - Technology
  - Application



16

Types of Mass Timber Products

- Sawn Lumber (Timbers)
- Glued Laminated Timber
- Mechanically Laminated
  - Nail-Laminated Timber (NLT)
  - Dowel-Laminated Timber (DLT)
- Structural Composite Lumber (SCL)
  - Laminated Veneer Lumber (LVL)
  - Parallel Strand Lumber (PSL)
  - Laminated Strand Lumber (LSL)
  - Oriented Strand Lumber (OSL)
- Cross-Laminated Timber (CLT)
  - Mass Plywood Panels (MPP)



17

Sawn Lumber (Timbers)

- Beams and Stringers
- Posts and Timbers
- Mechanically Laminated Decking
- Glulam
- 500,000 SF, 300 lbs./SF Design Load
- 24″ x 24″ columns on ground floor
- 9″ x 9″ columns on the 9th floor
- https://www.butlersquare.com/history



Butler Building – Minneapolis
Courtesy of WoodWorks

18

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Code Acceptance

- Grading practices and identification shall comply with rules published by an agency approved in accordance with the procedures of DOC PS 20 or equivalent
  - IBC 2301.1.1
  - Adobe version pdf version on NIST

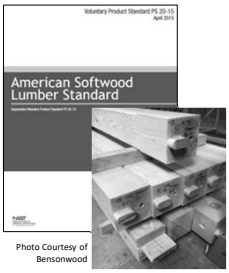


Photo Courtesy of Bensonwood

Mass Timber and the IBC 19

19

Code-referenced Standard

- National Design Specification for Wood Construction
  - Design Values Supplement

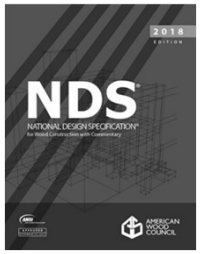


Mass Timber and the IBC 20

20

Sawn Lumber Design: 2018 NDS

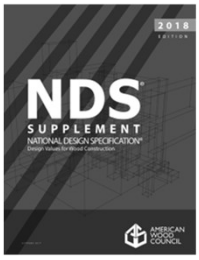
1. General Requirements for Building Design
2. Design Values for Structural Members
3. Design Provisions and Equations
4. **Sawn Lumber**
5. Structural Glued Laminated Timber
6. Round Timber Poles and Piles
7. Prefabricated Wood I-Joists
8. Structural Composite Lumber
9. Wood Structural Panels
10. Cross-laminated Timber
11. Mechanical Connections
12. Dowel-Type Fasteners
13. Split Ring and Shear Plate Connectors
14. Timber Rivets
15. Special Loading Conditions
16. Fire Design of Wood Members



Mass Timber and the IBC 21

21

2018 NDS Supplement



1. **Sawn Lumber Grading Agencies**
2. **Species Combinations**
3. **Section Properties**
4. **Reference Design Values**
   - Sawn Lumber and Timber
   - MSR and MEL
   - Decking
   - Non-North American Sawn Lumber
   - Structural Glued Laminated Timber
   - Timber Poles and Piles

Mass Timber and the IBC 22

22

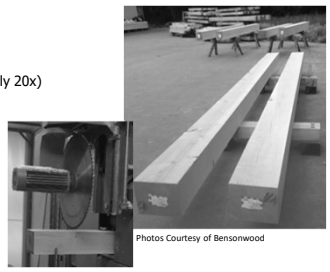
Sawn Lumber (Timbers)

Beams and Stringers

Posts and Timbers

- Readily available
- Western species 4x, 6x and 8x (possibly 20x)
- Southern Pine 2x (built-up)
- 8′ to 20′ lengths (2′ increments)

NOTE: always check for local availability



Photos Courtesy of Bensonwood

Mass Timber and the IBC 23

23

Sawn Lumber (Timbers)

- Manufacturing sizes
  - Nominal vs. Actual
  - Dry vs. Green



Photos Courtesy of Fraserwood

Mass Timber and the IBC 24

24

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Types of Mass Timber Products

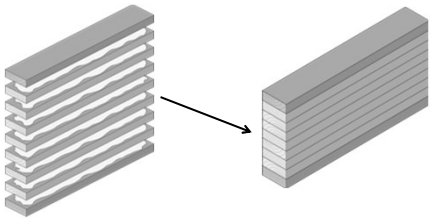
- Sawn Lumber (Timbers)
- Glued Laminated Timber
- Mechanically Laminated
  - Nail-Laminated Timber (NLT)
  - Dowel-Laminated Timber (DLT)
- Structural Composite Lumber (SCL)
  - Laminated Veneer Lumber (LVL)
  - Parallel Strand Lumber (PSL)
  - Laminated Strand Lumber (LSL)
  - Oriented Strand Lumber (OSL)
- Cross-Laminated Timber (CLT)
  - Mass Plywood Panels (MPP)



25

Glued Laminated Timber

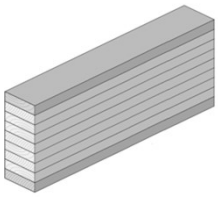
- STRUCTURAL GLUED LAMINATED TIMBER = Glued laminated timber = Glulam
  - composite of lumber laminations bonded with adhesives



26

Glulam – Characteristics

- Wood laminations bonded together
- Wood grain runs parallel to length



- Typical Widths
  - 3-1/8", 3-1/2", 5-1/8", 5-1/2" and 6-3/4" (possibly to 10-3/4")
  - Widths vary by species
- Laminations
  - 1-3/8" for Southern Pine
  - 1-1/2" for Douglas Fir

27

Glued Laminated Timber - Glulam

- Glulam – when used as a beam or column



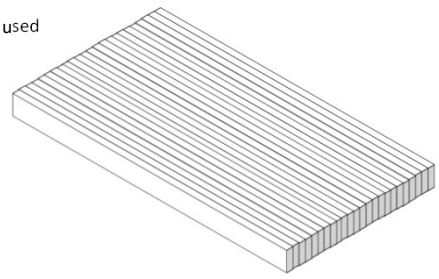
Photo courtesy of naturallywood.com. Photo - Steven Errico



28

Glued Laminated Timber - GLT

- GLT – when used as a panel



29

Code Acceptance

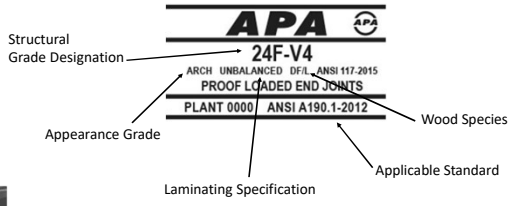
- IBC 2303.1.3 - Structural glued laminated timber manufactured and identified as required
  - Qualification and quality assurance
  - On-going third-party inspection
  - Grademark meeting ANSI A190.1
  - *D 3737: Practice for Establishing Allowable Properties for Structural Glued Laminated Timber (Glulam)*
  - Commonly uses sawn lumber - DOC PS 20



30

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

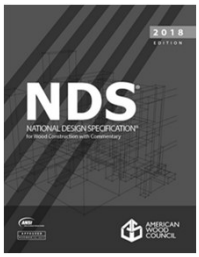
Marking per ANSI/APA A190.1



31

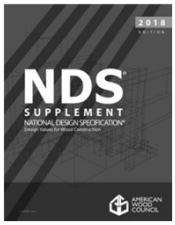
Glulam Design: 2018 NDS

1. General Requirements for Building Design
2. Design Values for Structural Members
3. Design Provisions and Equations
4. Sawn Lumber
5. **Structural Glued Laminated Timber**
6. Round Timber Poles and Piles
7. Prefabricated Wood I-Joists
8. Structural Composite Lumber
9. Wood Structural Panels
10. Cross-laminated Timber
11. Mechanical Connections
12. Dowel-Type Fasteners
13. Split Ring and Shear Plate Connectors
14. Timber Rivets
15. Special Loading Conditions
16. Fire Design of Wood Members



32

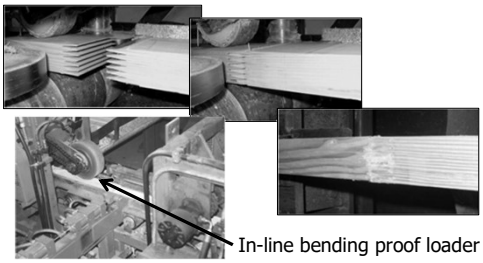
2018 NDS Supplement



1. **Sawn Lumber Grading Agencies**
2. **Species Combinations**
3. **Section Properties**
4. **Reference Design Values**
   - Sawn Lumber and Timber
   - MSR and MEL
   - Decking
   - Non-North American Sawn Lumber
   - Structural Glued Laminated Timber
   - Timber Poles and Piles

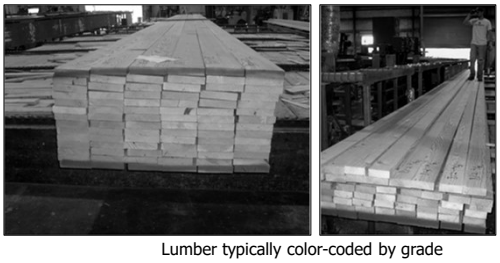
33

Finger Jointing Using RF Curing



34

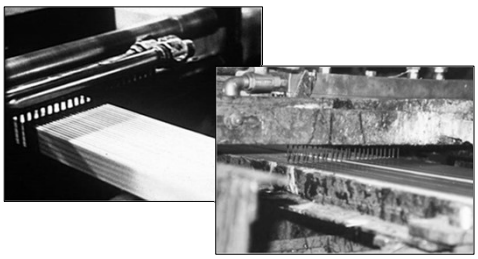
Pre-Adhesive Layup



Lumber typically color-coded by grade

35

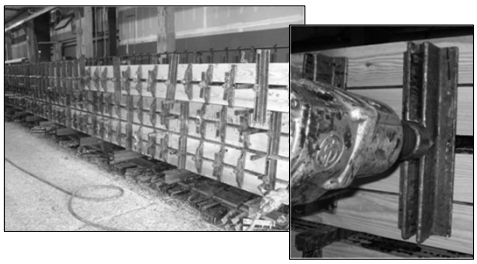
Face Bonding



36

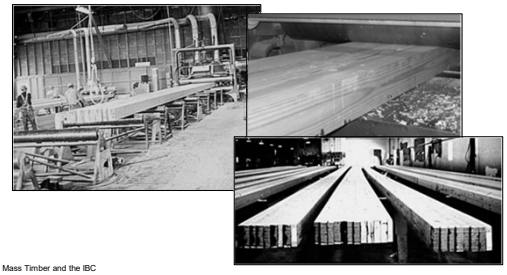
Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Clamping and Curing



37

Fabrication & Finishing



38

Church in Louisville, KY





12-1/4" x 84"
140' clear span

39

Bullitt Center – Seattle, WA



250 YEAR STRUCTURE
HEAVY TIMBER, CONCRETE & STEEL





Architect: Miller Hull Partnership
Structural Engineer: DCI Engineers
Photo Credit: Miller Hull Partnership

40

Bullitt Center – Seattle, WA



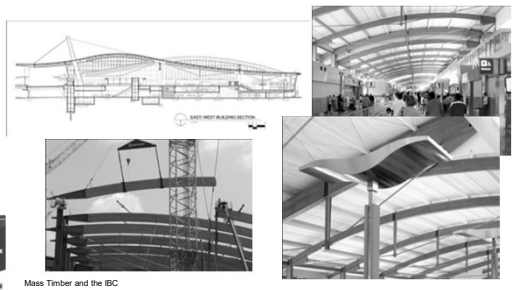
- Glulam beams and columns
- Nail-laminated timber floors



Architect: Miller Hull Partnership
Structural Engineer: DCI Engineers
Photo Credit: Miller Hull Partnership

41

Raleigh Durham Airport



42

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Cathedral of Christ the Light - Oakland





43

Cathedral of Christ the Light - Oakland

Design Team: Skidmore Owings & Merrill, Craig W. Harman
Webcore Builders
Glulam Manufacturer: Western Wood Structures
Photo Credit: Timothy Hursley, Cesar Rubio, and John Blaustein





44

Fire House - Multnomah County, OR



Owner: Multnomah County Rural Fire Protection District 10. Oregon
Architect: Hennebery Eddy Architects, Inc
Photo by Josh Partee

45

Denver – Platte15



46

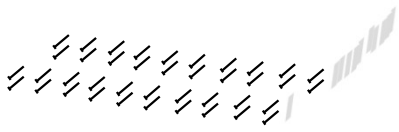
Types of Mass Timber Products

- Sawn Lumber (Timbers)
- Glued Laminated Timber
- Mechanically Laminated
  - Nail-Laminated Timber (NLT)
  - Dowel-Laminated Timber (DLT)
- Structural Composite Lumber (SCL)
  - Laminated Veneer Lumber (LVL)
  - Parallel Strand Lumber (PSL)
  - Laminated Strand Lumber (LSL)
  - Oriented Strand Lumber (OSL)
- Cross-Laminated Timber (CLT)
  - Mass Plywood Panels (MPP)



47

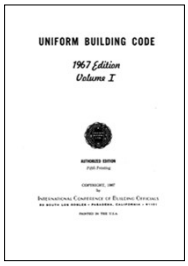
What is Nail-Laminated Timber?



48

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Code Acceptance


UNIFORM BUILDING CODE

1967 Edition
Volume I

(g) **Mechanically Laminated Floors and Decks.** A laminated lumber floor or deck built up of wood members set on edge, when meeting the following requirements, may be designed as a solid floor or roof deck of the same thickness, and continuous spans may be designed on the basis of the full cross section using the simple span moment coefficient.

Laminations shall be driven up and spiked closely together with a row of nails near each edge at spaced intervals and staggered vertically. Nail spacing in each row shall not exceed eighteen inches (18") for two-inch by eight-inch (2" x 8") nominal width and be proportional for other plank widths. Nail length shall be not less than two and one-half times the net thickness of each lamination.

A single span deck shall have all laminations full length.

A continuous deck of two spans shall have not more than every fourth lamination spliced within quarter points adjoining supports.

A continuous deck of more than two spans shall have not more than every third lamination spliced within quarter points adjoining supports.

Joints shall be closely butted over supports or staggered across the deck but within the adjoining quarter spans.

No lamination shall be spliced more than twice in any span.



49

Code Acceptance

- 2304.9.3 Mechanically laminated decking. Mechanically laminated decking shall comply with Sections 2304.9.3.1 through 2304.9.3.3.
- 2304.9.3.1 General. Mechanically laminated decking consists of square-edged dimension lumber laminations set on edge and nailed to the adjacent pieces and to the supports.
- 2304.9.3.2 Nailing. The length of nails connecting laminations shall not be less than two and one-half times the net thickness of each lamination. Where decking supports are 48 inches (1219 mm) on center (o.c.) or less, side nails shall be installed not more than 30 inches (762 mm) o.c. alternating between top and bottom edges and staggered one-third of the spacing in adjacent laminations. Where supports are spaced more than 48 inches (1219 mm) o.c., side nails shall be installed not more than 18 inches (457 mm) o.c. alternating between top and bottom edges and staggered one-third of the spacing in adjacent laminations. Two side nails shall be installed at each end of butt-jointed pieces.

  Laminations shall be toenailed to supports with 20d or larger common nails. Where the supports are 48 inches (1219 mm) o.c. or less, alternate laminations shall be toenailed to alternate supports; where supports are spaced more than 48 inches (1219 mm) o.c., alternate laminations shall be toenailed to every support.
- 2304.9.3.3 Controlled random pattern. There shall be a minimum distance of 24 inches (610 mm) between end joints in adjacent courses. The pieces in the first and second courses shall bear on at least two supports with end joints in these two courses occurring on alternate supports. A maximum of seven intervening courses shall be permitted before this pattern is repeated.

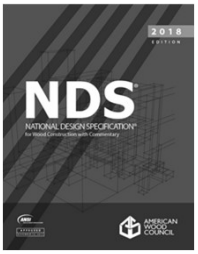




50

Sawn Lumber Design: 2018 NDS

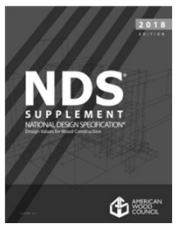
1. General Requirements for Building Design
2. Design Values for Structural Members
3. Design Provisions and Equations
4. **Sawn Lumber**
5. Structural Glued Laminated Timber
6. Round Timber Poles and Piles
7. Prefabricated Wood I-Joists
8. Structural Composite Lumber
9. Wood Structural Panels
10. Cross-laminated Timber
11. Mechanical Connections
12. Dowel-Type Fasteners
13. Split Ring and Shear Plate Connectors
14. Timber Rivets
15. Special Loading Conditions
16. Fire Design of Wood Members





51

2018 NDS Supplement



1. **Sawn Lumber Grading Agencies**
2. **Species Combinations**
3. **Section Properties**
4. **Reference Design Values**
   - Sawn Lumber and Timber
   - MSR and MEL
   - Decking
   - Non-North American Sawn Lumber
   - Structural Glued Laminated Timber
   - Timber Poles and Piles



52

Nail-Laminated Timber







Courtesy: StructureCraft



53

Nail-Laminated Timber



Courtesy : StructureCraft



54

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Nail-Laminated Timber



Courtesy : StructureCraft

55

Nail-Laminated Timber





- Nail-Laminated Timber – 2x12 vertical
- Mechanically connected w/nails
- NDS principles of mechanics



Architect: Profeta Royalty Architecture
Structural Engineer: Structural Focus 2011

56

Nail-Laminated Timber

- Samuel Brighouse Elementary School (Richmond, BC)



Design Team: Perkins + Will Canada, Fast + Epp
Photo Credit: Stephan Pasche





Courtesy : StructureCraft

57

Nail-Laminated Timber



Architect: DLR Group
https://vimeo.com/162580838

- T3 – Minneapolis
  - Glued & Nail-laminated Timber – vertical 2x sawn lumber mechanically connected w/nails
  - Engineered with NDS principles of mechanics
  - **7 Stories total**
  - **6 Stories Type IV Construction**
  - **1 Story Type 1-A Podium**
  - **IBC Section 510**

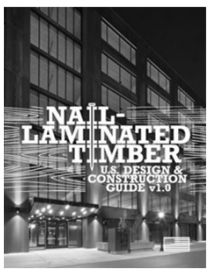


58

Nail-Laminated Timber Handbook

- Architecture
- Fire
- Structure
- Enclosures
- Supply & Fabrication
- Construction & Installation
- Erection Engineering

https://www.thinkwood.com/products-and-systems/mass-timber/nltguide



59

Dowel-Laminated Timber

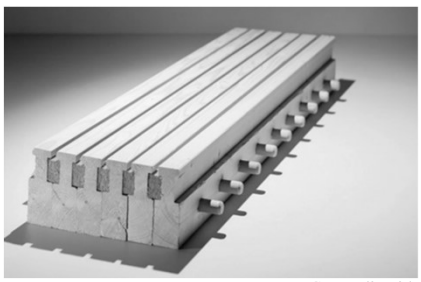


Photo courtesy of StructureCraft

60

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Dowel-Laminated Timber



61

Dowel-Laminated Timber



Photo provided by B.Bishop

62

Dowel-Laminated Timber

ICC-ES Evaluation Report

ESR-4069

Issued November 2019
Revised November 8, 2019
This report is subject to renewal November 2020.

www.icc-es.org | (800) 423-6587 | (562) 699-0543 *A Subsidiary of the International Code Council®*

DIVISION: 06 00 00 —WOOD, PLASTICS AND COMPOSITES
Section: 06 17 21—Dowel-Laminated Timber

REPORT HOLDER:

STRUCTURECRAFT BUILDERS INC.

EVALUATION SUBJECT:

DOWEL-LAMINATED TIMBER (DLT)

1.0 EVALUATION SCOPE

Compliance with the following codes:

- 2018, 2015, 2012 and 2009 *International Building Code®*

time of manufacture does not exceed 19 percent, and the dowels are dried to 5 to 9 percent moisture content prior to insertion. Once inserted, the dowels swell as they come into equilibrium with the higher moisture content of the surrounding lumber, providing additional friction for a tight fit of the dowel in the laminations.

The StructureCraft Dowel-Laminated Timber panels are available in thicknesses of 4 inches nominal (89 mm) to 12 inches nominal (286 mm), widths of 12 inches (305 mm) to 14 feet (4.3 m) and lengths up to 60.7 feet (18.5 m).

3.2 Material:

3.2.1 Wood Laminations: Wood laminations used in manufacturing StructureCraft Dowel-Laminated Timber are

63

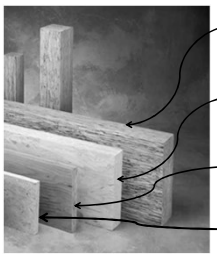
Types of Mass Timber Products

- Sawn Lumber (Timbers)
- Glued Laminated Timber
- Mechanically Laminated
  - Nail-Laminated Timber (NLT)
  - Dowel-Laminated Timber (DLT)
- Structural Composite Lumber (SCL)
  - Laminated Veneer Lumber (LVL)
  - Parallel Strand Lumber (PSL)
  - Laminated Strand Lumber (LSL)
  - Oriented Strand Lumber (OSL)
- Cross-Laminated Timber (CLT)
  - Mass Plywood Panels (MPP)



64

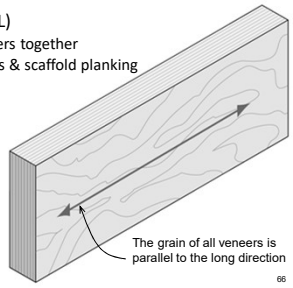
Structural Composite Lumber (SCL)



65

SCL – Features & Applications

- Laminated Veneer Lumber (LVL)
  - Produced by bonding thin veneers together
  - Used for beams, headers, rafters & scaffold planking
- Common Thicknesses
  - 1-3/4" to 7"
- Depths
  - 5-1/2" – 24"
- Lengths
  - Up to 60'



66

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Code Acceptance

- **2303.1.10 Structural composite lumber.** Structural capacities…in accordance with ASTM D 5456
- D 5456: *Specification for Evaluation of Structural Composite Lumber Products*


Designation: D5456 – 14b

Standard Specification for Evaluation of Structural Composite Lumber Products[1]

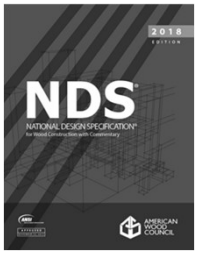
INTRODUCTION

Mass Timber and the IBC 67

67

SCL Design: 2018 NDS

1. General Requirements for Building Design
2. Design Values for Structural Members
3. Design Provisions and Equations
4. Sawn Lumber
5. Structural Glued Laminated Timber
6. Round Timber Poles and Piles
7. Prefabricated Wood I-Joists
8. **Structural Composite Lumber**
9. Wood Structural Panels
10. Cross-laminated Timber
11. Mechanical Connections
12. Dowel-Type Fasteners
13. Split Ring and Shear Plate Connectors
14. Timber Rivets
15. Special Loading Conditions
16. Fire Design of Wood Members



Mass Timber and the IBC 68

68

SCL – Features & Applications

- Features
  - Wood veneers or strands primarily oriented in the same direction
  - Strong when face- or edge-loaded
  - Milled (sawn) to consistent sizes
- Strength Properties
  - APA publishes strength properties
  - See manufacturer criteria


Photo Courtesy of www.naturallywood.com

Mass Timber and the IBC 69

69

Types of Mass Timber Products

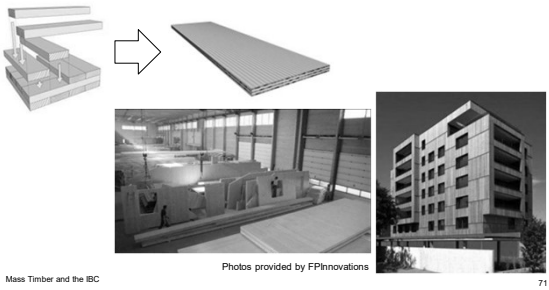
- Sawn Lumber (Timbers)
- Glued Laminated Timber
- Mechanically Laminated
  - Nail-Laminated Timber (NLT)
  - Dowel-Laminated Timber (DLT)
- Structural Composite Lumber (SCL)
  - Laminated Veneer Lumber (LVL)
  - Parallel Strand Lumber (PSL)
  - Laminated Strand Lumber (LSL)
  - Oriented Strand Lumber (OSL)
- Cross-Laminated Timber (CLT)
  - Mass Plywood Panels (MPP)



Mass Timber and the IBC 70

70

Cross-Laminated Timber


Photos provided by FPInnovations

Mass Timber and the IBC 71

71

Code Acceptance

- 2303.1.4 Structural glued cross-laminated timber is to be manufactured and identified in accordance with ANSI/APA PRG 320



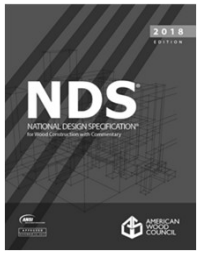
Mass Timber and the IBC 72

72

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

CLT Design: 2018 NDS

1. General Requirements for Building Design
2. Design Values for Structural Members
3. Design Provisions and Equations
4. Sawn Lumber
5. Structural Glued Laminated Timber
6. Round Timber Poles and Piles
7. Prefabricated Wood I-Joists
8. Structural Composite Lumber
9. Wood Structural Panels
10. **Cross-laminated Timber**
11. Mechanical Connections
12. Dowel-Type Fasteners
13. Split Ring and Shear Plate Connectors
14. Timber Rivets
15. Special Loading Conditions
16. Fire Design of Wood Members

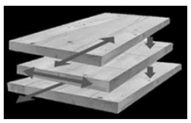


Mass Timber and the IBC 73

73

History of CLT

- 1985 1st CLT patent - France
- 1993 1st CLT projects - Switzerland and Germany
- 1995-1996 Improved press technology
- 1998 1st multi-story res building - Austria
- Early 2000's
  - CLT use (Europe) increased significantly
  - Green building movement driven
  - Better efficiencies, product approvals, improved marketing and distribution channels
  - Over 500 CLT buildings in England
- Recent - US and Canadian use of CLT





Mass Timber and the IBC 74

74

CLT Press & Assembly Line

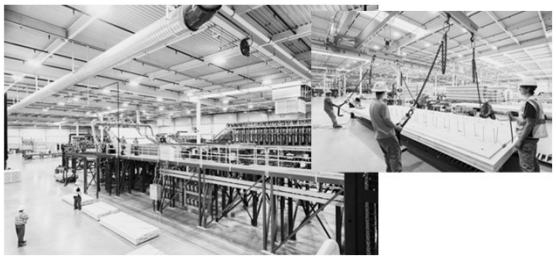


Photos Courtesy of Katerra

Mass Timber and the IBC 75

75

CLT Manufacturing Process

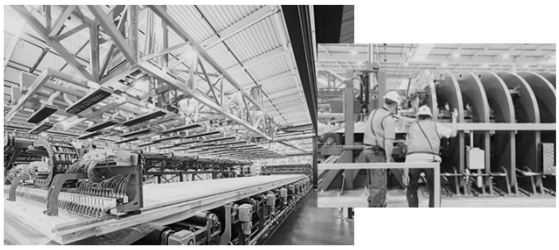


Photos Courtesy of Katerra

Mass Timber and the IBC 76

76

CLT Manufacturing Process



Photos Courtesy of Katerra

Mass Timber and the IBC 77

77

Ready to Ship



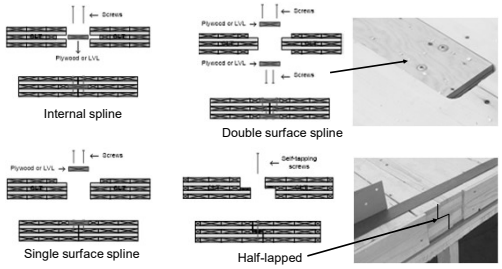
Photo Courtesy of Katerra

Mass Timber and the IBC 78

78

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

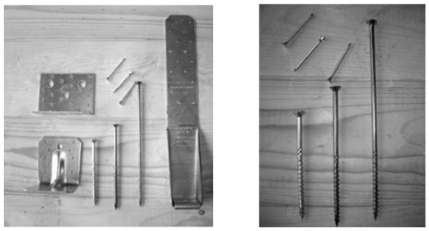
Typical Construction Details



Mass Timber and the IBC 79

79

Typical Panel Connectors



Mass Timber and the IBC 80

80

Typical Panel Connectors



Mass Timber and the IBC 81

81

CLT – Fitchburg, WI

- Factory
- Promega Feynman Center
- Fitchburg, WI



Owner: Promega Corporation
Architect: Uihlein-Wilson
Photos by J.B. Smith

Mass Timber and the IBC 82

82

CLT – Huntsville, AL

- Private Army Hotel – Redstone Arsenal
- Four stories and 58,000 sq ft



Owner/GC: Lendlease (US) Public Partnerships LLC
Architect: Leidos (now Benham)
Structural Engineer: Schaefer Structural Engineers
Photo: Lendlease

Mass Timber and the IBC 83

83

CLT – Huntsville, AL



Mass Timber and the IBC 84

84

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

CLT – Huntsville, AL



Mass Timber and the IBC 85

85

CLT – Huntsville, AL



Mass Timber and the IBC 86

86

CLT – Huntsville, AL



Mass Timber and the IBC 87

87

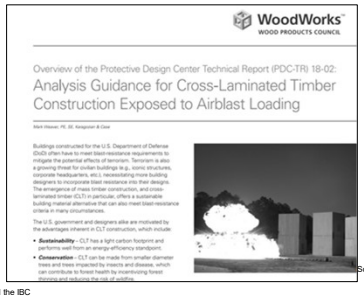
CLT – Huntsville, AL



Mass Timber and the IBC 88

88

CLT – Blast Testing



WoodWorks
WOOD PRODUCTS COUNCIL

Overview of the Protective Design Center Technical Report (PDC-TR) 18-02:
Analysis Guidance for Cross-Laminated Timber Construction Exposed to Airblast Loading

Source: WoodWorks

Mass Timber and the IBC 89

89

CLT – WV Elementary School

- 46,200 sq. ft.
- 8-week assembly
- Architect: MSES Architects Fairmont, WV



Source: LignaTerra

Mass Timber and the IBC 90

90

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

CLT – WV Elementary School






Photos: LignaTerra

91

CLT – Clemson University




Courtesy of Clemson University

92

CLT – Boston



Courtesy of Generate Architecture and Technologies

93

CLT – Canadian Projects

- The Arbora
- Québec, Canada
  - 8 Stories
  - 434 Residential condos, townhouses and rentals



94

CLT and Glulam – Vancouver, BC

- Brock Commons
  - 18 Stories
  - Mixed use student housing
  - Glulam columns
  - CLT floors




95

Mass Timber Worldwide



www.Thinkwood.com/tallerwood

Source: ThinkWood

96

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Mass Plywood Panel - MPP

- SCL-based "panel" or slab
- Alternative to CLT
- Like LVL – parallel laminations



Photo Courtesy
Freres Lumber



97

Mass Plywood Panel



Photos Courtesy
of Freres Lumber



Photo courtesy of
Stephen A. Miller
and Skylab



98

Q&A





99



Outline

- Introduction to Mass Timber Products
- 2015/2018 IBC for Mass Timber Construction
- Break – 15 minutes
- 2021 IBC for Tall Mass Timber Construction
  - Part 1: Background and Overview
  - Lunch – 1 hour
  - Part 2: New Construction Types and Heights & Areas
  - Part 3: Fire Safety
  - Break – 15 minutes
  - Part 4: Fire & Connection Design and Special Inspection
  - Part 5: Acoustics, Energy, and Lateral Resistance
  - Part 6: Construction Fire Safety



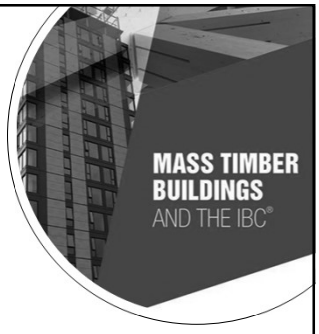




100

2015/2018 IBC for Mass Timber Construction





101

Sub-Outline

- 2015 IBC Related to CLT and SCL
- 2018 IBC Related to Heavy Timber





102

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

2015 IBC: SCL in Type IV

- Structural Composite Lumber (SCL) defined as heavy timber

Minimum Nominal Solid Sawn Size		Minimum Glued Laminated Timber Net Size		Minimum Structural Composite Lumber Net Size	
Width, inch	Depth, inch	Width, inch	Depth, inch	Width, inch	Depth, inch
8	8	6¾	8¼	7	7½
6	10	5	10½	5¼	9½
6	8	5	8¼	5¼	7½
6	6	5	6	5¼	5½
4	6	3	6⅞	3½	5½

103

2015 IBC: CLT in Type IV

- Cross Laminated Timber (CLT) defined as heavy timber
  - Ext/Int Walls
  - Floors
  - Roofs



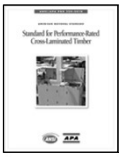
Photo provided by FPInnovations

104

2015 IBC: Definition and Standard

[BS] CROSS-LAMINATED TIMBER. A prefabricated engineered wood product consisting of not less than three layers of solid-sawn lumber or *structural composite lumber* where the adjacent layers are cross oriented and bonded with structural adhesive to form a solid wood element.

2303.1.4 Structural glued cross-laminated timber. Cross-laminated timbers shall be manufactured and identified in accordance with ANSI/APA PRG 320.



105

Supporting Data: CLT Fire Test



Fire Testing Laboratory

NGC Testing Services

ACCREDITED Testing Laboratory TL-216

TEST REPORT Page 1 of 53

for

American Wood Council

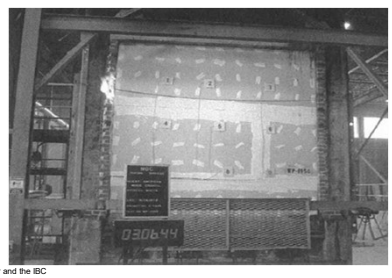
222 Catoctin Circle SE, Suite 201
Leesburg, VA 20175

Standard Methods of
Fire Tests of Building Construction and Materials
ASTM E 119 – 11a

Test Report No: WP-1950

106

Supporting Data: CLT Fire Test



107

2015 IBC: CLT Permitted Uses

- Types I and II – balcony and canopy or roof construction
- Type III – interior building elements
  - Roof-ceiling assemblies
  - Floor-ceiling assemblies
  - Interior walls
- Types IV or V – any



108

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

2015 IBC: CLT in Type IV

- Heavy Timber Family

602.4 Type IV. Type IV construction (Heavy Timber, HT) is that type of construction in which the exterior walls are of noncombustible materials and the interior building elements are of solid or laminated wood without concealed spaces. The details of Type IV construction shall comply with the provisions of this section and Section 2304.11. Exterior walls complying with Section 602.4.1 or 602.4.2 shall be permitted. Minimum solid sawn nominal dimensions are required for structures built using Type IV construction (HT). For glued-laminated members and structural composite lumber (SCL) members, the equivalent net finished width and depths corresponding to the minimum nominal width and depths of solid sawn lumber are required as specified in Table 602.4. Cross-laminated timber (CLT) dimensions used in this section are actual dimensions.

Mass Timber and the IBC 109

109

2015 IBC: CLT in Type IV

- Exterior Walls (2 hours or less)

602.4.2 Cross-laminated timber in exterior walls. Cross-laminated timber complying with Section 2303.1.4 shall be permitted within exterior wall assemblies with a 2-hour rating or less, provided the exterior surface of the cross-laminated timber is protected by one the following:

1. Fire-retardant-treated wood sheathing complying with Section 2303.2 and not less than $^{15}/_{32}$ inch (12 mm) thick;
2. Gypsum board not less than $^{1}/_{2}$ inch (12.7 mm) thick; or
3. A noncombustible material.

Mass Timber and the IBC 110

110

2015 IBC: Plank Floors in Type IV

- Floors

602.4.6.1 Sawn or glued-laminated plank floors. Sawn or glued-laminated plank floors shall be one of the following:

1. Sawn or glued-laminated planks, splined or tongue-and-groove, of not less than 3 inches (76 mm) nominal in thickness covered with 1-inch (25 mm) nominal dimension tongue-and-groove flooring, laid crosswise or diagonally, $^{15}/_{32}$-inch (12 mm) wood structural panel or $^{1}/_{2}$-inch (12.7 mm) particleboard.

Mass Timber and the IBC 111

111

2015 IBC: CLT Floors in Type IV

- Floors

602.4.6.2 Cross-laminated timber floors. Cross-laminated timber shall be not less than 4 inches (102 mm) in thickness. Cross-laminated timber shall be continuous from support to support and mechanically fastened to one another. Cross-laminated timber shall be permitted to be connected to walls without a shrinkage gap providing swelling or shrinking is considered in the design. Corbelling of masonry walls under the floor shall be permitted to be used.

Mass Timber and the IBC 112

112

2015 IBC: CLT in Type IV

- Roofs

602.4.7 Roofs. Roofs shall be without concealed spaces and wood roof decks shall be sawn or glued laminated, splined or tongue-and-groove plank, not less than 2 inches (51 mm) nominal in thickness; $1^{1}/_{8}$-inch-thick (32 mm) wood structural panel (exterior glue); planks not less than 3 inches (76 mm) nominal in width, set on edge close together and laid as required for floors; or of cross-laminated timber. Other types of decking shall be permitted to be used if providing equivalent fire resistance and structural properties.

Cross-laminated timber roofs shall be not less than 3 inches (76 mm) nominal in thickness and shall be continuous from support to support and mechanically fastened to one another.

Mass Timber and the IBC 113

113

2015 IBC: CLT in Type IV

- Interior Walls

602.4.8 Partitions and walls. Partitions and walls shall comply with Section 602.4.8.1 or 602.4.8.2.

602.4.8.1 Interior walls and partitions. Interior walls and partitions shall be of solid wood construction formed by not less than two layers of 1-inch (25 mm) matched boards or laminated construction 4 inches (102 mm) thick, or of 1-hour fire-resistance-rated construction.

Mass Timber and the IBC 114

114

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

2015 IBC: CLT in Type IV

- Exterior walls – assembly must be 6" thick

602.4.8.2 Exterior walls. Exterior walls shall be of one of the following:

1. Noncombustible materials.
2. Not less than 6 inches (152 mm) in thickness and constructed of one of the following:
   - 2.1. Fire-retardant-treated wood in accordance with Section 2303.2 and complying with Section 602.4.1.
   - 2.2. Cross-laminated timber complying with Section 602.4.2.

115

Sub-Outline

- 2015 IBC Related to CLT and SCL
- 2018 IBC Related to Heavy Timber



116

2018 IBC: Heavy Timber Reorg

2018 IBC	2015 IBC	Provision
602.4	602.4	Type IV construction
602.4.1, 602.4.2	602.4.1	Wall assembly thickness
602.4.3	602.4.9	Exterior structural members
2304.11	2304.11	Heavy timber construction
Table 2304.11	Table 602.4	Minimum dimensions
2304.11.1	New	Details of heavy timber structural members
2304.11.1.1	602.4.3, 2304.11.1	Columns
2304.11.1.2	602.4.4, 2304.11.2	Floor framing
2304.11.1.3	602.4.5, 2304.11.3	Roof framing
2304.11.2.1	602.4.8.2	Exterior walls
2304.11.2.2	602.4.8.1	Partitions and interior walls
2304.11.3	602.4.6	Floors
2304.11.3.1	602.4.6.2	CLT floors
2304.11.3.2	602.4.6.1, 2304.11.4	Sawn or glued-laminated plank floors
2304.11.4	2304.11.5	Roof decks

117

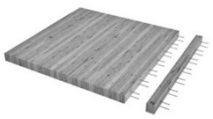
2018 IBC: Mech Laminated Decking

2304.11 Heavy timber construction. Where a structure, portion thereof or individual structural elements are required by provisions of this code to be of heavy timber, the building elements therein shall comply with the applicable provisions of Sections 2304.11.1 through 2304.11.4. Minimum dimensions of heavy timber shall comply with the applicable requirements in Table 2304.11 based on roofs or floors supported and the configuration of each structural element, or in Sections 2304.11.2 through 2304.11.4. Lumber decking shall be in accordance with Section 2304.9.

118

2018 IBC: Mech Laminated Decking

- Nail-laminated timber



2304.9.3.2 Nailing. The length of nails connecting laminations shall be not less than two and one-half times the net thickness of each lamination. Where decking supports are 48 inches (1219 mm) on center or less, side nails shall be installed not more than 30 inches (762 mm) on center alternating between top and bottom edges, and staggered one-third of the spacing in adjacent laminations. Where supports are spaced more than 48 inches (1219 mm) on center, side nails shall be installed not more than 18 inches (457 mm) on center alternating between top and bottom edges and staggered one-third of the spacing in adjacent laminations. For mechanically laminated decking constructed with laminations of 2-inch (51 mm) nominal thickness, nailing in accordance with Table 2304.9.3.2 shall be permitted. Two side nails shall be installed at each end of butt-jointed pieces.

Laminations shall be toenailed to supports with 20d or larger common nails. Where the supports are 48 inches (1219 mm) on center or less, alternate laminations shall be toenailed to alternate supports; where supports are spaced more than 48 inches (1219 mm) on center, alternate laminations shall be toenailed to every support. For mechanically laminated decking constructed with laminations of 2-inch (51 mm) nominal thickness, toenailing in accordance with Table 2304.9.3.2 shall be permitted.

119

2018 IBC: Mech Laminated Decking

TABLE 2304.9.3.2
FASTENING SCHEDULE FOR MECHANICALLY LAMINATED DECKING USING LAMINATIONS OF 2-INCH NOMINAL THICKNESS

MINIMUM NAIL SIZE (Length x Diameter) (inches)	MAXIMUM SPACING BETWEEN FACE NAILS [a,b] (inches)		NUMBER OF TOENAILS INTO SUPPORTS[c]
	Decking Supports ≤ 48 inches o.c.	Decking Supports > 48 inches o.c.	
4 × 0.192	30	18	1
4 × 0.162	24	14	2
4 × 0.148	22	13	2
3½ × 0.162	20	12	2
3½ × 0.148	19	11	2
3½ × 0.135	17	10	2
3 × 0.148	11	7	2
3 × 0.128	9	5	2
2½ × 0.148	10	6	2
2½ × 0.131	9	6	3
2½ × 0.120	8	5	3

120

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

2018 IBC: CLT Exterior Walls – Type IV

602.4.2 Cross-laminated timber in exterior walls. *Cross-laminated timber* complying with Section 2303.1.4 shall be permitted within exterior wall assemblies not less than 6 inches (152 mm) in thickness with a 2-hour rating or less, provided the exterior surface of the cross-laminated timber is protected by one the following:

1. *Fire-retardant-treated wood* sheathing complying with Section 2303.2 and not less than $^{15}/_{32}$ inch (12 mm) thick;
2. *Gypsum board* not less than $^{1}/_{2}$ inch (12.7 mm) thick; or
3. A noncombustible material.

Mass Timber and the IBC 121

121

2018 IBC: Flame Spread

803.3 Heavy timber exemption. Exposed portions of building elements complying with the requirements for buildings of ~~Type IV~~ heavy timber construction in Section 602.4 or Section 2304.11 shall not be subject to interior finish requirements except in interior exit stairways, interior exit ramps, and exit passageways.



Mass Timber and the IBC 122

122

2018 IBC: SCL Dimensions

602.4 Type IV. Type IV construction ~~(Heavy Timber, HT)~~ is that type of construction in which the exterior walls are of noncombustible materials and the interior building elements are of solid ~~or~~ wood, laminated wood, heavy timber (HT) or structural composite lumber (SCL) without concealed spaces. The minimum dimensions for permitted materials including solid timber, glued-laminated timber, structural composite lumber (SCL), and cross-laminated timber and details of Type IV construction shall comply with the provisions of this section and Section 2304.11. Exterior walls complying with Section 602.4.1 or 602.4.2 shall be permitted. Interior walls and partitions not less than 1-hour fire-resistance rating or heavy timber complying with Section 2304.11.2.2 shall be permitted.



Mass Timber and the IBC 123

123

2018 IBC: Heights & Areas

- IBC Chapter 5 – Heights & Areas
- IBC Chapter 6 – Types of Construction
- Addressed in Sections 5 and 6 of CCWD

Free at awc.org



Mass Timber and the IBC 124

124

2018 IBC: Types of Construction

- IBC Chapter 6
  - Defines types of construction
  - Wood frame construction is typical in Types III, IV and V
  - Specific applications permitting use of wood in Types I and II



Mass Timber and the IBC 125

125

2018 IBC: Type V

- Permits use of wood or other approved materials for loadbearing and nonloadbearing structural elements
  - Including heavy timber



Mass Timber and the IBC 126

126

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

2018 IBC: Type IV – Heavy Timber

- Exterior walls of noncombustible materials, FRTW or protected CLT
- Interior elements of solid or laminated wood without concealed spaces



127

2018 IBC: Type IV – Column/Beam

- Columns
  - Minimum 6″ × 8″ supporting roof/ceiling
  - Minimum 8″ × 8″ supporting floors
- Beams and Girders
  - Minimum 6″ × 10″ for floors
  - Minimum 4″ × 6″ for roofs



Old Faithful Inn, Yellowstone National Park

128

2018 IBC: Type IV – Floor/Roof

- Floors
  - Minimum 3-inch thickness covered with 1-inch nominal dimension T&G flooring or 4-inch thick CLT
- Roof decking
  - Minimum 2-inch thickness, 1-1/8-inch wood structural panels, or 3-inch thick CLT
- Partitions
  - 1-hour-fire-resistance-rated; or
  - Minimum 2 layers of 1-inch nominal board; or
  - Laminated construction 4-inches thick



Free at awc.org

129

2018 IBC: Type III

- Requires noncombustible or FRTW exterior bearing walls with minimum 2-hr FRR
  - Type IIIA – 1-hr FRR for building elements other than nonbearing walls
  - Type IIIB does not require any FRR other than exterior bearing walls



130

2018 IBC: Types I and II

- Requires most structural loadbearing elements to be noncombustible
  - Heavy timber permitted in roof
    - Table 601 footnote c (Type IB, IIA & IIB)
    - Alternate to 1-hr FRR noncombustible roof elements



131

2018 IBC: Heights & Areas

- IBC Chapter 5
  - Size thresholds for wood frame structures often determined by structural rather than code limitations
  - CLT and developments in mass timber technology are changing structural limitations for wood



132

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

2018 IBC: Heights & Areas

Table 504.3: Allowable Building Height (ft above grade)

	Occupancy Classification		Type of Construction				
			Type III		Type IV	Type V	
			A	B	HT	A	B
TABLE 504.3: Allowable Building Height (ft above Grade)	A, B, E, F, M, S, U	NS	65	55	65	50	40
		S	85	75	85	70	60
	I-1 Condition 1, I-3	NS	65	55	65	50	40
		S	85	75	85	70	60
	I-1 Condition 2, I-2	NS	65	55	65	50	40
		S					
	I-4	NS	65	55	65	50	40
		S	85	75	85	70	60
	R	NS	65	55	65	50	40
		S13R	60	60	60	60	60
		S	85	75	85	70	60

133

2018 IBC: Heights & Areas

Table 504.4: Allowable Number of Stories above Grade

	Occupancy Classification		Type of Construction				
			Type III		Type IV	Type V	
			A	B	HT	A	B
TABLE 504.4: Allowable Number of Stories above Grade	A-1, A-2, A-3, A-4	NS	3	2	3	2	1
		S	4	3	4	3	2
	B	NS	5	3	5	3	2
		S	6	4	6	4	3
	E	NS	3	2	3	1	1
		S	4	3	4	2	2
	M	NS	4	2	4	3	1
		S	5	3	5	4	2
	S-2	NS	4	3	4	4	2
		S	5	4	5	5	3
	R-1	NS	4	4	4	3	2
		S13R				4	3
		S	5	5	5	4	3
	R-2	NS	4	4	4	3	2
		S13R				4	3
		S	5	5	5	4	3

134

2018 IBC: Heights & Areas

Table 506.2: Allowable Area Factor

	Occupancy Classification		Type of Construction				
			Type III		Type IV	Type V	
			A	B	HT	A	B
TABLE 506.2: Allowable Area Factor	A-2, A-3	NS	14,000	9,500	15,000	11,500	6,000
		S1	56,000	38,000	60,000	46,000	24,000
		SM	42,000	28,500	45,000	34,500	18,000
	B	NS	28,500	19,000	36,000	18,000	9,000
		S1	114,000	76,000	144,000	72,000	36,000
		SM	85,500	57,000	108,000	54,000	27,000
	E	NS	23,500	14,500	25,500	18,500	9,500
		S1	94,000	58,000	102,000	74,000	38,000
		SM	70,500	43,500	76,500	55,500	28,500
	M	NS	18,500	12,500	20,500	14,000	9,000
		S1	74,000	50,000	82,000	56,000	36,000
		SM	55,500	37,500	61,500	42,000	27,000
	S-2	NS	39,000	26,000	38,500	21,000	13,500
		S1	156,000	104,000	154,000	84,000	54,000
		SM	117,000	78,000	115,500	63,000	40,500
	R-1, R-2	NS	24,000	16,000	20,500	12,000	7,000
		S13R					
		S1	96,000	64,000	82,000	48,000	28,000
		SM	72,000	48,000	61,500	36,000	21,000

135

2018 IBC: Allowable Increases

- Automatic Sprinkler Systems
- Building equipped with NFPA 13 automatic sprinkler system, allowable floor area can be increased
  - Single-story building – 3x
  - Multi-story building – 2x



136

2018 IBC: Single Occupancy

- IBC 506.2.3 – Buildings 3+ stories above grade have a total building area per story (A_a) calculated by Equation 5-2 with $S_a = 3$

$A_a = A_t + (NS \times I_f)$ Equation 5-1
$A_a = [A_t + (NS \times I_f)] \times S_a$ Equation 5-2

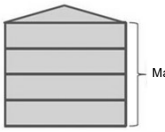
S_a = Actual number of building stories above grade plane, not to exceed three. For buildings equipped throughout with an automatic sprinkler system installed in accordance with Section 903.3.1.2, use the actual number of building stories above grade plane, not to exceed four



137

2018 IBC: Building Area

- **4 and 4+ Story Building**
  - Total Allowable Building Area
  - $A_a = 3 \times A_t$ (single story)
- **where**
  - A_a = allowable building area
  - A_t = allowable building area per story



- **Type IV (HT) Business**
  - Sprinklered
  - SM = 108,000 ft²
  - No frontage increase
- Stories of equal area
  - Each story may not exceed 324,000/4 = 81,000 ft²
- Stories of unequal area
  - No single story can exceed 108,000 ft²

138

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

2018 IBC: Wood Interior Finish

- Exceptions
  - Traditional wood floor covering exempt from interior floor finish requirements (804.1)
  - Exposed portions of Type IV structural members also exempt, except in exit elements (803.3)



Butler Building – Minneapolis
Courtesy of WoodWorks

Mass Timber and the IBC 139

139

2018 IBC: Fire Walls

- Fire walls define separate buildings for allowable building size (706)
  - Not fire barriers (707)
  - Not fire partitions (708)
  - Not smoke barriers, smoke partitions or horizontal assemblies
  - Table 706.4 gives required ratings based on occupancies separated

TABLE 706.4
FIRE WALL FIRE-RESISTANCE RATINGS

GROUP	FIRE-RESISTANCE RATING (hours)
A, B, E, H-4, I, R-1, R-2, U	3[a]
F-1, H-3[b], H-5, M, S-1	3
H-1, H-2	4[b]
F-2, S-2, R-3, R-4	2

Mass Timber and the IBC 140

140

2018 IBC: Fire Walls

- Type V construction
  - May be wood frame

706.3 Materials. *Fire walls* shall be of any *approved* noncombustible materials.
Exception: Buildings of Type V construction.

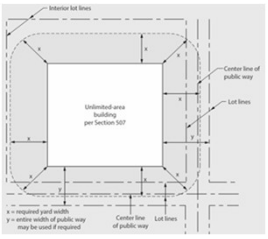
- Types III and IV construction
  - Must be noncombustible in accordance with IBC 706.3

Mass Timber and the IBC 141

141

2018 IBC: Unlimited Area

- One-Story – NFPA 13 Sprinklers
  - Public ways or yards not less than 60 feet wide – all sides
  - Group B, F, M and S
  - Limits in IBC 507.4

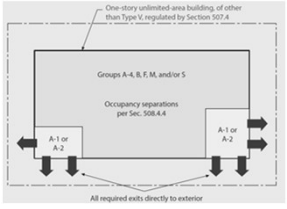


Mass Timber and the IBC 142

142

2018 IBC: Unlimited Area

- One-Story – NFPA 13 Sprinklers
- Group A-1 and A-2 allowed in unlimited area mixed occupancy containing Group B, F, M or S
  - Limits in IBC 507.4.1
  - Type III or IV construction
  - Occupancies separated per IBC 508.4.4
  - A-1 and A-2 portions shall not exceed max areas permitted by IBC 503.1
  - Group A-1 and A-2 exit doors must discharge directly to building exterior



Mass Timber and the IBC 143

143

2018 IBC: Unlimited Area

- One-Story – NFPA 13 Sprinkler System
- Group A-3
  - Limits in IBC 507.7
  - Types III or IV
  - Religious worship, community hall, dance hall, exhibition hall, gymnasium, lecture hall, indoor swimming pool or tennis
- Group A-4
  - Limits in IBC 507.4
  - Types IIIA, IIIB and IV
  - Tennis, swimming, skating and equestrian venues



Mass Timber and the IBC 144

144

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

2018 IBC: Unlimited Area

- One-Story – NFPA 13 Sprinkler System
- Group E
  - Limits in Section 507.11
  - Type IIIA or IV
  - Each classroom must have 2 means of egress, with one outside exit
  - Public ways or yards not less than 60 feet wide – all sides



Exit sign licensed under CC0 Public Domain

145

2018 IBC: Unlimited Area

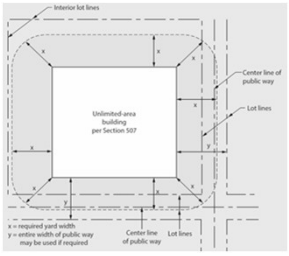
- One-Story – Non-sprinklered Buildings
- Group F-2 or S-2
  - Limits in IBC 507.3
  - Public ways or yards not less than 60 feet wide – all sides



146

2018 IBC: Unlimited Area

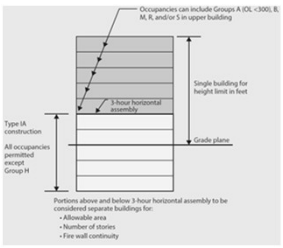
- Two-Story – NFPA 13 Sprinkler System
- Group B, F, M or S
  - Limits in Section 507.5
  - Public ways or yards not less than 60 feet wide – all sides



147

2018 IBC: Stacked Buildings – 510.2

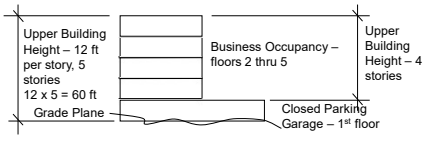
- 3-hour FRR Horizontal Assembly between upper & lower buildings
  - Upper Building
    - Group B, M and R
    - Group S-2 open & enclosed parking
    - Group A's (occupant load < 300)
  - Lower Building
    - Any occupancy except Group H



148

2018 IBC: Stacked Buildings – 510.2

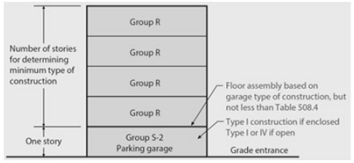
- Upper Building Height – in feet
  - Measured from grade plane
- Upper Building Height – in stories
  - Measured from top of lower building



149

2018 IBC: Stacked Buildings – 510.4

- Parking Beneath Group R
- Single-story Group S-2 parking garage
  - Grade entrance to parking
  - Type I if enclosed
  - Type I or IV if open



150

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

2018 IBC: Stacked Buildings – 510.7

- Open Parking Garage
- Beneath Groups A, B, I, M and R
- Height of upper building measured from grade plane and includes open parking garage level
- Open parking garage of Type IV construction permitted



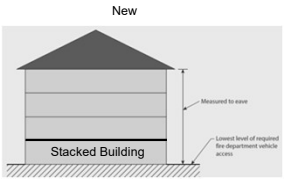
Image courtesy of SRG Partnership

Mass Timber and the IBC 151

151

2018 IBC: Stacked Buildings

- Attic Protection per IBC 903.3.1.2.3 (NFPA 13R)
- Types III, IV, and V when using IBC 510.2 and 510.4
  - Alternatives are attic sprinklers, noncombustible construction, FRTW, or filling entire space with noncombustible insulation
  - Protection applies when roof assembly > 55 feet above lowest level of required fire department access
  - Additional requirements for living or storage use, when fuel-fire equipment is present, and in R-4 Condition 2



Mass Timber and the IBC 152

152

Q&A



Mass Timber and the IBC 153

153

Outline

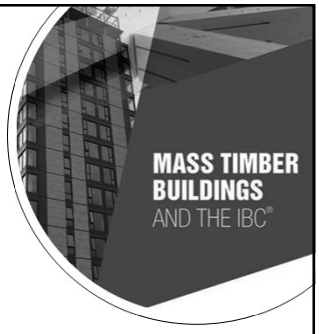
- Introduction to Mass Timber Products
- 2015/2018 IBC for Mass Timber Construction
- Break – 15 minutes
- 2021 IBC for Tall Mass Timber Construction
  - Part 1: Background and Overview
  - Lunch – 1 hour
  - Part 2: New Construction Types and Heights & Areas
  - Part 3: Fire Safety
  - Break – 15 minutes
  - Part 4: Fire & Connection Design and Special Inspection
  - Part 5: Acoustics, Energy, and Lateral Resistance
  - Part 6: Construction Fire Safety

Mass Timber and the IBC 154

154

Tall Mass Timber Construction per 2021 IBC

Part 1: Background and Overview



Mass Timber and the IBC 155

155

Mass Timber vs Traditional

Mass Timber		Conventional Light-Frame
	<-->	

Mass Timber and the IBC 156

156

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Mass Timber vs Traditional

Type IV-A, IV-B, IV-C <--> **Type IV-HT**





Mass Timber and the IBC 157

157

Sub-Outline

- TWB Ad Hoc Committee
- Consensus Process



Mass Timber and the IBC 158

158

ICC Tall Wood Ad Hoc Committee

- ICC Board Established ICC Ad Hoc Committee on Tall Wood Buildings - December 2015
  - Explore science of tall wood buildings
  - Investigate feasibility
  - Take action on developing code changes for tall wood buildings



Mass Timber and the IBC 159

159

ICC Tall Wood Ad Hoc Committee

- Consensus committee with necessary balance of stakeholders
- Building and Fire Officials
- Architects and engineers
- Fire protection experts
- Representatives from building construction material industries
- Other construction-related professionals



Photo courtesy of Susan Jones, atelierjones

Mass Timber and the IBC 160

160

ICC Tall Wood Ad Hoc Committee

- Four Work Groups appointed
  - Definitions and Standards
  - Fire
  - Structural
  - Codes
- 82 major issues investigated
- Hundreds of reports reviewed
- Performance Objectives discussed



Mass Timber and the IBC 161

161

ICC Tall Wood Ad Hoc Objectives

- TWB identified performance objectives
  - No collapse under reasonable scenarios of complete burn-out of fuel without automatic sprinkler protection considered
  - No unusually high radiation exposure from the subject building to adjoining properties to present a risk of ignition under reasonably severe fire scenarios
  - No unusual response from typical radiation exposure from adjacent properties to present a risk of ignition of the subject building under reasonably severe fire scenarios



Mass Timber and the IBC 162

162

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

ICC Tall Wood Ad Hoc Objectives

- TWB identified performance objectives (cont.)
  - No unusual fire department access issues
  - Egress systems designed to protect building occupants during design escape time, plus a safety factor
  - Highly reliable fire suppression systems to reduce risk of failure during reasonably expected fire scenarios – degree of reliability proportional to evacuation time (height) and collapse risk



163

ICC Tall Wood Ad Hoc Objectives

TWB determined that its comprehensive package of proposals met all performance objectives



164

ICC Tall Wood Ad Hoc Committee

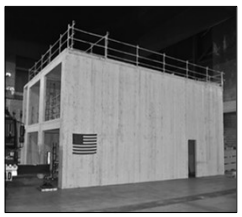
- Fire Work Group created fire test scenarios to study and validate TWB code change proposals
  - 2-story condo situation
  - 30 ft x 30 ft interior dimensions
  - Corridor and stair included in the structure
  - UL "modern furnishings" fuel load imposed → 570 MJ/m²
    - Fuel load was approximately 85th percentile of Group R fuel loads from survey of Group R's



165

Multi-Story Fire Tests

- Purpose: Perform tests of realistic fire scenarios applicable to tall wood construction in order to evaluate occupant and firefighter tenability for egress and suppression efforts, and provide data necessary to guide further development of relevant code and standard provisions
  - Conducted at U.S. government facilities (ATF)
  - Supervised by U.S. Forest Product Laboratory staff



166



167

ATF Fire Test Plan

- **Tests 1 through 3:** unlikely scenario in which automatic sprinklers fail to activate and fire service unable to respond
- **Test 4:** normal sprinkler activation
- **Test 5:** automatic sprinklers fail to activate, but are later manually charged by fire service



168

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

ATF Fire Test Scenarios

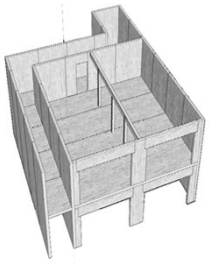
Test	Description	Date	Duration
1	All mass timber surfaces protected with 2-layers of 5/8" Type X GWB – establishes baseline	5/23/17	3 hours
2	30% of CLT ceiling area in living room and bedroom exposed – represents maximum exposure in Type IV-B	5/31/17	4 hours
3	Two opposing CLT walls exposed – one in bedroom and one in living room (there is a partition wall) – Type IV-B	6/20/17	4 hours
4	All mass timber surfaces fully exposed in bedroom and living room. Sprinklered – normal activation	6/27/17	6 minutes
5	All mass timber surfaces fully exposed in bedroom and living room (except bathroom). Sprinklered – 23 min delayed activation	6/29/17	30 minutes

Mass Timber and the IBC 169

169

Two-Story Structure

- Two stories, one apartment per level
- Each apartment: 30 ft x 30 ft
- Ceiling height: 9 ft
- 5-ply CLT
  - Douglas Fir-Larch species group
  - Lamination Thickness: 1.375 inches
  - CLT Thickness: 6.875 inches
  - Polyurethane Adhesive
- Corridor around each apartment
- Stairwell

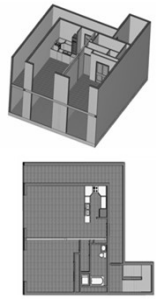


Mass Timber and the IBC 170

170

Apartment Layout

- Partitions used unrated ½" gypsum wallboard
- Kitchen & Living Room: 15 ft x 30 ft
- Bedroom & Bath: 15 ft x 30 ft
- 20-min rated door between compartment and corridor
- 90-min rated door between corridor and stairwell
- Fuel load ~570 MJ/m^2 (23 MW)



Mass Timber and the IBC 171

171

Apartment Furnishings – Bedroom & Bath



Photos provided by U.S. Forest Products Laboratory, USDA

Mass Timber and the IBC 172

172

Apartment Furnishings – Kitchen & Living Room



Photos provided by U.S. Forest Products Laboratory, USDA

Mass Timber and the IBC 173

173

ATF Fire Tests

Fire Test #1

All mass timber surfaces protected with **2 layers of 5/8" Type X GWB**

awc.org/codes-and-standards
Link to Youtube videos available on this page



Mass Timber and the IBC 174

174

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

ATF Fire Test #1 – All Mass Timber Protected



Video

175

ATF Fire Tests

Fire Test #2

30% of CLT ceiling area in living room and bedroom **exposed**

awc.org/codes-and-standards
Link to Youtube videos available on this page



176

ATF Fire Test #2 – 30% CLT



Photos provided by U.S. Forest Products Laboratory, USDA

Video

177

ATF Fire Test #2 – 30% CLT Ceilings Exposed

Results and Post-Fire Condition of Glulam and CLT After Gypsum Removal

- Fire intensity **decreased** subsequent to consumption of furnishings and contents (known as *decay phase*)
- Exposed mass timber surfaces **self-extinguished** in the decay phase
- Mass timber surfaces protected with 2 layers of 5/8" Type X GWB **remained mostly uncharred**



178

Section of Exposed CLT



179

ATF Fire Tests

Fire Test #3

Two **opposing CLT walls exposed** one in bedroom and one in living room

awc.org/codes-and-standards
Link to Youtube videos available on this page

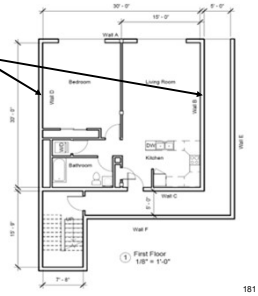


180

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

ATF Fire Test #3 – Exposed Walls

- Two opposing CLT walls exposed
  - Bedroom (D) and living room (B)
  - Results comparable to Test #2



Mass Timber and the IBC 181

181

ATF Fire Test #3 – Exposed Walls









Mass Timber Contribution declining

Video

Mass Timber and the IBC 182

182

ATF Fire Tests

Fire Test #4

All mass timber surfaces fully exposed
in bedroom and living room

Sprinklered – normal activation

awc.org/codes-and-standards
Link to Youtube videos available on this page



Mass Timber and the IBC 183

183

ATF Fire Test #4 – Sprinklers, Exposed

- All mass timber surfaces fully exposed in bedroom and living room
- Sprinkler – normal activation
- Fire extinguished in 6 minutes









Video

Mass Timber and the IBC 184

184

ATF Fire Tests

Fire Test #5

All mass timber surfaces fully exposed
in bedroom and living room

Sprinklered
- activation delayed for 20 minutes after first head activation in Test #4
- …approximately 23 minutes from ignition…

awc.org/codes-and-standards
Link to Youtube videos available on this page



Mass Timber and the IBC 185

185

ATF Test #5 – Delayed Sprinklers, Exposed

- All mass timber surfaces fully exposed in bedroom and living room
- Sprinkler – water delayed 20 minutes after Test #4 sprinkler activation…approximately 23 minutes from ignition
- Flashover conditions reached in kitchen
- Bedroom nearly reached flashover
- Sprinkler system effectively suppressed fire





Video

Mass Timber and the IBC 186

186

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

ATF Fire Test Results – Event Log

Test No.	Flashover (600°C) Living Room	Flashover (600°C) Bedroom	Time After Ignition (mm:ss) Flames in Hallway	Compartment door Fails	Sprinkler Activation
1 1st floor	13:27	17:20	26:51	57:46	N/A
2 2nd floor	11:42	17:20	30:38	63:59	N/A
3 2nd floor	12:37	17:00	13:06 (door frame installation error)	29:42 (door frame installation error)	N/A
4 1st floor	-	-	-	-	2:37
5 1st floor	-	-	-	-	23:00

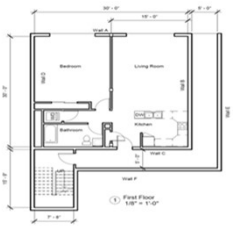
Tests 2 and 3 terminated at 4 hours with no re-growth

Mass Timber and the IBC 187

187

ATF Fire Test Results – Event Log

- Tests 2 and 3 terminated at 4 hours with no re-growth
- Flashover in living room consistent around 12-13 minutes
- Time to flashover in bedroom consistent at around 17 minutes
- Flames breach 20-minute hallway door about 27-30 minutes
- Test 3: 20-minute door failed early – improperly installed

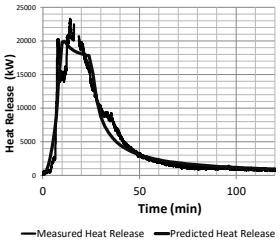


Mass Timber and the IBC 188

188

Comparison of Modeling & Measured Data

- Heat Release Data Comparison
  - Modeling conducted by Research Institutes of Sweden (RISE)
  - Measured data from ATF #2 with 30% Ceiling exposed

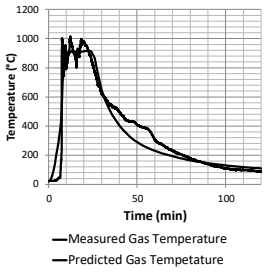


Mass Timber and the IBC 189

189

Comparison of Modeling & Measured Data

- Comparison of Ceiling Gas Temperature
  - Modeling conducted by Research Institutes of Sweden (RISE)
  - Measured data from ATF #2 with 30% Ceiling exposed



Mass Timber and the IBC 190

190

Research Justification

- Each new Construction Type based on conditions in at least 1 of 5 ATF fire tests
- Fire Test Plan developed by TWB Fire Work Group
- Test Plan included testing various "generic" connections as recommended by Structural Work Group
- Both mass timber (CLT) panels and other mass timber (glulam beams and columns) tested



Mass Timber and the IBC 191

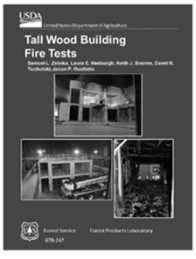
191

ATF Tall Mass Timber Fire Tests

Full Report on AWC Website

awc.org/codes-and-standards

Link to Youtube videos available on this page



Mass Timber and the IBC 192

192

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Sub-Outline

- TWB Ad Hoc Committee
- Consensus Process



Mass Timber and the IBC 193

193

TWB Committee Proposals

- 17 code change proposals under Group A and Group B
- 3 new types of construction approved
- New entries in Height & Area
- Multiple new requirements for safety during construction
- Exterior wall test standard still required (NFPA 285)



ALL 17 PROPOSALS APPROVED AS RECOMMENDED

Mass Timber and the IBC 194

194

TWB Group A Proposals

ALL APPROVED AS SUBMITTED OR APPROVED AS MODIFIED

- G108 New types of construction (602.4)
- G75 Height in feet (Table 504.3)
- G80 Height in stories (Table 504.4)
- G84 Allowable area per floor (Table 506.2)
- G89 Fire barriers (508.4 & 509.4)
- G146 MT Membrane/Special Const. (3102)
- G152 Appendix D-Fire Districts (G152)
- G28 Redundant water supply (403.3.2)
- FS5 Performance-based noncom protection (703.8)
- FS6 Sealing of Splices and intersections (703.9)
- FS73 Mass timber as fire blocking (718.2.1)
- FS81 Prescriptive noncom protection (722.7)
- IFC
  - F88 Owner responsibility (701.6)
  - F266 Fire safety during construction (3308.4)



Mass Timber and the IBC 195

195

TWB Group B Proposals

ALL APPROVED AS SUBMITTED OR APPROVED AS MODIFIED

- S170 Fire resistance of connections (2304.10.1)
- S100 Special inspection provisions (1705.5.3)
- ADM35 Inspection of connection protection (110.3.5)



Mass Timber and the IBC 196

196

Q&A



Mass Timber and the IBC 197

197



Outline

- Introduction to Mass Timber Products
- 2015/2018 IBC for Mass Timber Construction
- Break – 15 minutes
- 2021 IBC for Tall Mass Timber Construction
  - Part 1: Background and Overview
  - Lunch – 1 hour
  - Part 2: New Construction Types and Heights & Areas
  - Part 3: Fire Safety
  - Break – 15 minutes
  - Part 4: Fire & Connection Design and Special Inspection
  - Part 5: Acoustics, Energy, and Lateral Resistance
  - Part 6: Construction Fire Safety

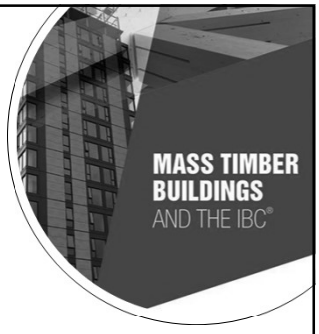
198

198

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Tall Mass Timber Construction per 2021 IBC

Part 2: New Construction Types and Heights & Areas



Mass Timber and the IBC 199

199

Sub-Outline

- Noncombustible Protection
- New Construction Types
- Heights and Areas



Mass Timber and the IBC 200

200

Definitions

DEFINITIONS FOR NEW IBC TERMS

- Mass Timber: Structural elements of Type IV construction primarily of solid, built-up, panelized or engineered wood products that meet minimum cross section dimensions of Type IV construction.
- Noncombustible Protection (FOR MASS TIMBER): Noncombustible material, in accordance with Section 703.6, designed to increase the fire-resistance rating and delay the combustion of mass timber.

Mass Timber and the IBC 201

201

Definitions

DEFINITIONS FOR NEW IBC TERMS

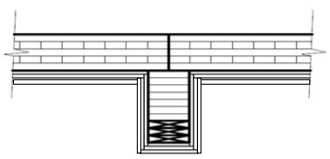
- Mass Timber: Structural elements of Type IV construction primarily of solid, built-up, panelized or engineered wood products that meet minimum cross section dimensions of Type IV construction.
- Noncombustible Protection (FOR MASS TIMBER): Noncombustible material, in accordance with Section 703.6, designed to increase the fire-resistance rating and delay the combustion of mass timber.

Mass Timber and the IBC 202

202

Noncombustible Time Contribution

722.7 Fire-resistance rating of mass timber. The required fire resistance of mass timber elements in Section 602.4 shall be determined in accordance with Section 703.2. The fire resistance rating of building elements shall be as required in Tables 601 and 705.5 and as specified elsewhere in this code. The fire-resistance rating of the mass timber elements shall consist of the fire resistance of the unprotected element added to the protection time of the noncombustible protection.



IV-A

IV-B

IV-C

Mass Timber and the IBC 203

203

Noncombustible Time Contribution

Protection Required

722.7.1 Minimum required protection. Where required by Section 602.4.1 through 602.4.3, *noncombustible protection* shall be provided for *mass timber* building elements in accordance with Table 722.7.1(1). The rating, in minutes, contributed by the *noncombustible protection* of *mass timber* building elements, components, or assemblies, shall be established in accordance with Section 703.6. The protection contributions indicated in Table 722.7.1(2) shall be deemed to comply with this requirement when installed and fastened in accordance with Section 722.7.2.

IV-A

IV-B

IV-C

Mass Timber and the IBC 204

204

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Noncombustible Time Contribution



IV-A

IV-B

IV-C

Protection Required

TABLE 722.7.1(1)
PROTECTION REQUIRED FROM NONCOMBUSTIBLE COVERING MATERIAL

Required Fire-Resistance Rating of Building Element per Tables 601 and 705.5 (hours	Minimum Protection Required from Noncombustible Protection (minutes)
1	40
2	80
3 or more	120



205

Noncombustible Time Contribution



IV-A

IV-B

IV-C

Protection Required

722.7.1 Minimum required protection. Where required by Section 602.4.1 through 602.4.3, *noncombustible protection* shall be provided for *mass timber* building elements in accordance with Table 722.7.1(1). The rating, in minutes, contributed by the *noncombustible protection* of *mass timber* building elements, components, or assemblies, shall be established in accordance with Section 703.6. The protection contributions indicated in Table 722.7.1(2) shall be deemed to comply with this requirement when installed and fastened in accordance with Section 722.7.2.



206

Noncombustible Time Contribution



IV-A

IV-B

IV-C

Performance Method

703.6 Determination of noncombustible protection time contribution. The time, in minutes, contributed to the fire-resistance rating by the noncombustible protection of mass timber building elements, components, or assemblies, shall be established through a comparison of assemblies tested using procedures set forth in ASTM E119 or UL 263. The test assemblies shall be identical in construction, loading, and materials, other than the noncombustible protection. The two test assemblies shall be tested to the same criteria of structural failure.

1. Test Assembly 1 shall be without protection.
2. Test Assembly 2 shall include the representative noncombustible protection. The protection shall be fully defined in terms of configuration details, attachment details, joint sealing details, accessories and all other relevant details.

The noncombustible protection time contribution shall be determined by subtracting the fire-resistance time, in minutes, of Test Assembly 1 from the fire-resistance time, in minutes, of Test Assembly 2.



207

Noncombustible Time Contribution



IV-A

IV-B

IV-C

Protection Required

722.7.1 Minimum required protection. Where required by Section 602.4.1 through 602.4.3, *noncombustible protection* shall be provided for *mass timber* building elements in accordance with Table 722.7.1(1). The rating, in minutes, contributed by the *noncombustible protection* of *mass timber* building elements, components, or assemblies, shall be established in accordance with Section 703.6. The protection contributions indicated in Table 722.7.1(2) shall be deemed to comply with this requirement when installed and fastened in accordance with Section 722.7.2.



208

Noncombustible Time Contribution



IV-A

IV-B

IV-C

Prescriptive Method

TABLE 722.7.1(2)
PROTECTION PROVIDED BY NONCOMBUSTIBLE COVERING MATERIAL

Noncombustible Protection	Protection Contribution (minutes)
1/2 inch Type X Gypsum Board	25
5/8 inch Type X Gypsum Board	40



209

Noncombustible Protection –722.7.2



IV-A

IV-B

IV-C

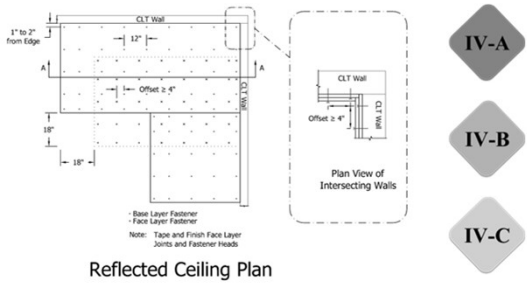
- Type X Gypsum Board Used as Noncombustible Protection
  - Screws shall penetrate ≥ 1" into mass timber
  - Screws shall be spaced no more than 12" o.c. in each direction
  - Screws at panel edges shall be between 1" and 2" from the edge
  - Panel edges shall be offset 18" from those of adjacent layers
  - Stair-step profile required at wall-to-wall & wall-to-ceiling intersections
  - Screw heads and panel joints shall be covered with joint compound



210

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

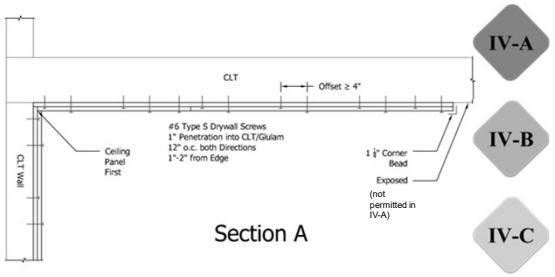
Noncombustible Protection –722.7.2



IV-A IV-B IV-C

211

Noncombustible Protection –722.7.2



IV-A IV-B IV-C

212

Exterior Surfaces

722.7.2.2 Exterior surfaces. Layers of Type X gypsum board serving as noncombustible protection for the outside of the exterior heavy timber walls determined in accordance with Table 722.7.1(a) shall be fastened 12 inches on center each way and 6 inches on center at all joints or ends. All panel edges shall be attached with fasteners located at least 1 inch but not more than 2 inches from the panel edge. Fasteners shall comply with one of the following:

1. Galvanized nails of minimum 12 Gage with a 7/16-inch head of sufficient length to penetrate the mass timber a minimum of 1 inch.

2. Screws which comply with ASTM C 1002 (Type S, Type W, or Type G) of sufficient length to penetrate the mass timber a minimum of 1 inch.

IV-A IV-B IV-C

213

Sub-Outline

- Noncombustible Protection
- New Construction Types
- Heights and Areas



214

Building Element Fire-Resistance Ratings

TABLE 601
FIRE-RESISTANCE RATING REQUIREMENTS FOR BUILDING ELEMENTS (HOURS)

BUILDING ELEMENT	TYPE I		TYPE II		TYPE III		TYPE IV			HT	TYPE V	
	A	B	A	B	A	B	A	B	C		A	B
Primary structural frame[2] (see Section 202)	3[a, b]	2[a, b]	1[b, c]	0	1[b, c]	0	3[c]	2	2	HT	1[b, c]	0
Bearing walls												
Exterior[e, f]	3	2	1	0	2	2	3	2	2	2	1	0
Interior	3[c]	2[c]	1	0	1	0	3	2	2	1/HT[g]	1	0
Nonbearing walls and partitions Exterior	See Table 705.5											
Nonbearing walls and partitions Interior[d]	0	0	0	0	0	0	0	0	0	See Section 2304.11.2	0	0
Floor construction and associated secondary structural members (see Section 202)	2	2	1	0	1	0	2	2	2	HT	1	0
Roof construction and associated secondary structural members (see Section 202)	1½[b]	1[b, c]	1[b, c]	0[c]	1[b, c]	0	1½[c]	1[c]	1[c]	HT	1[b, c]	0

215

Building Element Fire-Resistance Ratings

TABLE 705.5 (formerly Table 602)
FIRE-RESISTANCE RATING REQUIREMENTS FOR EXTERIOR WALLS BASED ON FIRE SEPARATION DISTANCE[a, d, g]

FIRE SEPARATION DISTANCE = X (feet)	TYPE OF CONSTRUCTION	OCCUPANCY GROUP H[e]	OCCUPANCY GROUP F-1, M, S-1[f]	OCCUPANCY GROUP A, B, E, F-2, I, R[c], S-2, U[b]
X < 5[b]	All	3	2	1
5 ≤ X < 10	IA, IVA	3	2	1
	Others	2	1	1
10 ≤ X < 30	IA, IB, IVA, IVB	2	1	1[c]
	IIB, VB	1	0	0
	Others	1	1	1[c]
X ≥ 30	All	0	0	0

216

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

2021 IBC Construction Types

- Revise IBC 602.4 to reflect 3 new construction types

IV-A IV-B IV-C

- No changes to existing heavy timber provisions (formerly Type IV)
- Rename heavy timber to IV-HT (throughout code where referring to heavy timber as a construction type)
- Indicate heavy timber in sections where building elements are permitted to be "heavy timber" (e.g. Types I & II roofs)

IV-HT

Mass Timber and the IBC 217

217

2021 IBC Construction Types

Type of Construction -- Comparison			
Feature	**Type IV-A**	**Type IV-B**	**Type IV-C**
Description of New Construction Types	100% Noncombustible (NC) protection on all surfaces of Mass Timber (MT)	100% NC protection on all surfaces of mass timber (MT) except for limited exposed mass timber (MT) elements	100% exposed mass timber (MT) except: shafts, concealed spaces, and outside of exterior walls
Permitted Materials			
Structural Building Elements	MT or NC	MT or NC	MT or NC
Non-loadbearing Exterior Walls	MT or NC	MT or NC	MT or NC
Non-loadbearing Interior Walls	MT or NC	MT or NC	MT or NC
Shaft and Exit Enclosures			
Highrise* to 12 stories or 180 ft: *see IBC definition of highrise	NC or MT protected with 2 (or 3 when 3 hr FRR) layers of 5/8" type X	NC or MT protected with 2 layers of 5/8" type X gypsum or equiv each side of enclosure	NC or MT protected with one layer of 5/8" type X gypsum each side of shaft or enclosure
Above 12 stories or 180 feet:	NC	Not Permitted	Not Permitted

Mass Timber and the IBC 218

218

2021 IBC Construction Types

Type of Construction -- Comparison			
Feature	**Type IV-A**	**Type IV-B**	**Type IV-C**
Description of New Construction Types	100% Noncombustible (NC) protection on all surfaces of Mass Timber (MT)	100% NC protection on all surfaces of mass timber (MT) except for limited exposed mass timber (MT) elements	100% exposed mass timber (MT) except: shafts, concealed spaces, and outside of exterior walls
Permitted Materials			
Structural Building Elements	MT or NC	MT or NC	MT or NC
Non-loadbearing Exterior Walls	MT or NC	MT or NC	MT or NC
Non-loadbearing Interior Walls	MT or NC	MT or NC	MT or NC
Shaft and Exit Enclosures			
Highrise* to 12 stories or 180 ft: *see IBC definition of highrise	NC or MT protected with 2 (or 3 when 3 hr FRR) layers of 5/8" type X	NC or MT protected with 2 layers of 5/8" type X gypsum or equiv each side of enclosure	NC or MT protected with one layer of 5/8" type X gypsum each side of shaft or enclosure
Above 12 stories or 180 feet:	NC	Not Permitted	Not Permitted

Mass Timber and the IBC 219

219

2021 IBC Construction Types

Type of Construction -- Comparison			
Feature	**Type IV-A**	**Type IV-B**	**Type IV-C**
Description of New Construction Types	100% Noncombustible (NC) protection on all surfaces of Mass Timber (MT)	100% NC protection on all surfaces of mass timber (MT) except for limited exposed mass timber (MT) elements	100% exposed mass timber (MT) except: shafts, concealed spaces, and outside of exterior walls
Permitted Materials			
Structural Building Elements	MT or NC	MT or NC	MT or NC
Non-loadbearing Exterior Walls	MT or NC	MT or NC	MT or NC
Non-loadbearing Interior Walls	MT or NC	MT or NC	MT or NC
Shaft and Exit Enclosures			
Highrise* to 12 stories or 180 ft: *see IBC definition of highrise	NC or MT protected with 2 (or 3 when 3 hr FRR) layers of 5/8" type X	NC or MT protected with 2 layers of 5/8" type X gypsum or equiv each side of enclosure	NC or MT protected with one layer of 5/8" type X gypsum each side of shaft or enclosure
Above 12 stories or 180 feet:	NC	Not Permitted	Not Permitted

Mass Timber and the IBC 220

220

2021 IBC Construction Types

Type of Construction -- Comparison			
Feature	**Type IV-A**	**Type IV-B**	**Type IV-C**
Description of New Construction Types	100% Noncombustible (NC) protection on all surfaces of Mass Timber (MT)	100% NC protection on all surfaces of mass timber (MT) except for limited exposed mass timber (MT) elements	100% exposed mass timber (MT) except: shafts, concealed spaces, and outside of exterior walls
Permitted Materials			
Structural Building Elements	MT or NC	MT or NC	MT or NC
Non-loadbearing Exterior Walls	MT or NC	MT or NC	MT or NC
Non-loadbearing Interior Walls	MT or NC	MT or NC	MT or NC
Shaft and Exit Enclosures			
Highrise* to 12 stories or 180 ft: *see IBC definition of highrise	NC or MT protected with 2 (or 3 when 3 hr FRR) layers of 5/8" type X	NC or MT protected with 2 layers of 5/8" type X gypsum or equiv each side of enclosure	NC or MT protected with one layer of 5/8" type X gypsum each side of shaft or enclosure
Above 12 stories or 180 feet:	NC	Not Permitted	Not Permitted

Mass Timber and the IBC 221

221

2021 IBC Construction Types

- TYPE IV-A – Mass Timber with noncombustible protection
  - Noncombustible protection at least 2/3 FRR for Building Elements (Table 601, 705.5)
  - Taller buildings – no exposed mass timber
- TYPE IV-B – Mass Timber with limited exposed MT
  - Limits how much mass timber can be exposed
  - Limits how close exposed areas can be to one another
- TYPE IV-C – Mass Timber with no requirement for noncombustible protection, except certain features

IV-A IV-B IV-C

Mass Timber and the IBC 222

222

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

2021 IBC Construction Types

- TYPE IV-A – Mass Timber with noncombustible protection
  - Noncombustible protection at least 2/3 FRR for Building Elements (Table 601, 602)
  - Taller buildings – no exposed mass timber
- TYPE IV-B – Mass Timber with limited exposed MT
  - Limits how much mass timber can be exposed
  - Limits how close exposed areas can be to one another
- TYPE IV-C – Mass Timber with no requirement for noncombustible protection, except certain features

IV-A

Mass Timber and the IBC 223

223

2021 IBC Construction Types

- TYPE IV-A – Mass Timber with noncombustible protection
  - Noncombustible protection at least 2/3 FRR for Building Elements (Table 601, 602)
  - Taller buildings – no exposed mass timber
- TYPE IV-B – Mass Timber with limited exposed MT
  - Limits how much mass timber can be exposed
  - Limits how close exposed areas can be to one another
- TYPE IV-C – Mass Timber with no requirement for noncombustible protection, except certain features

IV-B

Mass Timber and the IBC 224

224

2021 IBC Construction Types

- TYPE IV-A – Mass Timber with noncombustible protection
  - Noncombustible protection at least 2/3 FRR for Building Elements (Table 601, 602)
  - Taller buildings – no exposed mass timber
- TYPE IV-B – Mass Timber with limited exposed MT
  - Limits how much mass timber can be exposed
  - Limits how close exposed areas can be to one another
- TYPE IV-C – Mass Timber with no requirement for noncombustible protection, except certain features

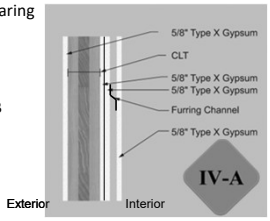
IV-C

Mass Timber and the IBC 225

225

2021 IBC Type IV-A Exterior Wall

- 3-hr FRR for exterior and interior bearing walls (Table 601)
- 2/3 FRR noncombustible protection
- 2-hr FRR noncombustible protection
- 2-hr FRR = 3 layers 5/8" Type X GWB
  - 40-min x 3 layers = 120-min
- Furring channel per AISI S220



Mass Timber and the IBC 226

226

2021 IBC Type IV-A

- Fire research
- Full-scale, multi-story
- Simulated new construction types
- ATF Fire Test Lab



IV-A

Mass Timber and the IBC 227

227

2021 IBC 602.4.1 Type IV-A

- All mass timber must have noncombustible protection – interior and exterior
- Floors must have minimum 1-inch noncombustible material above the mass timber



IV-A

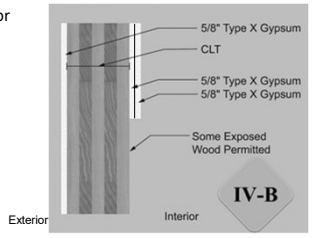
Mass Timber and the IBC 228

228

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

2021 IBC Type IV-B Exterior Wall

- 2-hr FRR for exterior and interior bearing walls (Table 601)
- 2/3 FRR noncom protection = 2 layers 5/8" GB @ 40-min
- 2-hr x 2/3 = 80-min
- 40-min x 2 = 80-min



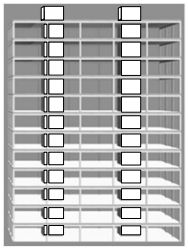
Mass Timber and the IBC 229

229

2021 IBC 602.4.2 Type IV-B

- Interior MT can be partially exposed
- Noncombustible protection certain areas
  - Exterior of exterior walls protected 40 min noncom
  - MT in concealed spaces protected
  - Shafts protected inside and room-side with 80 min noncom
  - Floors must have minimum 1-inch noncombustible material above the mass timber

IV-B



Mass Timber and the IBC 230

230

2021 IBC 602.4.2 Type IV-B

602.4.2.2.2 Protected Area. Interior faces of mass timber elements shall be protected in accordance with Section 602.4.2.2.1, including the inside faces of exterior mass timber walls and mass timber roofs.

Exceptions: Unprotected portions of mass timber ceilings and walls complying with Section 602.4.2.2.4 and the following:

1. Unprotected portions of mass timber ceilings and walls complying with one of the following:
   - 1.1 Unprotected portions of mass timber ceilings, including attached beams, shall be permitted and shall be limited to an area equal to 20% of the floor area in any dwelling unit or fire area.
   - 1.2 Unprotected portions of mass timber walls, including attached columns, shall be permitted and shall be limited to an area equal to 40% of the floor area in any dwelling unit or fire area.
   - 1.3 Unprotected portions of both walls and ceilings of mass timber, including attached columns and beams, in any dwelling unit or fire area shall be permitted in accordance with section 602.4.2.2.3.

IV-B

Mass Timber and the IBC 231

231

2021 IBC 602.4.2 Type IV-B

602.4.2.2.2 Protected Area

Exceptions (continued)

2. Mass timber columns and beams that are not an integral portion of walls or ceilings, respectively, shall be permitted to be unprotected without restriction of either aggregate area or separation from one another.

Exception 2 may be applied simultaneously with Exception 1.1, 1.2 or 1.3

IV-B

Mass Timber and the IBC 232

232

2021 IBC 602.4.2 Type IV-B

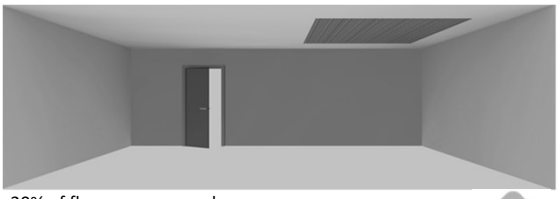


IV-B

Mass Timber and the IBC 233

233

2021 IBC 602.4.2 Type IV-B



20% of floor area exposed

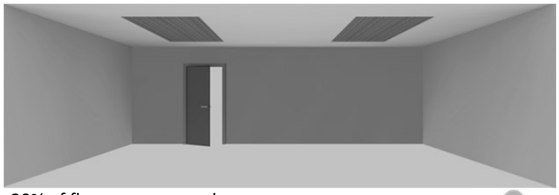
IV-B

Mass Timber and the IBC 234

234

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

2021 IBC 602.4.2 Type IV-B

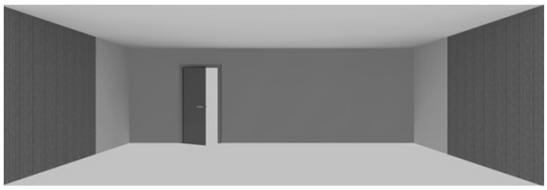


20% of floor area exposed

IV-B

235

2021 IBC 602.4.2 Type IV-B



40% of floor area exposed

IV-B

236

2021 IBC 602.4.2 Type IV-B

602.4.2.2.3 Mixed Unprotected Areas. In each dwelling unit or fire area, where both portions of ceilings and portions of walls are unprotected, the total allowable unprotected area shall be determined in accordance with Equation 6-1.

$$(U_{tc}/U_{ac}) + (U_{tw}/U_{aw}) \leq 1 \qquad \text{(Equation 6-1)}$$

IV-B

where:

U_{tc} = Total unprotected mass timber ceiling areas

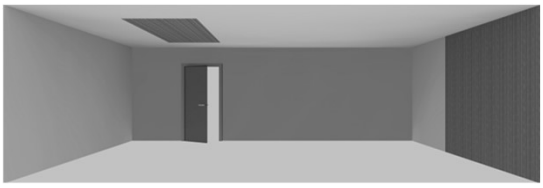
U_{ac} = Allowable unprotected mass timber ceiling area conforming to Exception 1.1 of Section 602.4.2.2.2

U_{tw} = Total unprotected mass timber wall areas

U_{aw} = Allowable unprotected mass timber wall area conforming to Exception 1.2 of Section 602.4.2.2.2

237

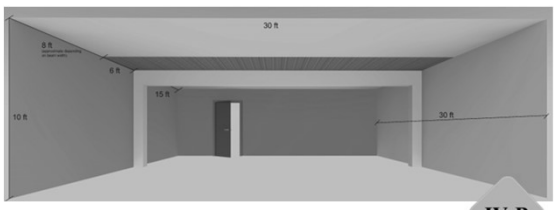
2021 IBC 602.4.2 Type IV-B



IV-B

238

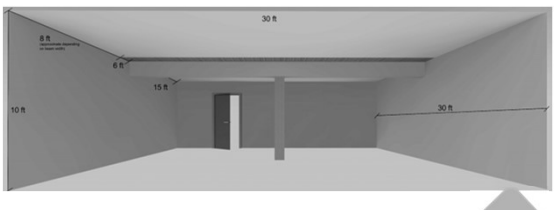
2021 IBC 602.4.2 Type IV-B



IV-B

239

2021 IBC 602.4.2 Type IV-B

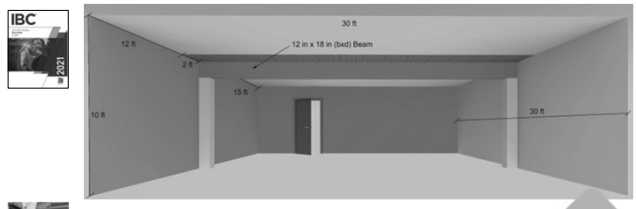


IV-B

240

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

2021 IBC 602.4.2 Type IV-B

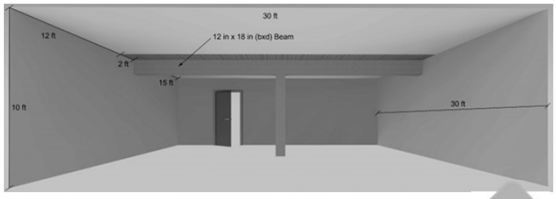


IV-B

Mass Timber and the IBC 241

241

2021 IBC 602.4.2 Type IV-B



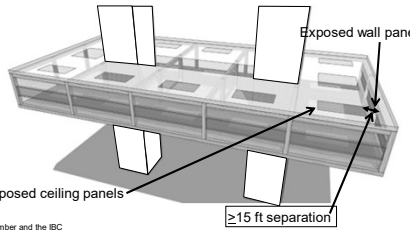
IV-B

Mass Timber and the IBC 242

242

Separation of Unprotected MT

602.4.2.2.4 Separation Distance Between Unprotected Mass Timber Elements. In each *dwelling unit* or *fire area*, unprotected portions of mass timber walls and ceilings shall be not less than 15 feet from unprotected portions of other walls and ceilings, measured horizontally along the ceiling and from other unprotected portions of walls measured horizontally along the floor.

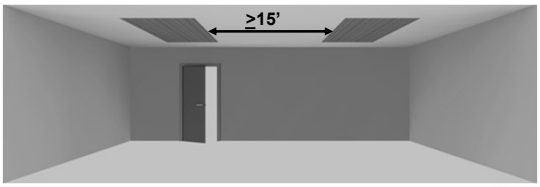


IV-B

Mass Timber and the IBC 243

243

2021 IBC 602.4.2 Type IV-B

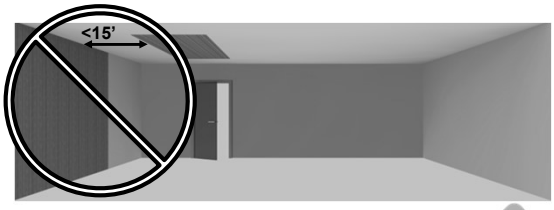


IV-B

Mass Timber and the IBC 244

244

2021 IBC 602.4.2 Type IV-B

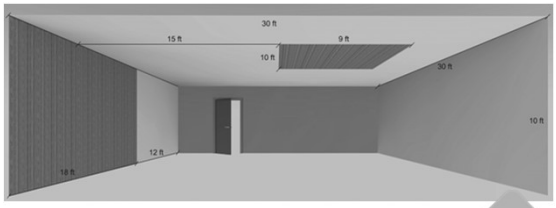


IV-B

Mass Timber and the IBC 245

245

2021 IBC 602.4.2 Type IV-B



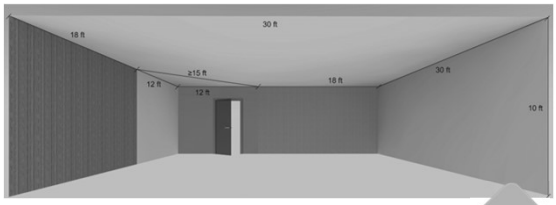
IV-B

Mass Timber and the IBC 246

246

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

2021 IBC 602.4.2 Type IV-B

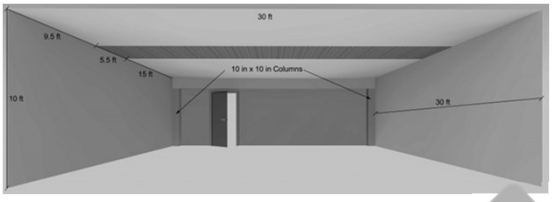


IV-B

Mass Timber and the IBC 247

247

2021 IBC 602.4.2 Type IV-B



IV-B

Mass Timber and the IBC 248

248

2021 IBC Type IV-C



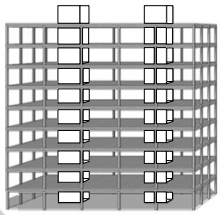
IV-C

Mass Timber and the IBC 249

249

2021 IBC 602.4.3 Type IV-C

- Interior MT can be exposed
- Noncombustible protection certain areas
  - Exterior of exterior walls protected 40 min noncom
  - Floors must meet IBC 804
  - MT in concealed spaces protected
    - No combustibles other than plenum
  - Shafts protected inside and room-side with 40 min noncom



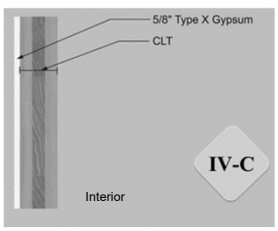
IV-C

Mass Timber and the IBC 250

250

2021 IBC Type IV-C Exterior Wall

- 2-hr FRR for exterior and interior bearing walls (Table 601)
- CLT must be designed for 2-hr FRR if exposed



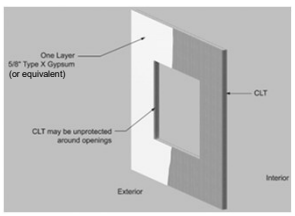
IV-C

Mass Timber and the IBC 251

251

Exterior Wall Section

All material outboard of Mass Timber MUST BE NONCOMBUSTIBLE
Except: water resistive barrier



IV-A
IV-B
IV-C

Mass Timber and the IBC 252

252

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

NFPA 285 Fire Tests

1402.5 ~~Vertical and lateral flame propagation~~ Water-resistive Barriers. *Exterior walls* on buildings of Type I, II, III or IV construction that are greater than 40 feet in height above grade plane and contain a combustible *water-resistive barrier* shall be tested in accordance with and comply with the acceptance criteria of NFPA 285…



Mass Timber and the IBC 253

253

Outline

- Noncombustible Protection
- New Construction Types
- Heights and Areas



Mass Timber and the IBC 254

254

Allowable Heights – Table 504.3

TABLE 504.3
ALLOWABLE BUILDING HEIGHT IN FEET ABOVE GRADE PLANE[a]

OCCUPANCY CLASSIFICATION	SEE FOOTNOTES	TYPE OF CONSTRUCTION: TYPE I A	TYPE I B	TYPE II A	TYPE II B	TYPE III A	TYPE III B	TYPE IV A	TYPE IV B	TYPE IV C	TYPE IV HT	TYPE V A	TYPE V B
A, B, E, F, M, S, U	NS[b]	UL	160	65	55	65	55	65	65	65	65	50	40
	S	UL	180	85	75	85	75	270	180	85	85	70	60
H-1, H-2, H-3, H-5	NS[c,d]	UL	160	65	55	65	55	120	90	65	65	50	40
	S												
H-4	NS[c,d]	UL	160	65	55	65	55	65	65	65	65	50	40
	S	UL	180	85	75	85	75	140	100	85	85	70	60
I-1 Condition 1, I-3	NS[d,e]	UL	160	65	55	65	55	65	65	65	65	50	40
	S	UL	180	85	75	85	75	180	120	85	85	70	60
I-1 Condition 2, I-2	NS[d,e,f]	UL	160	65	55	65	55	65	65	65	65	50	40
	S	UL	180	85									
I-4	NS[d,e]	UL	160	65	55	65	55	65	65	65	65	50	40
	S	UL	180	85	75	85	75	180	120	85	85	70	60
R[h]	NS[d]	UL	160	65	55	65	55	65	65	65	65	50	40
	S13D	60	60	60	60	60	60	60	60	60	60	50	40
	S13R	60	60	60	60	60	60	60	60	60	60	60	60
	S	UL	180	85	75	85	75	270	180	85	85	70	60

No changes to footnotes.

Sprinklered: IV-B = I-B & IV-A = 1.5 x IV-B with exceptions

IV-A IV-B IV-C

Mass Timber and the IBC 255

255

Allowable Stories – Table 504.4

ALLOWABLE NUMBER OF STORIES ABOVE GRADE PLANE[a,b]

OCCUPANCY CLASSIFICATION	SEE FOOTNOTES	TYPE OF CONSTRUCTION: TYPE I A	TYPE I B	TYPE II A	TYPE II B	TYPE III A	TYPE III B	TYPE IV A	TYPE IV B	TYPE IV C	TYPE IV HT	TYPE V A	TYPE V B
A-1	NS	UL	5	3	2	3	2	3	3	3	3	2	1
	S	UL	6	4	3	4	3	9	6	4	4	3	2
A-2	NS	UL	11	3	2	3	2	3	3	3	3	2	1
	S	UL	12	4	3	4	3	18	12	6	4	3	2
A-3	NS	UL	11	3	2	3	2	3	3	3	3	2	1
	S	UL	12	4	3	4	3	18	12	6	4	3	2
A-4	NS	UL	11	3	2	3	2	3	3	3	3	2	1
	S	UL	12	4	3	4	3	18	12	6	4	3	2
A-5	NS	UL	UL	UL	UL	UL	UL	1	1	1	UL	UL	UL
	S	UL	UL	UL	UL	UL	UL	UL	UL	UL	UL	UL	UL
B	NS	UL	11	5	3	5	3	5	5	5	5	3	2
	S	UL	12	6	4	6	4	18	12	9	6	4	3
E	NS	UL	5	3	2	3	2	3	3	3	3	1	1
	S	UL	6	4	3	4	3	9	6	4	4	2	2
F-1	NS	UL	11	4	2	3	2	3	3	3	4	2	1
	S	UL	12	5	3	4	3	10	7	5	5	3	2
F-2	NS	UL	11	5	3	4	3	5	5	5	5	3	2
	S	UL	12	6	4	5	4	12	8	6	6	4	3

Sprinklered: IV-B = I-B & IV-A = 1.5 x IV-B with exceptions

IV-A IV-B IV-C

Mass Timber and the IBC 256

256

Allowable Stories – Table 504.4 (cont'd)

ALLOWABLE NUMBER OF STORIES ABOVE GRADE PLANE[a,b]

OCCUPANCY CLASSIFICATION	SEE FOOTNOTES	TYPE OF CONSTRUCTION: TYPE I A	TYPE I B	TYPE II A	TYPE II B	TYPE III A	TYPE III B	TYPE IV A	TYPE IV B	TYPE IV C	TYPE IV HT	TYPE V A	TYPE V B
H-1	NS[c,d]	1	1	1	1	1	1	NP	NP	NP	1	1	NP
	S							1	1	1			
H-2	NS[c,d]	UL	3	2	1	2	1	1	1	1	2	1	1
	S							2	2	2			
H-3	NS[c,d]	UL	6	4	2	4	2	3	3	3	4	2	1
	S							4	4	4			
H-4	NS[c,d]	UL	7	5	3	5	3	5	5	5	5	3	2
	S	UL	8	6	4	6	4	8	7	6	6	4	3
H-5	NS[c,d]	4	4	3	3	3	3	2	2	2	3	3	2
	S							3	3	3			
I-1 Condition 1	NS[d,e]	UL	9	4	3	4	3	4	4	4	4	3	2
	S	UL	10	5	4	5	4	10	7	5	5	4	3
I-1 Condition 2	NS[d,e]	UL	9	4	3	4	3	3	3	3	4	3	2
	S	UL	10	5				10	6	4			
I-2	NS[d,f]	UL	4	2	1	1	NP	NP	NP	NP	1	1	NP
	S	UL	5	3				7	5	4			
I-3	NS[d,e]	UL	4	2	1	2	1	2	2	2	2	2	1
	S	UL	5	3	2	3	2	7	5	3	3	3	2
I-4	NS[d,g]	UL	5	3	2	3	2	3	3	3	3	1	1
	S	UL	6	4	3	4	3	9	6	4	4	2	2

IV-C = IV-HT with exceptions

IV-A IV-B IV-C

Mass Timber and the IBC 257

257

Allowable Stories – Table 504.4 (cont'd)

ALLOWABLE NUMBER OF STORIES ABOVE GRADE PLANE[a,b]

OCCUPANCY CLASSIFICATION	SEE FOOTNOTES	TYPE OF CONSTRUCTION: TYPE I A	TYPE I B	TYPE II A	TYPE II B	TYPE III A	TYPE III B	TYPE IV A	TYPE IV B	TYPE IV C	TYPE IV HT	TYPE V A	TYPE V B
M	NS	UL	11	4	2	4	2	4	4	4	4	3	1
	S	UL	12	5	3	5	3	12	8	6	5	4	2
R-1	NS[c]	UL	11					4	4	4	4	3	2
	S13R	4	4	4	4	4	4					4	3
	S	UL	12	5	5	5	5	18	12	8	5	4	3
R-2	NS[c]	UL	11	4	4	4	4	4	4	4	4	3	2
	S13R	4	4	4								4	3
	S	UL	12	5	5	5	5	18	12	8	5	4	3
R-3[h]	NS[c]	UL	11									3	3
	S13D	4	4	4	4	4	4	4	4	4	4	3	3
	S13R	4	4									4	4
	S	UL	12	5	5	5	5	18	12	8	5	4	4
R-4[h]	NS[c]	UL	11									3	2
	S13D	4	4	4	4	4	4	4	4	4	4	3	2
	S13R	4	4									4	3
	S	UL	12	5	5	5	5	18	12	8	5	4	3
S-1	NS	UL	11	4	2	3	2	4	4	4	4	3	1
	S	UL	12	5	3-4	4	3-4	10	7	5	5	4	2
S-2	NS	UL	11	5	3	4	3	4	4	4	4-5	4	2
	S	UL	12	6	4	5	4	12	8	5	5-6	5	3
U	NS	UL	5	4	2	3	2	4	4	4	4	2	1
	S	UL	6	5	3	4	3	9	6	5	5	3	2

IV-A IV-B IV-C

Mass Timber and the IBC 258

258

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Allowable Areas – Table 506.2

ALLOWABLE AREA FACTOR (A_t = NS, S1, S13R, S13D OR SM, as applicable) IN SQUARE FEET[a,h]

OCCUPANCY CLASSIFICATION	SEE FOOTNOTES	TYPE I		TYPE II		TYPE III		TYPE IV				TYPE V	
		A	B	A	B	A	B	A 3xHT	B 2xHT	C 1.25xHT	HT	A	B
A-1	NS	UL	UL	15,500	8,500	14,000	8,500	45,000	30,000	18,750	15,000	11,500	5,500
	S1	UL	UL	62,000	34,000	56,000	34,000	180,000	120,000	75,000	60,000	46,000	22,000
	SM	UL	UL	46,500	25,500	42,000	25,500	135,000	90,000	56,250	45,000	34,500	16,500
A-2	NS	UL	UL	15,500	9,500	14,000	9,500	45,000	30,000	18,750	15,000	11,500	6,000
	S1	UL	UL	62,000	38,000	56,000	38,000	180,000	120,000	75,000	60,000	46,000	24,000
	SM	UL	UL	46,500	28,500	42,000	28,500	135,000	90,000	56,250	45,000	34,500	18,000
A-3	NS	UL	UL	15,500	9,500	14,000	9,500	45,000	30,000	18,750	15,000	11,500	6,000
	S1	UL	UL	62,000	38,000	56,000	38,000	180,000	120,000	75,000	60,000	46,000	24,000
	SM	UL	UL	46,500	28,500	42,000	28,500	135,000	90,000	56,250	45,000	34,500	18,000
A-4	NS	UL	UL	15,500	9,500	14,000	9,500	45,000	30,000	18,750	15,000	11,500	6,000
	S1	UL	UL	62,000	38,000	56,000	38,000	180,000	120,000	75,000	60,000	46,000	24,000
	SM	UL	UL	46,500	28,500	42,000	28,500	135,000	90,000	56,250	45,000	34,500	18,000
A-5	NS	UL	UL	UL	UL	UL	UL	UL	UL	UL	UL	UL	UL
	S1												
	SM												
B	NS	UL	UL	37,500	23,000	28,500	19,000	108,000	72,000	45,000	36,000	18,000	9,000
	S1	UL	UL	150,000	92,000	114,000	76,000	432,000	288,000	180,000	144,000	72,000	36,000
	SM	UL	UL	112,500	69,000	85,500	57,000	324,000	216,000	135,000	108,000	54,000	27,000
E	NS	UL	UL	26,500	14,500	23,500	14,500	76,500	51,000	31,875	25,500	18,500	9,500
	S1	UL	UL	106,000	58,000	94,000	58,000	306,000	204,000	127,500	102,000	74,000	38,000
	SM	UL	UL	79,500	43,500	70,500	43,500	229,500	153,000	95,625	76,500	55,500	28,500

IV-A IV-B IV-C

Mass Timber and the IBC — General approach with exceptions. — 259

259

Allowable Areas – Table 506.2 (cont'd)

ALLOWABLE AREA FACTOR (A_t = NS, S1, S13R, S13D OR SM, as applicable) IN SQUARE FEET[a,h]

OCCUPANCY CLASSIFICATION	SEE FOOTNOTES	TYPE I		TYPE II		TYPE III		TYPE IV				TYPE V	
		A	B	A	B	A	B	A 3xHT	B 2xHT	C 1.25xHT	HT	A	B
F-1	NS	UL	UL	25,000	15,500	19,000	12,000	100,500	67,000	41,875	33,500	14,000	8,500
	S1	UL	UL	100,000	62,000	76,000	48,000	402,000	268,000	167,500	134,000	56,000	34,000
	SM	UL	UL	75,000	46,500	57,000	36,000	301,500	201,000	125,625	100,500	42,000	25,500
F-2	NS	UL	UL	37,500	23,000	28,500	18,000	151,500	101,000	63,125	50,500	21,000	13,000
	S1	UL	UL	150,000	92,000	114,000	72,000	606,000	404,000	252,500	202,000	84,000	52,000
	SM	UL	UL	112,500	69,000	85,500	54,000	454,500	303,000	189,375	151,500	63,000	39,000
H-1	NS[f]	21,000	16,500	11,000	7,000	9,500	7,000	10,500	10,500	10,500	10,500	7,500	NP
	S1												
	SM												
H-2	NS[f]	21,000	16,500	11,000	7,000	9,500	7,000	10,500	10,500	10,500	10,500	7,500	3,000
	S1												
	SM												
H-3	NS[f]	UL	60,000	26,500	14,000	17,500	13,000	25,500	25,500	25,500	25,500	10,000	5,000
	S1												
	SM												
H-4	NS[f]	UL	UL	37,500	17,500	28,500	17,500	72,000	54,000	40,500	36,000	18,000	6,500
	S1	UL	UL	150,000	70,000	114,000	70,000	288,000	216,000	162,000	144,000	72,000	26,000
	SM	UL	UL	112,500	52,500	85,500	52,500	216,000	162,000	121,500	108,000	54,000	19,500
H-5	NS[f]	UL	UL	37,500	23,000	28,500	19,000	72,000	54,000	40,500	36,000	18,000	9,000
	S1	UL	UL	150,000	92,000	114,000	76,000	288,000	216,000	162,000	144,000	72,000	36,000
	SM	UL	UL	112,500	69,000	85,500	57,000	216,000	162,000	121,500	108,000	54,000	27,000

IV-A IV-B IV-C

Mass Timber and the IBC — General approach with exceptions. — 260

260

Allowable Areas – Table 506.2 (cont'd)

ALLOWABLE AREA FACTOR (A_t = NS, S1, S13R, S13D OR SM, as applicable) IN SQUARE FEET[a,h]

OCCUPANCY CLASSIFICATION	SEE FOOTNOTES	TYPE I		TYPE II		TYPE III		TYPE IV				TYPE V	
		A	B	A	B	A	B	A 3xHT	B 2xHT	C 1.25xHT	HT	A	B
I-1	NS[d,e]	UL	55,000	19,000	10,000	16,500	10,000	54,000	36,000	18,000	18,000	10,500	4,500
	S1	UL	220,000	76,000	40,000	66,000	40,000	216,000	144,000	72,000	72,000	42,000	18,000
	SM	UL	165,000	57,000	30,000	49,500	30,000	162,000	108,000	54,000	54,000	31,500	13,500
I-2	NS[d,e]	UL	UL	15,000	11,000	12,000	NP	36,000	24,000	12,000	12,000	9,500	NP
	S1	UL	UL	60,000	44,000	48,000	NP	144,000	96,000	48,000	48,000	38,000	NP
	SM	UL	UL	45,000	33,000	36,000	NP	108,000	72,000	36,000	36,000	28,500	NP
I-3	NS[d,e]	UL	UL	15,000	10,000	10,500	7,500	36,000	24,000	12,000	12,000	7,500	5,000
	S1	UL	UL	60,000	40,000	42,000	30,000	144,000	96,000	48,000	48,000	30,000	20,000
	SM	UL	UL	45,000	30,000	31,500	22,500	108,000	72,000	36,000	36,000	22,500	15,000
I-4	NS[d,e]	UL	60,500	26,500	13,000	23,500	13,000	76,500	51,000	25,500	25,500	18,500	9,000
	S1	UL	121,000	106,000	52,000	94,000	52,000	306,000	204,000	102,000	102,000	74,000	36,000
	SM	UL	181,500	79,500	39,000	70,500	39,000	229,500	153,000	76,500	76,500	55,500	27,000
M	NS	UL	UL	21,500	12,500	18,500	12,500	61,500	41,000	25,625	20,500	14,000	9,000
	S1	UL	UL	86,000	50,000	74,000	50,000	246,000	164,000	102,500	82,000	56,000	36,000
	SM	UL	UL	64,500	37,500	55,500	37,500	184,500	123,000	76,875	61,500	42,000	27,000

IV-A IV-B IV-C

General approach with exceptions.

Mass Timber and the IBC — 261

261

Allowable Areas – Table 506.2 (cont'd)

ALLOWABLE AREA FACTOR (A_t = NS, S1, S13R, S13D OR SM, as applicable) IN SQUARE FEET[a,h]

OCCUPANCY CLASSIFICATION	SEE FOOTNOTES	TYPE I		TYPE II		TYPE III		TYPE IV				TYPE V	
		A	B	A	B	A	B	A 3xHT	B 2xHT	C 1.25xHT	HT	A	B
R-1[b]	NS[f]	UL	UL	24,000	16,000	24,000	16,000	61,500	41,000	25,625	20,500	12,000	7,000
	S13R												
	S1	UL	UL	96,000	64,000	96,000	64,000	246,000	164,000	102,500	82,000	48,000	28,000
	SM	UL	UL	72,000	48,000	72,000	48,000	184,500	123,000	76,875	61,500	36,000	21,000
R-2[b]	NS[f]	UL	UL	24,000	16,000	24,000	16,000	61,500	41,000	25,625	20,500	12,000	7,000
	S13R												
	S1	UL	UL	96,000	64,000	96,000	64,000	246,000	164,000	102,500	82,000	48,000	28,000
	SM	UL	UL	72,000	48,000	72,000	48,000	184,500	123,000	76,875	61,500	36,000	21,000
R-3[b]	NS[f]												
	S13D	UL	UL	UL	UL	UL	UL	UL	UL	UL	UL	UL	UL
	S13R												
	S1												
	SM												
R-4[b]	NS[f]												
	S13D	UL	UL	24,000	16,000	24,000	16,000	61,500	41,000	25,625	20,500	12,000	7,000
	S13R												
	S1	UL	UL	96,000	64,000	96,000	64,000	246,000	164,000	102,500	82,000	48,000	28,000
	SM	UL	UL	72,000	48,000	72,000	48,000	184,500	123,000	76,875	61,500	36,000	21,000

IV-A IV-B IV-C

General approach with exceptions.

Mass Timber and the IBC — 262

262

Allowable Areas – Table 506.2 (cont'd)

ALLOWABLE AREA FACTOR (A_t = NS, S1, S13R, S13D OR SM, as applicable) IN SQUARE FEET[a,h]

OCCUPANCY CLASSIFICATION	SEE FOOTNOTES	TYPE I		TYPE II		TYPE III		TYPE IV				TYPE V	
		A	B	A	B	A	B	A 3xHT	B 2xHT	C 1.25xHT	HT	A	B
S-1	NS	UL	48,000	26,000	17,500	26,000	17,500	76,500	51,000	31,875	25,500	14,000	9,000
	S1	UL	192,000	104,000	70,000	104,000	70,000	306,000	204,000	127,500	102,000	56,000	36,000
	SM	UL	144,000	78,000	52,500	78,000	52,500	229,500	153,000	95,625	76,500	42,000	27,000
S-2	NS	UL	79,000	39,000	26,000	39,000	26,000	115,500	77,000	48,125	38,500	21,000	13,500
	S1	UL	316,000	156,000	104,000	156,000	104,000	462,000	308,000	192,500	154,000	84,000	54,000
	SM	UL	237,000	117,000	78,000	117,000	78,000	346,500	231,000	144,375	115,500	63,000	40,500
U	NS[i]	UL	35,500	19,000	8,500	14,000	8,500	54,000	36,000	22,500	18,000	9,000	5,500
	S1	UL	142,000	76,000	34,000	56,000	34,000	216,000	144,000	90,000	72,000	36,000	22,000
	SM	UL	106,500	57,000	25,500	42,000	25,500	162,000	108,000	67,500	54,000	27,000	16,500

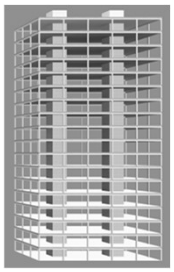
IV-A IV-B IV-C

General approach with exceptions.

Mass Timber and the IBC — 263

263

Type of Construction IV-A



IV-A

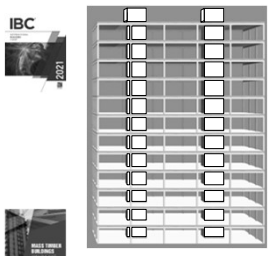
Building Elements	
Maximum Height	270'
Number of Stories (except H's)	9 - 18
Exposed Mass Timber	Fully Protected
Sprinklers	Yes
Primary Frame FRR	3 hours
Floor FRR	2 hours
FRR from Noncom Protection	120 minutes
Stairs Tower	Non-combustible
Concealed Spaces	OK if protected
Floor Topping	Noncombustible

Mass Timber and the IBC — 264

264

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Type of Construction IV-B



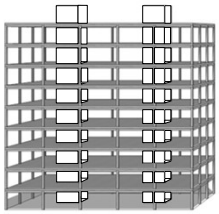
IV-B

Building Elements	
Maximum Height	180′
Number of Stories (except H's)	6 - 12
Exposed Mass Timber	Partially
Sprinklers	Yes
Primary Frame FRR	2 hours
Floor FRR	2 hours
FRR from Noncom Protection	80 minutes
Stairs Tower	Protected mass timber
Concealed Spaces	OK if protected
Floor Topping	Noncombustible

Mass Timber and the IBC 265

265

Type of Construction IV-C

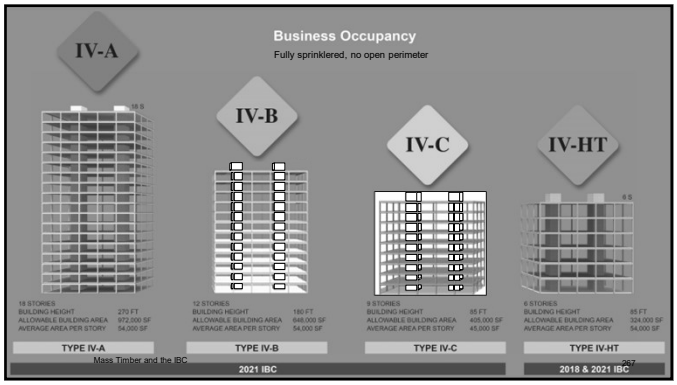


IV-C

Building Element	
Maximum Height	85′
Number of Stories	4 - 9
Exposed Mass Timber	Fully Exposed
Sprinklers	Yes
Primary Frame FRR	2 hours
Floor FRR	2 hours
Stairs Tower	Protected mass timber
FRR from Non-com Protection	0 hours
Concealed Spaces	OK if Protected
Floor Topping	No requirement

Mass Timber and the IBC 266

266



Mass Timber and the IBC 267

267

Q&A



Mass Timber and the IBC 268

268

Outline

- Introduction to Mass Timber Products
- 2015/2018 IBC for Mass Timber Construction
- Break – 15 minutes
- 2021 IBC for Tall Mass Timber Construction
  - Part 1: Background and Overview
  - Lunch – 1 hour
  - Part 2: New Construction Types and Heights & Areas
  - Part 3: Fire Safety
  - Break – 15 minutes
  - Part 4: Fire & Connection Design and Special Inspection
  - Part 5: Acoustics, Energy, and Lateral Resistance
  - Part 6: Construction Fire Safety

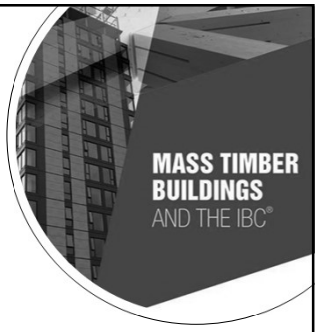


Mass Timber and the IBC 269

269

Tall Mass Timber Construction per 2021 IBC

Part 3: Fire Safety



Mass Timber and the IBC 270

270

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Sub-Outline

- Fire Barriers
- Shaft Walls
- Sealing Abutting Edges/Intersections and Fire Blocking Material
- New Redundant Sprinkler Water Supply Systems
- Concealed Spaces and Heavy Timber
- Owner's Responsibilities



271

Occupancy Separation

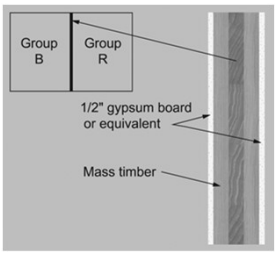
508.4.4.1 Construction. Required separations shall be *fire barriers* constructed in accordance with Section 707 or *horizontal assemblies* constructed in accordance with Section 711, or both, so as to completely separate adjacent occupancies. Mass timber elements serving as fire barriers or horizontal assemblies to separate occupancies in Type IV-B or IV-C construction shall be separated from the interior of the building with an approved thermal barrier consisting of a minimum of ½ gypsum board or a material that is tested in accordance with and meets the acceptance criteria of both the Temperature Transmission Fire Test and the Integrity Fire Test of NFPA 275.

IV-B

IV-C

272

Separated Mixed Use



IV-B

IV-C

273

Incidental Use Separation

509.4.1.1 Type IV-B and IV-C construction. Where Table 509 specifies a fire-resistance-rated separation, mass timber elements serving as fire barriers or a horizontal assembly in Type IV-B or IV-C construction shall be separated from the interior of the incidental use with an approved thermal barrier consisting of a minimum of ½ inch gypsum board or a material that is tested in accordance with and meets the acceptance criteria of both the Temperature Transmission Fire Test and the Integrity Fire Test of NFPA 275.

IV-B

IV-C

274

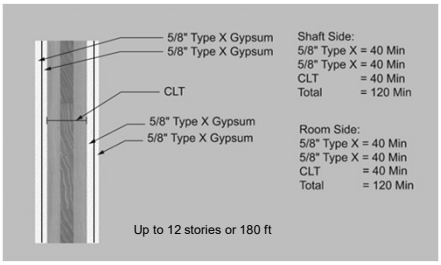
Sub-Outline

- Fire Barriers
- Shaft Walls
- Sealing Abutting Edges/Intersections and Fire Blocking Material
- New Redundant Sprinkler Water Supply Systems
- Concealed Spaces and Heavy Timber
- Owner's Responsibilities



275

Shaft Walls



IV-A

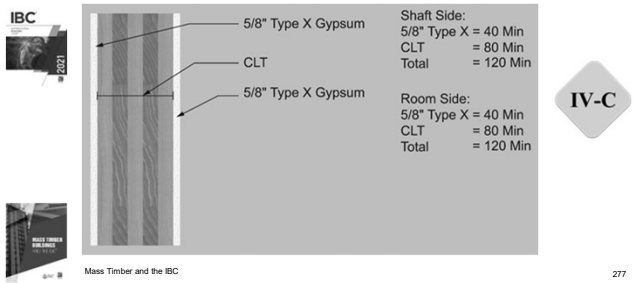
Height restricted

IV-B

276

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Shaft Walls



IV-C

Mass Timber and the IBC 277

277

Sub-Outline

- Fire Barriers
- Shaft Walls
- Sealing Abutting Edges/Intersections and Fire Blocking Material
- New Redundant Sprinkler Water Supply Systems
- Concealed Spaces and Heavy Timber
- Owner's Responsibilities



Mass Timber and the IBC 278

278

Sealing Intersections

- Mandatory sealing of adjacent mass timber elements in Section 703.7
  - Mass timber to mass timber
  - Mass timber to other materials

IV-A IV-B IV-C



Mass Timber and the IBC 279

279

Sealing Intersections (cont'd)

703.7 Sealing of adjacent mass timber elements. In buildings of Type IV-A, IV-B, and IV-C construction, sealant or adhesive shall be provided to resist the passage of air in the following locations:

1. At abutting edges and intersections of *mass timber* building elements required to be fire resistance-rated.

2. At abutting intersections of *mass timber* building elements and building elements of other materials where both are required to be fire resistance-rated.

Sealants shall meet the requirements of ASTM C920. Adhesives shall meet the requirements of ASTM D3498.

Exception: Sealants or adhesives need not be provided where they are not a required component of a tested fire resistance-rated assembly.

IV-A IV-B IV-C

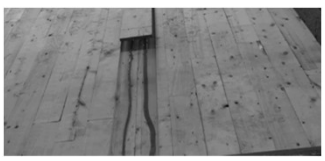
Mass Timber and the IBC 280

280

Sealing Intersections (cont'd)

1705.20 Sealing of mass timber
Periodic special inspections of sealants or adhesives shall be conducted where sealant or adhesive required by Section 703.7 is applied to *mass timber* building elements as designated in the *approved* construction documents.

IV-A IV-B IV-C



Mass Timber and the IBC 281

281

Fireblocking

718.2.1 Fireblocking materials. *Fireblocking* shall consist of the following materials:

1. Two-inch nominal lumber.

…laundry list continues with existing unchanged Items 2 through 8…

9. *Mass timber* complying with Section 2304.11.



Mass Timber and the IBC 282

282

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Penetrations

Through penetrations

- Tested in ATF research

Not Specific to Tall Mass Timber



Mass Timber and the IBC 283

283

Sub-Outline

- Fire Barriers
- Shaft Walls
- Sealing Abutting Edges/Intersections and Fire Blocking Material
- New Redundant Sprinkler Water Supply Systems
- Concealed Spaces and Heavy Timber
- Owner's Responsibilities



Mass Timber and the IBC 284

284

Water Supply to Required Fire Pumps

403.3.2 Water supply to required fire pumps. In all buildings that are more than 420 feet in building *height,* and buildings of Type IV-A and IV-B that are more than 120' in building height, required fire pumps shall be supplied by connections to not fewer than two water mains located in different streets. Separate supply piping shall be provided between each connection to the water main and the pumps. Each connection and the supply piping between the connection and the pumps shall be sized to supply the flow and pressure required for the pumps to operate.

IV-A

IV-B

Mass Timber and the IBC 285

285

Sub-Outline

- Fire Barriers
- Shaft Walls
- Sealing Abutting Edges/Intersections and Fire Blocking Material
- New Redundant Sprinkler Water Supply Systems
- Concealed Spaces and Heavy Timber
- Owner's Responsibilities



Mass Timber and the IBC 286

286

Concealed Spaces

Type IV-A & IV-B…at least 80 minutes of protection

602.4.1.5 & 602.4.2.5 Concealed spaces…Combustible construction forming concealed spaces shall be protected in accordance with Section 602.4.1.2.

602.4.1.2 Interior protection. Interior faces of all *mass timber* elements, including the inside faces of exterior *mass timber* walls and *mass timber* roofs, shall be protected…

602.4.1.2.1 Protection time. *Noncombustible protection* shall contribute a time equal to or greater than times assigned in Table 722.7.1(1), but not less than 80 minutes. The use of materials and their respective protection contributions listed in Table 722.7.1(2) shall be permitted to be used for compliance with Section 722.7.1.

TABLE 722.7.1(2)
PROTECTION PROVIDED BY NONCOMBUSTIBLE COVERING MATERIAL

Noncombustible Protection	Protection Contribution (minutes)
1/2 inch Type X Gypsum Board	25
5/8 inch Type X Gypsum Board	40

IV-A IV-B

Mass Timber and the IBC 287

287

Concealed Spaces

Type IV-C…40 minutes of protection

602.4.3.5 Concealed spaces…Combustible construction forming concealed spaces shall be protected with *noncombustible protection* with a minimum assigned time of 40 minutes as determined in Section 722.7.1.

TABLE 722.7.1(2)
PROTECTION PROVIDED BY NONCOMBUSTIBLE COVERING MATERIAL

Noncombustible Protection	Protection Contribution (minutes)
1/2 inch Type X Gypsum Board	25
5/8 inch Type X Gypsum Board	40

IV-C



Mass Timber and the IBC 288

288

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Concealed Spaces

IBC

Type IV-HT (only)

602.4.4.3 Concealed spaces…Concealed spaces shall be protected in accordance with one or more of the following:

1. The building shall be sprinklered throughout in accordance with Section 903.3.1.1 and automatic sprinklers shall also be provided in the concealed space.
2. The concealed space shall be completely filled with noncombustible insulation.
3. Surfaces within the concealed space shall be fully sheathed with not less than 5/8-inch Type X gypsum board.

Exception: Concealed spaces within interior walls and partitions with a one-hour or greater fire resistance rating complying Section 2304.11.2.2 shall not require additional protection.



IV-HT

289

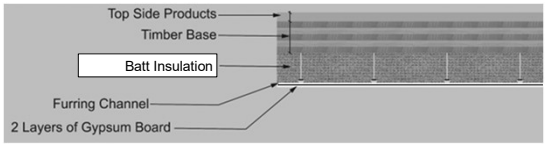
Concealed Spaces

IBC

2304.11.3 Floors. Floors shall be without concealed spaces or with concealed spaces complying with Section 602.4.4.3…

2304.11.4 Roof decks. Roofs shall be without concealed spaces ~~and roof~~ or with concealed spaces complying with Section 602.4.4.3…

IV-HT



290

Concealed Spaces

IBC

IV-A, IV-B } Assigned NC Protection (at least 80-min)

IV-C 40-min protection

IV-HT 3 options (NFPA 13)

291

Concealed Spaces

IBC





Photos provided by ATF Fire Research Laboratory

292

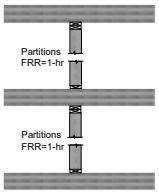
Concealed Space Exception

IBC

602.4 Type IV…

Combustible concealed spaces are not permitted except as otherwise indicated in Sections 602.4.1 through 602.4.4. Combustible stud spaces within light-frame walls of Type IV-HT construction shall not be considered concealed spaces but shall comply with Section 718.

IV-HT



293

CLT Wall Thickness

IBC

- Clarify min CLT thickness in Type IV-HT exterior walls
  - Requires min actual 4-inch CLT thickness rather than overall 6-inch wall thickness

IV-HT

602.4.4.2 Cross-laminated timber in exterior walls. *Cross-laminated timber* (CLT) not less than 4 inches in thickness complying with Section 2303.1.4 shall be permitted within exterior wall assemblies ~~not less than 6 inches in thickness~~ with a 2-hour rating or less. ~~provided the~~ Heavy timber structural members appurtenant to the CLT exterior wall shall meet the requirements of Table 2304.11 and be fire-resistance rated as required for the exterior wall. The exterior surface of the *cross-laminated timber* and heavy timber elements shall be ~~is~~ protected by one of the following:

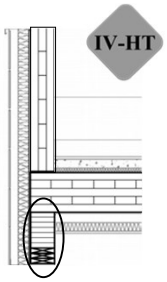
294

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

HT in Exterior Walls

- Provides for glulam and SCL in CLT exterior walls of Type IV-HT construction

602.4.4.2 Cross-laminated timber in exterior walls. *Cross-laminated timber* (CLT) not less than 4 inches in thickness complying with Section 2303.1.4 shall be permitted within exterior wall assemblies ~~not less than 6 inches in thickness~~ with a 2-hour rating or less. ~~provided the~~ Heavy timber structural members appurtenant to the CLT exterior wall shall meet the requirements of Table 2304.11 and be fire-resistance rated as required for the exterior wall. The exterior surface of the *cross-laminated timber* and heavy timber elements shall be ~~is~~ protected by one of the following:



295

HT Roof Beams/Frames

TABLE 601

FIRE-RESISTANCE RATING REQUIREMENTS FOR BUILDING ELEMENTS (HOURS)

BUILDING ELEMENT	TYPE I		TYPE II		TYPE III		TYPE IV				TYPE V	
	A	B	A	B	A	B	A	B	C	HT	A	B
Primary structural frame[f] (see Section 202)	3[a,b]	2[a,b,g]	1[b,g]	0[c]	1[b,g]	0	3[a]	2[a]	2[a]	HT	1[b,g]	0
Bearing walls												
Exterior[e,f]	3	2	1	0	2	2	3	2	2	2	1	0
Interior	3[a]	2[a]	1	0	1	0	3	2	2	1/HT[g]	1	0

c. In all occupancies, heavy timber complying with Section 2304.11 shall be allowed for roof construction, including primary structural frame members, where a 1-hour or less fire-resistance rating is required.
g. Heavy timber bearing walls supporting more than two floors or more than a floor and a roof shall have a fire resistance rating of not less than 1 hour.

IV-HT

296

HT Interior Bearing Walls

TABLE 601

FIRE-RESISTANCE RATING REQUIREMENTS FOR BUILDING ELEMENTS (HOURS)

BUILDING ELEMENT	TYPE I		TYPE II		TYPE III		TYPE IV				TYPE V	
	A	B	A	B	A	B	A	B	C	HT	A	B
Primary structural frame[f] (see Section 202)	3[a,b]	2[a,b,g]	1[b,g]	0[c]	1[b,g]	0	3[a]	2[a]	2[a]	HT	1[b,g]	0
Bearing walls												
Exterior[e,f]	3	2	1	0	2	2	3	2	2	2	1	0
Interior	3[a]	2[a]	1	0	1	0	3	2	2	1/HT[g]	1	0

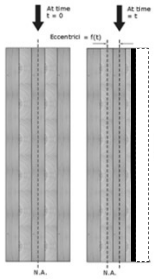
c. In all occupancies, heavy timber complying with Section 2304.11 shall be allowed for roof construction, including primary structural frame members, where a 1-hour or less fire-resistance rating is required.
g. Heavy timber bearing walls supporting more than two floors or more than a floor and a roof shall have a fire resistance rating of not less than 1 hour.

IV-HT

297

HT Interior Bearing Walls

- Table 601 Type IV-HT
  - Footnote g. Heavy timber bearing walls supporting more than two floors or more than a floor and a roof shall have a fire resistance rating of not less than 1 hour.
  - Calculated or protected



IV-HT

298

Primary vs. Secondary Frame

TABLE 601
FIRE-RESISTANCE RATING REQUIREMENTS FOR BUILDING ELEMENTS (HOURS)

BUILDING ELEMENT	TYPE I		TYPE II		TYPE III		TYPE IV				TYPE V	
	A	B	A	B	A	B	A	B	C	HT	A	B
Primary structural frame [f] (see Section 202)	3[a,b]	2[a,b,c]	1[b,c]	0[c]	1[b,c]	0	3[a]	2[a]	2[a]	HT	1[b,c]	0
Bearing walls												
Exterior [e, f]	3	2	1	0	2	2	3	2	2	2	1	0
Interior	3[a]	2[a]	1	0	1	0	3	2	2	1/HT[b]	1	0
Nonbearing walls and partitions – Exterior	See Table 705.5											
Nonbearing walls and partitions – Interior [d]	0	0	0	0	0	0	0	0	0	See Section 2304.11.2	0	0
Floor construction and associated secondary structural members (see Section 202)	2	2	1	0	1	0	2	2	2	HT	1	0
Roof construction and associated secondary structural members (see Section 202)	1 ½[b]	1[b,c]	1[b,c]	0[c]	1[b,c]	0	1 ½	1	1	HT	1[b,c]	0

299

Primary vs. Secondary Frame

Primary Structural Frame. The primary structural frame shall include all of the following structural members:
- The columns.
- Structural members having direct connections to the columns, including girders, beams, trusses and spandrels.
- Members of the floor construction and roof construction having direct connections to the columns.
- Bracing Members that are essential to the vertical stability of the primary structural frame under gravity loading. ~~shall be considered part of the primary structural frame whether or not the bracing member carries gravity *loads*.~~

Secondary Structural Members. The following structural members shall be considered secondary members and not part of the primary structural frame:
- Structural members not having direct connections to the columns.
- Members of the floor construction and roof construction not having direct connections to the columns.
- Bracing members ~~other than those that are part of the *primary structural frame*~~ that are not designated as part of a primary structural frame or bearing wall.

300

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Primary vs. Secondary Frame

IBC 2021

Primary
- Columns and Beams

Secondary
- Floor Panels



Mass Timber and the IBC 301

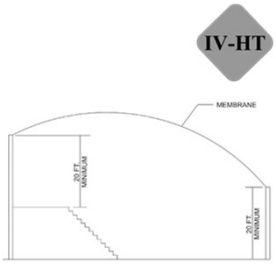
301

Membrane Structures

IBC 2021

3102.3 Type of construction…
Heavy timber frame-supported structures covered by an *approved* membrane in accordance with Section 3102.3.1 shall be classified as Type IV-HT construction.

Note: The Exception to 3102.3 remains unchanged.



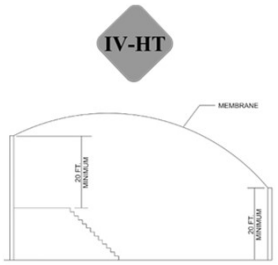
Mass Timber and the IBC 302

302

Membrane Structures

IBC 2021

3102.6.1.1 Membrane.
A membrane meeting the fire propagation performance criteria of Test Method 1 or Test Method 2, as appropriate, of NFPA 710 shall be permitted to be used as the roof or as a skylight on buildings of Type II B, III, IV-HT and V construction, provided that the membrane is not less than 20 feet above and floor, balcony or gallery.



Mass Timber and the IBC 303

303

Sub-Outline

- Fire Barriers
- Shaft Walls
- Sealing Abutting Edges/Intersections and Fire Blocking Material
- New Redundant Sprinkler Water Supply Systems
- Concealed Spaces and Heavy Timber
- Owner's Responsibilities



Mass Timber and the IBC 304

304

Owner's Responsibility

IFC 2021

IFC 701.6 Owner's responsibility. The owner shall maintain an inventory of all required fire-resistance-rated construction, construction installed to resist the passage of smoke and the construction included in Sections 703 through 707 and Sections 602.4.1 and 602.4.2 of the *International Building Code*. Such construction shall be visually inspected by the owner annually and properly repaired, restored or replaced where damaged, altered, breached or penetrated. Records of inspections and repairs shall be maintained…

IV-A

IV-B

Mass Timber and the IBC 305

305

Q&A



Mass Timber and the IBC 306

306

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.



Outline

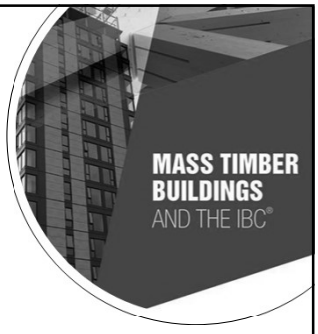
- Introduction to Mass Timber Products
- 2015/2018 IBC for Mass Timber Construction
- Break – 15 minutes
- 2021 IBC for Tall Mass Timber Construction
  - Part 1: Background and Overview
  - Lunch – 1 hour
  - Part 2: New Construction Types and Heights & Areas
  - Part 3: Fire Safety
  - Break – 15 minutes
  - Part 4: Fire & Connection Design and Special Inspection
  - Part 5: Acoustics, Energy, and Lateral Resistance
  - Part 6: Construction Fire Safety



307

Tall Mass Timber Construction per 2021 IBC

Part 4: Principles of Fire Resistance Design, Protection of Connections and Special Inspections



308

Sub-Outline

- Principles of Fire-resistance Design for New Construction Types IV-A, IV-B, and IV-C
- Design of Fire-resistance Protection for Mass Timber Connections
- Special Inspection of Tall Mass Timber Structures





309

Mass Timber Fire-Resistance Design



TABLE 601
FIRE-RESISTANCE RATING REQUIREMENTS FOR BUILDING ELEMENTS (HOURS)

BUILDING ELEMENT	TYPE I		TYPE II		TYPE III		TYPE IV			HT	TYPE V	
	A	B	A	B	A	B	A	B	C		A	B
Primary structural frame [f] (see Section 202)	3[a,b]	2[a,b,c]	1[b,c]	0[c]	1[b,c]	0	3[a]	2[a]	2[a]	HT	1[a]	0
Bearing walls												
Exterior [e, f]	3	2	1	0	2	2	3	2	2	2	1	0
Interior	3[a]	2[a]	1	0	1	0	3	2	2	1/HT[a]	1	0
Nonbearing walls and partitions – Exterior	See Table 705.5											
Nonbearing walls and partitions – Interior [d]	0	0	0	0	0	0	0	0	0	See Section 2304.11.2	0	0
Floor construction and associated secondary structural members (see Section 202)	2	2	1	0	1	0	2	2	2	HT	1	0
Roof construction and associated secondary structural members (see Section 202)	1 ½[a]	1[b,c]	1[b,c]	0[c]	1[b,c]	0	1 ½	1	1	HT	1[b,c]	0



310

Mass Timber Fire-Resistance Design

Noncombustible

(703.3)

≠

Fire-resistant

(703.2)



311

Mass Timber Fire-Resistance Design

Heavy timber inherent fire resistance

⇕

minimum prescriptive dimensions

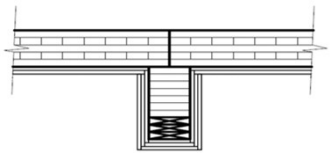


312

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Noncombustible Time Contribution

722.7 Fire-resistance rating of mass timber. The required fire resistance of mass timber elements in Section 602.4 shall be determined in accordance with Section 703.2. The fire resistance rating of building elements shall be as required in Tables 601 and 705.5 and as specified elsewhere in this code. The fire-resistance rating of the mass timber elements shall consist of the fire resistance of the unprotected element added to the protection time of the noncombustible protection.



IV-A

IV-B

IV-C

313

Noncombustible Time Contribution

Protection Required

TABLE 722.7.1(1)
PROTECTION REQUIRED FROM NONCOMBUSTIBLE COVERING MATERIAL

Required Fire-Resistance Rating of Building Element per Tables 601 and 705.5 (hours)	Minimum Protection Required from Noncombustible Protection (minutes)
1	40
2	80
3 or more	120

IV-A

IV-B

IV-C

314

Noncombustible Time Contribution

Prescriptive Method

TABLE 722.7.1(2)
PROTECTION PROVIDED BY NONCOMBUSTIBLE COVERING MATERIAL

Noncombustible Protection	Protection Contribution (minutes)
1/2 inch Type X Gypsum Board	25
5/8 inch Type X Gypsum Board	40

IV-A

IV-B

IV-C

315

Mass Timber Fire-Resistance Design

Methods for establishing fire resistance (703.2.2)

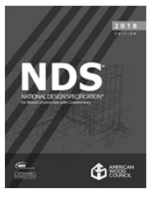
1. Tested fire assembly (ASTM E119 or UL 263)
2. Fire-resistance designs documented in approved sources
3. Prescriptive assemblies using fire-resistance rated designs in Section 721
4. **Calculation of fire-resistance per Section 722**
5. Engineering analysis based on a comparison of building element, component or assembly designs that have been tested
6. Fire-resistance designs certified by an approved agency

703.2.3 Alternative protection methods per Section 104.11

316

Mass Timber Fire-Resistance Design







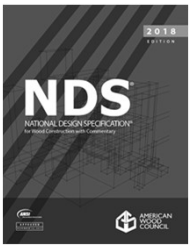
IBC 722.1 | **NDS Chapter 16** | **TR-10**

317

Mass Timber Fire-Resistance Design

SECTION 722
CALCULATED FIRE RESISTANCE

722.1 General. The provisions of this section contain procedures by which the *fire resistance* of specific materials or combinations of materials is established by calculations. These procedures apply only to the information contained in this section and shall not be otherwise used…The calculated *fire resistance* of exposed wood members and wood decking shall be permitted in accordance with Chapter 16 of ANSI/AWC *National Design Specification for Wood Construction (NDS)*.



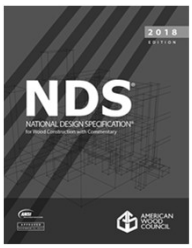
318

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Mass Timber Fire-Resistance Design

NDS Section 16.2

- Fire design up to 2 hours
- Beams, columns, walls, floors/roofs
- Products
  - Sawn lumber
  - Glulam (softwood)
  - LVL
  - PSL
  - LSL
  - CLT



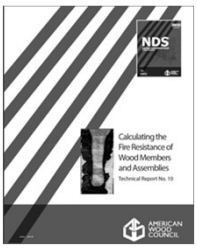
Mass Timber and the IBC 319

319

Mass Timber Fire-Resistance Design

AWC Technical Report 10

- NDS Chapter 16 basis
  - Background
  - Commentary
  - Examples



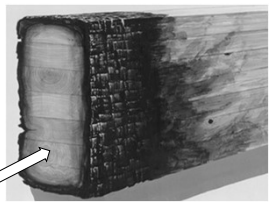
Mass Timber and the IBC 320

320

Mass Timber Fire-Resistance Design

Wood at high temperature

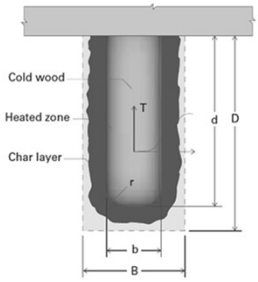
- **Low thermal conductivity**
- Dimensionally stable
- Predictable char rate
- **Inner portion remains cool**
  - Does not lose strength



Mass Timber and the IBC 321

321

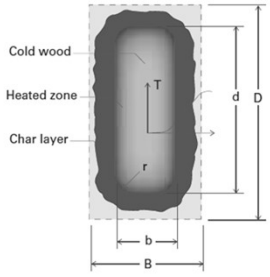
Mass Timber Fire-Resistance Design



Mass Timber and the IBC 322

322

Mass Timber Fire-Resistance Design



Mass Timber and the IBC 323

323

Mass Timber Fire-Resistance Design

Table 16.2.1A Char Depth and Effective Char Depth (for β_n = 1.5 in./hr.)

Required Fire Resistance (hr.)	Char Depth, a_{char} (in.)	Effective Char Depth, a_{eff} (in.)
1-Hour	1.5	1.8
1½-Hour	2.1	2.5
2-Hour	2.6	3.2

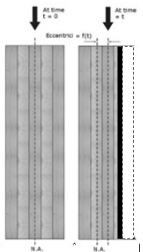
Mass Timber and the IBC 324

324

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Mass Timber Fire-Resistance Design





CLT: modified char depth model

Mass Timber and the IBC 325

325

Mass Timber Fire-Resistance Design

Table 16.2.1B Effective Char Depths (for CLT with β_n = 1.5in./hr.)

Required Fire Resistance (hr.)	Effective Char Depths, a_{eff} (in.) lamination thicknesses, h_{lam} (in.)								
	5/8	3/4	7/8	1	1-1/4	1-3/8	1-1/2	1-3/4	2
1-Hour	2.2	2.2	2.1	2.0	2.0	1.9	1.8	1.8	1.8
1½-Hour	3.4	3.2	3.1	3.0	2.9	2.8	2.8	2.8	2.6
2-Hour	4.4	4.3	4.1	4.0	3.9	3.8	3.6	3.6	3.6

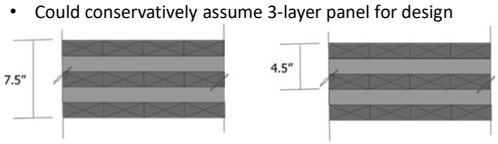
Mass Timber and the IBC 326

326

Mass Timber Fire-Resistance Design

Determination of effective CLT floor cross-section

- Assume 5-layers @ 1.5" (total = 7.5")
- Determine thickness for 1-hr FRR
- a_{char} = 1.8" (NDS Table 16.2.1B)
- d = 7.5" – 1.8" = 5.7"
- Could conservatively assume 3-layer panel for design

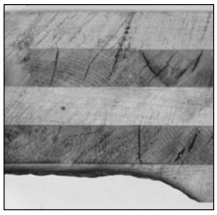


Mass Timber and the IBC 327

327

Mass Timber Fire-Resistance Design

- Fire-resistance of exposed mass timber
  - Cross-sectional dimensions
  - Load ratio



Mass Timber and the IBC 328

328

Mass Timber Fire-Resistance Design

- Fire-resistance of protected mass timber
  - Cross-sectional dimensions
  - Load ratio

- plus -

- Noncombustible protection



Mass Timber and the IBC 329

329

Mass Timber Fire-Resistance Design



Waugh Thistleton Architects (Stradthaus – Murry Grove)

Mass Timber and the IBC 330

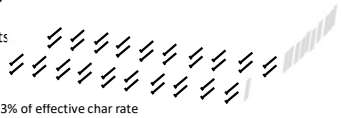
330

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Mass Timber Fire-Resistance Design

Nail-Laminated Timber (NLT)

- NDS 16.2.5. Timber Decks
  - ≥ 2" thick (actual)
  - Clear-span between supports
  - Assembly of wood beams
    - Exposed partially on sides
    - Exposed fully on one face
    - Char rate on sides reduced to 33% of effective char rate
    - Does not address thermal separation
    - Typically requires one layer of Type X gypsum



331

Mass Timber Fire-Resistance Design

16.2.4 Special Provisions for Structural Glued Laminated Timber Beams

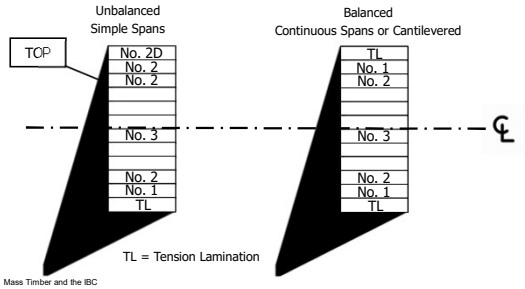
For structural glued laminated timber bending members given in Table 5A and rated for 1-hour fire endurance, an outer tension lamination shall be substituted for a core lamination on the tension side for unbalanced beams and on both sides for balanced beams. For structural glued laminated timber bending members given in Table 5A and rated for 1½- or 2-hour fire endurance, 2 outer tension laminations shall be substituted for 2 core laminations on the tension side for unbalanced beams and on both sides for balanced beams.



Glulam column caps at the Bullitt Center

332

Glulam - Engineered Layups



333

Tension Lams - Unbalanced

3-sided exposure only (protected compression side)

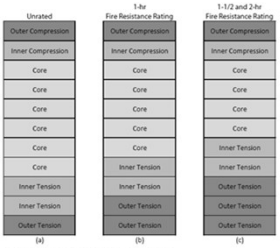


Figure 3-1 Typical glulam unbalanced beam layups

334

Tension Lams - Balanced

3- or 4-sided beam (or column) exposure

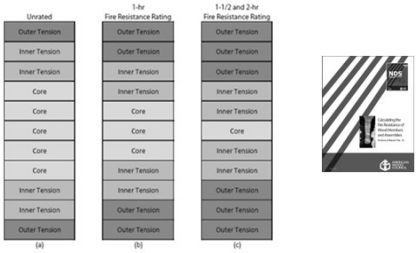


Figure 3-2 Typical glulam balanced beam layups

335

Sub-Outline

- Principles of Fire-resistance Design for New Construction Types IV-A, IV-B, and IV-C
- Design of Fire-resistance Protection for Mass Timber Connections
- Special Inspection of Tall Mass Timber Structures



336

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Fire-Resistive Connection Protection

IBC 2021

IV-A IV-B IV-C

704.2 Column protection. Where columns are required to have protection to achieve a *fire-resistance rating*, the entire column shall be provided individual encasement protection by protecting it on all sides for the full column height, including connections to other structural members, with materials having the required *fire-resistance rating*. Where the column extends through a ceiling, the encasement protection shall be continuous from the top of the foundation or floor/ceiling assembly below through the ceiling space to the top of the column.

704.3 Protection of the primary structural frame other than columns. Members of the primary structural frame other than columns that are required to have protection to achieve a *fire-resistance rating* and support more than two floors or one floor and roof, or support a load-bearing wall or a nonload-bearing wall more than two stories high, shall be provided individual encasement protection by protecting them on all sides for the full length, including connections to other structural members, with materials having the required *fire-resistance rating*.



Mass Timber and the IBC 337

337

Fire-Resistive Connection Protection

IBC 2021

2304.10.1 Connection fire-resistance rating. Fire-resistance ratings for connections in Type IV-A, IV-B or IV-C shall be determined by one of the following:

IV-A IV-B IV-C

1. Testing in accordance with Section 703.2 where the connection is a part of the fire-resistance test.
2. Engineering analysis that demonstrates that the temperature rise at any portion of the connection is limited to an average temperature rise of 250°F, and a maximum temperature rise of 325°F, for a time corresponding to the required fire-resistance rating of the structural element being connected. For the purposes of this analysis, the connection includes connectors, fasteners, and portions of wood members included in the structural design of the connection.



Beam-to-column connection tested at ATF Fire Research Lab.



Mass Timber and the IBC 338

338

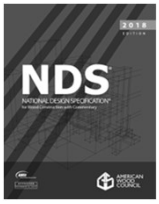
Fire-Resistive Connection Protection

IBC 2021

But we can't test every connection!

2304.10.1 Connection fire resistance rating. Fire-resistance ratings for connections in Type IV-A, IV-B or IV-C shall be determined by one of the following:

1. Testing in accordance with Section 703.2 where the connection is a part of the fire resistance test.
2. Engineering analysis that demonstrates . . .



IV-A IV-B IV-C



Mass Timber and the IBC 339

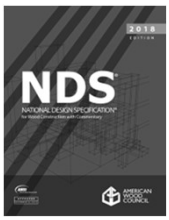
339

Fire-Resistive Connection Protection

NDS 16.3 Wood Connections

Where fire resistance is required, connectors and fasteners shall be protected from fire exposure

- Additional wood cover
- Fire-rated gypsum board
- Other approved materials like coatings or insulation (approved for required endurance time)
- OR a combination thereof





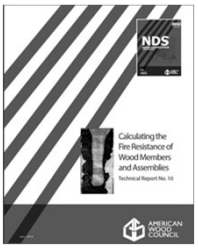
Mass Timber and the IBC 340

340

Fire-Resistive Connection Protection

AWC *Technical Report 10*

- NDS Chapter 16 basis
  - Protecting connections
    - Background
    - Commentary
    - Examples





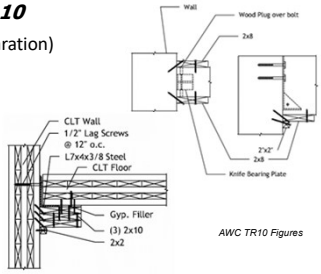
Mass Timber and the IBC 341

341

Fire-Resistive Connection Protection

AWC *Technical Report 10*

- Thermal protection (separation)
- Example details
- Common fasteners and connectors



AWC TR10 Figures



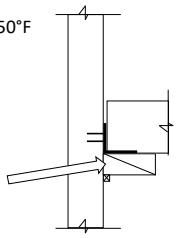
Mass Timber and the IBC 342

342

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Fire-Resistive Connection Protection

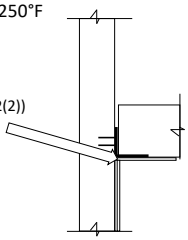
- Thermal Separation – limit avg temp rise ≤ 250°F
- 2-hr Example
  - 3 inches of wood protection
  - $t_p = 60\left(\frac{3.0}{1.5}\right)^{1.23} = 141\ minutes$
  - Wood protecting a connection
  - 0.85 x (calculated protection time)
  - $0.85\ t_p = (0.85)\ 141\ minutes = 120\ minutes$



343

Fire-Resistive Connection Protection

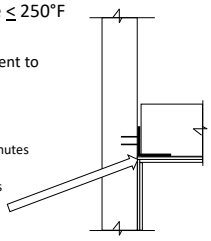
- Thermal Separation – limit avg temp rise ≤ 250°F
- 1-hr Example
  - Gypsum Board
  - 0.5 x (NC Protection Time)
  - 5/8" Type X GB = 40 minutes (IBC Table 722.7.2(2))
  - $0.5\ t_p = (0.5)\ 40\ minutes = 20\ minutes$ NG



344

Fire-Resistive Connection Protection

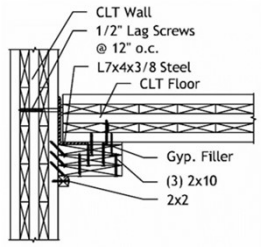
- Thermal Separation – limit avg temp rise ≤ 250°F
- Multiple layers of protection
  - Reduction factor only applies to layer adjacent to connection
- 1-hr Example
  - 2 layers of 5/8" Type X GB
    - Layer adjacent to connection = 40 (0.5) = 20 minutes
    - Second layer = 40 minutes
    - Total thermal separation = 40 + 20 = 60 minutes



345

Fire-Resistive Connection Protection

- Char contraction
  - Abutting edges
  - Char layer < char depth
  - Wedge-shaped gap
  - Additional wood cover protects abutting edges
  - Fasteners attaching cover do not require protection

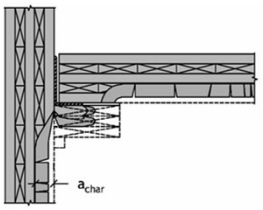


AWC TR10 Figure 8-4. Example connection protection

346

Fire-Resistive Connection Protection

- Char contraction
  - Abutting edges
  - Char layer < char depth
  - Wedge-shaped gap
  - Additional wood cover or blocking to protect abutting edges
  - Fasteners attaching cover do not require protection



AWC TR10 Figure 8-3. Char pattern with wood strip added

347

Fire-Resistive Connection Protection

Code Official Inspection

110.3.5 Type IV-A, IV-B and IV-C connection protection inspection. In buildings of Type IV-A, IV-B and IV-C Construction, where connection fire-resistance ratings are provided by wood cover calculated to meet the requirements of Section 2304.10.1, inspection of the wood cover shall be made after the cover is installed, but before any other coverings or finishes are installed.



348

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Sub-Outline

- Principles of Fire-resistance Design for New Construction Types IV-A, IV-B, and IV-C
- Design of Fire-resistance Protection for Mass Timber Connections
- Special Inspection of Tall Mass Timber Structures



Mass Timber and the IBC 349

349

Special Inspection

- New Section 1705.5.3 on Tall Mass Timber Construction
- New Table 1705.5.3
  - Required special inspections for new mass timber types
    - IV-A, IV-B & IV-C
- NOT Type IV-HT



IV-A IV-B IV-C

Mass Timber and the IBC 350

350

Special Inspection

Table 1705.5.3. Required Special Inspections of Mass Timber Construction

	Type		Continuous Special Inspection	Periodic Special Inspection
1.	Inspection of anchorage and connections of mass timber construction to timber deep foundation systems.			X
2.	Inspect erection of mass timber construction.			X
3.	Inspection of connections where installation methods are required to meet design loads.			
	Threaded fasteners	Verify use of proper installation equipment.		
		Verify use of pre-drilled holes where required.		X
		Inspect screws, including diameter, length, head type, spacing, installation angle, and depth.		X
	Adhesive anchors installed in horizontal or upwardly inclined orientation to resist sustained tension loads.		X	
	Adhesive anchors not defined in preceding cell.			X
	Bolted connections.			X
	Concealed connections.			X

IV-A IV-B IV-C

Mass Timber and the IBC 351

351

Special Inspection

- Connections for TMT can be designed with common connectors
  - Screws, bolts, etc.
  - Thus, periodic
- Continuous inspection
  - Adhesive anchors under sustained tension
  - Similar to precast



IV-A IV-B IV-C

Mass Timber and the IBC 352

352

Special Inspection

1705.20 Sealing of mass timber
Periodic special inspections of sealants or adhesives shall be conducted where sealant or adhesive required by Section 703.7 is applied to *mass timber* building elements as designated in the *approved* construction documents.

IV-A IV-B IV-C



Mass Timber and the IBC 353

353

Special Inspection

703.7 Sealing of adjacent mass timber elements…

- Sealants per ASTM C920

or

- Adhesives per ASTM D3498

Exception: Sealants or adhesives need not be provided where they are not a required component of a tested fire-resistance-rated assembly.



IV-A IV-B IV-C

Mass Timber and the IBC 354

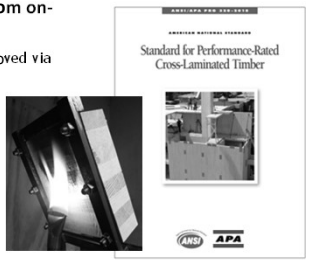
354

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Special Inspection

Fabricated items exempt from on-site special inspection

- IBC 1704.2.5 – fabricator approved via QC/QA and third-party audit
  - CLT
  - SCL
  - Glulam
  - Sawn Timber



Mass Timber and the IBC 355

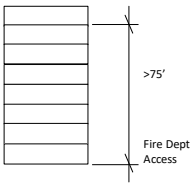
355

Structural Observation

1704.6.1 Structural observations for structures. Structural observations shall be provided for those structures where one or more of the following conditions exist:

1. The structure is classified as Risk Category III or IV.
2. The structure is a high-rise building.
3. The structure is assigned to Seismic Design Category E and is greater than two stories above the grade plane.
4. Such observation is required by the registered design professional responsible for the structural design.
5. Such observation is specifically required by the building official.

Not Specific to Tall Mass Timber



Mass Timber and the IBC 356

356

Q&A



Mass Timber and the IBC 357

357



Outline

- Introduction to Mass Timber Products
- 2015/2018 IBC for Mass Timber Construction
- Break – 15 minutes
- 2021 IBC for Tall Mass Timber Construction
  - Part 1: Background and Overview
  - Lunch – 1 hour
  - Part 2: New Construction Types and Heights & Areas
  - Part 3: Fire Safety
  - Break – 15 minutes
  - Part 4: Fire & Connection Design and Special Inspection
  - Part 5: Acoustics, Energy, and Lateral Resistance
  - Part 6: Construction Fire Safety

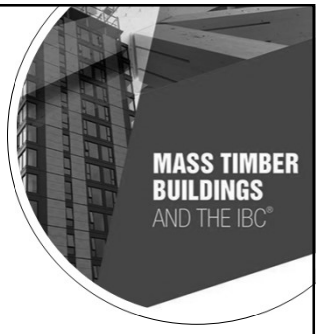


Mass Timber and the IBC 358

358

Tall Mass Timber Construction per 2021 IBC

Part 5: Acoustics, Energy and Lateral Load Performance



Mass Timber and the IBC 359

359

Sub-Outline

- Acoustics
- Energy
- Lateral Resistance



Mass Timber and the IBC 360

360

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Acoustics

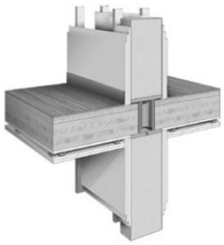
- IBC 1206
  - Airborne sound – STC
  - Structure-borne sound – IIC



361

Acoustics

- Multi-family
  - STC minimum = 50
  - IIC minimum = 50
  - Field-test = 45



362

Acoustics

Sound Transmission Ratings of Selected Mass Timber Panels

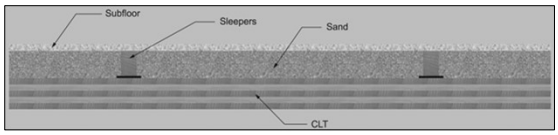
Mass Timber Panel	Thickness	STC Rating	IIC Rating
3-ply CLT wall	3"	33	N/A
5-ply CLT wall	$6^{7}/_{8}$"	38	N/A
5-ply CLT floor	$5^{1}/_{16}$"	39	22
5-ply CLT floor	$6^{7}/_{8}$"	41	25
7-ply CLT floor	$9^{5}/_{8}$"	44	30
2x4 NLT wall	3-1/2" bare NLT 3-1/2" with 3/4" plywood	24 bare NLT 29 with 3/4" plywood	N/A
2x6 NLT wall	5-1/2" bare NLT 5-1/2" with 3/4" plywood	22 bare NLT 31 with 3/4" plywood	N/A
2x6 NLT floor + 1/2" plywood	5-1/2" with 1/2" plywood	34	33

Source: Inventory of Acoustically-Tested Mass Timber Assemblies, WoodWorks

363

Acoustics

- Example – floor with exposed mass timber

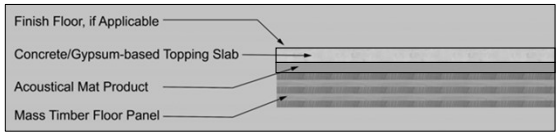


IV-HT

364

Acoustics

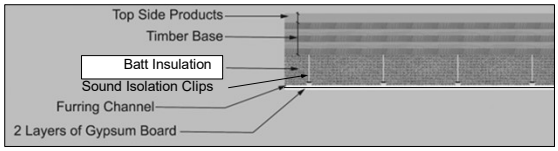
- Example – floor with exposed mass timber



365

Acoustics

- Examples – floors with ceiling concealed



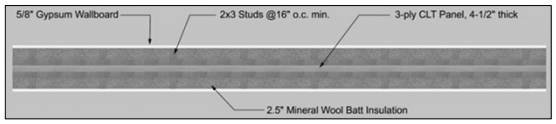
IV-HT

366

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Acoustics

- Example – walls

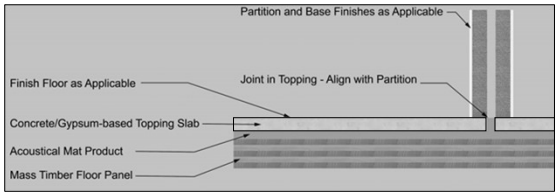


IV-HT

367

Acoustics

- Example – flanking control



368

Sub-Outline

- Acoustics
- Energy
- Lateral Resistance



369

Energy Performance

- Exterior walls
  - Mass timber panels (e.g. CLT)
  - Curtain walls
- IBC Chapter 13
  - IECC compliance paths
    - ANSI/ASHRAE/IES Standard 90.1
    - Prescriptive design per IECC C402 through C405
    - Performance design per IECC C407



370

Energy Performance

IECC TABLE C402.1.4
OPAQUE THERMAL ENVELOPE ASSEMBLY MAXIMUM REQUIREMENTS, U-FACTOR METHOD

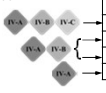
CLIMATE ZONE	1		2		3		4 EXCEPT MARINE		5 AND MARINE 4		6		7		8	
	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R
Walls, above grade																
Mass	U-0.151	U-0.151	U-0.151	U-0.123	U-0.123	U-0.104	U-0.104	U-0.090	U-0.090	U-0.080	U-0.080	U-0.071	U-0.071	U-0.071	U-0.037	U-0.037
Wood framed and other	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.051	U-0.051	U-0.051	U-0.051	U-0.051	U-0.051	U-0.032	U-0.032
Floors																
Mass	U-0.322	U-0.322	U-0.107	U-0.087	U-0.074	U-0.074	U-0.057	U-0.051	U-0.057	U-0.051	U-0.051	U-0.051	U-0.042	U-0.042	U-0.038	U-0.038

R-value method does not account for the mass effect

371

Energy Performance

- Does a CLT wall qualify as a "mass" wall?
  - Assume 1-3/8" lamination thickness
    - 3 layers = 4.125"
    - 5 layers = 6.875"
    - 7 layers = 9.625"
- Exterior fire protection required
  - All new construction types



Required Mass Timber Thickness for Minimum Heat Capacity of 5 Btu/ft²•°F	
Layers of 5/8" Type X Gypsum	Minimum Thickness of Mass Timber (in.)
0[1]	6.36 (5 layers)
1	5.53 (5 layers)
2	4.71 (5 layers)
3	3.88 (3 layers)
4	3.05 (3 layers)

372

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Energy Performance

Required Minimum Thickness of Mass Wall to Meet IECC U-Factors

CZ	Req. U-Factor	All Except Residential: Layers of 5/8" Gypsum 0[1]	1	2	3
1	0.151	4.62	4.23	3.85	3.47
2	0.151	4.62	4.23	3.85	3.47
3	0.123	5.82	5.44	5.06	4.67
4	0.104	7.01	6.63	6.24	5.86
5	0.090	8.21	7.82	7.44	7.06
6	0.080	9.32	8.94	8.55	8.17
7	0.071	10.59	10.20	9.82	9.44
8	0.037	20.94	20.56	20.17	19.79

IV-A IV-B IV-C IV-A IV-B

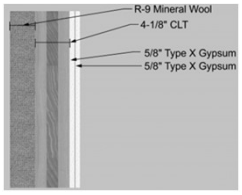
CLT
3 layers = 4.125"
5 layers = 6.875"
7 layers = 9.625"

373

Energy Performance

Additional Minimum R-value for a Non-mass 4-1/8-inch-thick Wall under IECC

CZ	Req. U-Factor	All Except Residential: Layers of 5/8" Gypsum 0[1]	1	2	3
		Additional required R-value			
1	0.064	9.62	9.14	8.66	8.18
2	0.064	9.62	9.14	8.66	8.18
3	0.064	9.62	9.14	8.66	8.18
4[2]	0.064	9.62	9.14	8.66	8.18
5[3]	0.051	13.60	13.12	12.64	12.16
6	0.051	13.60	13.12	12.64	12.16
7	0.051	13.60	13.12	12.64	12.16
8	0.032	25.24	24.76	24.28	23.80



R-9 mineral wool works

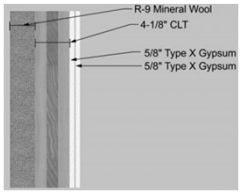
IV-A IV-B IV-C IV-A IV-B

374

Energy Performance

Additional Minimum R-value for a Mass 4-1/8-inch-thick Wall under IECC

CZ	Req. U-Factor	All Except Residential: Layers of 5/8" Gypsum 0[1]	1	2	3
		Additional required R-value			
1	0.151	0.62	0.14	0.00	0.00
2	0.151	0.62	0.14	0.00	0.00
3	0.123	2.12	1.64	1.16	0.68
4[2]	0.104	3.61	3.13	2.65	2.17
5[3]	0.090	5.10	4.62	4.14	3.66
6	0.080	6.49	6.01	5.53	5.05
7	0.071	8.08	7.60	7.12	6.64
8	0.037	21.02	20.54	20.06	19.58



R-9 mineral wool works

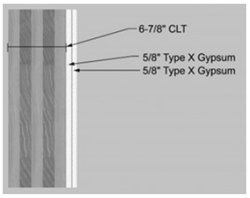
IV-A IV-B IV-C IV-A IV-B

375

Energy Performance

Additional Minimum R-value for a Mass 6-7/8-inch-thick Wall under IECC

CZ	Req. U-Factor	All Except Residential: Layers of 5/8" Gypsum 0[1]	1	2	3
		Additional required R-value			
1	0.151	0.00	0.00	0.00	0.00
2	0.151	0.00	0.00	0.00	0.00
3	0.123	0.00	0.00	0.00	0.00
4	0.104	0.17	0.00	0.00	0.00
5	0.090	1.67	1.19	0.71	0.23
6	0.080	3.06	2.58	2.10	1.62
7	0.071	4.64	4.16	3.68	3.20
8	0.037	17.58	17.10	16.62	16.14



IV-A IV-B IV-C IV-A IV-B

376

Sub-Outline

- Acoustics
- Energy
- Lateral Resistance



377

Seismic Design Options

- *ASCE 7 Minimum Design Loads for Buildings and Other Structures*
- Response Modification Coefficient (R)
  - CLT not recognized vertical SFRS in ASCE 7-16
  - Options
    - Performance-based design procedure per ASCE 7
    - Demonstrating equivalence to an existing ASCE 7 system
    - ASCE 7, FEMA P695, and FEMA P795 Quantification of Building Seismic Performance Factors; Component Equivalency Methodology
- R-factor anticipated in ASCE 7-22



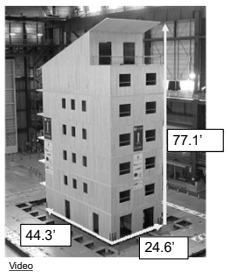
378

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Shake Table Test

7-story CLT Building – 2007

- Conducted at E-Defense
- Building weight 270t
  - Self-weight 120t
  - Added weight 150t
- Panel thickness
  - 5.5" floors 1 and 2
  - 4.9" floors 3 and 4
  - 3.3" top 3 floors
- Wall panels length 7.5'



Video

379

Lateral Design Options

- Horizontal diaphragm example
  - Wood structural panels over CLT
  - Acceptable under current codes





Photo courtesy of StructureCraft

www.structurlam.com

380

Current Research

- Colorado State University
  - CLT shear wall testing (P695) to determine seismic R factor
- Colorado School of Mines
  - NEES project on rocking CLT shear wall
- Arup
  - Heavy timber buckling-restrained braced frame system
- Oregon State University
  - CLT diaphragm testing



photo courtesy of Robert Beckley



photo courtesy of Shiling Pei

381

Current Standards

- *2021 Special Design Provisions for Wind and Seismic*
  - CLT Diaphragms
  - CLT shear walls
  - Ductility via nailed metal connectors
  - Referenced in 2021 IBC

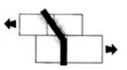


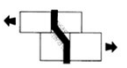
382

CLT Diaphragms

- Cross-laminated Timber (CLT) Diaphragm Design
  - Deflection per engineering
  - Unit shear capacity
    - Nominal dowel fastener shear capacities
      - 4.5 x Z*
      - Z* = Z x NDS adjustments except C_D, K_θ, ϕ, and λ
      - Mode III_s or IV
    - Wood, steel, and chord splices
      - 2 x diaphragm forces – seismic
      - 1.5 x diaphragm forces – wind
    - Chord splice fasteners – Mode III_s and IV
      - 1.5 x diaphragm forces – seismic
      - 1.0 x diaphragm forces – wind

§ 4.5





Ductile connections

383

CLT Shear Walls

- CLT Shear Wall Design
  - Deflection per engineering
  - Shear capacity
    - Nominal capacities per SDPWS Appendix B or
    - Approved alternative (by AHJ) CLT shear wall
  - NOT permitted
    - FTAO
    - PSW
    - ASCE 7 light-frame seismic

§ 4.6 & App. B



384

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

CLT Shear Walls

- Aspect Ratio Limit
  - $2 \leq h/b_s \leq 4$
- Hold-downs
  - 2 x v_s – seismic
  - 1.5 x v_s – wind
  - NDS App. E net section
- Dowel-type fasteners
  - Mode III_s or IV (ductile)
  - NDS App. E net section
- Deflection – 5-part equation

§ 4.6 & App. B



Mass Timber and the IBC 385

385

CLT Shear Walls

$$v_s = n\left(\frac{2605}{b_s}\right)C_G$$

§ 4.6 & App. B

where:

n = number of angle connectors along bottom of panel face

2605 = NDS connector nominal shear capacity (lbs)

b_s = individual CLT panel length (ft)

C_G = CLT panel specific gravity adjustment factor.

- C_G = 1.0 for G ≥ 0.42
- C_G = 0.86 for G = 0.35
- Linear interpolation permitted for G of 0.35 to 0.42

CLT Shear Wall Capacities* (ASD)

		Seismic		Wind	
Panel b_s x h (ft)	No. of Angles (n)	Shear (plf)	Hold-down (lbs)	Shear (plf)	Hold-down (lbs)
4 x 8	2	465	7443	651	7815
4 x 8	3	698	11,164	977	11,723
4 x 8	4	930	14,886	1303	15,630
4 x 8	5	1163	18,607	1628	19,538

*Capacity based on angles on one face

Mass Timber and the IBC 386

386

Q&A



Mass Timber and the IBC 387

387



Outline

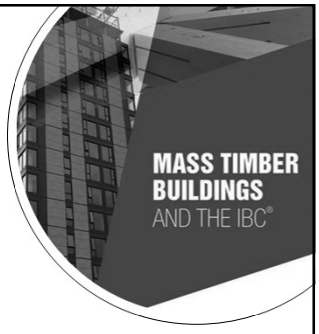
- Introduction to Mass Timber Products
- 2015/2018 IBC for Mass Timber Construction
- Break – 15 minutes
- 2021 IBC for Tall Mass Timber Construction
  - Part 1: Background and Overview
  - Lunch – 1 hour
  - Part 2: New Construction Types and Heights & Areas
  - Part 3: Fire Safety
  - Break – 15 minutes
  - Part 4: Fire & Connection Design and Special Inspection
  - Part 5: Acoustics, Energy, and Lateral Resistance
  - Part 6: Construction Fire Safety

Mass Timber and the IBC 388

388

Tall Mass Timber Construction per 2021 IBC

Part 6: Construction Fire Safety



Mass Timber and the IBC 389

389

Construction Fire Safety

- Standpipes
- Water Supply
- Noncombustible Protection
- Exterior Wall Coverings
- Owner's Responsibility



Mass Timber and the IBC 390

390

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Construction Fire Safety

IFC 3308.4 Fire safety requirements for buildings of Types IV-A, IV-B, and IV-C construction. Buildings of Types IV-A, IV-B, and IV-C construction designed to be greater than six stories above grade plane shall meet the following requirements during construction unless otherwise approved by the *fire code official.*

1. Standpipes shall be provided during construction in accordance with Section 3313.
2. A water supply . . .



391

Standpipes

3313.1 Where required. In buildings required to have standpipes by Section 905.3.1, not less than one standpipe shall be provided for use during construction. Such standpipes shall be . . .

- Installed prior to construction exceeding 40 feet in height above lowest level of FD apparatus access.
- Have FD hose connection at locations adjacent to stairways complying with Section 3311.1
- Keep extending to stay within one floor of the highest construction having secured decking or flooring

Not 2021 IBC change



392

Water Supply

3312.1 When required. An approved water supply for fire protection, either temporary or permanent, shall be made available as soon as combustible building materials arrive on the site, upon commencement of vertical combustible construction, and upon installation of a standpipe system in buildings under construction, in accordance with Sections 3312.2 through 3312.5.

Exception: The fire code official is authorized to reduce the fire-flow requirements for isolated buildings or a group of buildings in rural areas or small communities where the development of full fire-flow requirements is impractical.

Not Specific to Tall Mass Timber



393

Water Supply

3312.2 Combustible building materials. When combustible building materials of the building under construction are delivered to a site, a minimum fire flow of 500 gpm shall be provided. The fire hydrant used to provide this fire flow supply shall be within 500 feet of the combustible building materials, as measured along an approved fire apparatus access lane. Where the site configuration is such that one fire hydrant cannot be located within 500 feet of all combustible building materials, additional fire hydrants shall be required to provide coverage in accordance with this section.

Not Specific to Tall Mass Timber



394

Water Supply

3312.3 Vertical construction of Types III, IV, and V construction. Prior to commencement of vertical construction of Type III, IV, or V buildings that utilize any combustible building materials, the fire flow required by Sections 3312.3.1 through 3312.3.3 shall be provided, accompanied by fire hydrants in sufficient quantity to deliver the required fire flow and proper coverage.

- 3312.3.1 Fire separation up to 30 ft
- 3312.3.2 Fire separation 30-60 ft
- 3312.3.3 Fire separation over 60 ft

Not Specific to Tall Mass Timber



395

Water Supply

3312.5 Standpipe supply. Regardless of the presence of combustible building materials, the construction type or the fire separation distance, where a standpipe is required in accordance with Section 3313, a water supply providing a minimum flow of 500 gpm shall be provided. The fire hydrant used for this water supply shall be located within 100 feet of the Fire Department Connection supplying the standpipe.

Not Specific to Tall Mass Timber



396

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Fire Safety Reqmt's - Water Supply

IV-A IV-B IV-C

IFC 3308.4 Fire safety requirements for buildings of Types IV-A, IV-B, and IV-C construction…(cont'd)

1. Standpipes . . .
2. A water supply for fire department operations, as approved by the fire code official and the fire chief.



Mass Timber and the IBC 397

397

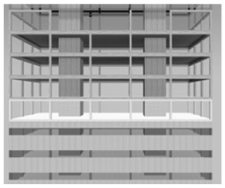
Noncombustible Protection

IFC 3308.4 Fire safety requirements for buildings of Types IV-A, IV-B, and IV-C construction…(cont'd)

IV-A IV-B

3. Where building construction exceeds six stories above grade plane, at least one layer of noncombustible protection where required by Section 602.4 of the International Building Code shall be installed on all building elements more than 4 floor levels, including mezzanines, below active mass timber construction before erecting additional floor levels.

Exception: Shafts and vertical exit enclosures…

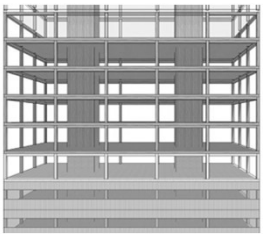


Mass Timber and the IBC 398

398

Noncombustible Protection

Protection (gray) applied to mass timber on all levels more than 4 stories below active construction floor



IV-A

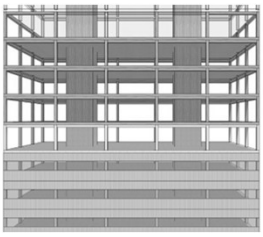
IV-B

Mass Timber and the IBC 399

399

Noncombustible Protection

Work can only proceed on 9th floor after mass timber protection is applied as required on 4th floor



IV-A

IV-B

Mass Timber and the IBC 400

400

Noncombustible Protection



18-story Brock Commons Example

IV-A IV-B

Mass Timber and the IBC 401

401

Exterior Wall Coverings

IFC 3308.4 Fire safety requirements for buildings of Types IV-A, IV-B, and IV-C construction…(cont'd)

IV-A IV-B IV-C

4. Where building construction exceeds six stories above grade plane required exterior wall coverings shall be installed on all floor levels more than 4 floor levels, including mezzanines, below active mass timber construction before erecting additional floor level.

Exception: Shafts and vertical exit enclosures…



Mass Timber and the IBC 402

402

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

Owner's Responsibility

3303.3 Daily fire safety inspection. The site safety director shall be responsible for completion of a daily fire safety inspection at the project site. Each day, all building and outdoor areas shall be inspected to ensure compliance with the inspection list in this section. The results of each inspection shall be documented and maintained on site until a certificate of occupancy has been issued. Documentation shall be immediately available on site for presentation to the fire code official upon request…

3rd offense → stop work

Not Specific to Tall Mass



403

Owner's Responsibility

3303.3 Daily fire safety inspection…(cont'd)

- Inspect hot work areas
- Inspect all temporary heating equipment
- Ensure trash/debris removed
- No exposed conductors on temporary wiring
- Flammable/hazardous materials stored properly
- Hydrants unobstructed and "clearly visible"
- Fire access roads obstruction-free
- Standpipes/sprinklers identifiable from access road
- Standpipes within 1 floor of highest construction
- Portable fire extinguishers in-service and properly spaced

Not Specific to Tall Mass Timber



404

Q&A



405

Conclusion

This concludes *Mass Timber Buildings & the IBC*. You should now be able to:

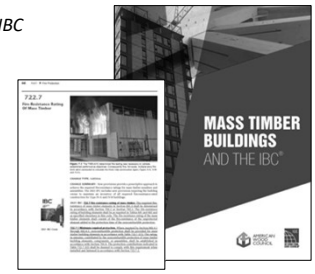
- Recognize unique fire-resistive characteristics of mass timber
- Summarize new provisions in 2015, 2018 and 2021 IBC related to mass timber products and Type IV construction
- Compare new and existing construction types and recognize inherent differences and conservative approaches for new construction types
- Evaluate new provisions for heights and areas, construction fire safety, fire and connection design and special inspection in tall mass timber construction

406

Resources

Mass Timber Buildings & the IBC

- AWC & ICC publication
- Available PDF and Print



407

Resources

Tall Mass Timber Special Inspector

- Exam now available
- PRONTO



408

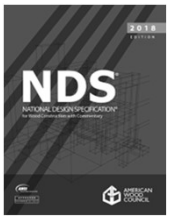
Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

2021 I-Codes



409

AWC Standards





410

AWC Tall Mass Timber Webpage

www.awc.org



411

AIA

American Wood Council and International Code Council are a Registered Providers with The American Institute of Architects Continuing Education Systems. Credit earned on completion of this program will be reported to CES Records for AIA members. Certificates of Completion for non-AIA members are available on request.

This program is registered with the AIA/CES for continuing professional education. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the AIA of any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product. Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

412

Copyright Materials

This presentation is protected by U.S. and International Copyright laws. Reproduction, distribution, display and use of the presentation without written permission of the speaker is prohibited.

© American Wood Council 2021

© International Code Council 2021

ICC INTERNATIONAL CODE COUNCIL®

AMERICAN WOOD COUNCIL

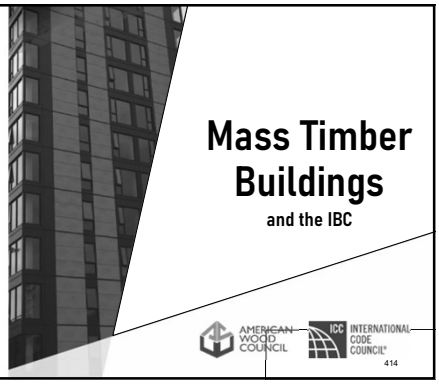
413

Thank you for participating!

To schedule a seminar, contact:
The Learning Center™
1-888-ICC-SAFE (422-7233) Ext. 33821
learn@iccsafe.org

or

AWC Education
202-463-2766
education@awc.org



Mass Timber Buildings
and the IBC

AMERICAN WOOD COUNCIL
ICC INTERNATIONAL CODE COUNCIL®

414

Copyright © 2021 American Wood Council and International Code Council. All rights reserved.

File Attachments for Item:

EC-22 Plan Examiner Round Table (Columbus)

All certifications (12 additional hours)

APPLICATION FOR CONTINUING EDUCATION APPROVAL
COURSE CONDITIONS AND GUIDELINES

The Ohio Board of Building Standards is committed to the ongoing education and professional development of board-certified personnel through the delivery of high-quality, accurate and engaging professional continuing education content. To this end, the Board reviews and approves Continuing Education Courses for building department personnel.

Board approval is granted for course instruction on current codes and standards, including the OBC, OMC, OPC, and RCO, and any other content areas directly related to the responsibilities of the certification for which credit is being requested.

Promotion: Any person or organization promoting an approved course is required to make full and accurate disclosure regarding course title, course approval number, number of credit hours, categories for which the BBS has approved the class, and fees in promotion materials and advertising. ***The Board does not grant retroactive approval. It is recommended that courses be submitted for approval well in advance of any scheduling of classes and advertising***. Advertising may not falsely state BBS approval before approval is granted. Course providers may state that BBS approval is pending.

Application Submission: All Applications and associated materials shall be submitted by email in .pdf format. Instructions for completing the application are attached.

Certificate of Completion: Course providers shall provide participants a certificate of completion containing the following information:

- Name of participant
- Title of approved courses
- BBS approval #
- BBS approved certifications
- Date of the continuing education program
- Number of approved credit hours awarded, and
- Signature of authorized sponsor or instructor.

Any person or organization administering an approved course shall return a completed BBS Course Attendance form by email.

Participants: Participants must attend the complete course as presented by the instructor to receive credit hours approved by the Board. The organization or instructor of online courses shall plan and execute methods to verify the individual's attendance and completion of the course. No partial credit will be given to any participant who failed to complete the entire course as approved.

Board approval: All courses are approved for the calendar year in which application is made. Courses may be renewed so long as the referenced code is in effect, and the CEUs, certification and content remain unchanged. When the referenced code is updated, courses must be updated, and new approvals obtained.

Facility/training area: BBS Course may be delivered in person or online, or both, at the sponsor's option.
Course facilities shall include the following:

In Person Classes:
Sufficient seating capacity
ADA accessible facilities
Appropriate Audio/Visual devices for delivery
Writing surfaces for participants

Online Classes:
Web-accessible
ADA accessible delivery
Tech support available
Live and recorded courses permitted

In-person facilities shall comfortably and safely seat at least the number of attendees present in the room and shall be climate controlled, non-smoking, and sound controlled so that outside noise will not interfere with the training.

Ohio | Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: Mark Heckenmueller

Organization: City of Columbus Building Department

Address: 111 N Front Street

E-mail: maheckenmueller@columbus.gov Telephone: 614-645-1887

Website: columbus.gov

Conference Sponsor (if applicable) _____ Conference Email: _____

Check here if Course Renewal: Yes Prior course number BBS2023-399 to 410 (*i.e. BBS2018-429*)

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: Plan Examiner Round Table Sessions

Course instructor: Mark Heckenmueller

Course description: Twelve sessions (BBS2023-399 to 410) were administratively renewed and the application is to extend the round table to twenty-four sessions

Instructional hours per session: 1 Number of Sessions: 12

Course Date(s) and Location: Regularly scheduled 2x per month

Special Content:

Code Administration: ☐
Existing Buildings: ☐
Electrical Instruction: ☐
Plumbing Instruction: ☐

Conference Course: _____
Conference Name: _____
Conference location: _____

Course to be offered online? ☐ **On Demand** ☐ **Webinar** ☐

Course Website: _____

Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation)*:

_____

Course applicable for the following certifications

Residential Certifications Only: ☐
Administrative Course, All Certifications: ☐

Commercial Certifications: ☑

Application materials included:

☑ Course Outline or Course Learning Objectives
☐ Presentation Materials/Slides (not required for roundtable courses)
☐ Assessment Materials (for online courses)
☑ Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

Instructions for new Continuing Education Approval form

Provider Information

1. Please include all contact information.
2. If course is not part of a conference, leave conference sponsor and email blank.

Course Renewal

1. Indicate if the course is being submitted for renewal. Include prior approval letter and write in prior course number.
2. Certification approval for courses has now changed: all existing courses being renewed will be approved within the new classification system.
    a. Courses previously approved for only residential certifications will be approved for all residential certifications.
    b. Courses previously approved for at least on commercial certification will now be approved for all commercial certifications and all residential certifications.
    c. Courses on required instruction topics, Ohio Ethics, Code Administration and Existing Buildings, will be noted as Administrative Courses and be approved for all certifications.
3. Courses being renewed should skip the New Course information section and are not required to submit outline, agenda, slides or other instructional materials for review. Skip to Special Content, and mark any item that applies to the course.

New Course Information

1. Enter course title, name of instructor, and a brief description of the course content. Learning objectives may be substituted for course description, if desired.
2. Number of instructional hours per session is the length of instructional time.
3. Number of sessions: can be 1 or the number of sessions planned.
4. Course date(s) and location: not necessary at this time, enter if known.

Special Content

1. Indicate if the course will meet instructional time in Code Administration or Existing Buildings.
2. Indicate if the course is a plumbing or electrical course, for ESIAC review and trainee course tracking.
3. If the course is associated with a conference, indicate the conference name and location, as this will allow BBS to coordinate approvals with the conference provider.
4. If the course will be offered online, specify whether it will be on demand or offered as a virtual webinar, or both. Include website where the course will be provided.

Course applicable for the following certifications

This section represents a major change from previous BBS course approval forms.

1. If the course is only for residential certifications, check 'Residential Certifications Only'. The course, if approved, will be approved for all residential certifications.
2. If the course is appropriate for any commercial certifications, check Commercial Certifications. The course, if approved, will be approved for all commercial certification **AND** all residential certifications.
3. If the course is intended to meet required instruction in Code Administration (Chapter 1) or Existing Buildings (commercial or residential) check 'Administrative Course, All Certifications'.

Application Materials Included

This is a checklist for the course submitter's use, to be sure all materials necessary for review are included with the application. All materials should be submitted in .pdf format, along with the application, via email to Michael.Lane@com.ohio.gov or BBS@com.ohio.gov

File Attachments for Item:

EC-23 Residential Code Round Table on Sections 328 and 507 (Miami Valley Building Officials Association)

Residential certifications only (2 hours)

Ohio | Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: Chris Mastrino

Organization: Miami Valley Building Officials Coouncil

Address: 333 James Bohanan, Vandalia Ohio 45377

E-mail: cmastrino@vandaliaohio.org Telephone: 937-415-2322

Website:

Conference Sponsor (if applicable) Conference Email:

Check here if Course Renewal: ☐ Prior course number _____ *(i.e. BBS2018-429)*

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: Residential code round table on 328, 507

Course instructor: Chris Mastrino

Course description: RCO code discussion on Sections 328, 507
See attached email print out for more info.

Instructional hours per session: 2 Number of Sessions: 1

Course Date(s) and Location: TBD after approval.

Special Content:

Code Administration: ☐
Existing Buildings: ☐
Electrical Instruction: ☐
Plumbing Instruction: ☐

Conference Course:
Conference Name:
Conference location:

Course to be offered online? ☐ **On Demand** ☐ **Webinar** ☐

Course Website:

Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation)*:
Participant discussion, round table.

Course applicable for the following certifications

Residential Certifications Only: ☑ Commercial Certifications: ☐
Administrative Course, All Certifications: ☐

Application materials included:

☐ Course Outline or Course Learning Objectives
☑ Presentation Materials/Slides (not required for roundtable courses)
☐ Assessment Materials (for online courses)
☐ Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

Chris Mastrino

From: mbresdesign@woh.rr.com
Sent: Monday, December 5, 2022 9:12 AM
To: Chris Mastrino
Subject: Residential Code Meeting

Good Morning Chris
Here is what I was thinking regarding the Topic of Discussion for a Residential Code Meeting.

The 2 issues referenced below are not referenced in the current RCO. In an effort to bypass the requirement of a Register Design Professional seal, clarification of these section would be helpful.

Section 328
Post Frame Accessory Structure
Purpose: Application for use in Residential Occupancy.
Reason:
There is an increasing interest in using this method to use this type of structure for homes.
There are no provisions for such use and Designers need a clear path to comply

Section 507
Exterior Decks
Purpose: Application of Section 328 Post Frame Accessory Structure.
Reason:
Section 507 does not reference Covered Decks or Patios

Miscellaneous RCO Discussion
Open Forum for Designers and Building Code Officials to discuss other issues of concern.

Do you need additional information to make application to the Board for CEU information?

Schedule:
January 2023 (actual day is adjustable based upon space availability)
Location: TBD. Maybe at your facility?
Time: 10am -12pm ? Adjustable

Michael J. Battaglia
Residential Design
182 Cushwa Drive
Centerville, Ohio 45459
o:937-439-1933
c:937-620-3096

Chris Mastrino

137 Littlejohn Road

Troy, Ohio 45373

937-477-1057

cmastrino@vandaliaohio.org

Notable Accomplishments:

- State of Ohio Certified Chief Building Official, Residential Building Official, Building Inspector and Residential Building Inspector.
- Past treasure Miami Valley Building Officials Council
- Past Board of Director for Miami Valley Building Officials Council
- Past Education Chairman Miami Valley Building Officials Council
- Past Board of Director TV5 Troy, Ohio

Employment History:

Building Inspector City of Vandalia 1991 – Current

Engineering Technician City of Vandalia 1990-1991

Lockwood Jones and Beals, Engineering Technician 1986-1990

United States Air Force, 1982-1986

Education:

Alpina Community College

Sinclair Community College

File Attachments for Item:

EC-24 Significant Changes to the NEC 2023 (Electrical Trades Center)

All certifications (20 hours in three sessions: 8, 8, and 4)

Ohio Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: THE ELECTRICAL TRADES CENTER

Organization:

Address: 942 GOODALE BLVD. Columbus, OH 43212

E-mail: trent@etctatc.org Telephone: 614-463-5282

Website: www.electricaltrades.org

Conference Sponsor (if applicable)_____ Conference Email:_____

Check here if Course Renewal:_____ Prior course number _____ (*i.e. BBS2018-429*)

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: SIGNIFICANT CHANGES to the NEC-2023

Course instructor:

Course description: THIS COURSE IS for informational PURPOSES ONLY. The intent is to discuss in detail the significant changes found in the 2023 NEC.

Instructional hours per session: 8 hrs, 8 hrs, 4 hrs Number of Sessions: 3

Course Date(s) and Location: March 14, 15, 16 same as above (20 hrs TOTAL)

Special Content:

Code Administration: X

Existing Buildings: X

Electrical Instruction: X

Plumbing Instruction:_____

Conference Course: _____

Conference Name: _____

Conference location:_____

Course to be offered online? NO **On Demand**_____ **Webinar**_____

Course Website: _____

Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation)*:

Course applicable for the following certifications

Residential Certifications Only: _____ Commercial Certifications: X

Administrative Course, All Certifications: X

Application materials included:

- ✓ Course Outline or Course Learning Objectives
- X Presentation Materials/Slides (not required for roundtable courses)
- _____ Assessment Materials (for online courses)
- X Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

Contents

Chapter 1

Articles 90, 100, and 110 2
Introduction, Definitions, and Requirements for Electrical Installations

90.1
Scope 4

90.2
Use and Application 5

90.4
Enforcement 6

90.5(C)
Explanatory Material 7

Article 100
Article 100 Reorganization 8

Article 100
Definition of Accessible (as applied to wiring methods) 9

Article 100
Definition of Attachment Fitting, Weight-Supporting 10

Article 100
Definition of Branch Circuit, Motor 11

Article 100
Definition of Class 4 Definitions 12

Article 100
Definition of Clothes Closet Storage Space 13

Article 100
Definition of Commissioning 14

Article 100
Definition of Corrosive Environment 15

Article 100
Definition of Counter (Countertop) 16

Article 100
Definition of Energized, Likely to Become 17

Article 100
Definitions of Equipotential Plane 18

Article 100
Definition of Fault Managed Power 19

Article 100
Definition of Fibers/Flyings, Combustible 20

Article 100
Definition of GFCI, Special Purpose 21

Article 100
Definition of Ground-Fault Detector-Interrupter 22

Article 100
Definition of Industrial Installation, Supervised 23

Article 100
Definition of Inverter, Multimode 24

Article 100
Definition of Location, Wet 25

Article 100
Definition of Locations, Hazardous (Classified) 26

Article 100
Definition of Microgrid, Health Care 27

Article 100
Definitions of Panelboard and Panelboard, Enclosed 28

Article 100
Definition of Receptacle, Weight-Supporting Ceiling 29

Article 100
Definition of Servicing 30

Article 100
Definition of Stranding (Compact and Compressed) 31

Article 100
Definition of Type P Cable 32

110.3(A)
Examination 33

110.3(B)
Installation and Use 34

110.8
Wiring Methods 35

110.12
Mechanical Execution of Work 36

110.14(A)
Terminals 37

110.16(B)
Service Equipment and Feeder Equipment 38

110.17
Servicing and Maintenance of Equipment 39

110.20
Reconditioned Equipment 40

110.21(A)
Reconditioned Equipment, Marking Requirements 41

Contents

110.22(A)
Identification of Disconnecting Means, General 42

110.26
Width of Working Space..... 43

110.26(A)(4)
Limited Workspace Requirements 44

110.26(A)(6)
Grade, Floor, or Working Platform..... 45

110.26(E)
Dedicated Equipment Space 46

Table 110.28
Table 110.28 Enclosure Types, Informational Notes 47

110.29
In Sight From (Within Sight From, Within Sight) 48

110.31(A)(4)
Locks, Personnel Doors 49

Chapter 2

Articles 200–250..... 50
Wiring and Protection

200.2(A)
General 52

210.6(D) & (E)
Branch Circuit Voltage Limitations 53

210.8
GFCI Protection for Personnel 54

210.8(A)
Dwelling Units..... 55

210.8(B)
Other Than Dwelling Units..... 56

210.8(D)
GFCI Protection for Personnel-Specific Appliances..... 57

210.8(F)
GFCI Protection for Personnel-Outdoor Outlets..... 58

210.11(C)(4)
Garage Branch Circuits 59

210.12
Arc-Fault Circuit-Interrupter Protection 60

210.18
Rating 61

210.19
Conductors — Minimum Ampacity and Size..... 62

210.23
Permissible Loads, Multiple-Outlet Branch Circuits..... 63

210.52(A)(2)
Wall Space..... 64

210.52(C)
Countertops and Work Surfaces .. 65

210.70
Lighting Outlets Required..... 66

215.15
Barriers 67

215.18
Surge Protection..... 68

Article 220
Article 220 Reorganization 69

220.5(C)
Floor Area 70

220.42
Lighting Load for Non-Dwelling Occupancies 71

220.50
Motors and Air-Conditioning Equipment 72

220.53
Appliance Load — Dwelling Units 73

220.57
Electric Vehicle Supply Equipment (EVSE) Load 74

220.60
Noncoincident Loads 75

220.70
Energy Management Systems (EMSs) 76

220.110
Receptacle Loads — Health Care Facilities..... 77

220.120
Receptacle Loads 78

225.41
Emergency Disconnects..... 79

225.42
Surge Protection..... 80

230.7
Other Conductors..... 81

Contents

230.24(A)
Above Roofs....82

230.43
Wiring Methods for 1000 Volts, Nominal, or Less....83

230.62(C)
Barriers....84

230.67
Surge Protection....85

230.71(B)
Two to Six Service Disconnecting Means....86

230.85
Emergency Disconnects....87

Article 235
Branch Circuits, Feeders, and Services Over 1000 Vac....88

240.2
Reconditioned Equipment....89

240.4(B)
Overcurrent Devices Rated 800 Amperes or Less....90

240.6(D)
Remotely Adjustable Trip Circuit Breakers....91

240.7
Listing Requirements....92

240.11
Selective Coordination....93

240.24
Location in or on Premises....94

240.89
Replacement Trip Units....95

242.9
Indicating....96

242.42
Surge Arrester Rating....97

Article 245
Overcurrent Prot. Sys. Rated Over 1000 Vac, 1500 Vdc....98

245.2
Reconditioned Equipment....99

250.6
Objectionable Current....100

250.20
Alternating-Current Systems to Be Grounded....101

250.24
Grounding of Service-Supplied AC Systems....102

250.36
Impedance Grounded Systems — 480 V to 1000 V....103

250.64
Grounding Electrode Conductor Installation....104

250.68(C)
Grounding Electrode Conductor Connections....105

250.94(B)
Bonding for Communications Systems-Other Means....106

250.104(C) & (D)
Bonding of Piping Systems and Exposed Struct. Metal....107

250.118
Types of Equipment Grounding Conductors....108

Contents

Chapter 3

Articles 300–398 110
Wiring Methods and Materials

Article 300
Limitations 112

300.2 & 300.3
Limitations 113

300.4(E)
Cables, Raceways, or Boxes Under Metal Decking 114

300.7(B)
Expansion, Expansion-Deflection, Deflection Fittings 115

300.15
Boxes, Conduit Bodies, or Fittings — Where Required 116

300.25 & Exception
Exit Enclosures (Stair Towers) 117

300.26
Remote-Control and Signaling Circuits Classification 118

Article 305
Systems Rated Over 1000 V ac, 1500 V dc, Nominal 119

312.8
Splices, Taps, and Feed-Through Conductors 120

312.10
Screws or Other Fasteners 121

314.5
Screws or Other Fasteners 122

314.16(B)
Box Fill Calculations 123

314.24
Dimensions of Boxes 124

314.25
Covers and Canopies 125

314.27(C) & (E)
Outlet Boxes, Ceiling-Suspended (Paddle Fans) 126

Article 315
Medium Voltage Conductors and Cables 127

342.24
Bends 128

342.30(A)
Securing and Supporting 129

344.28
Reaming and Threading 130

352.10
Insert Uses Permitted 131

358.10
Uses Permitted 132

362.10
Uses Permitted 133

Article 369
Insulated Bus Pipe (IBP)/Tubular Covered Conductors 134

370.18
Cablebus Installation 135

370.120
Marking 136

Article 371
Flexible Bus Systems 137

Contents

Chapter 4

Articles 400–495 138
Equipment for General Use

400.40 through 400.52
Portable Power Feeder Cables Over 2000 V, Nominal 140

404.1
Scope 141

404.14 & 404.14(D)
Snap Switch Terminations 142

404.16
Reconditioned Equipment 143

404.30
Switch Enclosures with Doors 144

406.3
Receptacle Rating and Type 145

406.4
General Installation Requirements 146

406.9
Receptacles in Damp or Wet Locations 147

406.12
Tamper-Resistant Receptacles 148

408.4
Descriptions Required 149

408.9
Replacement Panelboards 150

408.43
Panelboard Orientation 151

409.60
Bonding 152

409.70
Surge Protection 153

409.110
Marking 154

410.42
Luminaires with Exposed Conductive Surfaces 155

410.71
Disconnecting Means-Fluorescent or LED Luminaires 156

410.190 through 197
Provisions for Germicidal Irradiation Luminaires 157

Article 422
Appliances 158

422.18
Ceiling-Suspended (Paddle) Fans 159

424.48
Installation of Cables in Walls 160

430.1
Scope 161

430.6
Conductor Ampacity and Motor Rating Determination 162

430.52(C)
Rating or Setting 163

430.83(F)
Ratings 164

440.8
Single Machine and Location 165

440.22(A)
Rating or Setting for Individual Motor-Compressor 166

445.6
Listing 167

445.11
Marking 168

445.18 & 445.19
Disconnecting Means 169

450.43(C)
Accessibility 170

460.24(A)
Load Current 171

Article 480
Stationary Standby Batteries 172

Article 495
Equipment Over 1000 Volts ac, 1500 Volts dc, Nominal 173

Contents

Chapter 5

Articles 500–590 174
Special Occupancies

500.1
Scope 176

500.4
Documentation 177

500.5(D)
Class III Locations 178

500.6(C) & (D)
Class III Combustible and Ignitible Fibers/Flyings 179

500.7
Protection Techniques 180

500.8(E)(3)
Unused Openings 181

501.10
Wiring Methods, Class I 182

501.15
Sealing and Drainage 183

501.141
Flexible Cables, Class I, Division 2 184

501.145
Receptacles and Attachment Plugs, Class I Locations 185

502.10
Wiring Methods Class II Locations 186

502.15
Sealing, Class II, Divisions 1 and 2 187

502.30
Grounding and Bonding 188

503.10
Wiring Methods 189

503.30
Grounding and Bonding 190

504.30
Separation of Intrinsically Safe Conductors 191

Article 505
Zone 0, 1, and 2 Locations 192

505.8
Protection Techniques 193

505.16
Sealing and Drainage 194

505.20(C), Exc. Nos. 5 & 6
Equipment Requirements, Zone 2 195

Article 506
Zone 20, 21, and 22 Locations 196

506.6
Material Groups 197

511.2
Other Articles 198

511.7(A)
Fixed Wiring Above Hazardous (Classified) Locations 199

511.8
Underground Wiring Below Hazardous Locations 200

Article 512
Cannabis Oil Equipment and Cannabis Oil Systems 201

516.7(A)
Wiring & Equipment Not Within Hazardous Locations 202

517.6
Patient Care-Related Electrical Equipment 203

517.10(B)
Not Covered 204

517.13
Equipment Grounding Conductor 205

517.14
Panelboard Bonding 206

517.20(A)
Wet Procedure Locations 207

517.22
Demand Factors 208

517.30
Sources of Power 209

517.41
Required Power Sources 210

Article 517, Part V.
Diagnostic Imaging and Treatment Equipment 211

517.80
Patient Care Spaces 212

518.2(A)
Examples 213

518.4
Wiring Methods-General 214

520.53(C)
Construction 215

520.68(D)
Special-Purpose Multi-Circuit Cable Systems 216

Contents

Article 530
Motion Picture and TV Studios and Remote Locations 217

545.22
Power Supply 218

547.26
Physical Protection 219

547.44(B)
Bonding of Equipotential Planes 220

550.10(I)
Mast Weatherhead or Raceway 221

550.16(C)(1)
Exposed Non-Current-Carrying Metal Parts 222

550.32(A)
Mobile Home Service Equipment 223

550.33(A)
Feeder Equipment 224

551.3
Electrical Datum Plane Distances 225

551.40(D)
Loss of Ground Device 226

551.72
Distribution System 227

552.4
General Requirements 228

555.4
Location of Service Equipment 229

555.14
Equipotential Planes and Bonding of the Planes 230

555.15
Replacement of Equipment 231

555.30
Electrical Equipment and Connections 232

555.35
GFPE and GFCI 233

555.36(C)
Disconnecting Means for Shore Power Connection(s) 234

555.37
Equipment Grounding Conductor 235

555.38
Luminaires 236

590.8
Overcurrent Protective Devices 237

Chapter 6

Articles 600–695 238
Special Equipment

600.5
Branch Circuits 240

600.6
Disconnects 241

620.12(A)
Traveling Cables 242

620.22
Branch Circuits for Car Lighting, Receptacles, HVAC 243

620.23
Branch Circuits for Machine Room, Control Room… 244

625.1 Info. Notes
Scope 245

625.17
Cords and Cables 246

625.40
Electric Vehicle Circuit 247

625.42
Rating 248

625.43
Disconnecting Means 249

625.49
Island Mode 250

625.102
Installation 251

630.8
Ground-Fault Circuit-Interrupter Protection 252

645.5
Supply Circuits and Interconnecting Cables 253

670.3(A)
Permanent Nameplate 254

680.5
GFCI and SPGFCI Protection 255

680.6 & 680.7
Grounding and Bonding 256

680.10
Electric Pool Water Heater 257

Contents

680.12
Equipment Rooms, Vaults, and Pits **258**

680.14
Corrosive Environments **259**

680.21
Motors **260**

680.41
Location of Other Equipment **261**

680.43(A)
Ground-Fault Protection for Receptacles **262**

680.44
GFCI and SPGFCI Protection **263**

680.54
Bonding **264**

680.58
GFCI and SPGFCI Protection for Receptacles **265**

680.59
Ground-Fault Protection for Nonsubmersible Pumps **266**

680.83
Equipotential Bonding **267**

682.11
Location of Electrical Distribution Equipment **268**

682.12
Electrical Connections **269**

Article 690
Solar Photovoltaic (PV) Systems **270**

690.4
General Requirements **271**

690.7
Maximum Voltage **272**

690.8
Circuit Sizing and Current **273**

690.9(D)
Transformers **274**

690.12, Exception
Rapid Shutdown of PV Systems on Buildings **275**

690.15
Disconnecting Means for Isolating PV Equipment **276**

690.31
Wiring Methods **277**

691.1 & 691.4
Large-Scale Photovoltaic (PV) Electric Supply Stations **278**

Article 692
Fuel Cell Systems **279**

694.50 & 694.68
Interactive System Point of Interconnection **280**

695.1(B)
Not Covered **281**

695.7
Voltage Drop **282**

Chapter 7

Articles 700–770 ..... **284**
Special Equipment

700.3
Tests and Maintenance **286**

700.4
Capacity and Rating **287**

700.5
Transfer Equipment **288**

700.11
Wiring, Class-2-Powered Emergency Lighting Systems **289**

700.12
General Requirements **290**

700.24
Directly Controlled Emergency Luminaires **291**

Contents

700.32
Selective Coordination **292**

705.5
Parallel Operation **293**

705.10
Identification of Power Sources **294**

705.11
Source Connections to a Service **295**

705.12
Load-Side Source Connections **296**

705.20
Source Disconnecting Means **297**

705.80 through 705.82
Interconnected Systems Operating in Island Mode **298**

706.1 & 706.8
Scope **299**

706.7
Commissioning and Maintenance **300**

706.15
Disconnecting Means **301**

Article 722
Cables for Power-Limited Circuits **302**

722.10
Hazardous (Classified) Locations **303**

Article 724
Class 1 Power-Limited Circuits **304**

Article 725
Class 2 and 3 Power-Limited Circuits **305**

725.31
Safety-Control Equipment **306**

Article 726
Class 4 Power Systems **307**

Article 750
Energy Management Systems ... **308**

760.24
Mechanical Execution of Work ... **309**

Chapter 8

Articles 800–840 310
Communications Systems

Article 800
General Requirements for Communications Systems **312**

Article 810
Antenna Systems **313**

Chapter 9

Tables, Examples, Informative Annexes 314

Equipment Suitable for Hazardous Locations **316**

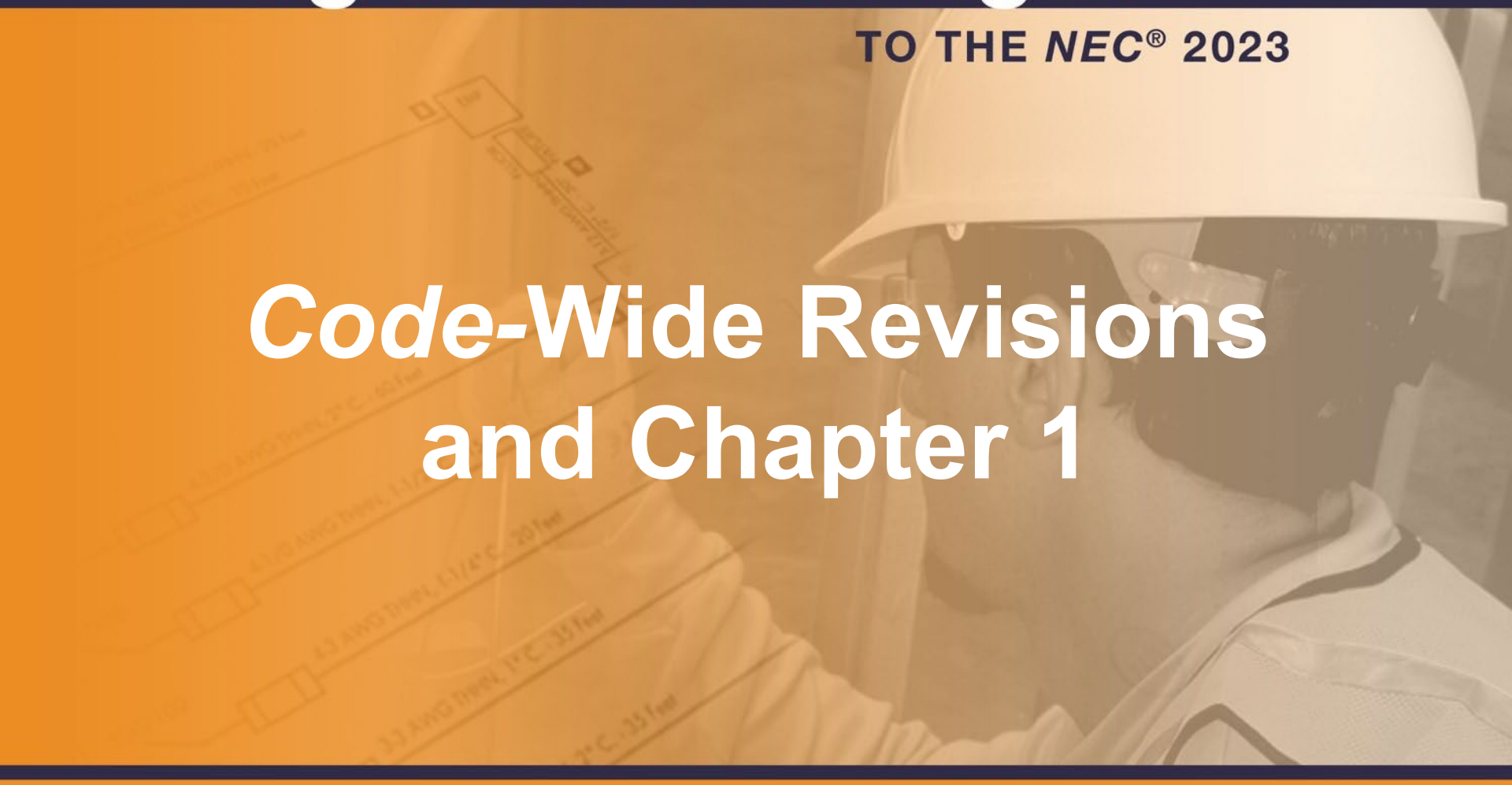
Biography



Michael Johnston is NECA's executive director of standards and safety. Mike holds a BS in Business Management from the University of Phoenix. Mike is a member of the NFPA Standards Council and current Chair of the NFPA NEC Correlating Committee. In addition to his responsibilities for managing the codes, standards, and safety functions for NECA, Mike is secretary of the NECA Codes and Standards Committee. Mike's career includes working as a journeyman electrician, foreman, and project manager on residential, commercial, and industrial projects. Johnston career includes work in electrical inspections and supervision of electrical inspectors. Johnston is a member of the IBEW and is an active member of ANSI, IAEI, NFPA, SES, ASSE, the UL Electrical Council, the National Safety Council and he is currently Chair of the NFPA Electrical Section

Significant Changes

TO THE *NEC*® 2023



Code-Wide Revisions and Chapter 1

electrical training ALLIANCE
IBEW - NECA

IN COLLABORATION WITH

NECA
NATIONAL ELECTRICAL CONTRACTORS ASSOCIATION

*Code*Wide Revisions

Reconditioned Equipment

Change Summary

- There are now several reconditioned equipment requirements in the *NEC*.
- The second section of some articles (XXX.2) is now reserved for any requirements that either permit or prohibit reconditioning of equipment that is covered by the article.

2958

© 2022 *electrical training ALLIANCE*

*Code*Wide Revisions

Definitions

Change Summary

- Article 100 now contains all definitions. No definitions will be in the other articles of the *Code*.
- Article 100 will no longer be divided into parts.
- Definitions are assigned to code-making panels based on the articles assigned to the panel and how closely the panel aligns with the definition. The responsible panel is indicated in each definition.
- Some definitions only apply to a single article. Where that is the case, the article number appears toward the end of the definition.
- In a few cases, multiple definitions continue to be required.

2959

© 2022 *electrical training ALLIANCE*

*Code*Wide Revisions

New, Deleted, and Relocated Articles and Revised Article Titles for the 2023 NEC

Change Summary

- Some Articles are new, three were deleted, some had title revisions, and others were relocated.
  - 110 General Requirements for Electrical Installations (Revised title)
  - 210 Branch Circuits, Not Over 1000 Volts ac, 1500 Volts dc, Nominal (Revised title)
  - 235 Branch Circuits, Feeders, and Services Over 1000 Volts ac, 1500 Volts dc, Nominal (New)
  - 245 Overcurrent and Overvoltage Protection for Systems Rated Over 1000 Volts ac, 1500 Volts dc, Nominal (New)
  - 305 General Requirements for Wiring Methods and Materials for Systems Rated Over 1000 Volts ac, 1500 Volts dc, Nominal (New)

2960

© 2022 *electrical training ALLIANCE*

*Code*Wide Revisions

New, Deleted, and Relocated Articles and Revised Article Titles for the 2023 NEC (continued)

Change Summary

- 315 Medium Voltage Conductors, Cable, Cable Joints, and Cable Terminations (Revised title and relocated)
- 335 Instrument Tray Cable: Type ITC (Relocated)
- 369 Insulated Bus Pipe (IBP)/Tubular Covered Conductors (TCC) Systems (New)
- 371 Flexible Bus Systems (New)
- 395 Outdoor Overhead Conductors over 1000 Volts (Relocated)
- 480 Stationary Standby Batteries (Revised title)
- 495 Equipment Over 1000 Volts ac, 1500 Volts dc, Nominal (Revised title and Relocated)
- 510 Hazardous (Classified) Locations-Specific (Deleted)

© 2022 *electrical training ALLIANCE*

*Code*Wide Revisions

New, Deleted, and Relocated Articles and Revised Article Titles for the 2023 NEC (continued)

Change Summary

- 512 Cannabis Oil Equipment and Cannabis Oil Systems Using Flammable Materials (New)
- 712 Direct Current Microgrids (Deleted)
- 720 Circuits and Equipment Operating at Less Than 50 Volts (Deleted)
- 722 Cables for Power-Limited Circuits and Fault-Managed Power Circuits (New)
- 724 Class 1 Power-Limited Circuits and Class 1 Power-Limited Remote Control and Signaling Circuits (New)
- 725 Class 2 and Class 3 Power-Limited Circuits (Revised title)
- 726 Class 4 Fault-Managed Power Systems (New)
- 810 Antenna Systems (Revised title)

2962

© 2022 *electrical training ALLIANCE*

*Code*Wide Revisions

NEC Style Manual Changes

Change Summary

- A new version of the style manual was issued in 2020.
- Text was simplified to avoid long paragraphs and long sentences by placing complex requirements into a list format.
- Many of the changes improved readability, and those changes are not covered in this book.

© 2022 *electrical training ALLIANCE*

*Code*Wide Revisions

Medium- and High-Voltage Requirements

Change Summary

- Many medium- and high-voltage requirements were removed from existing articles and moved to an article ending in number 5.
- For example, Article 235 now covers medium- and high-voltage services.
- New articles:
  - 235 Branch Circuits, Feeders, and Services Over 1000 Volts ac, 1500 Volts dc, Nominal
  - 245 Overcurrent and Overvoltage Protection for Systems Rated Over 1000 Volts ac, 1500 Volts dc, Nominal
  - 305 General Requirements for Wiring Methods and Materials for Systems Rated Over 1000 Volts ac, 1500 Volts dc, Nominal

2964

© 2022 *electrical training ALLIANCE*

*Code*Wide Revisions

Medium- and High-Voltage Requirements (continued)

Change Summary

- 315 Medium Voltage Conductors, Cable, Cable Joints, and Cable Terminations
- 395 Outdoor Overhead Conductors over 1000 Volts
- 495 Equipment Over 1000 Volts ac, 1500 Volts dc, Nominal

- Articles 395 and 495 were relocated from 399 and 490, respectively, for consistency with the numbering scheme for medium- and high-voltage articles.

2965

© 2022 *electrical training ALLIANCE*

*Code*Wide Revisions

Not a Change?

Change Summary

- Prior to the 2002 *Code*, NM cable was limited to buildings of three stories or less.
- Section 334.10 permitted NM cable in buildings of Types III, IV, and V construction, but the cables had to be concealed within walls, floors, or ceilings that provided a thermal barrier of material that provided at least a 15-minute finish rating.
- Limitations in 334.12 provided some applications and occupancies where NM cable was not permitted to be used.
- *International Building Code* and *NFPA 5000* limited Type IV heavy timber construction to five stories above grade.
- The *NEC* requirements were based on these limitations for 20 years.

2966

© 2022 *electrical training ALLIANCE*

*Code*Wide Revisions

Not a Change? (continued)

Change Summary

- The *International Building Code* changed its definition of Class IV construction to permit a heavy timber constructed building of up to 18 stories.
- *NFPA 5000* permits a Type IV heavy timber constructed building of up to 24 stories.
- These changes resulted in a significant change to the *NEC* that was not processed through the *NEC.*
- CMP 6 did not change the language.
- Significant changes took place in other codes outside of the *NEC* but affect the *NEC*.

© 2022 *electrical training ALLIANCE*

90.1

NEW

Scope

Change Summary

- Article 90 now has a scope that provides the scope of Article 90, rather than the scope of the *Code*.
- The material previously found in 90.1 has been combined with 90.2, which is now titled “Use and Application.”
- This change provides consistency and clarity but does not make any technical change to the *Code*.

2968

© 2022 *electrical training ALLIANCE*

90.1

NEW

Article 90 Introduction

90.1 Scope

This article covers use and application, arrangement, and enforcement of this *Code*. It also covers the expression of mandatory, permissive, and nonmandatory text, provides guidance on the examination of equipment and on wiring, planning, and specifies the use and expression of measurements.

~~90.1 Purpose.~~

~~(A) Practical Safeguarding.~~

~~The purpose of this *Code* is the practical safeguarding or persons and property from hazards arising from the user of electricity. This *Code* is not intended as a design specification or an instruction manual for untrained persons.~~

~~(B) Adequacy.~~

...

2969

© 2022 *electrical training ALLIANCE*

90.2

RELOCATE REORGANIZE

Use and Application

Change Summary

- Section 90.2 has a new title: Use and Application.
- All previous text in Section 90.1 has been blended into a reorganized 90.2
- The titles of 90.2(C) and (D) have been changed to accommodate the reorganization.

2970

© 2022 *electrical training ALLIANCE*

90.2

RELOCATE REORGANIZE

90.2 ~~Scope~~ Use and Application

(A) Practical Safeguarding (Formerly 90.1(A))

(B) Adequacy (Formerly 90.1(B))

(C) Installations Covered (Formerly 90.2(A))

(D) Installations Not Covered (Formerly 90.2(B))

(E) Relation to Other International Standards (Formerly 90.1(C))

(F) Special Permission (Formerly 90.1(D))

© 2022 *electrical training ALLIANCE*

90.4

REORGANIZE

Enforcement

Change Summary

- This section was reorganized for clarity.
- A list format is used to make this section clearer.
- A new reference was added to Informative Annex H to comply with the *NEC Style Manual*.

2972

© 2022 *electrical training ALLIANCE*

90.4

REORGANIZE



2973

© 2022 *electrical training ALLIANCE*

90.5(C)

REVISION

Explanatory Material

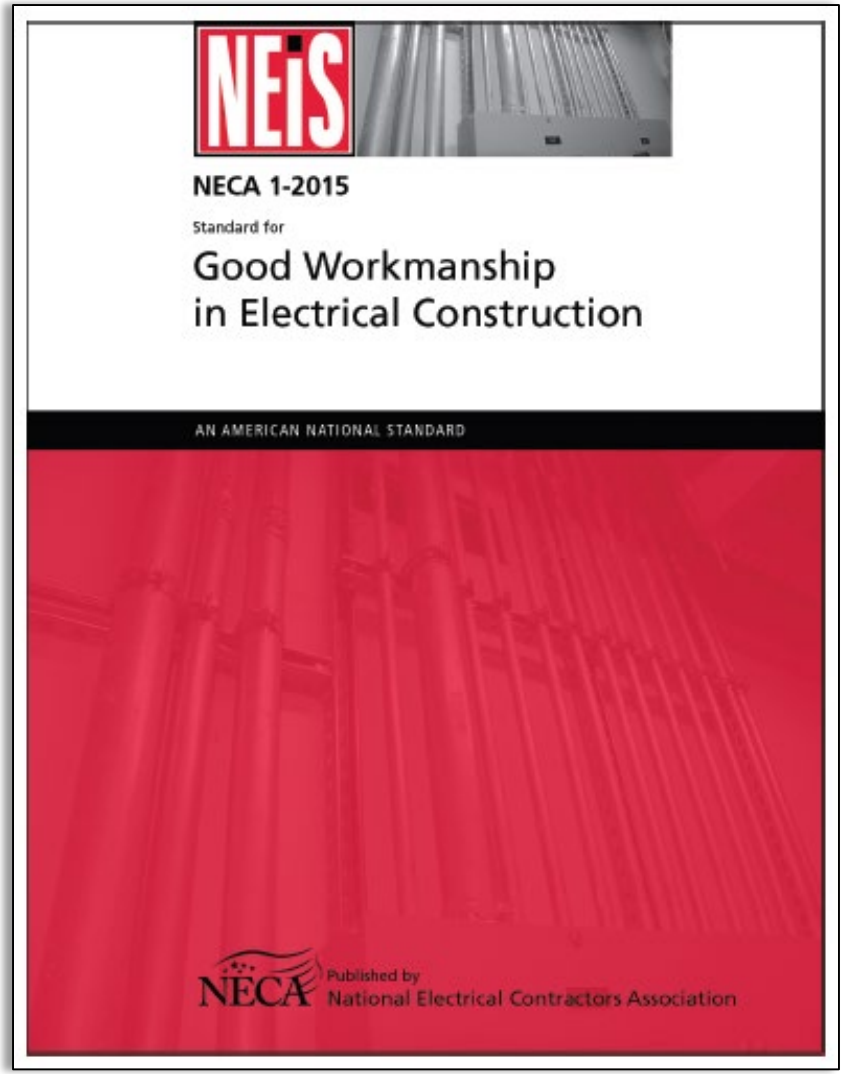
Change Summary

- If a referenced standard does not have an edition date, the latest edition can be assumed.
- Newer editions of standards could have been released after the *Code* committee considered the latest edition.
- Since references are not mandatory, there is no prohibition against using an updated edition.
- Standards references are for convenience only. Most installations can be completed without referring to the referenced standards.

© 2022 *electrical training ALLIANCE*

90.5(C)

REVISION



© 2022 *electrical training ALLIANCE*

Article 100

REORGANIZE

Article 100 Reorganization

Change Summary

- Article 100 has been consolidated into an article that is not divided into parts.
- All of the definitions from other articles have been relocated into Article 100.
- The XXX.2 sections of various articles no longer contain definitions.
- If a term had multiple uses, it has been modified to facilitate each use. In many cases, terms were modified to cover all appropriate applications.

2976

© 2022 *electrical training ALLIANCE*

Article 100

REORGANIZE

Article 100 Definitions

~~Part I-General~~
~~Part II. Over 1000 Volts, Nominal~~
~~Part III. Hazardous (Classified) Locations~~

This definition is extracted from the definitions chapter of *NFPA 99* (3.3.30). In most other NFPA documents, definitions are numbered.

Equipment Branch.
A system of feeders and branch circuits arranged for delayed, automatic, or manual connection to the alternate power source and that serves primarily 3-phase power equipment. [99:3.3.30] (517) (CMP-15)

This definition only applies within Article 517.

Assigned Code-Making Panel

The format of many defined terms were edited to comply with the new *NEC Style Manual*. To assist in electronic searching, some defined terms appear in parentheses as it would be found in the document.

Overcurrent Protective Device, Branch-Circuit. (Branch-Circuit Overcurrent Protective Device)
A device capable of providing protection for service, feeder, and branch circuits and equipment over the full range of overcurrents between its rated current and its interrupting rating. (CMP-10)

2977

© 2022 *electrical training ALLIANCE*

Article 100

REVISION

Definition of Accessible (as applied to wiring methods)

Change Summary

- For a wiring method to be considered accessible, it must not be closed in or blocked by the structure.
- Accessible wiring methods must also not be blocked by other electrical equipment.
- Coordination with other trades is often needed to ensure that accessible wiring methods are not blocked by building mechanical or plumbing systems.

2978

© 2022 *electrical training ALLIANCE*

Article 100

REVISION



2979

© 2022 *electrical training ALLIANCE*

Article 100

REVISION

Definition of Attachment Fitting, Weight Supporting

Change Summary

- This definition was revised to better describe the function of WSAF.
- The WSAF is a recognized component that is part of a listed luminaire or paddle fan.
- The combination of the WSAF and WSCR facilitate the modular replacement of luminaires and paddle fans in one- and two-family dwellings.
- Note also at the end of the definition the notation (CMP-18). This indicates the code-making panel that is responsible for the definition.
- NEMA WD6 recognizes WSAF configurations.

2980

© 2022 *electrical training ALLIANCE*

Article 100

REVISION



2981

© 2022 electrical training ALLIANCE
Courtesy of SKYX Platforms

Article 100

NEW

Definition of Motor Branch Circuit

Change Summary

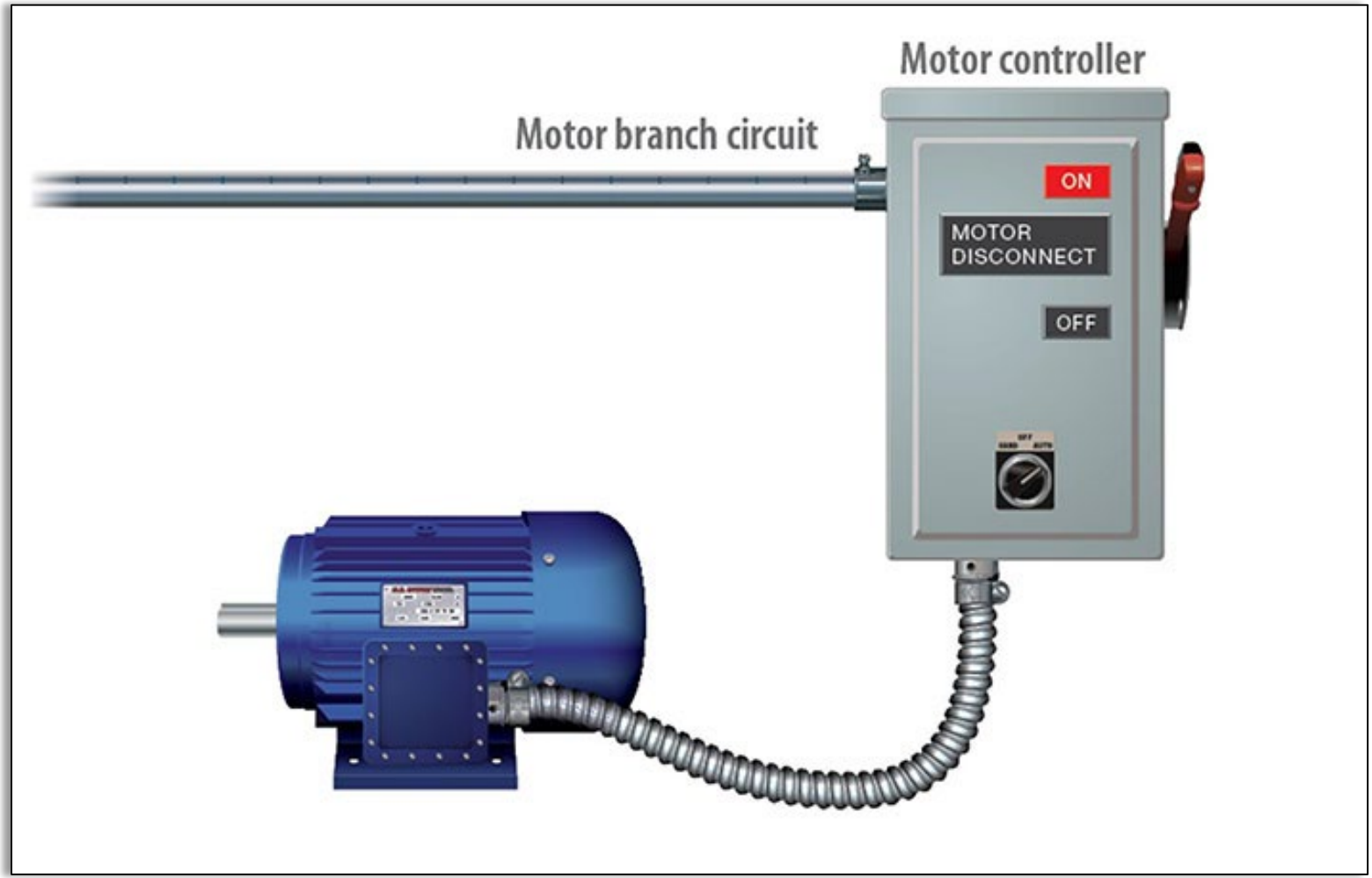
- A new definition was added to differentiate between a branch circuit and a motor branch circuit.
- Branch circuits originate at the last overcurrent protective device supplying the circuit.
- Motor branch circuits include controllers and adjustable speed drives.

2982

© 2022 *electrical training ALLIANCE*

Article 100

NEW



2983

© 2022 *electrical training ALLIANCE*

Article 100

NEW

Definition of Class 4 Definitions

Change Summary

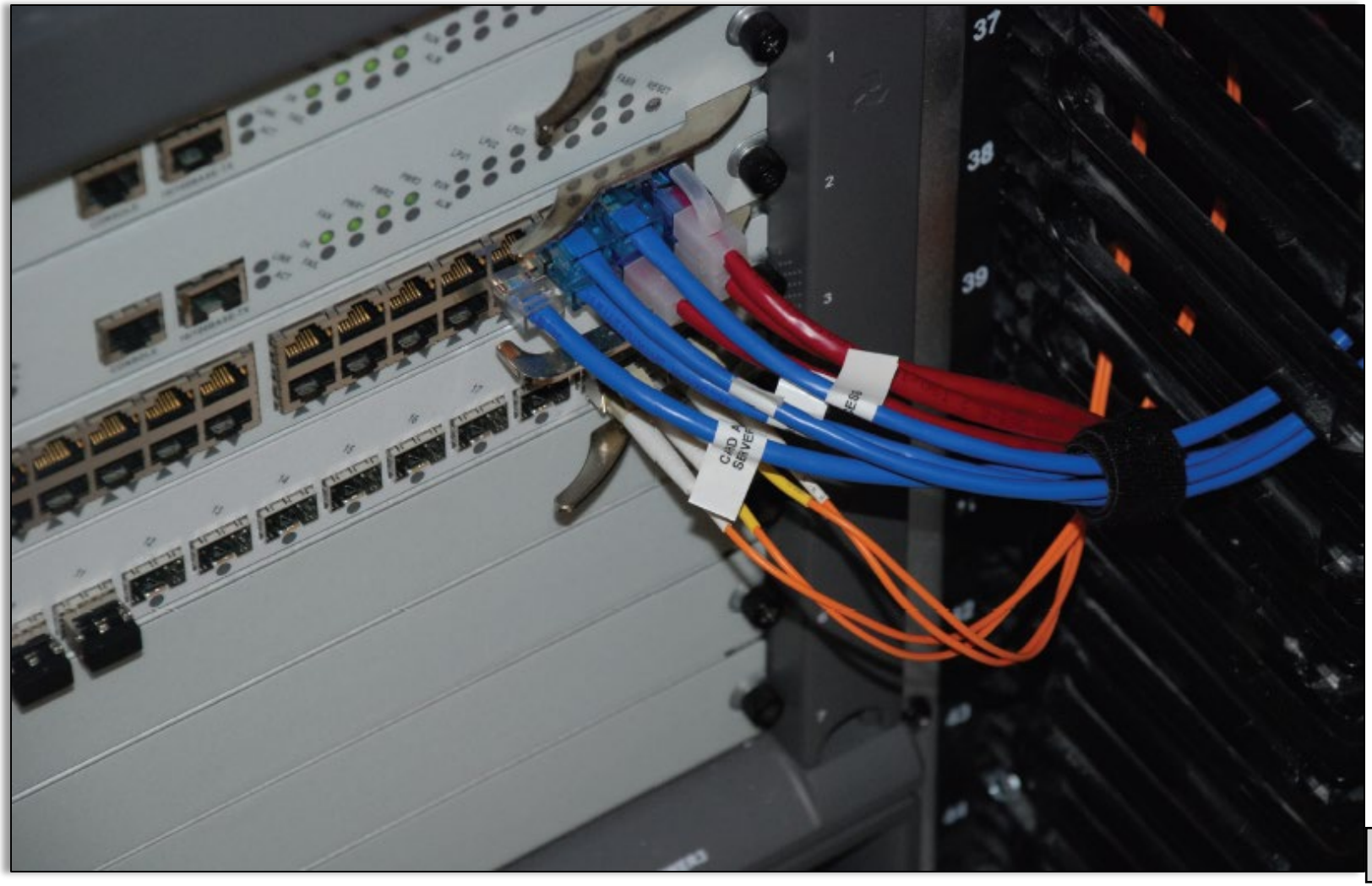
- These definitions are for terms used in new Article 726, Class 4 (CL4) Power Systems.
- Class 4 power systems will be used with equipment used in 5G Internet communications systems.
- A Class 4 Power System is a fault-managed system that relies on a continuous electronic handshake to ensure proper operation.
- Faults in Class 4 Power Systems result in immediate termination of output power.

2984

© 2022 *electrical training ALLIANCE*

Article 100

NEW



2985

© 2022 *electrical training ALLIANCE*
Courtesy of Michael J. Johnston

Article 100

NEW

Definition of Clothes Closet Storage Space

Change Summary

- A new simplified definition for clothes closet storage space has been added to Article 100.
- A clothes closet storage space is the area within a clothes closet in which combustible materials may be kept.
- The requirements for installation of luminaires remains in 410.16.

2986

© 2022 *electrical training ALLIANCE*

Article 100

NEW



2987

© 2022 *electrical training ALLIANCE*

Article 100

REVISION

Definition of Commissioning

Change Summary

- Revised definition to provide consistency in a commissioning process.
- Commissioning was previously covered only in Article 708, Critical Operations Power Systems.
- New commissioning requirements are found in 700.3, 701.3, and 706.7.
- Commissioning documentation should include as-built drawings and test results.

2988

© 2022 *electrical training ALLIANCE*

Article 100

REVISION



2989

© 2022 *electrical training ALLIANCE*
Courtesy of PDE Total Energy Solutions

Article 100

REVISION

Definition of Corrosive Environment

Change Summary

- Pool chemicals can cause corrosion of electrical equipment.
- Corrosive locations are those where pool sanitizing chemicals are present, and there is inadequate ventilation.
- Reference to *NFPA 400* was removed because it was not helpful for pool electrical equipment installers.
- The reference to the EPA website was removed, as a direct reference to the appropriate publications is more helpful.

2990

© 2022 *electrical training ALLIANCE*

Article 100

REVISION



2991

© 2022 *electrical training ALLIANCE*

Article 100

NEW

Definition of Counter (Countertop)

Change Summary

- A new definition was added for “counter (countertop)” to distinguish it from other work surfaces.
- An informational note reference was added for UL standards for receptacles and attachment plugs and GFCI devices.
- A second informational note references requirements for receptacles in countertops and work surfaces.

2992

© 2022 *electrical training ALLIANCE*

Article 100

NEW



2993

© 2022 *electrical training ALLIANCE*

Article 100

NEW

Definition of Energized, Likely to Become

Change Summary

- There is a new definition of the term *likely to become energized*.
- The term is used in 25 places in the 2020 *NEC*.
- *Likely to become energized* has been on a list of standard terms used in the *NEC Style Manual*, where it meant “failure of insulation on.” The new definition adds electrical spacing failure as an additional consideration.

2994

© 2022 *electrical training ALLIANCE*

Article 100

NEW



2995

© 2022 *electrical training ALLIANCE*
Courtesy of Michael J. Johnston

Article 100

REVISION

Definitions of Equipotential Plane

Change Summary

- There are now two definitions in Article 100 for Equipotential plane.
- The general definition is “Conductive elements that are connected together to minimize the voltage differences.” This definition is not limited to a single article.
- The second definition applies to natural and man-made bodies of water. This definition applies only to Article 682.

2996

© 2022 *electrical training ALLIANCE*

Article 100

REVISION



2997

© 2022 *electrical training ALLIANCE*

Article 100

NEW

Definition of Fault Managed Power

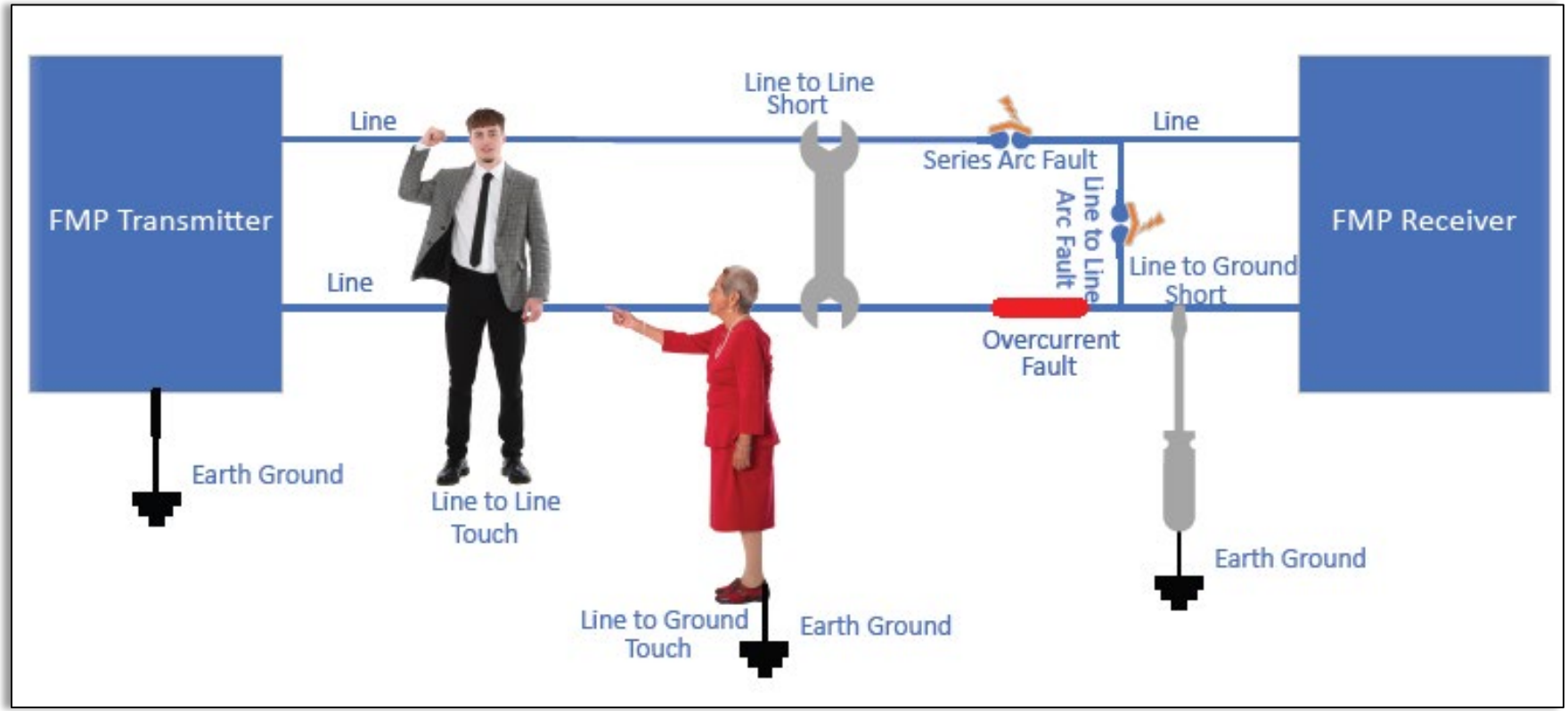
Change Summary

- Fault-managed power is one of the key definitions for new Article 726. Class 4 power systems are fault-managed power systems.
- Class 4 power systems provide a pulsed power output that relies on a continuous handshake to provide fault detection and ensure proper operation.
- Class 4 power systems can supply up to 450 volts dc line-to-line or 225 volts dc to ground to provide power and control of electronic equipment.

© 2022 *electrical training ALLIANCE*

Article 100

NEW



2999

© 2022 *electrical training ALLIANCE*
Courtesy of Cisco

Article 100

NEW

Definition of Fibers/Flyings, Combustible

Change Summary

- A new definition was added for combustible fibers/flyings.
- Combustible fibers/flyings consist of solid particles greater than 500 µm in size that can form an explosible mixture when suspended in air at standard atmospheric pressure and temperature.
- In contrast, combustible dusts consist of solid particles that are 500 µm or smaller that can form an explosible mixture.

3000

© 2022 *electrical training ALLIANCE*

Article 100

NEW



3001

© 2022 *electrical training ALLIANCE*

Article 100

NEW

Definition of GFCI, Special Purpose

Change Summary

- A new definition was added for Special Purpose Ground-Fault Circuit-Interrupter.
- SPGFCIs are used on circuits with voltage greater than 150 volts to ground.
- Traditional GFCIs are also known as Class A GFCIs. Special purpose GFCIs are either Class C, D, or E GFCIs.

3002

© 2022 *electrical training ALLIANCE*

Article 100

NEW



3003

© 2022 *electrical training ALLIANCE*

Article 100

NEW

Definition of Ground-Fault Detector-Interrupter

Change Summary

- GFDI protection is designed to provide ground-fault protection of photovoltaic dc circuits.
- As noted in 690.41(B), equipment that does not have ground-fault protection will often have a warning in the manual that indicates that the unit does not have a GFDI device.
- GFDIs are equipment protection, not personnel protection.

3004

© 2022 *electrical training ALLIANCE*

Article 100

NEW



3005

© 2022 *electrical training ALLIANCE*

Article 100

NEW

Definition of Industrial Installation, Supervised

Change Summary

- The term *Supervised Industrial Installation* is used in Articles 240 and 702, but it has been undefined until now.
- Industrial installations typically have a relaxation of some rules of the *Code*, as industrial installations are usually designed, installed, monitored, and maintained by qualified personnel.
- The definition was initially developed by CMP 10 and was revised by a task group including CMPs 1, 10, and 14; it remains limited to Article 240.

3006

© 2022 *electrical training ALLIANCE*

Article 100

NEW



3007

© 2022 *electrical training ALLIANCE*

Article 100

REVISION

Definition of Inverter, Multimode

Change Summary

- Multimode inverters can operate in both interactive mode and island mode.
- In the interactive mode, an inverter operates in parallel with the utility and can supply power back to the utility.
- In the island mode, it will separate from the utility to supply power to the premises through an energy storage system.

3008

© 2022 *electrical training ALLIANCE*

Article 100

REVISION



3009

© 2022 *electrical training ALLIANCE*

Article 100

REVISION

Definition of Location, Wet

Change Summary

- The definition of “wet location” has been rewritten into a list format.
- The previous format consisted of a sentence with commas, which made it more difficult to interpret.
- An informational note was added that gives an example of a wet location.
- The definitions of damp location and dry location were much shorter and clearer, so no changes to them were necessary.

3010

© 2022 *electrical training ALLIANCE*

Article 100

REVISION



3011

© 2022 *electrical training ALLIANCE*

Article 100

NEW

Definition of Locations, Hazardous (Classified)

Change Summary

- A new general definition has been added for Hazardous (Classified) Locations.
- Article 500 defines Classes I, II, and III, as well as the divisions and groups.
- Article 505 provides the classification system for gases, vapors, and liquids using the IEC Zone system.
- Article 506 provides the classification system for dusts and combustible fibers and flyings using the IEC Zone System.
- IEC uses the same zone system for dusts that is uses for fibers and flyings.

3012

© 2022 *electrical training ALLIANCE*

Article 100

NEW



3013

© 2022 *electrical training ALLIANCE*

Article 100

NEW

Definition of Microgrid, Health Care

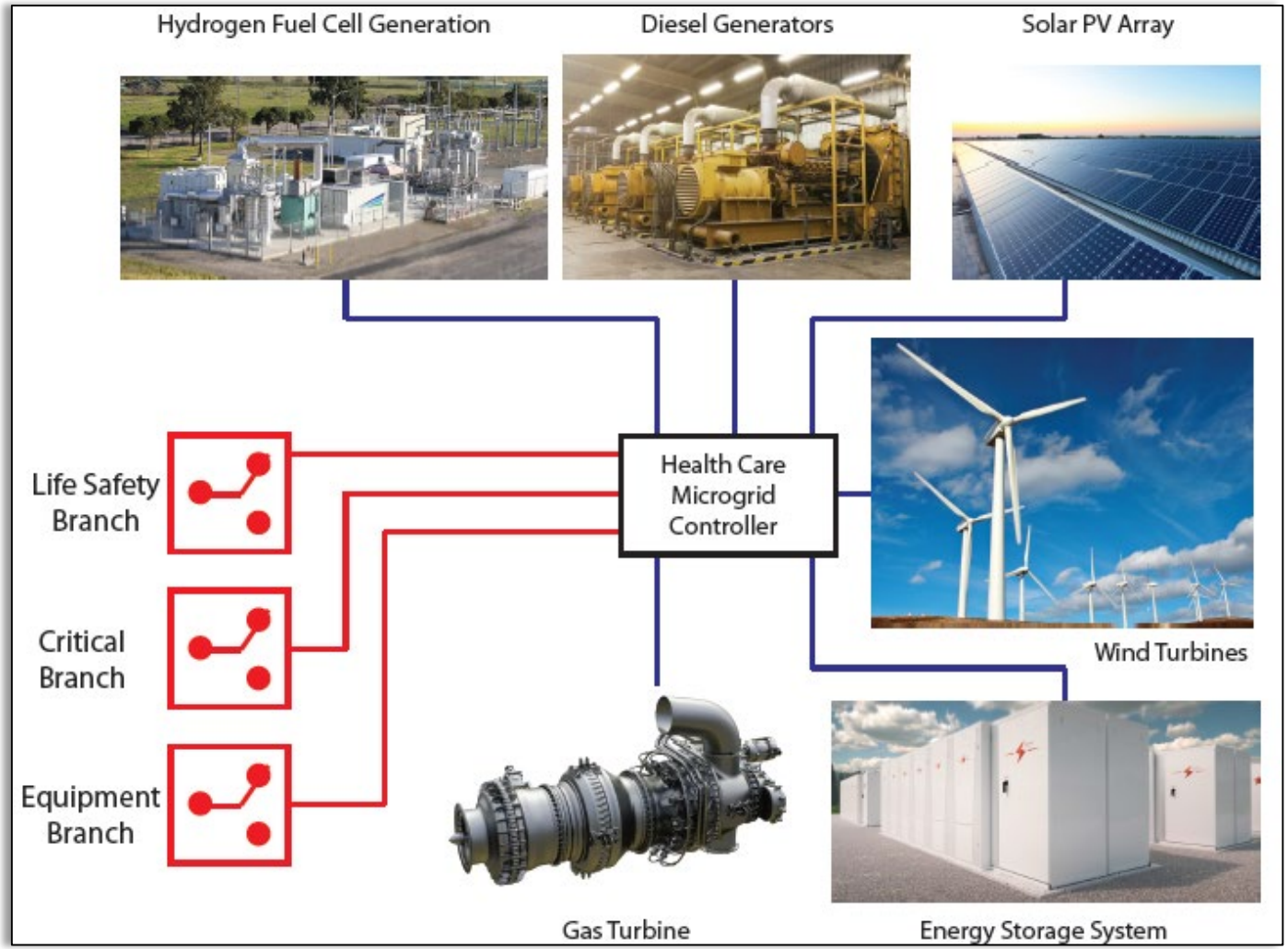
Change Summary

- A health care microgrid is now permitted to be used as the normal power source.
- If a health care microgrid is used as the normal source, it is not permitted to be used as the alternate source.
- Essential electrical systems are permitted to be supplied by a health care microgrid that also supplies non-essential loads.
- Note the nomenclature at the end of the definition that indicates that the source of this definition is *NFPA 99*, the *Health Care Facilities Code.*

© 2022 *electrical training ALLIANCE*

Article 100

NEW



© 2022 *electrical training ALLIANCE*

Article 100

NEW

Definitions of Panelboard and Panelboard, Enclosed

Change Summary

- The definition of “panelboard” was revised to recognize panelboards that are installed in an enclosure other than a cabinet or cutout box.
- A new definition was added for an “enclosed panelboard,” which is installed in a cabinet, cutout box, or enclosure suitable for a panelboard application.
- Sections 110.16(A) and 110.26(D) are among the requirements that apply to enclosed panelboards.

© 2022 *electrical training ALLIANCE*

Article 100

NEW



3017

© 2022 *electrical training ALLIANCE*

Article 100

NEW

Definition of Receptacle, Weight-Supporting Ceiling

Change Summary

- This is a new definition of a receptacle that was introduced in the 2017 *Code*.
- Weight-supporting ceiling receptacles (WSCR) are contact devices that are designed to mate with a weight-supporting attachment fitting (WSAF) to make an electrical connection and to support the weight of luminaires or paddle fans.
- A WSCR that is listed for fan support can also support luminaires without fans, while a WSCR that is listed for luminaire support will reject a paddle fan.

© 2022 *electrical training ALLIANCE*

Article 100

NEW



3019

© 2022 *electrical training ALLIANCE*
Courtesy of SKYX Platforms

Article 100

NEW

Definition of Servicing

Change Summary

- “Servicing” is defined as: The process of following a manufacturer’s set of instructions or applicable industry standards to analyze, adjust, or perform prescribed actions upon equipment with the intention to preserve or restore the operational performance of the equipment.
- “Reconditioned” is defined as: Electromechanical systems, equipment, apparatus, or components that are restored to operating conditions. This process differs from normal servicing of equipment that remains within a facility, or replacement of listed equipment on a one-to-one basis.
- The informational note points out that servicing includes maintenance and repair.

3020

© 2022 *electrical training ALLIANCE*

Article 100

NEW



3021

© 2022 *electrical training ALLIANCE*

Courtesy of Michael J. Johnston

Article 100

NEW

Definition of Stranding (Compact and Compressed)

Change Summary

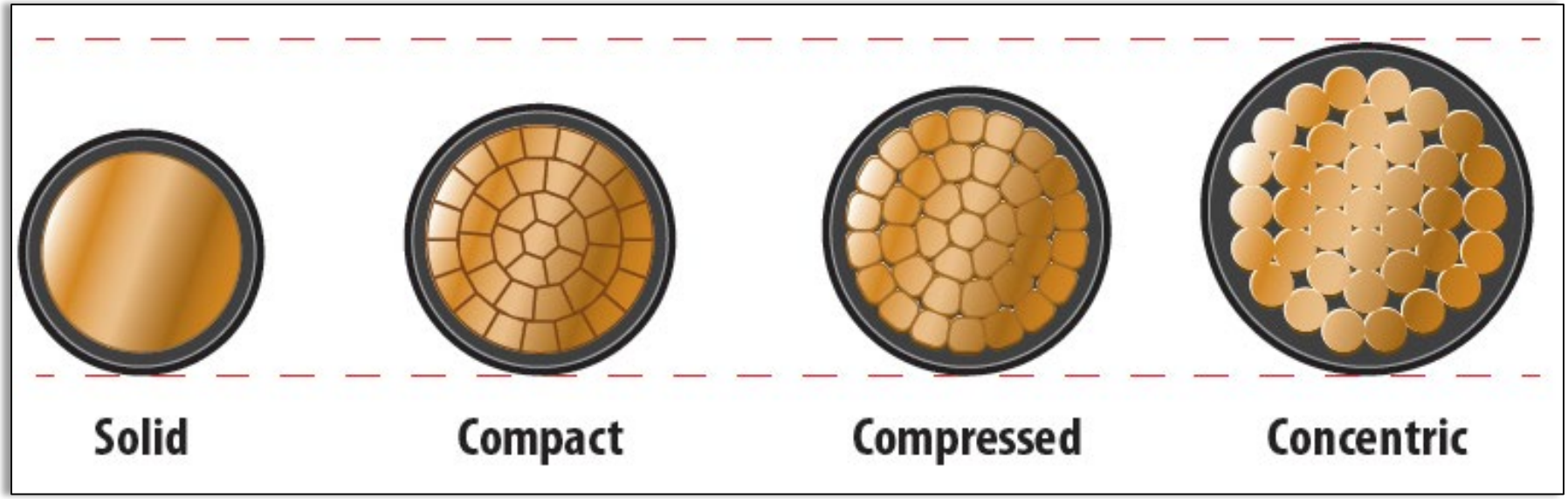
- New stranding definitions have been provided.
- Compact stranding: each layer is pressed together to minimize gaps between strands, reducing the overall diameter.
- Compressed stranding: conductors are pressed together, result is an overall diameter that is less than a concentric stranded conductor but greater than a compact stranded conductor.

3022

© 2022 *electrical training ALLIANCE*

Article 100

NEW



3023

© 2022 *electrical training ALLIANCE*

Article 100

REVISION

Definition of Type P Cable

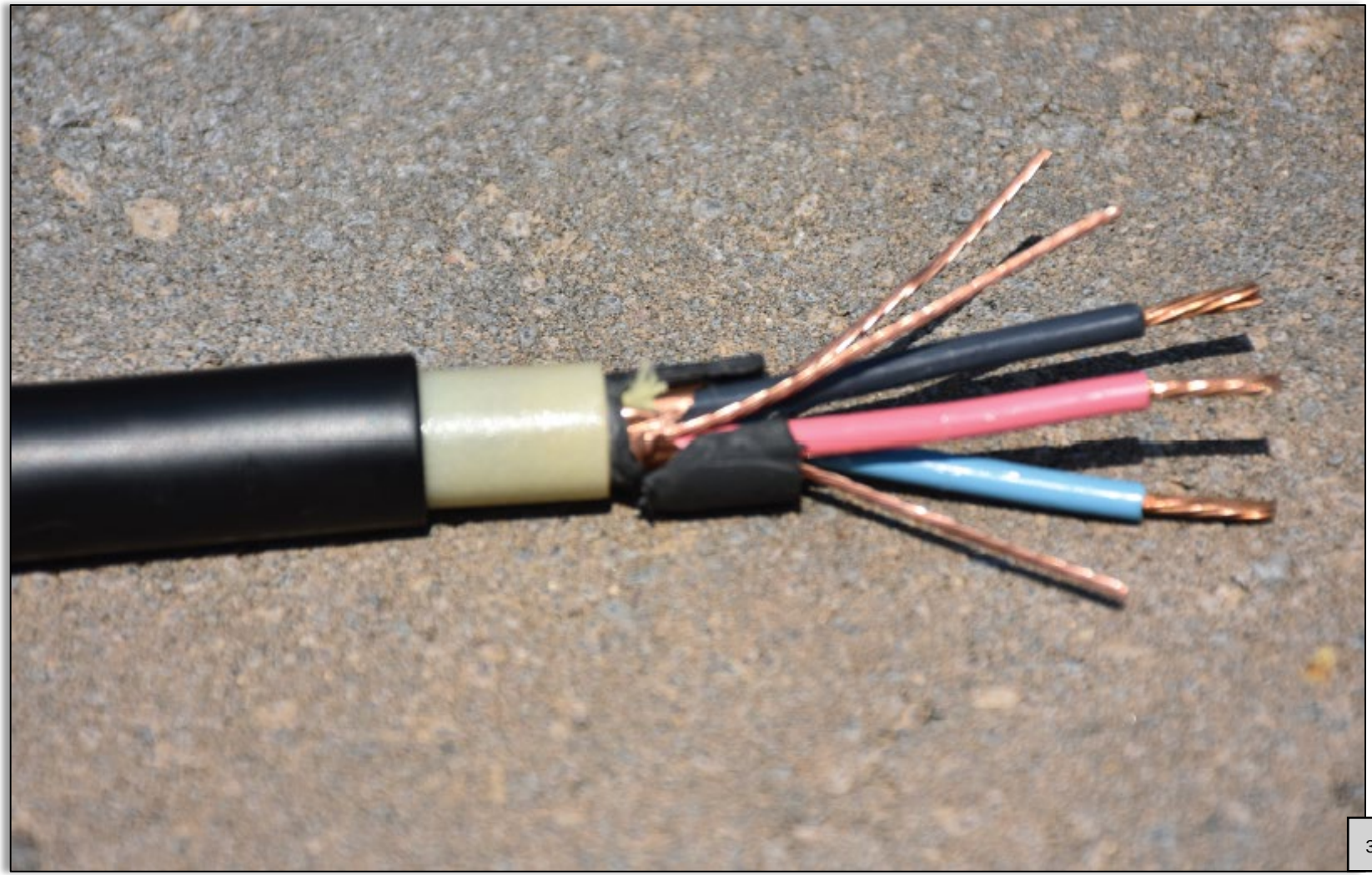
Change Summary

- Type P Cable has been used on drilling rigs for four decades.
- Type P Cable is limited to industrial locations where maintenance and supervision ensure that qualified personnel monitor and service the installation.
- Type P Cable is permitted in hazardous locations, where permitted in the article covering the location.

© 2022 *electrical training ALLIANCE*

Article 100

REVISION



3025

© 2022 *electrical training ALLIANCE*

110.3(A)

REVISION

Examination

Change Summary

- Cyber attacks on network connected electronic equipment are an increasing threat.
- Section 110.3(A)(8) now requires the evaluation of cyber security for network-connected life-safety equipment.
- An informational note was added that references standards for including the IEC 62443 series of standards on Industrial Automation and Control Systems and UL standards on cyber security, including UL 2900 and UL 5500.

© 2022 *electrical training ALLIANCE*

110.3(A)

REVISION



© 2022 *electrical training ALLIANCE*

110.3(B)

NEW

Installation and Use

Change Summary

- Listed or labeled equipment is required to be installed and used in accordance with any instructions included in the listing or labeling. The same now applies to equipment that is identified for a use.
- Installation instructions are often misplaced after installation. This informational note points out that QR codes on products or information on manufacturer websites can provide installation instructions.
- Online product information is often easier to access after the product is installed.

© 2022 *electrical training ALLIANCE*

110.3(B)

NEW



3029

© 2022 *electrical training ALLIANCE*

110.8

REVISION

Wiring Methods

Change Summary

- Section 90.2(C) indicates that if the installation is covered by the *Code*, the wiring methods recognized by the *Code* are permitted to be installed in any building, occupancy, or premises wiring system.
- The definition of premises wiring in Article 100 includes interior and exterior wiring and associated hardware.
- Premises wiring does not include the internal wiring of appliances, luminaires, motor controllers, motor control centers, and similar equipment.

3030

© 2022 *electrical training ALLIANCE*

110.8

REVISION



3031

© 2022 *electrical training ALLIANCE*

110.12

REVISION

Mechanical Execution of Work

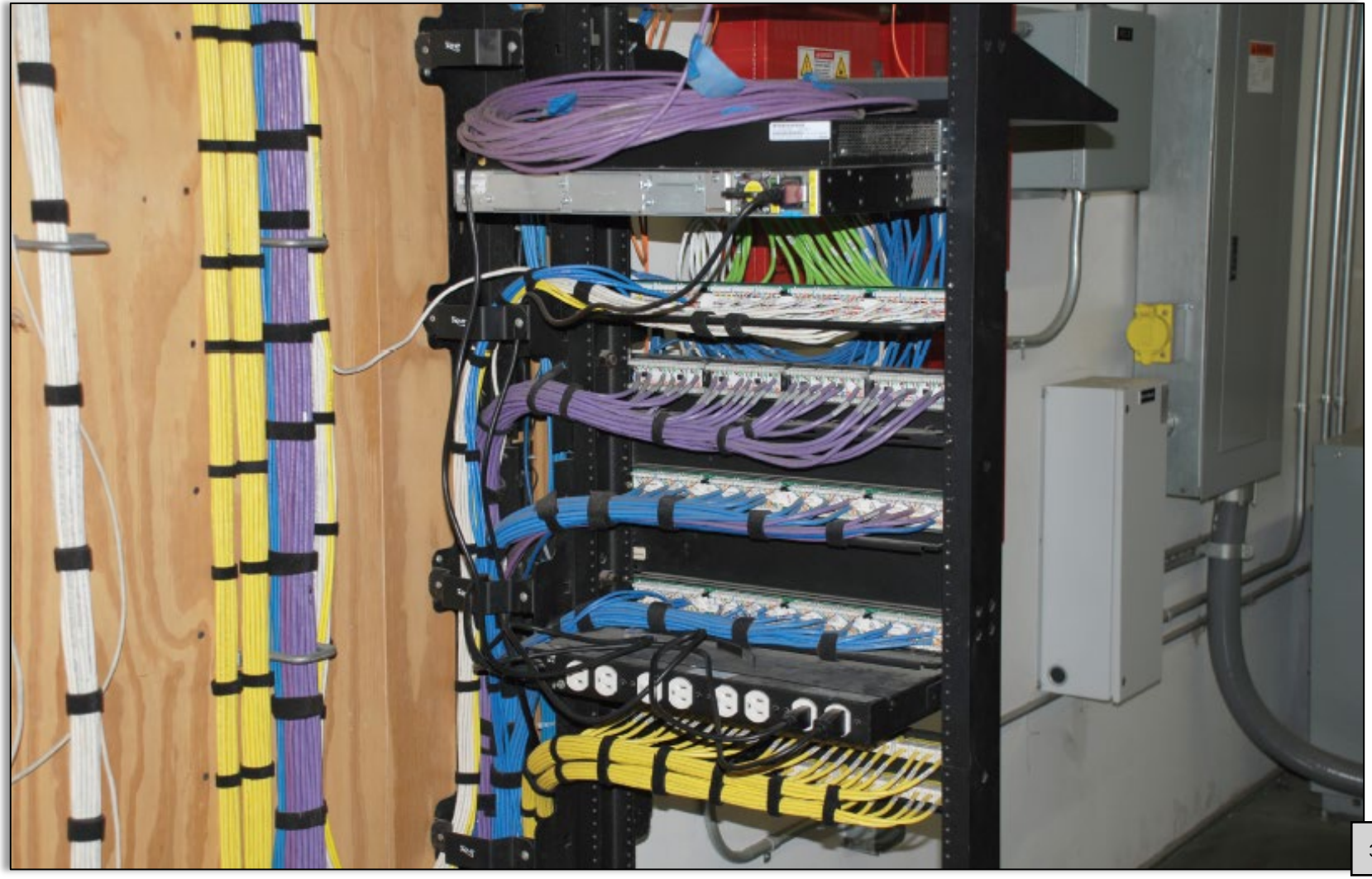
Change Summary

- The terms *neat* and *workmanlike* were replaced with *professional* and *skillful*.
- This editorial change uses more descriptive and gender-neutral terms.
- The informational note change is simply editorial.
- Informational Note No. 1 to 110.12(C) was deleted because this section applies to cables and conductors; it does not apply to fiber optic cables.

© 2022 *electrical training ALLIANCE*

110.12

REVISION



3033

© 2022 *electrical training ALLIANCE*

110.14(A)

REVISION

Terminals

Change Summary

- The requirement that terminal connections be “thoroughly good” has been replaced with the term *mechanically secure* to replace vague and unenforceable terminology.
- The text was revised to clarify that terminal connections must provide a good electrical connection.
- Requirements for connection methods for certain equipment, such as receptacles (covered by CMP 18), are the responsibility of the panel that covers that equipment.

3034

© 2022 *electrical training ALLIANCE*

110.14(A)

REVISION



3035

© 2022 *electrical training ALLIANCE*

110.16(B)

REVISION

Service Equipment and Feeder Equipment

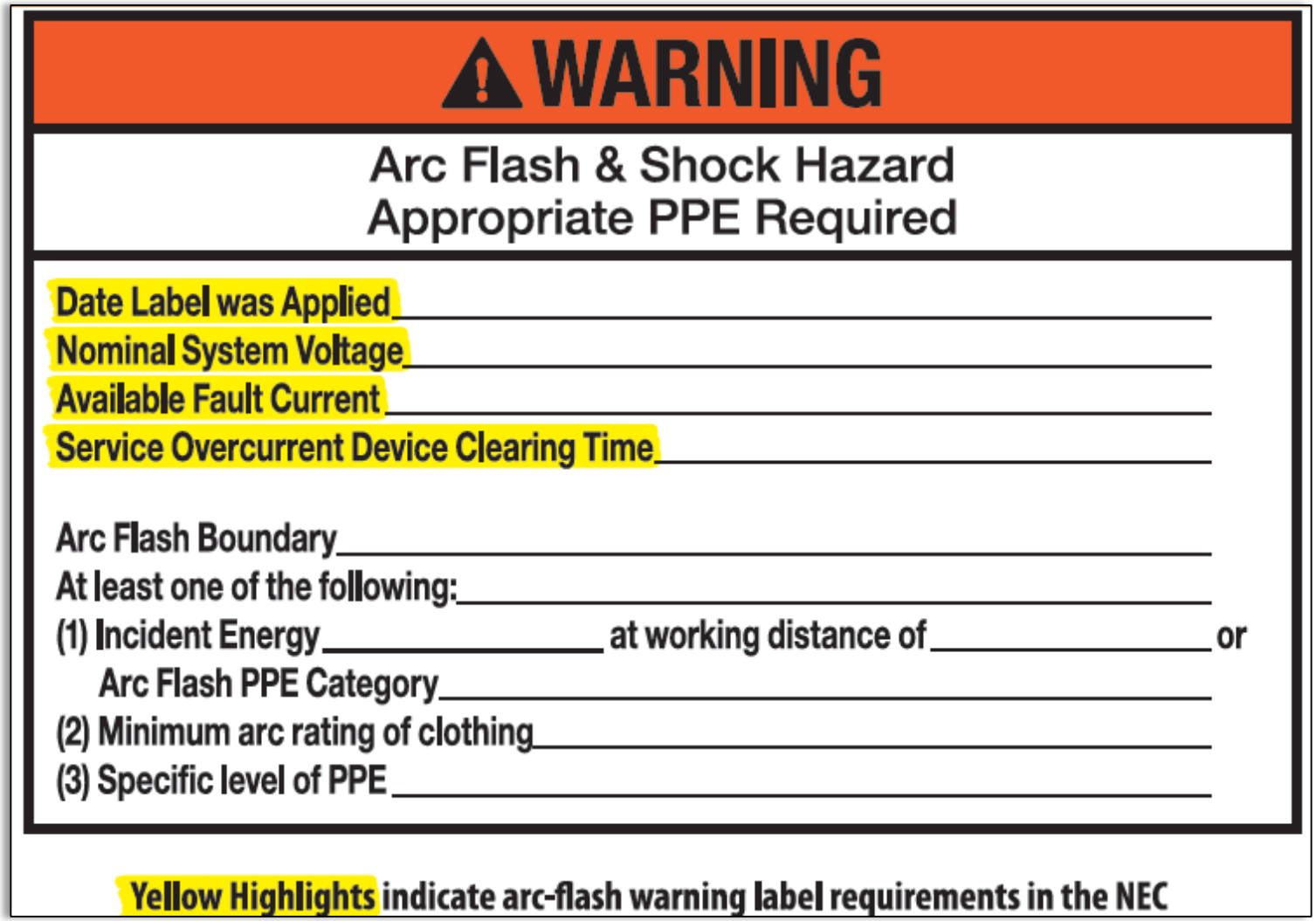
Change Summary

- Section 110.16(B) is expanded to apply to feeder supplied equipment, as well as service equipment.
- The requirement has been modified to make it clear that the required label is an arc flash warning label.
- The threshold for a required label has been lowered from 1,200 amperes to 1,000 amperes.
- The requirements for the content of the label have been deleted because they are included in 110.21(B).

© 2022 *electrical training ALLIANCE*

110.16(B)

REVISION



3037

© 2022 *electrical training ALLIANCE*

110.17

NEW

Servicing and Maintenance of Equipment

Change Summary

- This addition is significant because in addition to requiring a *qualified person* (a defined term), the individual must be a qualified person trained in servicing and maintenance of equipment.
- Servicing and maintenance must be performed in accordance with the manufacturer's instructions and applicable industry standards or as approved by the AHJ.
- Identified replacement parts must be verified under applicable product standards.

© 2022 *electrical training ALLIANCE*

110.17

NEW



3039

© 2022 *electrical training ALLIANCE*

Courtesy of Burlington Electrical Testing

110.20

NEW

Reconditioned Equipment

Change Summary

- Equipment is generally permitted to be reconditioned, unless prohibited elsewhere in the *Code*.
- Requirements are provided for parts and sources of information.
- If listing is required, the equipment must be listed or field-labeled as reconditioned.
- If listing is not required, it must be listed or field-labeled as reconditioned or reconditioned in accordance with the manufacturer's instructions.

© 2022 *electrical training ALLIANCE*

110.20

NEW



3041

© 2022 *electrical training ALLIANCE*

110.21(A)

REVISION

Reconditioned Equipment, Marking Requirements

Change Summary

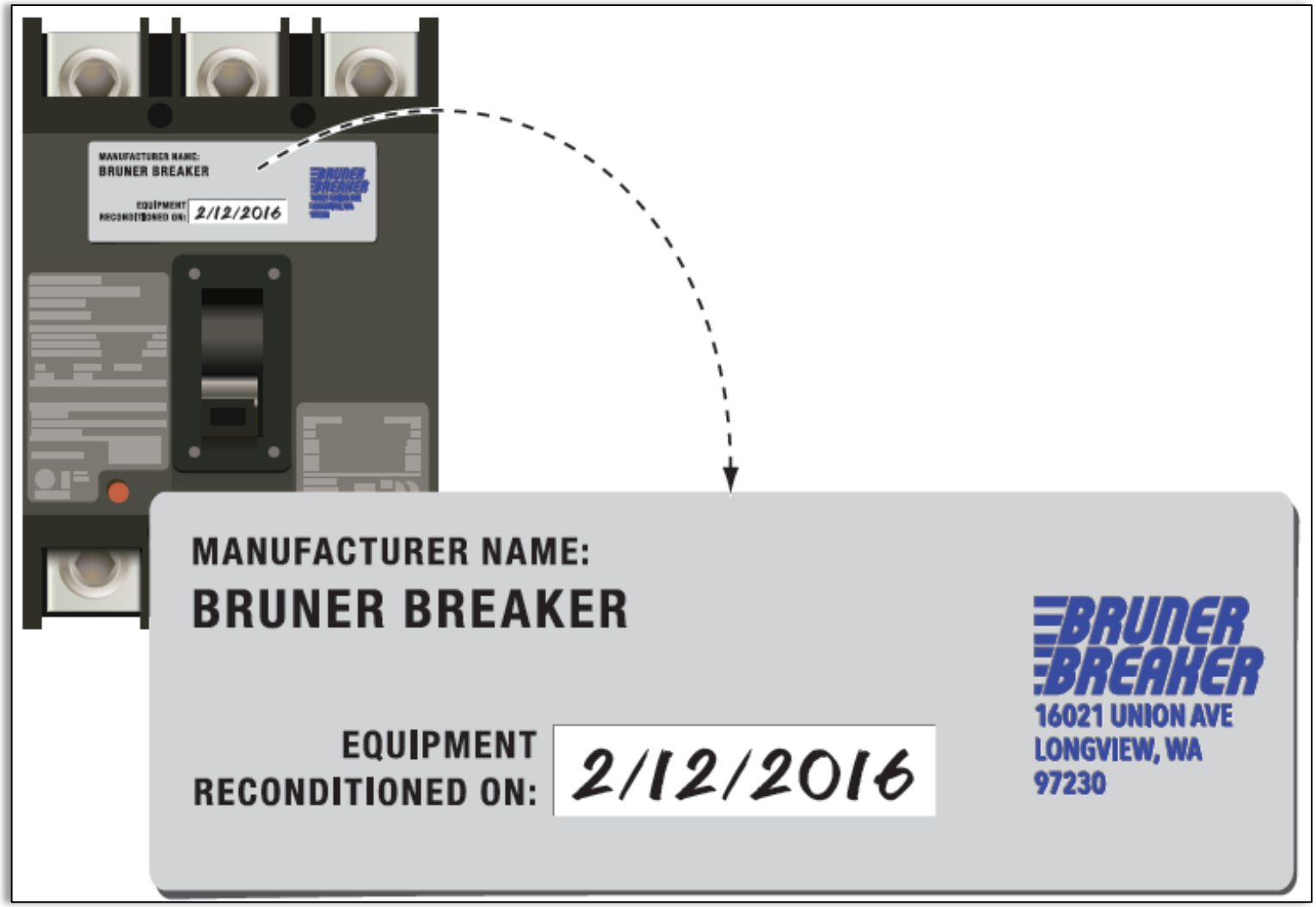
- The marking requirements for reconditioned equipment have been reorganized into list format.
- The original listing mark must be removed or made permanently illegible.
- The original equipment nameplate can remain, but the listing mark must be removed.
- The exception for industrial facilities still applies.

3042

© 2022 *electrical training ALLIANCE*

110.21(A)

REVISION



3043

© 2022 *electrical training ALLIANCE*

110.22(A)

REVISION

Identification of Disconnecting Means, General

Change Summary

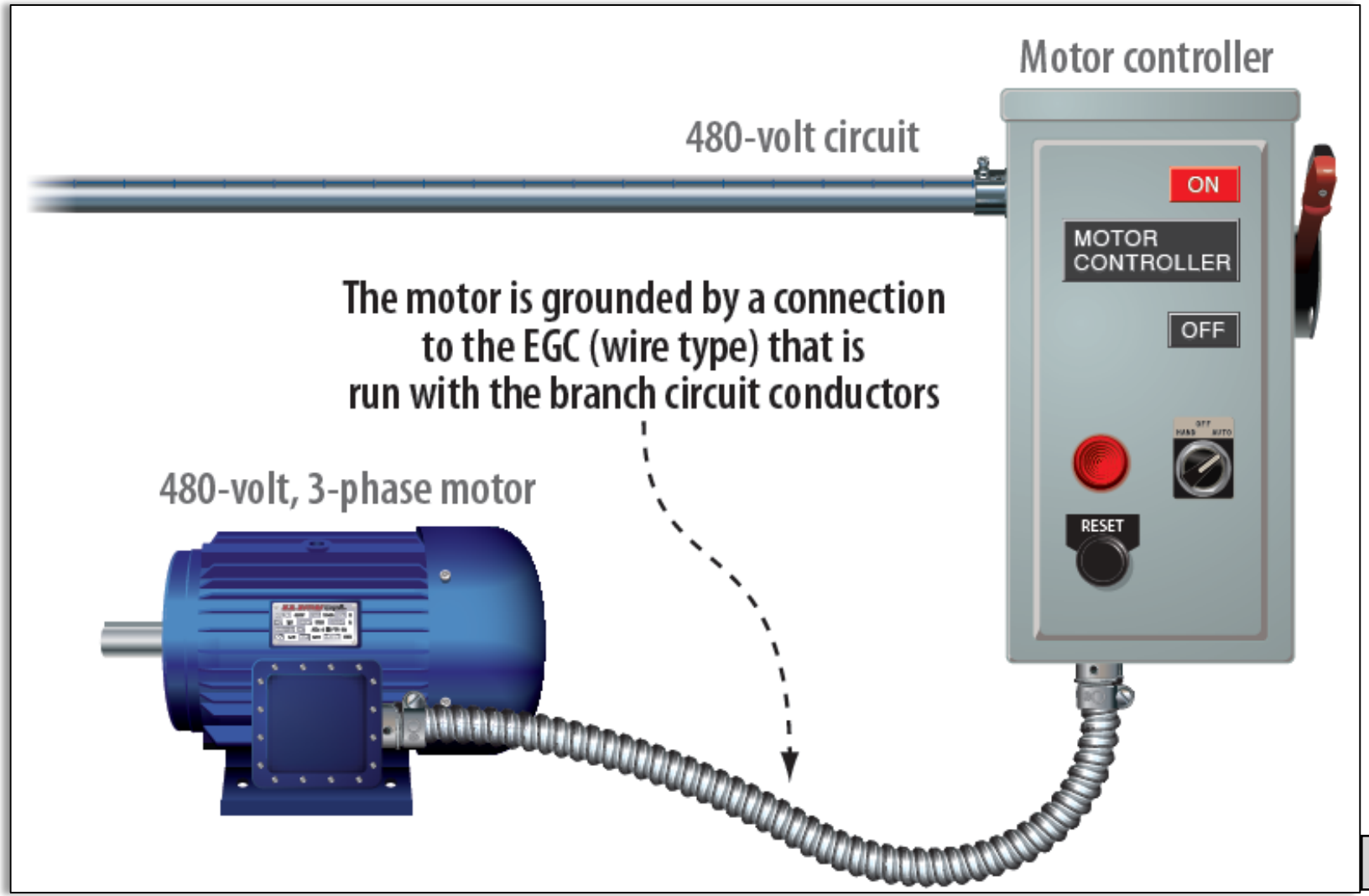
- Disconnecting means are required to be legibly marked to indicate their purpose, unless located and arranged to make the purpose evident.
- The marking must include the identification and location of the circuit source that supplies the disconnecting means, unless located and arranged to make the identification of the circuit source evident.
- This change is intended to make it easier for service personnel to quickly locate the power source. This is especially important in large and high-rise buildings.

3044

© 2022 *electrical training ALLIANCE*

110.22(A)

REVISION



© 2022 *electrical training ALLIANCE*

110.26

REORGANIZE

Depth and Width of Working Space

Change Summary

- The requirement that open equipment doors must not impede entry or egress to the working space was relocated from 110.26(C)(2) to 110.26.
- Relocation of the open equipment door requirement to 110.26 means that it now applies to all equipment, not just large equipment.
- Access or egress is impeded if one or more simultaneously-opened equipment doors restricts access to less than 24 inches wide or 6 ½ feet high.

© 2022 *electrical training ALLIANCE*

110.26

REORGANIZE



3047

© 2022 *electrical training ALLIANCE*

110.26(A)(4)

REVISION

Limited Workspace Requirements

Change Summary

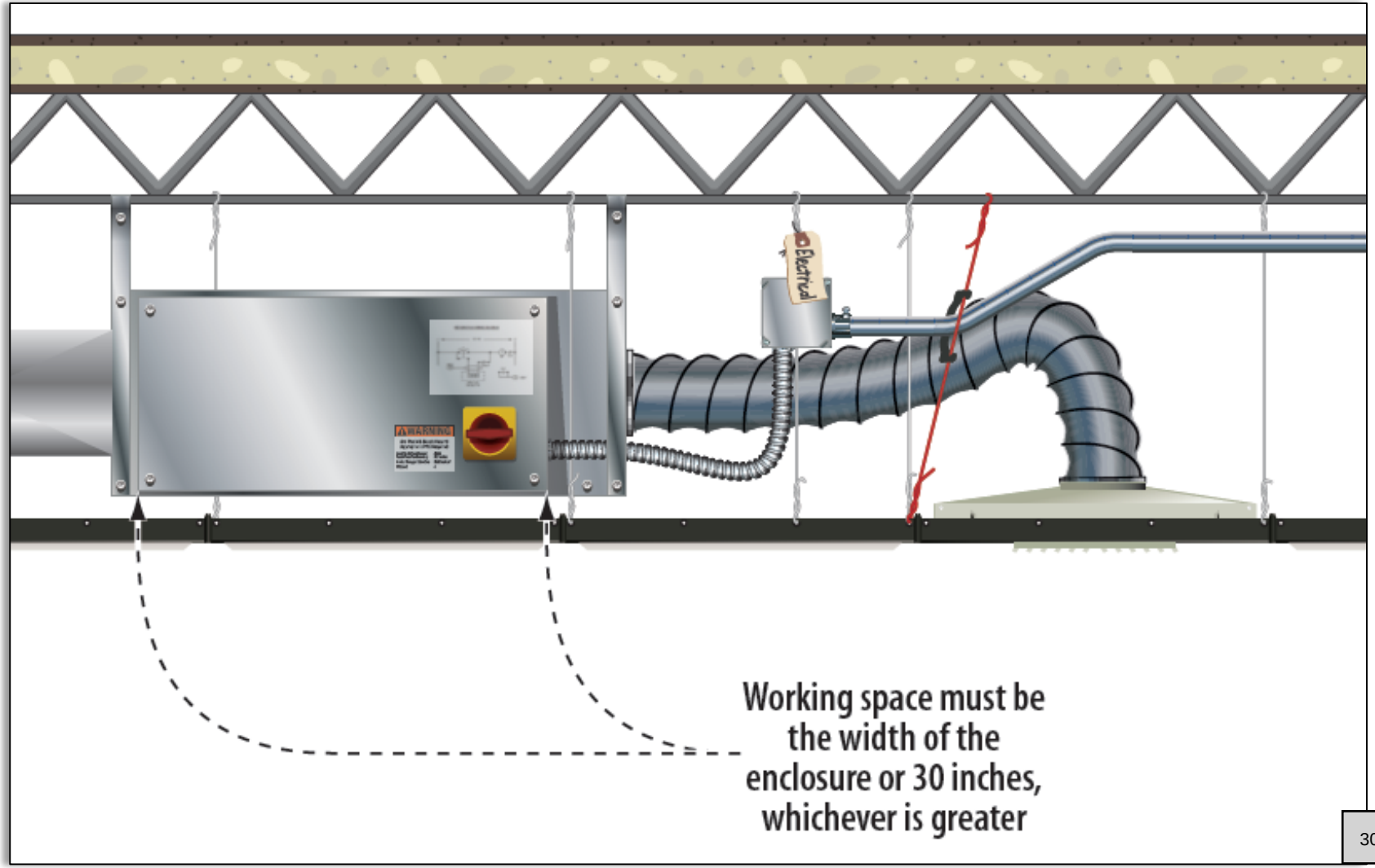
- The limited access workspace requirements were modified to provide requirements for workspaces in front of duct heaters installed above partitions.
- The workspace must be unobstructed to the floor by fixed cabinets, walls, or partitions.
- A horizontal ceiling structural member or access panel is permitted in the space if the location of weight-bearing structural members does not result in a side reach of more than 6 inches to work inside the enclosure.

3048

© 2022 *electrical training ALLIANCE*

110.26(A)(4)

REVISION



3049

© 2022 *electrical training ALLIANCE*

110.26(A)(6)

NEW

Grade, Floor, or Working Platform

Change Summary

- Section 110.26 requires access and workspace around all electrical equipment to permit ready and safe operation and to permit maintenance.
- The grade, floor, or platform in the workspace must be clear of obstructions and tripping hazards.
- The grade, floor, or platform in the workspace must be as level and flat as possible.
- Similar requirements have been added to 110.34(A) for equipment operating over 1,000 volts.

3050

© 2022 *electrical training ALLIANCE*

110.26(A)(6)

NEW



3051

© 2022 *electrical training ALLIANCE*

110.26(E)

REVISION

Dedicated Equipment Space

Change Summary

- The requirement for dedicated equipment space in 110.26(E) has been expanded to include all service equipment rated 1,000 volts or less.
- The requirement will now include service equipment for one- and two-family dwellings, including the emergency disconnects now required in 230.85
- A service rated disconnect will now have the same equipment space requirements as service rated switchgear and service rated panelboards for 1,000 volts or less.

© 2022 *electrical training ALLIANCE*

110.26(E)

REVISION



3053

© 2022 *electrical training ALLIANCE*

Table 110.28

REVISION

Table 110.28 Enclosure Types, Informational Notes

Change Summary

- Informational Note No. 3 was revised to add a reference to 502.10(A)(2) for Class II, Division 1 locations.
- Informational Note No. 5 notes that some Type 4X enclosures are marked “for indoor use only.”
- Informational Note No. 6 notes that some Type 4, 4X, and 12 enclosures are ventilated, but still provide the required ingress protection.
- Informational Note No. 7 references the NEMA Standard for enclosure type ratings.

© 2022 *electrical training ALLIANCE*

Table 110.28

REVISION



3055

© 2022 electrical training ALLIANCE
Courtesy of Michael J. Johnston

110.29

NEW

In Sight From (Within Sight From, Within Sight)

Change Summary

- A new requirement has been added that establishes that “in sight from” means that the equipment must be visible and not more than 50 feet from the other equipment.
- This requirement was created to comply with the *NEC Style Manual*.
- Definitions are not permitted to contain requirements. The establishment of limits constitutes a requirement.
- The definition with the requirement still exists.

3056

© 2022 *electrical training ALLIANCE*

110.29

NEW



3057

© 2022 *electrical training ALLIANCE*

110.31(A)(4)

REVISION

Locks, Personnel Doors

Change Summary

- Personnel doors for electrical vaults containing equipment rated over 1,000 volts are now required to open at least 90 degrees. These doors are required to be equipped with listed panic hardware or listed fire exit hardware.
- There is a similar requirement in 110.26(C)(3) for equipment rated 1,000 volts and less.
- An informational note was added to reference two UL Standards: UL 305, Standard for Panic Hardware; and UL 10C, Standard for Safety for Positive Pressure Fire Tests of Door Assemblies.

3058

© 2022 *electrical training ALLIANCE*

110.31(A)(4)

REVISION

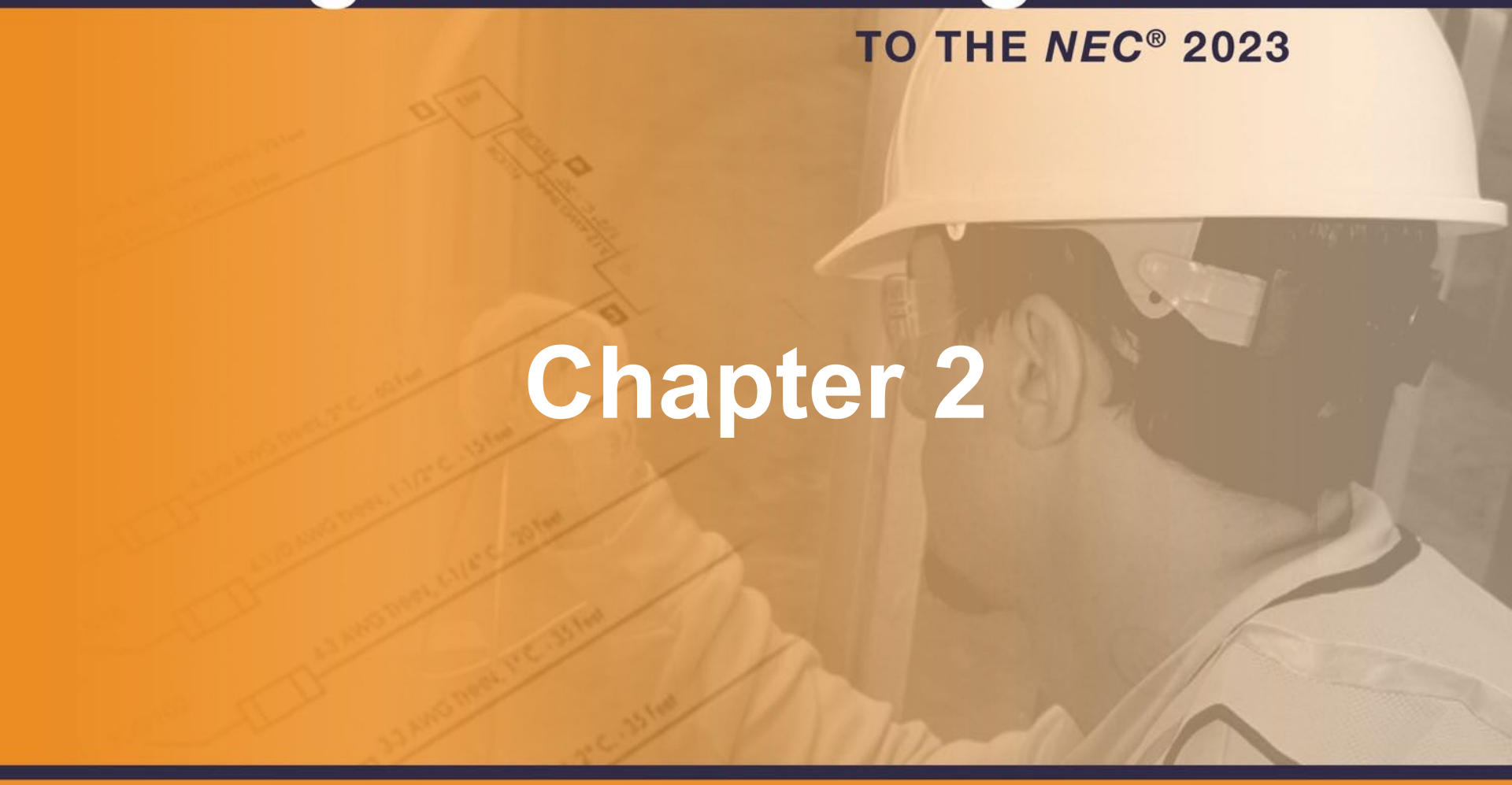


3059

© 2022 *electrical training ALLIANCE*

Significant Changes

TO THE *NEC*® 2023



Chapter 2

electrical training ALLIANCE IBEW - NECA IN COLLABORATION WITH NECA NATIONAL ELECTRICAL CONTRACTORS ASSOCIATION

200.2(A)

REVISION

General

Change Summary

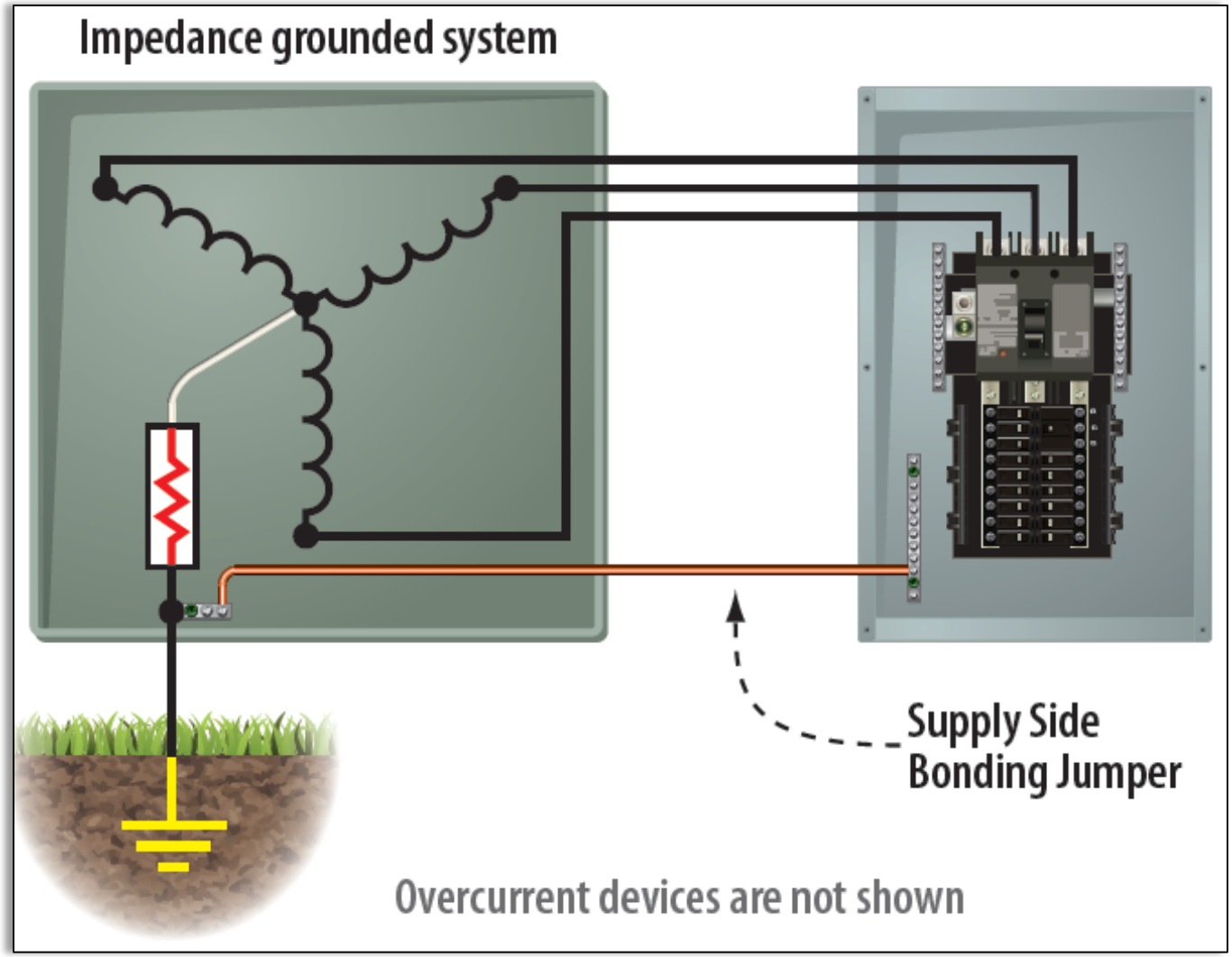
- This section was revised to correlate with the change in 250.36.
- “High-impedance grounded systems” are now referred to as “impedance grounded systems.”
- The grounded system conductor of impedance grounded systems is now referred to as the “impedance grounded conductor.” This section does not apply to the impedance grounded conductor.
- This section was changed from paragraph to list format.

3061

© 2022 *electrical training ALLIANCE*

200.2(A)

REVISION



© 2022 *electrical training ALLIANCE*

210.6(D) & (E)

REVISION RELOCATE

Branch Circuit Voltage Limitations

Change Summary

- The voltage limit in Section 210.6(D) was increased from 600 volts between conductors to 1,000 volts between conductors for consistency with other voltage limitations across the *Code*.
- The section has also been revised to reference a limit of 1,500 volts dc between conductors.
- Section 210.6(E) has been deleted.
- A new Article 235 has been created that will contain requirements for medium and high-voltage branch circuits, feeders, and services.

3063

© 2022 *electrical training ALLIANCE*

210.6(D) & (E)

REVISION RELOCATE



3064

© 2022 *electrical training ALLIANCE*

210.8

REVISION

GFCI Protection for Personnel

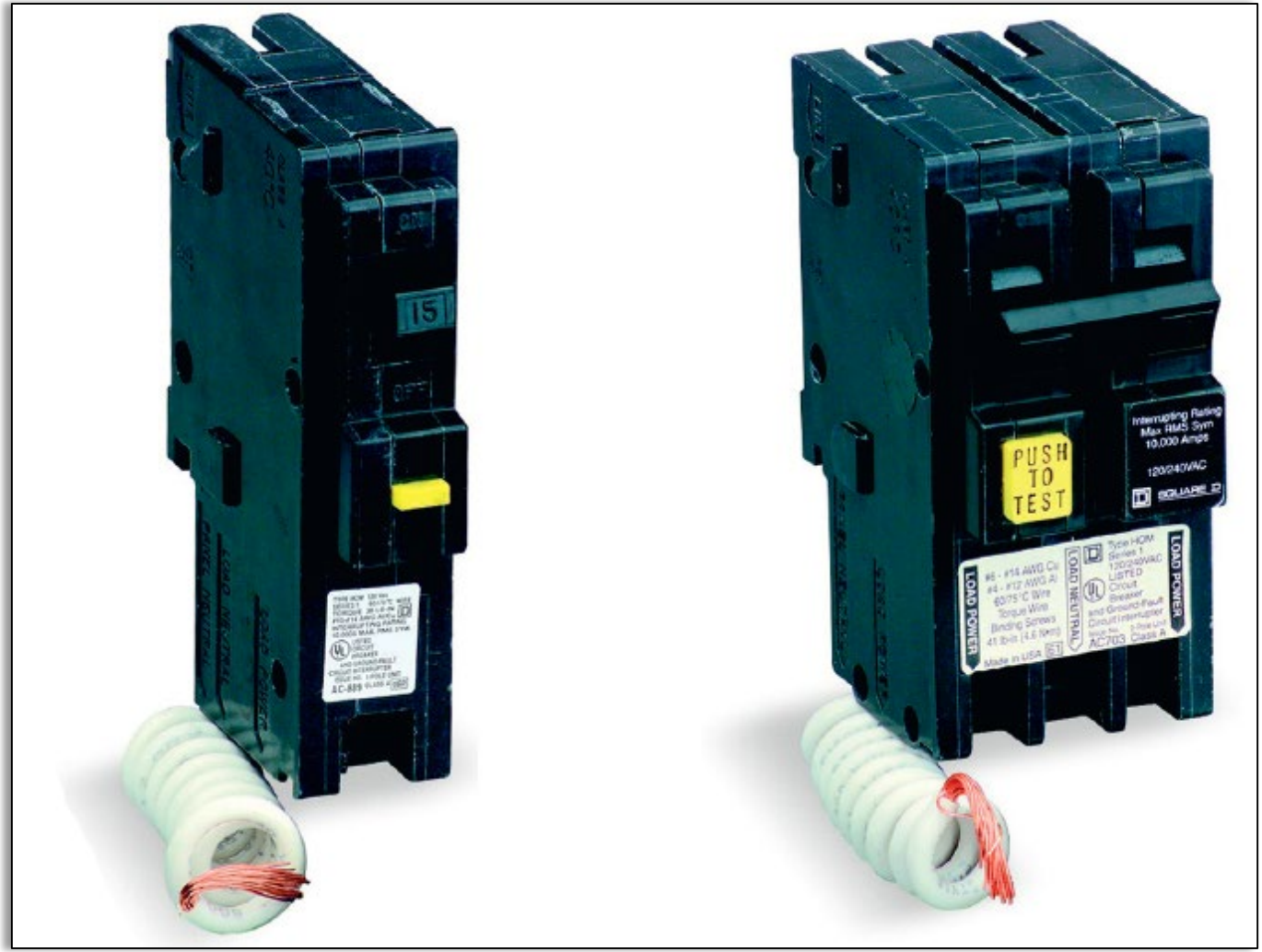
Change Summary

- The term *ground-fault circuit-interrupter protection for personnel* in the first sentence is replaced with the term *listed Class A GFCI*.
- Elsewhere in the section, the acronym GFCI is used to comply with the *NEC Style Manual*, which requires the use of acronyms where practical.
- The definition of “Ground-fault Circuit Interrupter (GFCI)” in Article 100 makes it clear that the term is used to describe a device that is intended to protect personnel. The informational note makes it clear that the device referred to is a Class A GFCI.

© 2022 *electrical training ALLIANCE*

210.8

REVISION



3066

© 2022 *electrical training ALLIANCE*

Courtesy of Schneider Electric

210.8(A)

REVISION

Dwelling Units

Change Summary

- The reference to fire alarm systems in an informational note to list item (5) has been deleted because it is covered in Article 760.
- GFCI requirements for kitchens now apply to all kitchen receptacles.
- GFCI requirements apply to any area of a dwelling unit with permanent provisions for food preparation, drink preparation, or cooking.
- Receptacles in bathroom exhaust fan assemblies that are not readily accessible do not require GFCI protection.

© 2022 *electrical training ALLIANCE*

210.8(A)

REVISION



3068

© 2022 *electrical training ALLIANCE*

210.8(B)

REVISION

Other Than Dwelling Units

Change Summary

- The GFCI requirements for other than dwelling units have been revised and clarified.
- List items (3) through (5) have been revised to clarify GFCI requirement for kitchens, food and beverage preparation and food serving areas, and any other preparation or food/beverage serving area where there is also cooking.
- A new requirement for GFCI protection of cord-and plug-connected fixed or stationary appliances has been added.
- A new GFCI requirement for receptacles within 6 feet of aquariums, bait wells, and similar open aquatic vessels or containers has been added.

3069

© 2022 *electrical training ALLIANCE*

210.8(B)

REVISION



3070

© 2022 *electrical training ALLIANCE*

210.8(D)

REVISION

GFCI Protection for Personnel-Specific Appliances

Change Summary

- In the 2020 *Code*, the determination of which appliances required GFCI protection was assigned to CMP 17, who placed them in 422.5.
- Section 422.5(A) specified several appliances that require GFCI protection. They could be protected via a branch circuit device, or they could be protected by a device in the cord.
- This section contained convoluted cross references to 422.5(A) for the list of appliances and 422.5(B) for the protection method.
- This revision brings back the list of appliances to 210.8, and it now requires GFCI protection of the branch circuit or the outlet.

3071

© 2022 *electrical training ALLIANCE*

210.8(D)

REVISION



3072

© 2022 *electrical training ALLIANCE*

210.8(F)

REVISION

GFCI Protection for Personnel-Outdoor Outlets

Change Summary

- The requirements of 210.8(F) have been revised to indicate that it applies to all outdoor outlets other than those covered by 210.8(A), Exception No. 1, rated 150 volts or less to ground, and 50 amperes or less.
- A list of four locations has been added to clarify which locations are included.
- If equipment supplied by one of the specified outlets is replaced, the outlet will now be required to be GFCI protected.
- Exception No. 2 does not require GFCI protection for listed HVAC equipment installed prior to September 1, 2026.

3073

© 2022 *electrical training ALLIANCE*

210.8(F)

REVISION



3074

© 2022 *electrical training ALLIANCE*

210.11(C)(4)

REVISION

Garage Branch Circuits

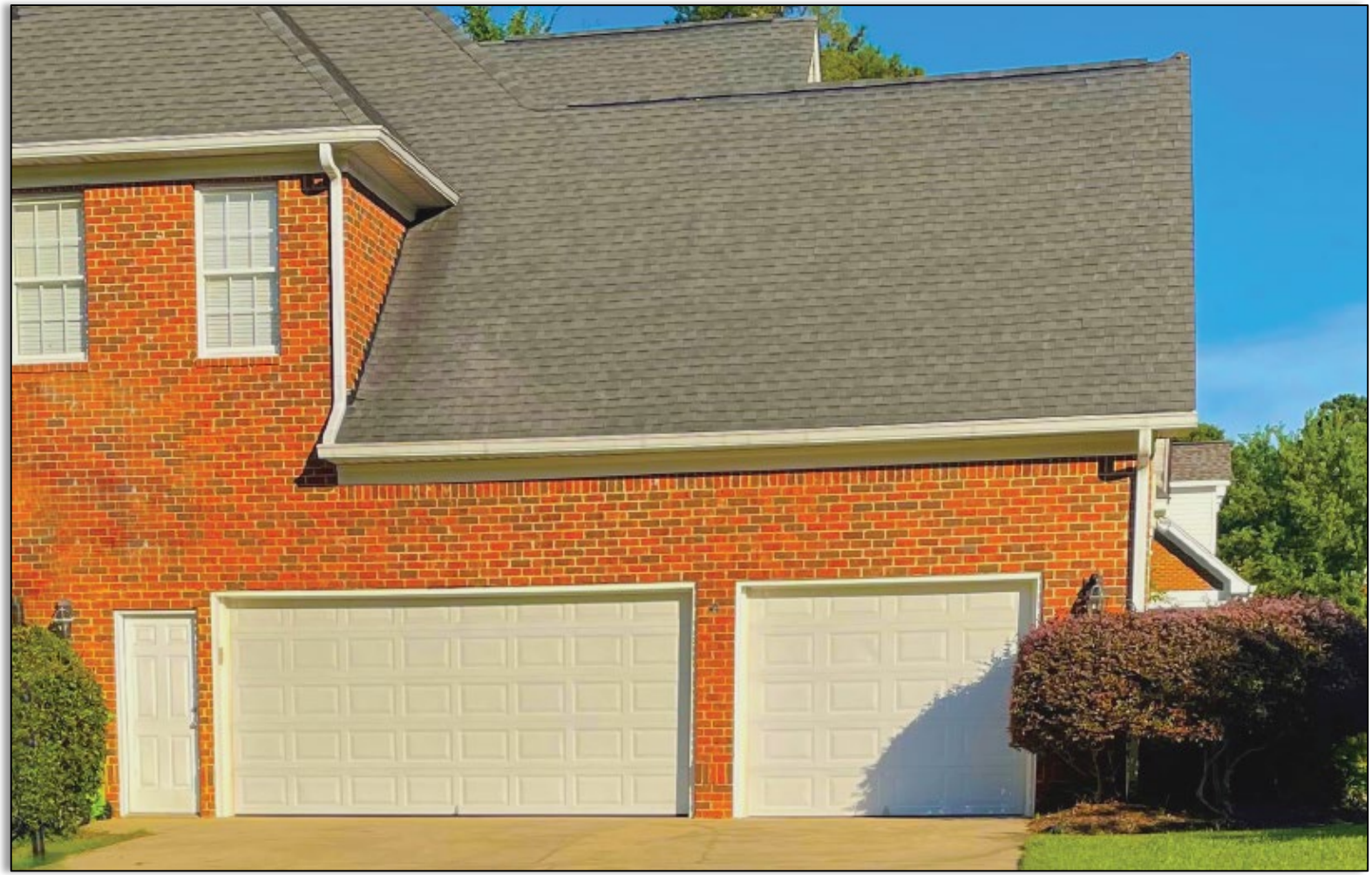
Change Summary

- Section 210.11(C)(4) was revised to clarify that garages must be supplied by at least one 20-ampere branch circuit for each vehicle bay. The circuits are NOT permitted to supply other garage receptacles.
- In a single-vehicle bay garage, the circuit is permitted to supply other outlets.
- The 20-ampere branch circuit was previously permitted to supply only readily accessible outdoor receptacle outlets. Exception No. 1 was revised to permit it to supply outdoor receptacle outlets.
- Additional branch circuits rated 15 amperes are permitted to supply other receptacle outlets.

© 2022 *electrical training ALLIANCE*

210.11(C)(4)

REVISION



3076

© 2022 *electrical training ALLIANCE*

210.12

REVISION

Arc-Fault Circuit-Interrupter Protection

Change Summary

- The main rule of 210.12 was rewritten to align with changes made to the subsections of 210.12, including a new requirement that all AFCIs be listed.
- The title of 210.12(A) was changed to “means of protection.” Information regarding the specific areas of the dwelling unit requiring AFCI protection has been moved into 210.12(B).
- Section 210.12(B), (C), and (D) have been changed into lists.
- Section 210.12(F) has been added to require AFCI protection of 120-volt, single-phase 15- and 20-ampere receptacles in areas designed exclusively for sleeping in fire stations, stations for rescue squads, and police stations.

3077

© 2022 *electrical training ALLIANCE*

210.12

REVISION



3078

© 2022 *electrical training ALLIANCE*

210.18

REVISION

Rating

Change Summary

- Section 210.18 now recognizes 10-ampere individual branch circuits.
- Exception No. 1 has been revised to permit individual branch circuits greater than 50 amperes that supply non-lighting loads in locations with conditions of maintenance to ensure that only qualified persons service the installations. This had previously been limited to industrial locations.
- A new Exception No. 2 was added that prohibits 10-ampere branch circuits from serving receptacle outlets.

© 2022 *electrical training ALLIANCE*

210.18

REVISION



© 2022 *electrical training ALLIANCE*

210.19

REVISION RELOCATE

Conductors – Minimum Ampacity and Size

Change Summary

- New branch circuit voltage limits have been added for ac and dc circuits.
- Section 210.19 now applies to branch circuits not exceeding 1,000 volts ac and 1,500 volts dc.
- The requirements for branch circuits exceeding 1,000 volts ac and 1,500 volts dc have been removed from this section and relocated to Article 235.
- There are several minor editorial changes to comply with the *NEC Style Manual*.

3081

© 2022 *electrical training ALLIANCE*

210.19

REVISION RELOCATE



3082

© 2022 electrical training ALLIANCE

Courtesy of Bill McGovern, City of Plano, TX

210.23

REVISION

Permissible Loads, Multiple-Outlet Branch Circuits

Change Summary

- New requirements have been added to 210.23(A) for 10-ampere branch circuits.
- This section contains an ascending list from the smallest sized branch circuit to the largest. Therefore, the 10-ampere branch circuits appear first.
- 210.23(A)(1) lists the types of loads that are permitted to be supplied by a 10-ampere branch circuit, while 210.23(A)(2) lists the loads that are not permitted to be supplied by a 10-ampere branch circuit.

© 2022 *electrical training ALLIANCE*

210.23

REVISION



3084

© 2022 *electrical training ALLIANCE*

210.52(A)(2)

REVISION

Wall Space

Change Summary

- The criteria for what is considered wall space that requires receptacles in dwelling units has been revised.
- Since there are wall spaces where receptacle installation is impractical, Section 210.52(A)(2) spells out which spaces must be considered wall space for receptacles.
- The space behind stationary appliances has been added to 210.52(A)(2)(1) to indicate that the wall space behind stationary appliances need not be considered as wall space that requires receptacles.

© 2022 *electrical training ALLIANCE*

210.52(A)(2)

REVISION



3086

© 2022 *electrical training ALLIANCE*

210.52(C)

REVISION

Countertops and Work Surfaces

Change Summary

- A new exception was added to 210.52(C)(1) for countertops with wall space where a receptacle cannot be installed in the required wall space to permit installation as near as practicable.
- Receptacles are no longer required in 210.52(C)(2) for island and peninsular counter tops. If not installed, provision is required for a future installation.
- Receptacles are permitted to be in or on but not below countertops.

© 2022 *electrical training ALLIANCE*

210.52(C)

REVISION



3088

© 2022 *electrical training ALLIANCE*

Courtesy of ABB Inc.

210.70

REVISION

Lighting Outlets Required

Change Summary

- Section 210.70 has been revised to make it clear that switches of control devices are not permitted to rely only on battery power unless the lighting outlets are energized upon battery failure.
- A lighting outlet that is controlled by a listed wall-mounted control device is now required in laundry areas of dwelling units.
- A lighting outlet is required for exterior illumination of exits or entrances of dwelling units, attached garages, and detached garages with power. This does not apply to doors for vehicles.
- Dimmer control of lighting in accordance with 210.70(A)(3) is not permitted, unless the listed control devices can provide dimming control that can provide maximum brightness at each location for stairway illumination.

3089

© 2022 *electrical training ALLIANCE*

210.70

REVISION



3090

© 2022 *electrical training ALLIANCE*

215.15

NEW

Barriers

Change Summary

- The widespread acceptance of *NFPA 70E, Electrical Safety in the Workplace*, has brought attention to the need to prevent electrical hazards that can exist while trying to establish an electrically-safe work condition.
- In the 2020 *Code*, the requirements for barriers in panelboards, switchboards, and switchgear were relocated from 408.3(A)(2) to 230.62(C), where they only applied to services.
- A similar hazard exists for panelboards, switchboards, switchgear, and motor control centers that are supplied by feeders or transformer secondary conductors.

© 2022 *electrical training ALLIANCE*

215.15

NEW



3092

© 2022 *electrical training ALLIANCE*

215.18

NEW

Surge Protection

Change Summary

- During the 2020 *Code* cycle, a new surge protection requirement was added for dwelling unit services in 230.67 (expanded for 2023).
- Surge protection is now required for feeders that supply dwelling units, dormitory units, guest rooms and guest suites of hotels and motels, and patient sleeping rooms of nursing homes and limited care facilities.
- The use of sensitive electronic equipment in these newly added areas, supplied by services, is identical to its usage in dwelling units.
- A similar requirement was adopted in 225.42 for outside feeders.

© 2022 *electrical training ALLIANCE*

215.18

NEW



© 2022 *electrical training ALLIANCE*

Article 220

REORGANIZE

Article 220 Reorganization

Change Summary

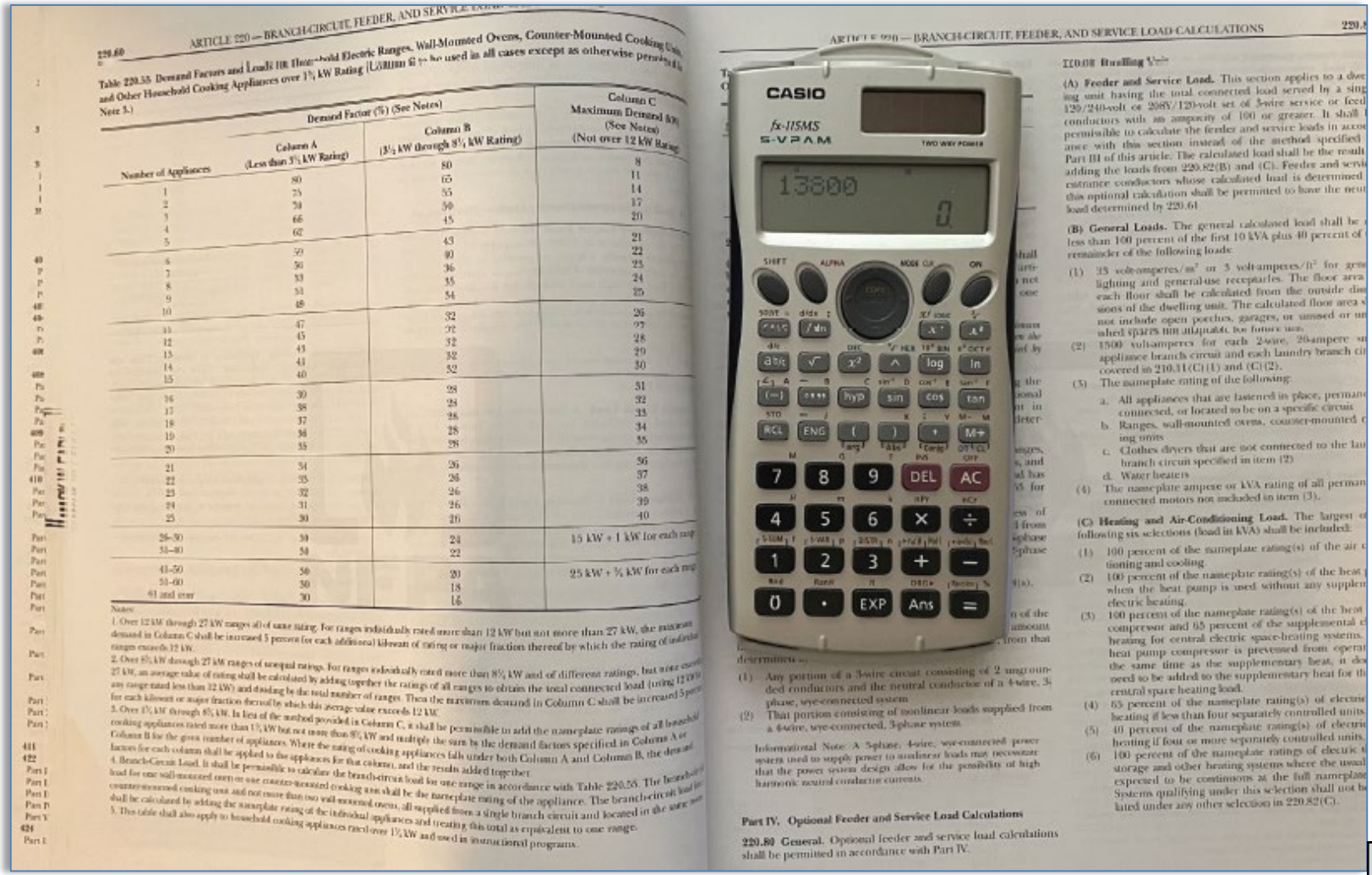
- Article 220 has been rewritten to improve its usability. This change covers the reorganization only.
- Requirements that were in 220.11 and 220.10 were moved from Part II, Branch-Circuit Load Calculations, to Part I, General.
- Section 220.12 was relocated to Part III because it addresses feeder and service load calculations.
- Sections 220.14(J), (K), and (M) were relocated to 220.41, 220.43, and 220.44, respectively, because they deal with loads.

3095

© 2022 *electrical training ALLIANCE*

Article 220

REORGANIZE



220.60 ARTICLE 220 — BRANCH-CIRCUIT, FEEDER, AND SERVICE LOAD CALCULATIONS

Table 220.55 Demand Factors and Loads for Household Electric Ranges, Wall-Mounted Ovens, Counter-Mounted Cooking Units, and Other Household Cooking Appliances over 1¾ kW Rating (Column C to be used in all cases except as otherwise permitted in Note 3.)

Number of Appliances	Demand Factor (%) (See Notes) Column A (Less than 3½ kW Rating)	Column B (3½ kW through 8¾ kW Rating)	Column C Maximum Demand (kW) (See Notes) (Not over 12 kW Rating)
1	80	80	8
2	75	65	11
3	70	55	14
4	66	50	17
5	62	45	20
6	59	43	21
7	56	40	22
8	53	36	23
9	51	35	24
10	48	34	25
11	47	32	26
12	45	32	27
13	43	32	28
14	43	32	29
15	40	32	30
16	39	28	31
17	38	28	32
18	37	28	33
19	36	28	34
20	35	28	35
21	34	26	36
22	33	26	37
23	32	26	38
24	31	26	39
25	30	26	40
26–30	30	24	15 kW + 1 kW for each range
31–40	30	22	
41–50	30	20	25 kW + ¾ kW for each range
51–60	30	18	
61 and over	30	16	

Notes:
1. Over 12 kW through 27 kW ranges all of same rating. For ranges individually rated more than 12 kW but not more than 27 kW, the maximum demand in Column C shall be increased 5 percent for each additional kilowatt of rating or major fraction thereof by which the rating of individual ranges exceeds 12 kW.
2. Over 8¾ kW through 27 kW ranges of unequal ratings. For ranges individually rated more than 8¾ kW and of different ratings, but none exceeding 27 kW, an average value of rating shall be calculated by adding together the ratings of all ranges to obtain the total connected load (using 12 kW for any range rated less than 12 kW) and dividing by the total number of ranges. Then the maximum demand in Column C shall be increased 5 percent for each kilowatt or major fraction thereof by which this average value exceeds 12 kW.
3. Over 1¾ kW through 8¾ kW. In lieu of the method provided in Column C, it shall be permissible to add the nameplate ratings of all household cooking appliances rated more than 1¾ kW but not more than 8¾ kW and multiply the sum by the demand factors specified in Column A or Column B for the given number of appliances. Where the rating of cooking appliances falls under both Column A and Column B, the demand factors for each column shall be applied to the appliances for that column, and the results added together.
4. Branch-Circuit Load. It shall be permissible to calculate the branch-circuit load for one range in accordance with Table 220.55. The branch-circuit load for one wall-mounted oven or one counter-mounted cooking unit shall be the nameplate rating of the appliance. The branch-circuit load for two wall-mounted ovens or two counter-mounted cooking units shall be the combined nameplate rating of the two appliances. If the two units have a combined rating of less than 3½ kW, the load shall be calculated by adding the nameplate rating of the individual appliances and treating this total as equivalent to one range.
5. This table shall also apply to household cooking appliances rated over 1¾ kW and used in instructional programs.

ARTICLE 220 — BRANCH-CIRCUIT, FEEDER, AND SERVICE LOAD CALCULATIONS 220.8

II.0.0 Dwelling U...

(A) Feeder and Service Load. This section applies to a dwelling unit having the total connected load served by a single 120/240-volt or 208Y/120-volt set of 3-wire service or feeder conductors with an ampacity of 100 or greater. It shall be permissible to calculate the feeder and service loads in accordance with this section instead of the method specified in Part III of this article. The calculated load shall be the result of adding the loads from 220.82(B) and (C). Feeder and service entrance conductors whose calculated load is determined by this optional calculation shall be permitted to have the neutral load determined by 220.61.

(B) General Loads. The general calculated load shall be not less than 100 percent of the first 10 kVA plus 40 percent of the remainder of the following loads:

(1) 33 volt-amperes/m² or 3 volt-amperes/ft² for general lighting and general-use receptacles. The floor area for each floor shall be calculated from the outside dimensions of the dwelling unit. The calculated floor area shall not include open porches, garages, or unused or unfinished spaces not adaptable for future use.

(2) 1500 volt-amperes for each 2-wire, 20-ampere small-appliance branch circuit and each laundry branch circuit covered in 210.11(C)(1) and (C)(2).

(3) The nameplate rating of the following:

a. All appliances that are fastened in place, permanently connected, or located to be on a specific circuit
b. Ranges, wall-mounted ovens, counter-mounted cooking units
c. Clothes dryers that are not connected to the laundry branch circuit specified in item (2)
d. Water heaters

(4) The nameplate ampere or kVA rating of all permanently connected motors not included in item (3).

(C) Heating and Air-Conditioning Load. The largest of the following six selections (load in kVA) shall be included:

(1) 100 percent of the nameplate rating(s) of the air conditioning and cooling.

(2) 100 percent of the nameplate rating(s) of the heat pump when the heat pump is used without any supplemental electric heating.

(3) 100 percent of the nameplate rating(s) of the heat pump compressor and 65 percent of the supplemental electric heating for central electric space-heating systems. If the heat pump compressor is prevented from operating at the same time as the supplementary heat, it does not need to be added to the supplementary heat for the central space heating load.

(4) 65 percent of the nameplate rating(s) of electric space heating if less than four separately controlled units.

(5) 40 percent of the nameplate rating(s) of electric space heating if four or more separately controlled units.

(6) 100 percent of the nameplate ratings of electric thermal storage and other heating systems where the usual load is expected to be continuous at the full nameplate value. Systems qualifying under this selection shall not be required to be calculated under any other selection in 220.82(C).

determined ...

(1) Any portion of a 3-wire circuit consisting of 2 ungrounded conductors and the neutral conductor of a 4-wire, 3-phase, wye-connected system

(2) That portion consisting of nonlinear loads supplied from a 4-wire, wye-connected, 3-phase system

Informational Note: A 3-phase, 4-wire, wye-connected power system used to supply power to nonlinear loads may necessitate that the power system design allow for the possible of high harmonic neutral conductor currents.

Part IV. Optional Feeder and Service Load Calculations

220.80 General. Optional feeder and service load calculations shall be permitted in accordance with Part IV.

3096

© 2022 *electrical training ALLIANCE*

220.5(C)

REVISION

Floor Area

Change Summary

- Section 220.11 has been relocated from Part II of Article 220 to become 220.5(C).
- Garages and unfinished spaces, as well as unused spaces, are now included in the floor area calculations.
- Open porches continue to not be included in the floor area calculation if they cannot be adapted for future use as a habitable room or occupiable space.

© 2022 *electrical training ALLIANCE*

220.5(C)

REVISION



3098

© 2022 *electrical training ALLIANCE*

220.42

REVISION

Lighting Load for Non-Dwelling Occupancies

Change Summary

- The lighting load requirements for non-dwelling occupancies have been moved from Part II to Part III, Feeder and Service Load Calculations.
- The informational note to 200.42(A) points out that unit load conditions of the table are now based on minimum load conditions and 80% power factor, not 100%, as previously indicated. These values might not provide sufficient capacity.
- The note to the table has been revised to make it clear that no additional multiplier is required for the unit loads.

© 2022 *electrical training ALLIANCE*

220.42

REVISION



3100

© 2022 *electrical training ALLIANCE*

220.50

REVISION

Motors and Air-Conditioning Equipment

Change Summary

- The title of Section 220.50 has been changed to “Motors and Air-Conditioning Equipment” to reflect the fact that it also provides a reference to the requirements for hermetic refrigerant motor-compressors.
- The section has been reformatted to clearly delineate the requirements for motors from those for air-conditioning equipment.
- The air-conditioning requirements now reference all of Part IV of Article 440 for sizing of the branch circuit conductors.

© 2022 *electrical training ALLIANCE*

220.50

REVISION



© 2022 *electrical training ALLIANCE*

220.53

REVISION

Appliance Load – Dwelling Units

Change Summary

- Section 220.53 permits a demand factor of 75% to be applied to the nameplate rating of four or more appliances fastened in place rated at least ¼ horsepower or 500 watts.
- Electric vehicle supply equipment has been added to the list of loads that are not permitted to have a reduced demand factor.
- Section 625.41 requires that the EVSE branch circuit be sized for continuous duty loads.

© 2022 *electrical training ALLIANCE*

220.53

REVISION



© 2022 *electrical training ALLIANCE*

220.57

NEW

Electric Vehicle Supply Equipment (EVSE) Load

Change Summary

- A new requirement has been added for sizing the load for electric vehicle supply equipment.
- The load must be sized at 7,200 volt-amperes or the nameplate rating of the equipment, whichever is larger.
- An informational note was added to reference 625.42, which provides the requirement for sizing an EVSE circuit.

© 2022 *electrical training ALLIANCE*

220.57

NEW



© 2022 *electrical training ALLIANCE*

220.60

REVISION

Noncoincident Loads

Change Summary

- This section covers requirements for calculating noncoincident loads on feeders and services. Noncoincident loads are loads that are unlikely to be used simultaneously, such as heating and air conditioning.
- The largest of the loads is permitted to be used for calculating the size of the feeder or service.
- Where a motor or air-conditioning load is part of the noncoincident load and is not the largest of the noncoincident loads, 125% of the larger of the motor load or the air-conditioning load must be used.

© 2022 *electrical training ALLIANCE*

220.60

REVISION



© 2022 *electrical training ALLIANCE*

220.70

NEW

Energy Management Systems (EMSs)

Change Summary

- Section 220.70 will allow listed energy management systems to be used to limit the load on feeders or services.
- Upon malfunction, the EMS must disconnect the loads.
- Access to the settings must be restricted to authorized personnel in accordance with 750.30(C)(3).
- There are field marking requirements indicating the maximum current setting, the date of the calculation and setting, and identification of current-limited loads and sources.

© 2022 *electrical training ALLIANCE*

220.70

NEW



© 2022 *electrical training ALLIANCE*

220.110

NEW

Receptacle Loads – Health Care Facilities

Change Summary

- Demand factors for receptacle loads in health care facilities have been added in 220.110, which is located in the new Part VI, Health Care Facilities.
- These new requirements are based on receptacle load data from health care facilities.
- Since load calculations and demand factors are found in Article 220, the demand factors are referenced in 517.22.

© 2022 *electrical training ALLIANCE*

220.110

NEW



© 2022 *electrical training ALLIANCE*

220.120

REVISION

Receptacle Loads

Change Summary

- Table 555.6 has been relocated to 220.120.
- The relocation of demand factors is consistent with the decision to place requirements for demand factors in health care facilities into 220.110.
- Note No. 2 was revised to provide a method for shore power load calculations for slips using individual kilowatt-hour submeters.
- A new note has been added to the table that notes that if a circuit feeds a boat hoist and shore power for the same boat slip, only the load with the larger demand factor must be counted in the calculation because the loads are not coincident.

© 2022 *electrical training ALLIANCE*

220.120

REVISION



3114

© 2022 *electrical training ALLIANCE*

225.41

NEW

Emergency Disconnects

Change Summary

- One- and two-family dwelling units that are supplied by a feeder now require an emergency disconnect that is installed in an outdoor, readily accessible location.
- If more than one disconnect is required, they must be grouped.
- The disconnecting means must be marked “EMERGENCY DISCONNECT.”
- The disconnect marking is required to be on the outside front of the enclosure. The label must be red with white lettering.

© 2022 *electrical training ALLIANCE*

225.41

NEW



© 2022 *electrical training ALLIANCE*

225.42

NEW

Surge Protection

Change Summary

- During the 2020 cycle, a new surge protection requirement was added for dwelling unit services in 230.67 (expanded for 2023).
- Surge protection is now required for outside feeders that supply dwelling units, dormitory units, guest rooms and guest suites of hotels and motels, and patient sleeping rooms of nursing homes and limited care facilities.
- A similar requirement is now located in 215.18 for feeders.
- There is no exception for outside feeder equipment for remotely-located SPD protection for upstream feeder or service equipment.

© 2022 *electrical training ALLIANCE*

225.42

NEW



© 2022 *electrical training ALLIANCE*

230.7

REVISION

Other Conductors

Change Summary

- Service conductors have been prohibited from being in the same cable or raceway with branch-circuit or feeder conductors.
- Service conductors are now also prohibited from being installed in underground boxes or handhole enclosures with branch-circuit or feeder conductors.
- Intermingling service conductors with other conductors is a hazard to workers and to connected equipment.
- Grounding electrode conductors and supply-side bonding jumpers are permitted in the same raceway or enclosure as the service conductors.

© 2022 *electrical training ALLIANCE*

230.7

REVISION



© 2022 *electrical training ALLIANCE*

230.24(A)

REVISION

Above Roofs

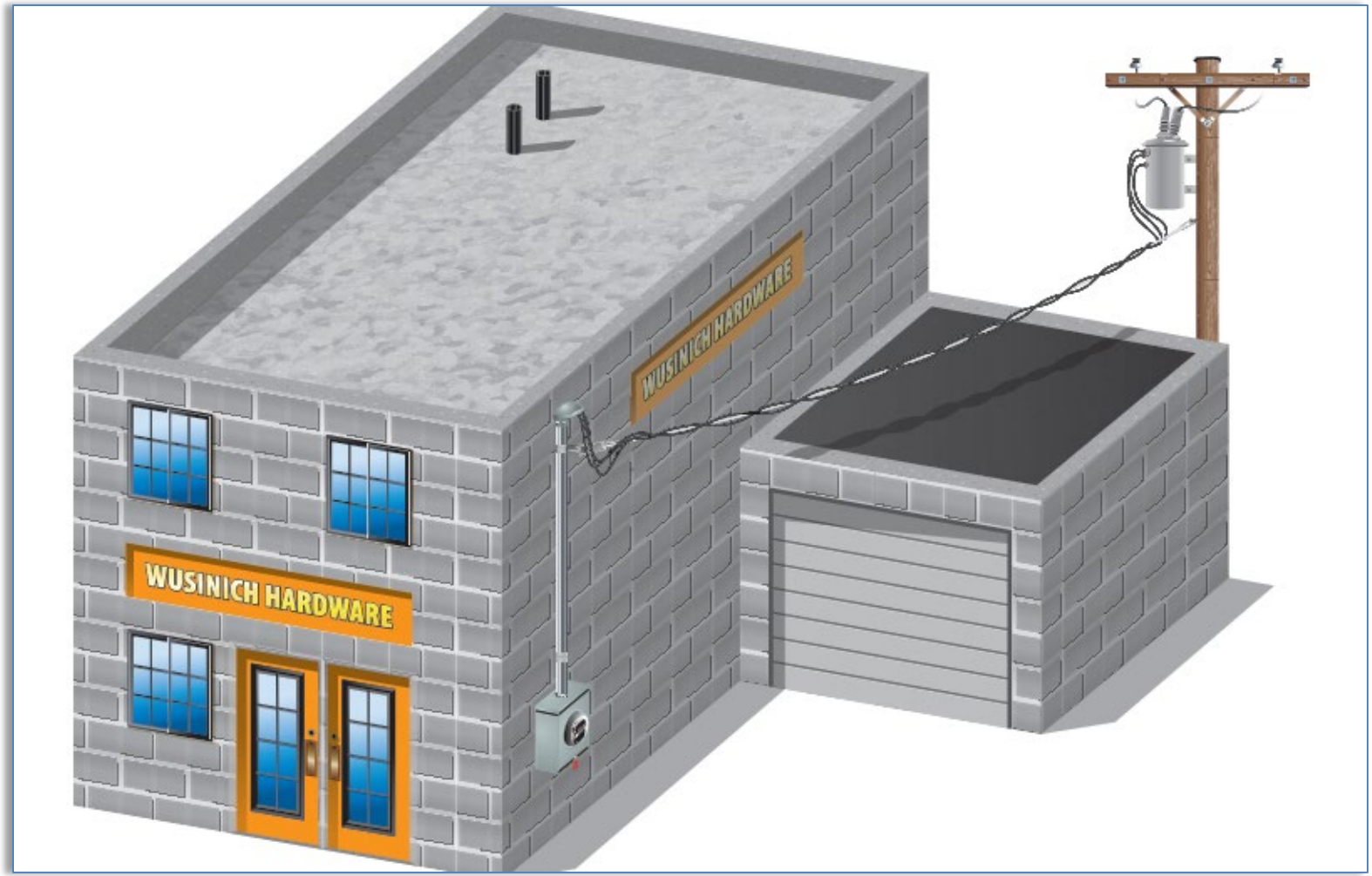
Change Summary

- The requirement for the minimum vertical clearance of overhead conductors above a roof surface has been increased from 2.5 meters (8 ft.) to 2.6 meters (8 ft. 6 in.)
- The vertical clearance extends 3 feet in every direction from the edge of the roof.
- The minimum clearance requirement for service conductors was less than for feeder conductors. Service conductors would be a greater hazard to workers on roofs than feeder conductors.
- The metric conversion in 225.19(A) was incorrect in the last edition of the *Code*.

© 2022 *electrical training ALLIANCE*

230.24(A)

REVISION



© 2022 *electrical training ALLIANCE*

230.43

REVISION

Wiring Methods for 1000 Volts, Nominal, or Less

Change Summary

- The list of permitted wiring methods for service entrance conductors has been revised.
- Type TC-ER cable is permitted where it is identified for use as service conductors.
- Flexible bus systems are a new wiring method that is now permitted for services.
- Article 371 provides installation requirements for flexible bus systems.

© 2022 *electrical training ALLIANCE*

230.43

REVISION



© 2022 *electrical training ALLIANCE*

230.62(C)

REVISION

Barriers

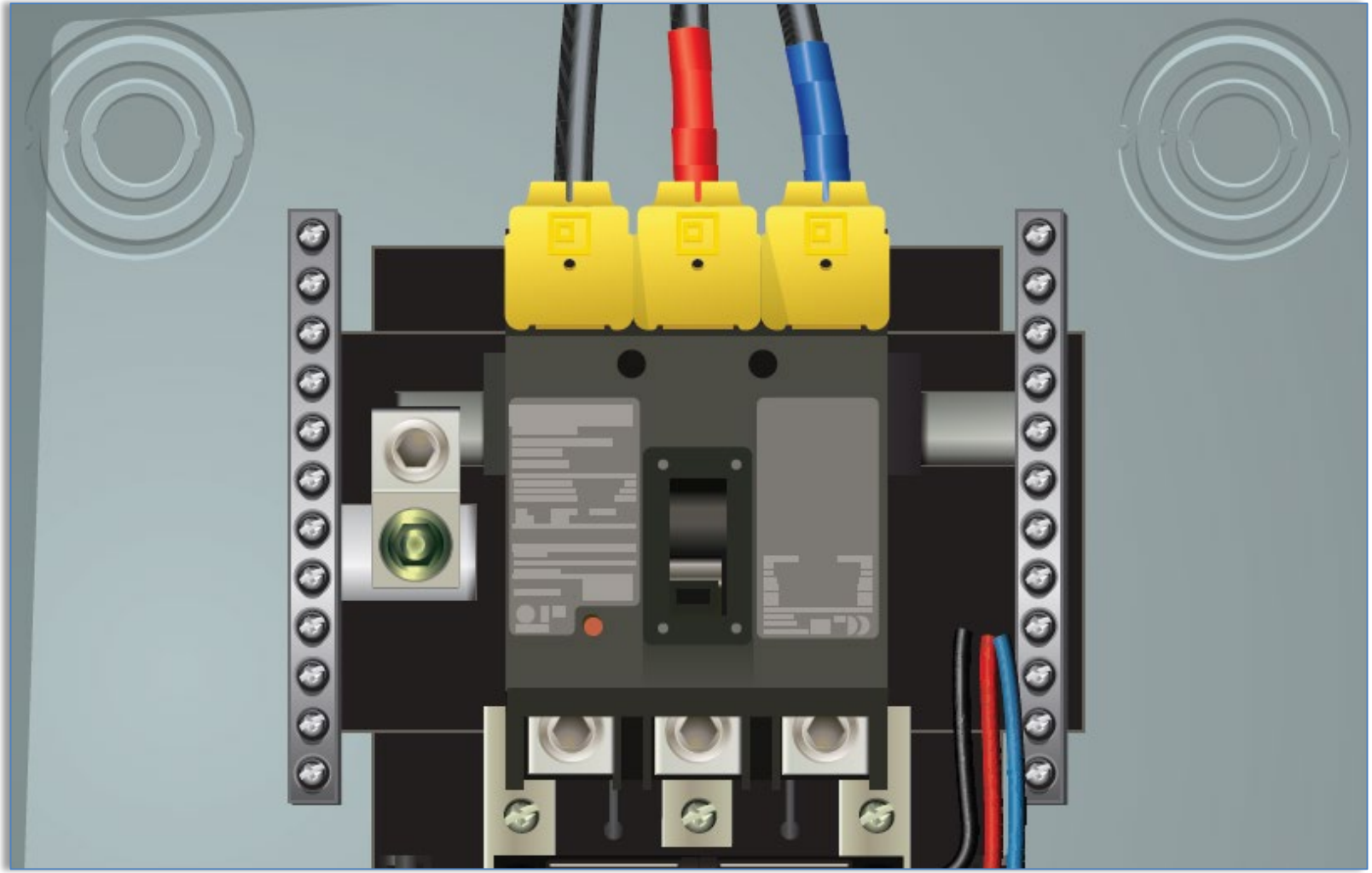
Change Summary

- Barriers are required in service equipment to minimize the likelihood of inadvertent contact with uninsulated, and ungrounded, service busbars and terminals.
- This requirement has been revised to make it clear that the requirement applies to protection from contact when the service disconnect is in the open position.
- The conductors and terminals being protected by barriers will remain energized when the service disconnect is in the open position.

© 2022 *electrical training ALLIANCE*

230.62(C)

REVISION



© 2022 *electrical training ALLIANCE*

230.67

REVISION

Surge Protection

Change Summary

- Surge protection will now be required to be provided in service equipment for dormitories, guest rooms and guest suites of hotels and motels, and sleeping areas of nursing homes and limited care facilities.
- With the expansion of the requirements, the section was reformatted into list format.
- Surge protective devices must have a nominal discharge current rating of not less than 10 kA.

© 2022 *electrical training ALLIANCE*

230.67

REVISION







© 2022 *electrical training ALLIANCE*

230.71(B)

REVISION

Two to Six Service Disconnecting Means

Change Summary

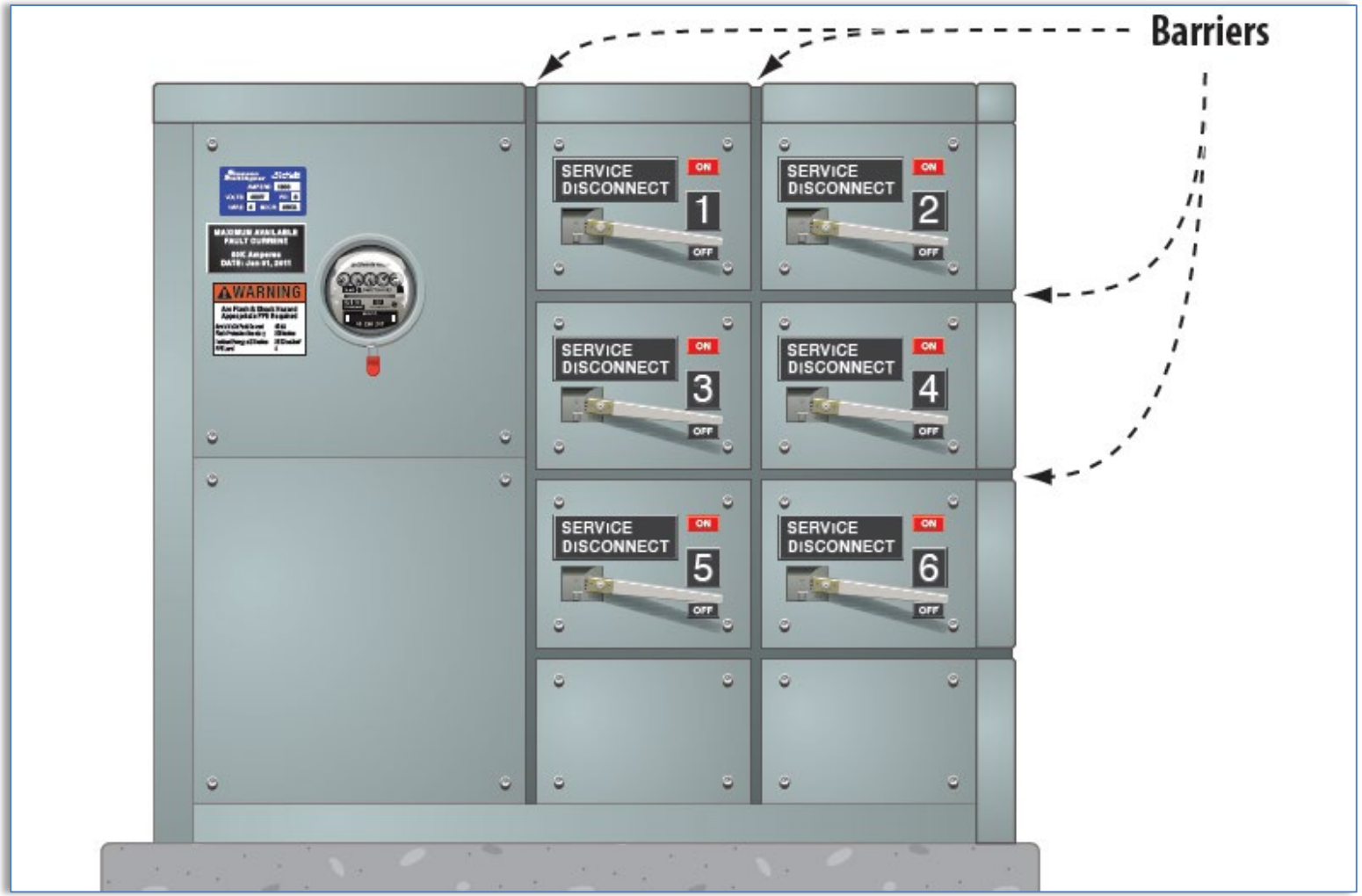
- The requirements for barriers in vertical sections of switchboards were clarified.
- Transfer switches in service equipment are now required to be in separate compartments.
- Barriers between a service disconnect for a motor control center and motor disconnects are now required.
- An exception was added that permits the addition of service disconnects (up to six) in a single enclosure in an existing installation that was installed in compliance with editions of the *Code* prior to 2020.

3129

© 2022 *electrical training ALLIANCE*

230.71(B)

REVISION



3130

© 2022 *electrical training ALLIANCE*

230.85

REVISION

Emergency Disconnects

Change Summary

- Section 230.85 was rewritten into a list format and the language was clarified.
- An exception was added to not require an outdoor service disconnect to be readily accessible, where an outdoor feeder disconnect is installed in accordance with 225.41.
- If multiple disconnects are required, they must be grouped.
- If disconnects are replaced, all of the requirements of this section apply. However, the exception to (C) permits some repairs.

© 2022 *electrical training ALLIANCE*

230.85

REVISION



3132

© 2022 *electrical training ALLIANCE*

Article 235

NEW

Branch Circuits, Feeders, and Services Over 1000 Vac…

Change Summary

- A new Article 235 has been created that covers requirements for branch circuits, feeders, and services over 1,000 volts ac or over 1,500 volts dc.
- This change is intended to locate the medium-voltage requirements to improve usability and clarity.
- Corresponding requirements have been deleted from Articles 210, 215, and 230.

© 2022 *electrical training ALLIANCE*

Article 235

NEW



© 2022 *electrical training ALLIANCE*

240.2

NEW

Reconditioned Equipment

Change Summary

- Section 240.2 has been created to indicate which equipment is permitted to be reconditioned.
- Equipment not permitted to be reconditioned includes GFPE, GFCI, low-voltage fuseholders, low-voltage nonrenewable fuses, molded-case circuit breakers, and low-voltage circuit breaker electronic trip units.
- Equipment permitted to be reconditioned includes low-voltage power circuit breakers, electromechanical relays, and current transformers.
- Reconditioned equipment covered by Article 240 must be listed.

© 2022 *electrical training ALLIANCE*

240.2

NEW



3136

© 2022 *electrical training ALLIANCE*

Courtesy of Eaton

240.4(B)

REVISION

Overcurrent Devices Rated 800 Amperes or Less

Change Summary

- Conductors must be protected from overcurrent in accordance with their ampacity. Where the ampacity does not equal a standard OCPD rating, the next standard size (not to exceed 800 amperes) is permitted to be used in accordance with 240.4(B).
- An adjustable trip OCPD is permitted to be used as long as the setting does not exceed the next standard rating size above the conductor ampacity.
- The means to adjust the setting of the adjustable trip mechanism must have restricted access in accordance with 240.6(C).

3137

© 2022 *electrical training ALLIANCE*

240.4(B)

REVISION



3138

© 2022 *electrical training ALLIANCE*

Courtesy of Michael J. Johnston

240.6(D)

NEW

Remotely Adjustable Trip Circuit Breakers

Change Summary

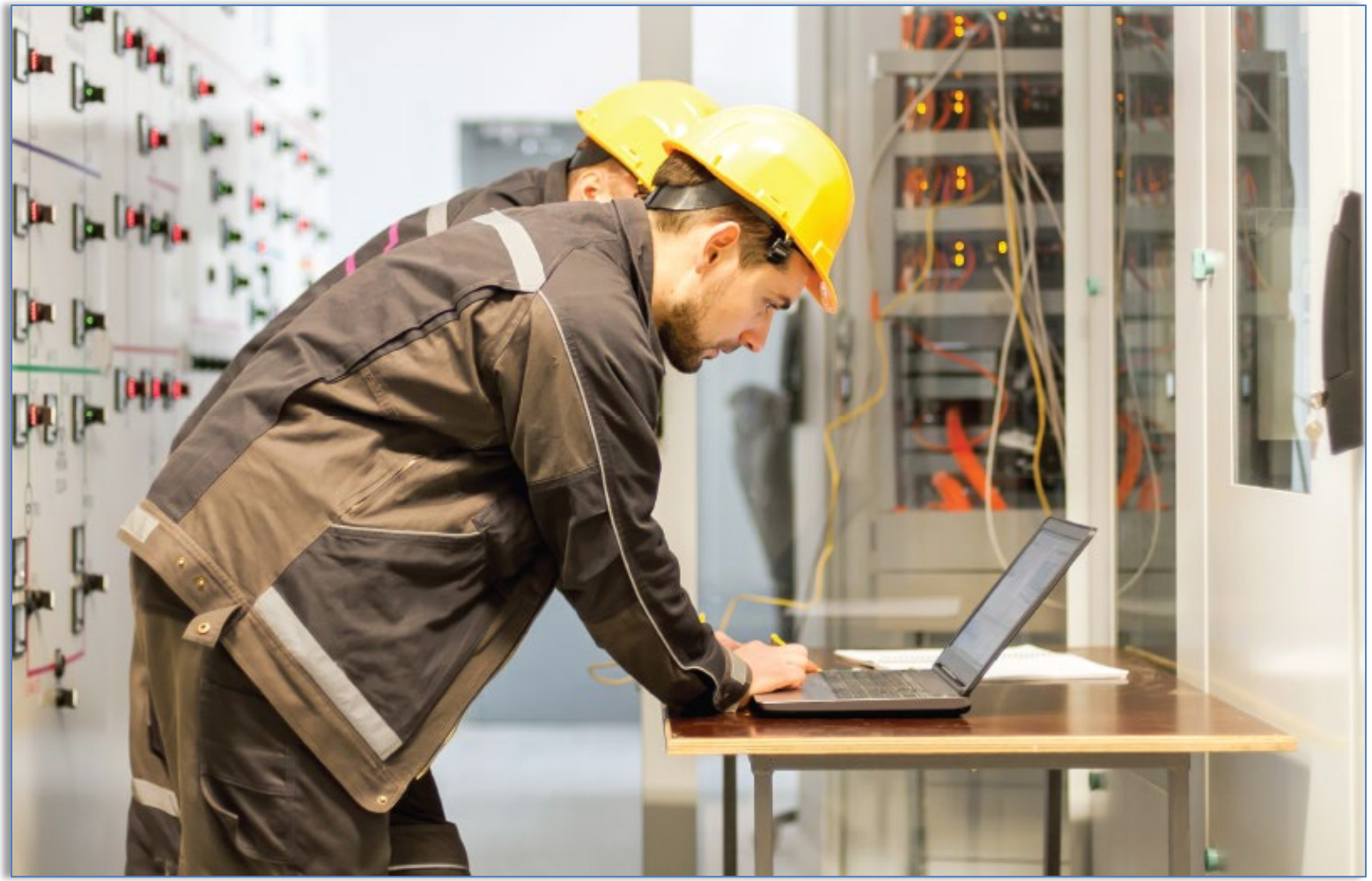
- Remotely adjustable circuit breakers are permitted to have an ampere rating that is equal to the adjusted current setting (long-time pickup setting).
- Access can be achieved directly through a local nonnetworked interface or through a networked interface where the circuit breaker and software are identified as being evaluated for cybersecurity or the network has had a documented cybersecurity assessment.
- Two informational notes were added that reference cybersecurity standards and recognized methods of commissioning to identify cyber threats.
- A third informational note points out that continuous vigilance is necessary.

3139

© 2022 *electrical training ALLIANCE*

240.6(D)

NEW



© 2022 *electrical training ALLIANCE*

240.7

NEW

Listing Requirements

Change Summary

- Branch-circuit overcurrent protective devices are now required to be listed.
- The listing standards include *UL 499 Standard for Safety: Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures*, and *UL 1066 Standard for Safety: Low-Voltage AC and DC Power Circuit Breakers Used in Enclosures.*
- Products that are not listed must be evaluated for safety in accordance with 110.3(A) as the basis for approval by the AHJ. Jurisdictions do not have the facilities to properly evaluate circuit breakers.

© 2022 *electrical training ALLIANCE*

240.7

NEW



3142

© 2022 *electrical training ALLIANCE*

Courtesy of Michael J. Johnston

240.11

NEW

Selective Coordination

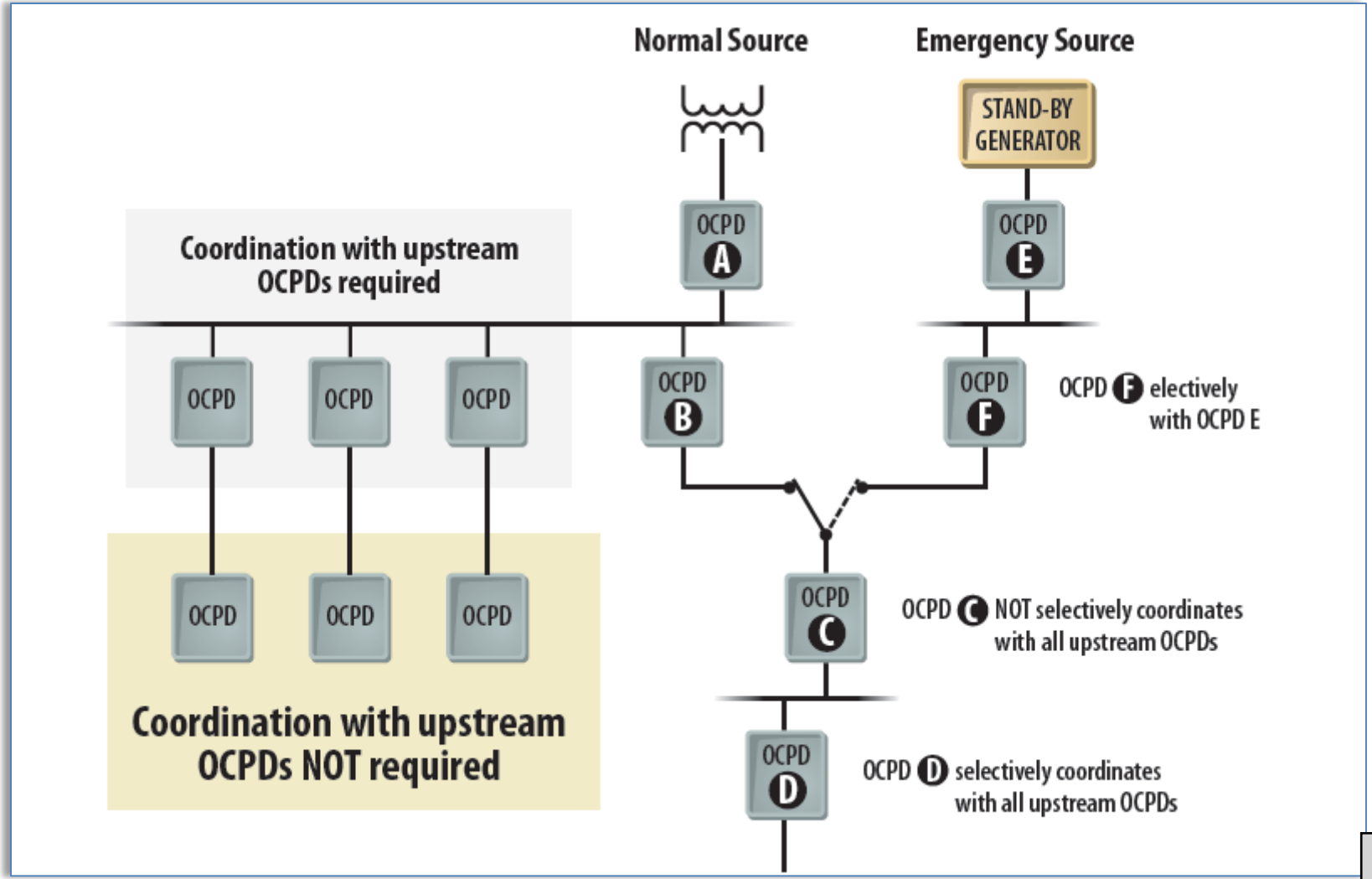
Change Summary

- Selective coordination of overcurrent protective devices limits the extent of an outage without opening the service.
- If there are feeders connected to the service that have loads that are not required to be coordinated, the uncoordinated loads could be capable of opening the service OCPD.
- The 2023 *Code* requires that when feeders are connected to a service that has loads that are required to be selectively coordinated, the feeders are also required to be selectively coordinated.

© 2022 *electrical training ALLIANCE*

240.11

NEW



© 2022 *electrical training ALLIANCE*

240.24

REVISION

Location in or on Premises

Change Summary

- The use of a tool to access overcurrent protective devices will be permitted in enclosures designed for hazardous (classified) locations and for enclosures to protect against environmental conditions.
- Branch-circuit overcurrent protective devices will not have to be accessible to all residents in sleeping rooms in dormitory units.
- The prohibition against locating overcurrent protection in bathrooms of dwelling units, dormitory units, and guest rooms and guest suites has been expanded to include all bathrooms, showering facilities, and locker rooms with showering facilities.

© 2022 *electrical training ALLIANCE*

240.24

REVISION



3146

© 2022 *electrical training ALLIANCE*

240.89

NEW

Replacement Trip Units

Change Summary

- Replacement trip units for circuit breakers must be listed for use in the specific circuit breaker type.
- The trip unit may be identical to the original, or it could provide additional features.
- Listing ensures that the new trip unit will not compromise the operation of the circuit breaker.
- This action correlates with the action taken during the 2020 cycle in 490.21(A)(5) for circuit breakers rated over 1,000 volts (245.21(A)(5) in this edition).

© 2022 *electrical training ALLIANCE*

240.89

NEW



© 2022 *electrical training ALLIANCE*

242.9

NEW

Indicating

Change Summary

- Surge protective devices are required to provide an indication that they are operating properly.
- A surge protective device can be damaged by a high-level surge, even if it has protected the equipment.
- Previously, the occupant may not have known that the SPD operation may have damaged it, precluding future protection.

© 2022 *electrical training ALLIANCE*

242.9

NEW



© 2022 *electrical training ALLIANCE*

242.42

REVISION

Surge Arrester Rating

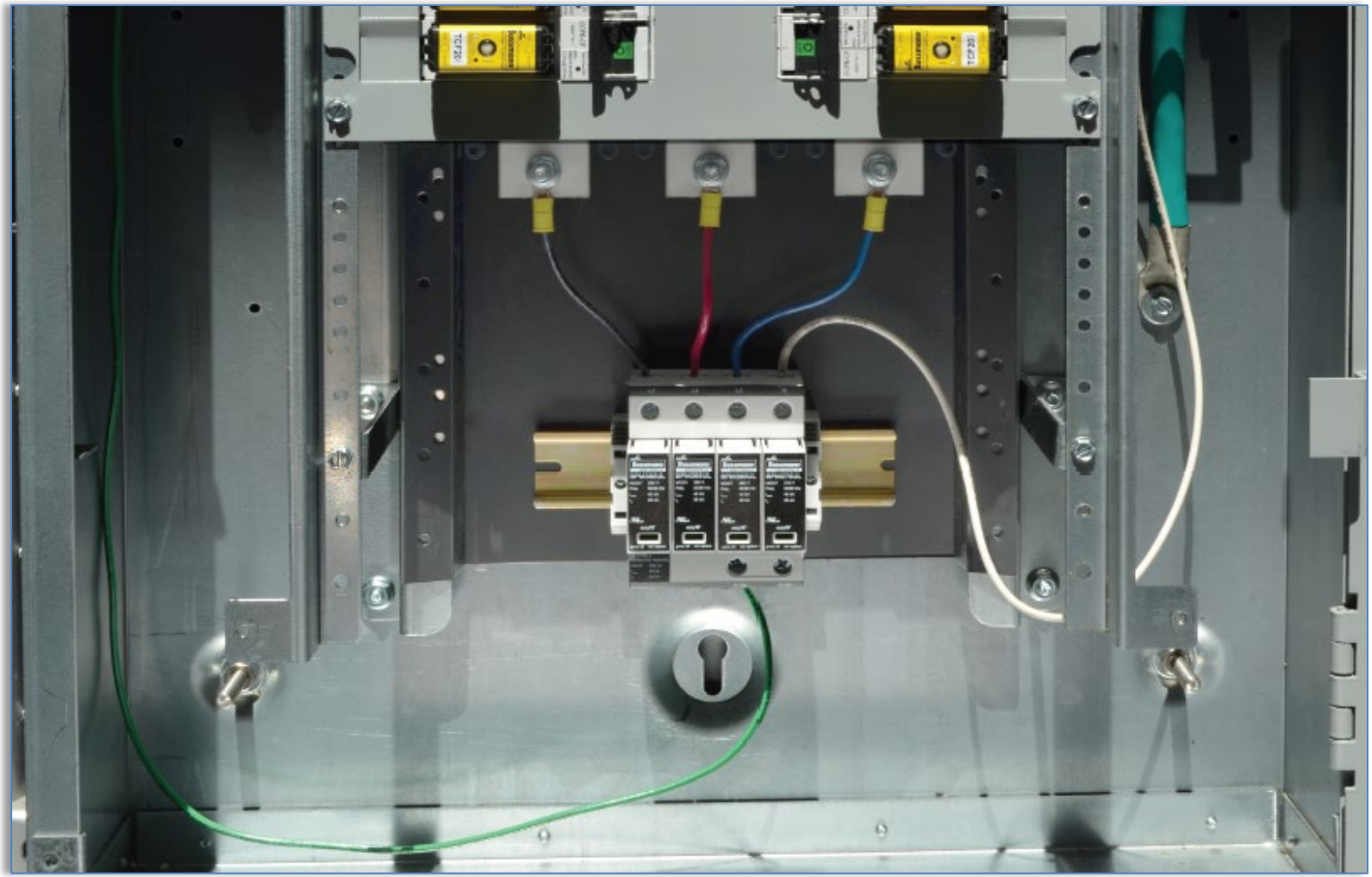
Change Summary

- Previously, the rating of a surge arrester was required to be equal to or greater than the maximum continuous operating voltage at the point of application.
- The duty cycle is now required to be not less than 125% of the maximum continuous operating voltage available at the point of application.
- The reference to silicon-carbon type surge arresters was deleted because they are no longer manufactured.

© 2022 *electrical training ALLIANCE*

242.42

REVISION



3152

© 2022 *electrical training ALLIANCE*

Article 245

NEW

Overcurrent Prot. Sys. Rated Over 1000 Vac, 1500 Vdc

Change Summary

- A new Article 245 has been created on overcurrent protection for systems rated over 1,000 volts ac and 1,500 volts dc.
- This new article will replace previous requirements for systems over 1,000 volts, which were located in Articles 240 and 490.
- This is one of several new articles that are intended to enhance the *NEC*'s coverage of medium- and high-voltage applications.

© 2022 *electrical training ALLIANCE*

Article 245

NEW



3154

© 2022 *electrical training ALLIANCE*
Courtesy of Michael J. Johnston

245.2

REVISION

Reconditioned Equipment

Change Summary

- This section was revised, placed into list format, and relocated to become 245.2.
- Medium- and high-voltage circuit breakers are now permitted to be reconditioned.
- Electromechanical protective relays and current transformers are now permitted to be reconditioned.
- Medium-voltage fuseholders and medium-voltage nonrenewable fuseholders are not permitted to be reconditioned.

© 2022 *electrical training ALLIANCE*

245.2

REVISION



© 2022 *electrical training ALLIANCE*

250.6

REVISION

Objectionable Current

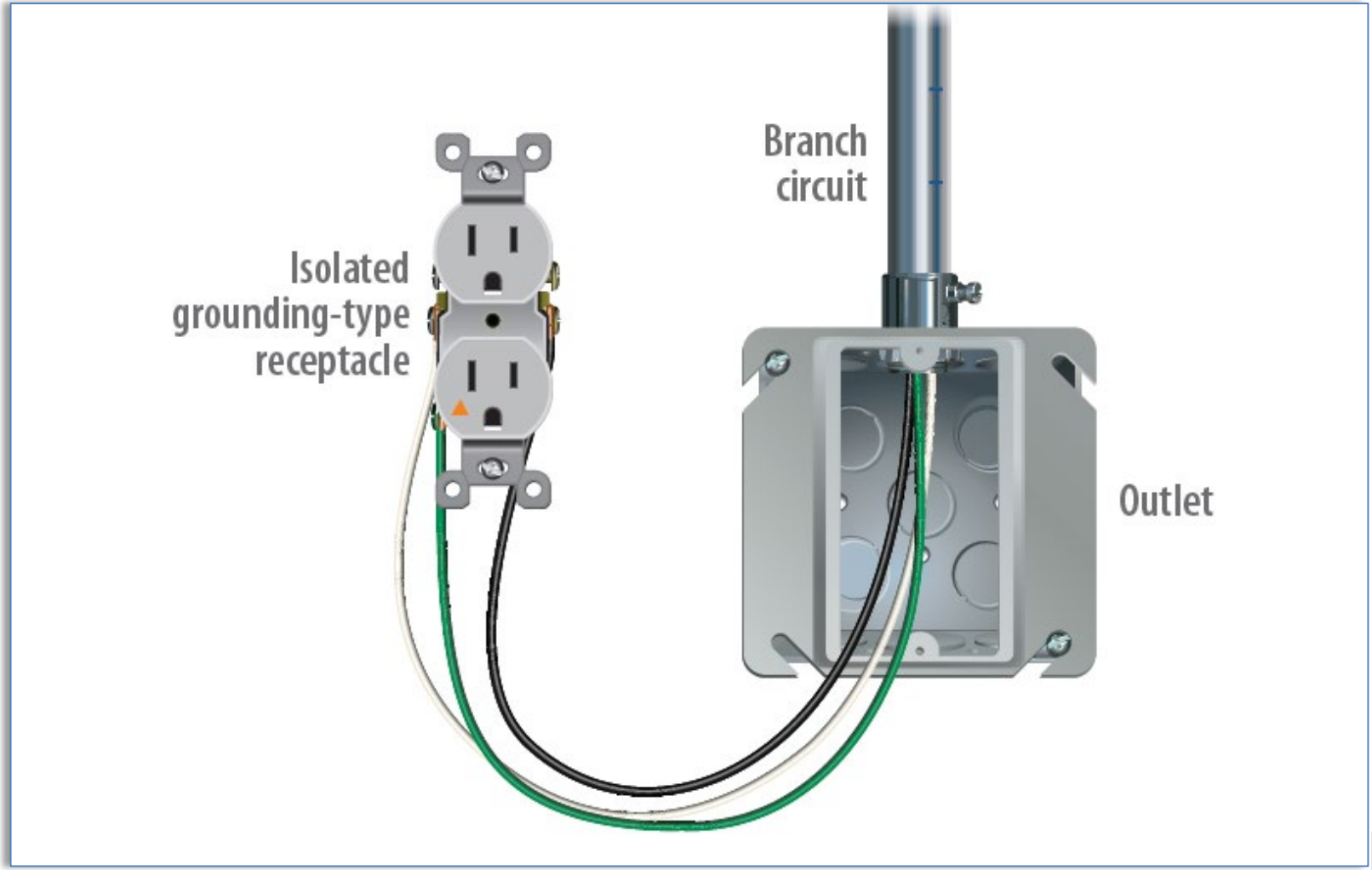
Change Summary

- This section was revised to recognize that bonding of various parts of electrical systems and equipment can also cause objectionable currents.
- 250.6(B) now provides remedies to objectionable currents resulting from bonding.
- 250.6(C) was revised to recognize that currents resulting from abnormal conditions may not be temporary and could also exist due to required grounding and bonding connections.

© 2022 *electrical training ALLIANCE*

250.6

REVISION



© 2022 *electrical training ALLIANCE*

250.20

REVISION

Alternating-Current Systems to Be Grounded

Change Summary

- Alternating current systems are now required to be grounded in accordance with 250.20, unless prohibited elsewhere in the *Code.*
- A new informational note has been added to point to specific examples of applications where grounding is prohibited. In addition, 250.22 was deleted because it was a reference to some of these requirements elsewhere in the *Code*.
- 250.20(D) was revised to recognize that impedance grounded systems do not have a neutral conductor.

© 2022 *electrical training ALLIANCE*

250.20

REVISION



© 2022 *electrical training ALLIANCE*

250.24

REVISION

Grounding of Service-Supplied AC Systems

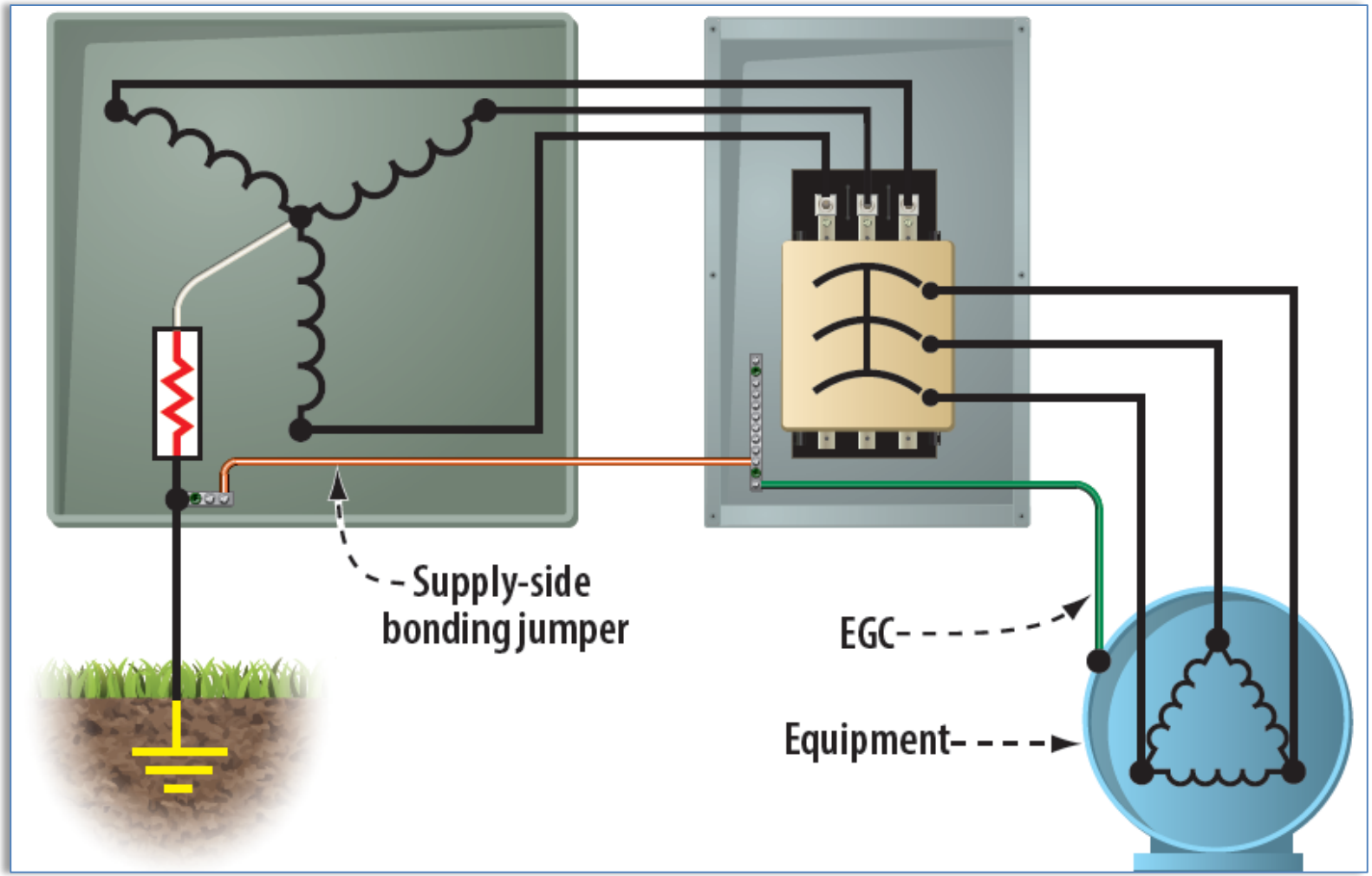
Change Summary

- The term *high impedance grounded system* is now changed to *impedance grounded system.*
- The conductor that connects to the neutral point through an impedance is not a grounded conductor – it is an impedance grounded conductor. Correlating changes were made in 250.36.
- Parallel grounded service conductors in two or more parallel raceways are required to be connected in parallel. The grounded conductor in each raceway is to be sized based on the conductor in the raceway.

© 2022 *electrical training ALLIANCE*

250.24

REVISION



3162

© 2022 electrical training ALLIANCE

250.36

REVISION

Impedance Grounded Systems – 480 V to 1000 V

Change Summary

- The term *high impedance grounded neutral system* is now changed to *impedance grounded system.*
- The conductor that connects to the neutral point through an impedance is not a grounded conductor – it is an impedance grounded conductor.
- The conductor is also not a neutral conductor.

© 2022 *electrical training ALLIANCE*

250.36

REVISION



© 2022 *electrical training ALLIANCE*

250.64

REVISION

Grounding Electrode Conductor Installation

Change Summary

- Section 250.64(B) has been updated to include copper-clad aluminum conductors in the requirements for securing and supporting.
- Section 250.64(D)(2)(2) has been revised to recognize that some buildings are supplied by branch circuits, rather than by feeders or services. This removes a conflict with 250.24(A)(1).
- A new 250.64(G) was added to prohibit grounding electrode conductors from being run through the ventilation openings of equipment.
- There were several minor editorial corrections in this section.

© 2022 *electrical training ALLIANCE*

250.64

REVISION



© 2022 *electrical training ALLIANCE*

Courtesy of Copperweld Bimetallics LLC

250.68(C)

REVISION

Grounding Electrode Conductor Connections

Change Summary

- Interior metal piping that is electrically continuous with a metal underground water pipe electrode that is not more than 5 feet from the point of entrance is permitted to extend the grounding electrode.
- The measurement has been clarified in three places to make it clear that the measurement is along the water piping.
- In 250.68(C)(2) and (C)(3), there were references to “the usual steel tie wires” without explanation. The phrase “the usual” was deleted.

© 2022 *electrical training ALLIANCE*

250.68(C)

REVISION



© 2022 *electrical training ALLIANCE*

250.94(B)

REVISION

Bonding for Communications Systems-Other Means

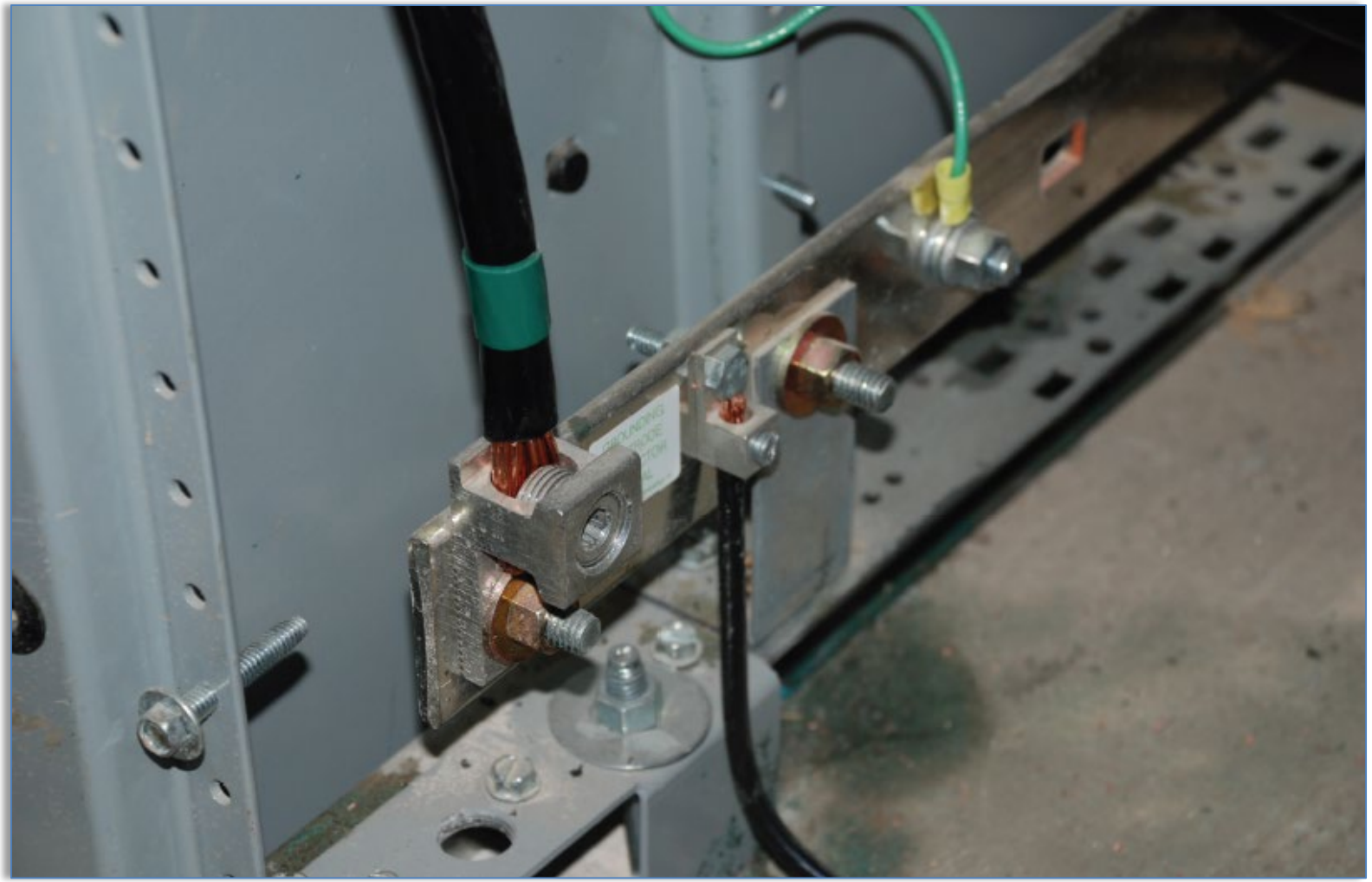
Change Summary

- Section 250.94(B) was revised to clarify the requirement for the connection to a busbar, which is connected to the grounding electrode conductor. The conductor must be the larger of one of the following:
  - A conductor that is sized at least as large as the largest conductor connected to the busbar.
  - A 6 AWG conductor in accordance with 250.94(A)(4)

© 2022 *electrical training ALLIANCE*

250.94(B)

REVISION



© 2022 *electrical training ALLIANCE*

250.104(C) & (D)

REVISION

Bonding of Piping Systems and Exposed Struct. Metal

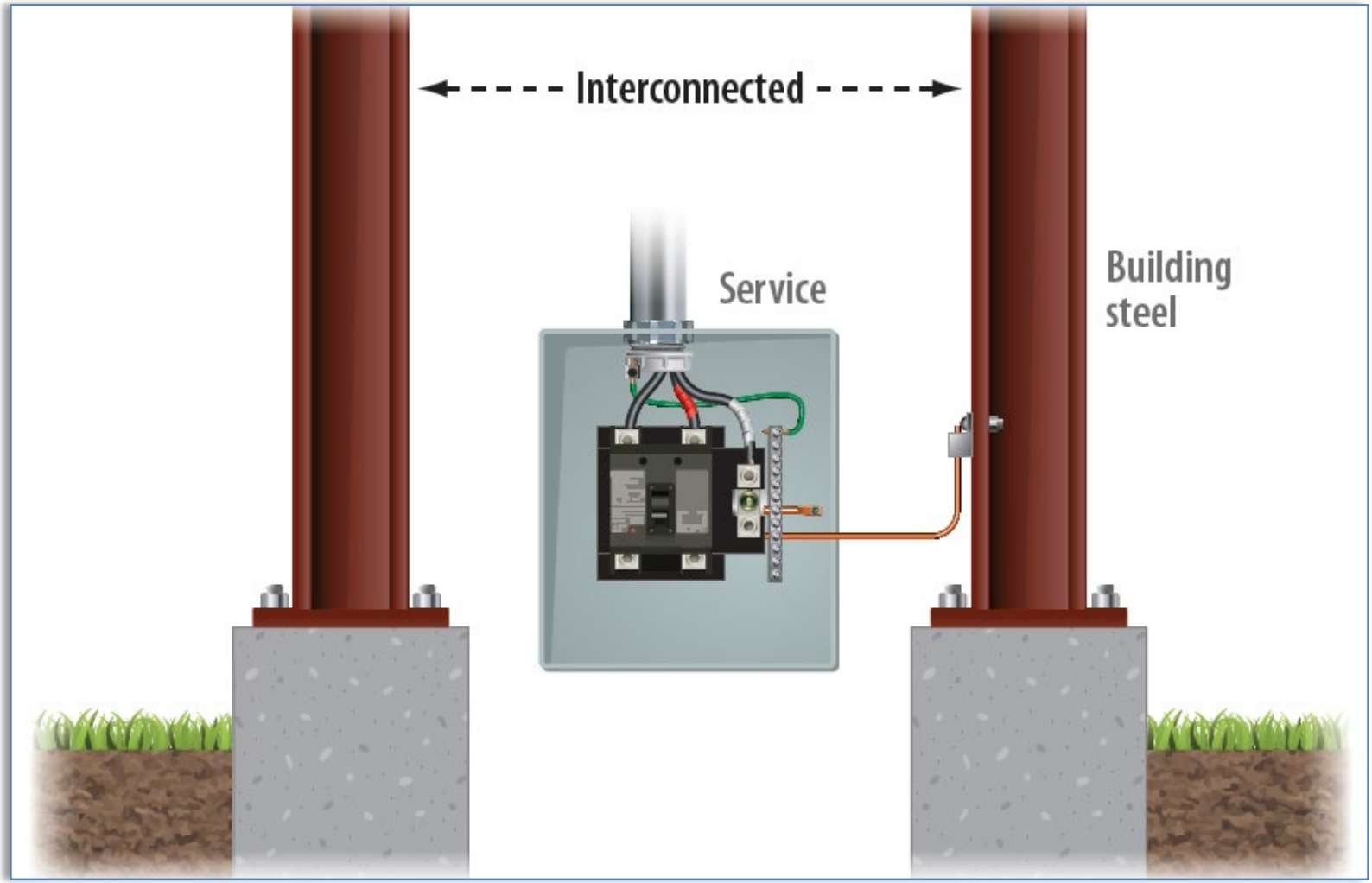
Change Summary

- Changes were made in 250.104(C) to replace the vague language about conductors of “sufficient size” with a reference to Table 250.102(C)(1) to specify the size.
- Changes were made in 250.104(D)(3) to make it clear that the piping being referred to is metal water piping.
- Changes were also made to recognize that connections to grounding electrodes in the earth may be extended through portions of the pipe or structural electrodes that are above ground, provided the installation complies with 250.68(C).

© 2022 *electrical training ALLIANCE*

250.104(C) & (D)

REVISION



3172

© 2022 electrical training ALLIANCE

250.118

REVISION

Types of Equipment Grounding Conductors

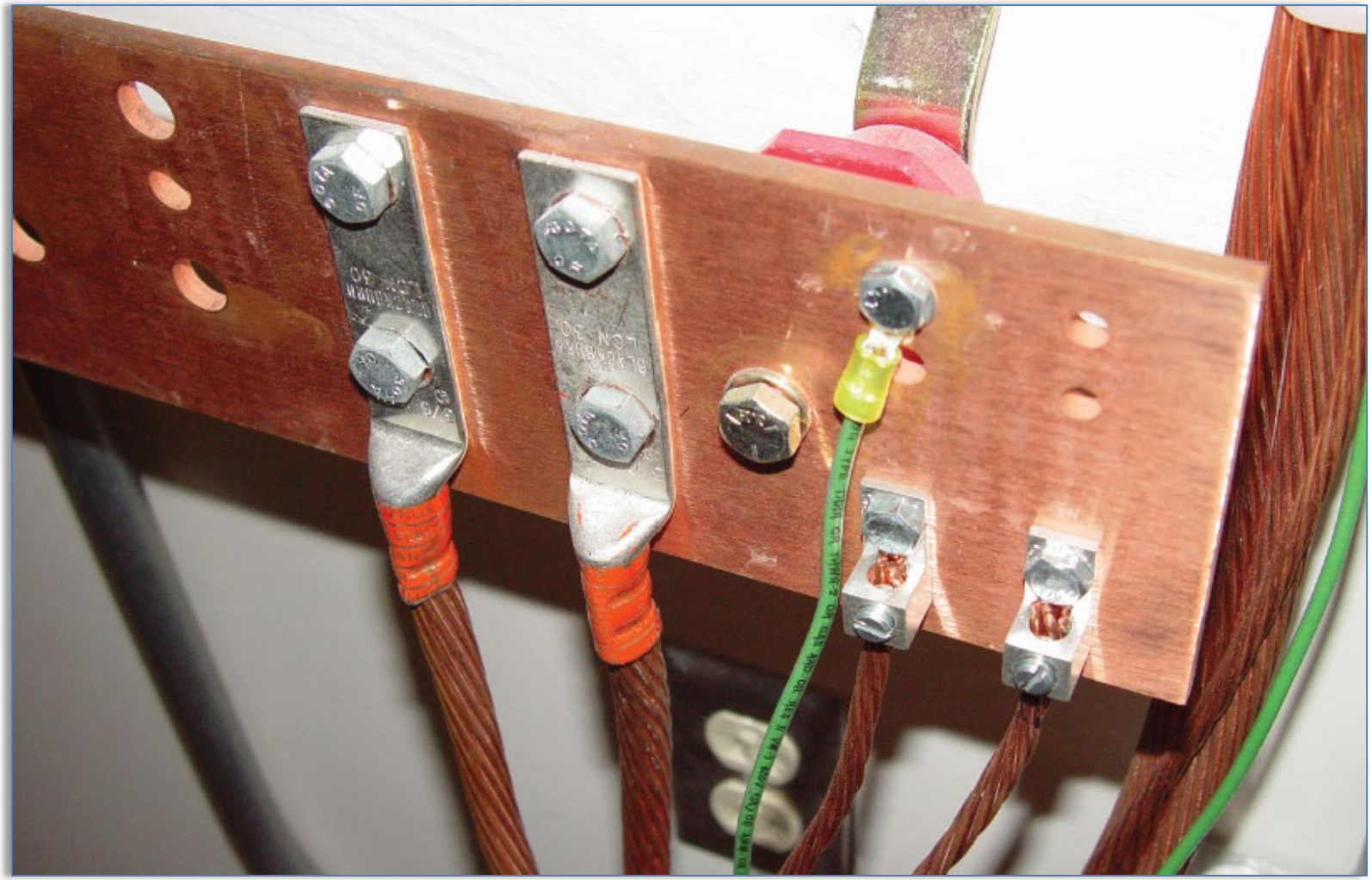
Change Summary

- Section 250.118, Types of Equipment Grounding Conductors, was reformatted into two subdivisions: (A) Permitted, and (B) Not Permitted.
- Section 250.118(A)(5)(f) and (A)(6)(f) were added for locations where there is a need for high resistance to corrosion. A stainless-steel core has a higher electrical resistance than other metals used in the construction of liquidtight flexible metal conduit. The bonding jumper can be internal or external to the liquidtight flexible metal conduit.
- A requirement for a bonding jumper was also added to 250.118(A)(5)(e).

© 2022 *electrical training ALLIANCE*

250.118

REVISION



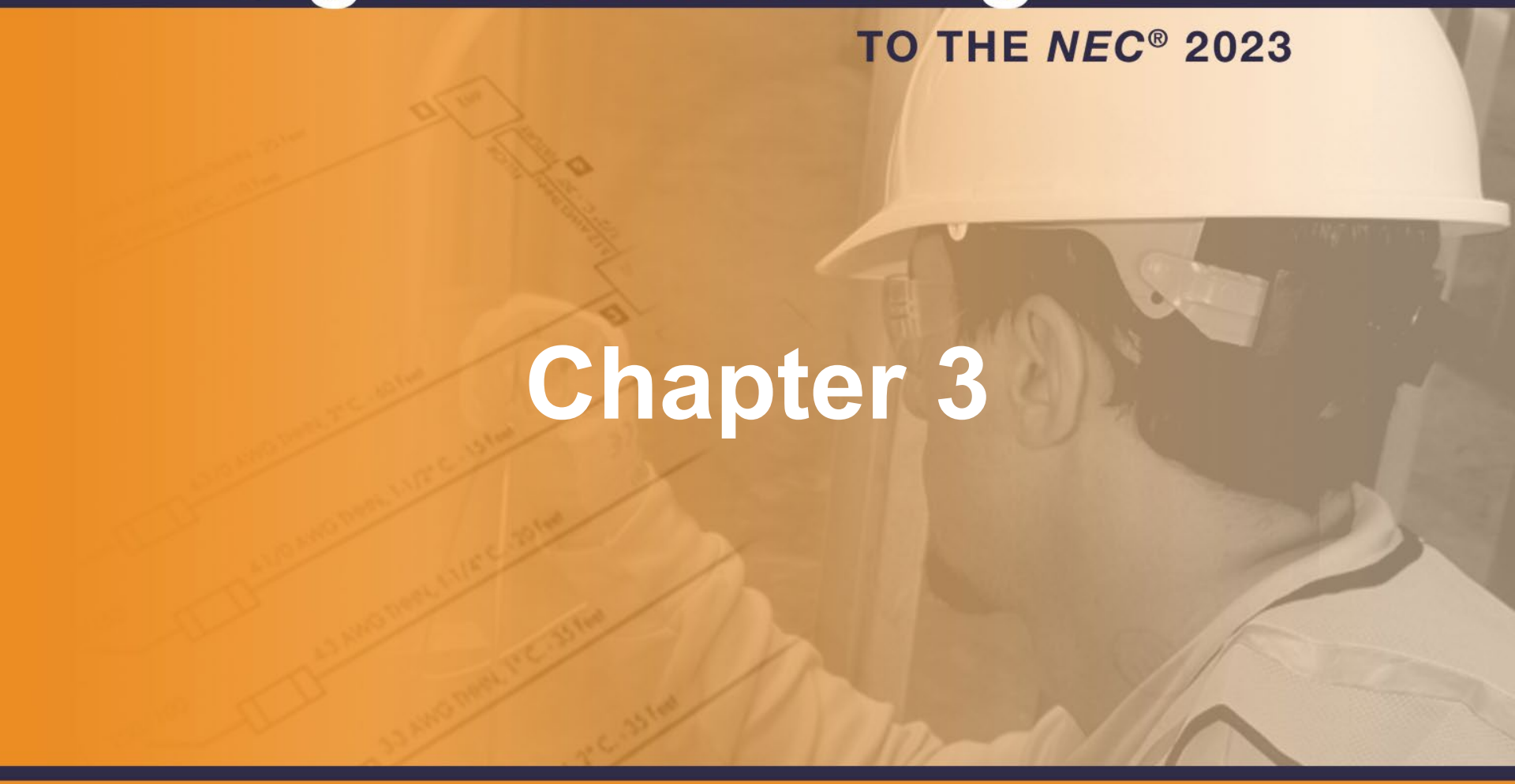
3174

© 2022 electrical training ALLIANCE

Courtesy of Michael J. Johnston

Significant Changes

TO THE *NEC*® 2023



Chapter 3

electrical training ALLIANCE IBEW - NECA IN COLLABORATION WITH NECA NATIONAL ELECTRICAL CONTRACTORS ASSOCIATION

Article 300

REORGANIZE NEW

Limitations

Change Summary

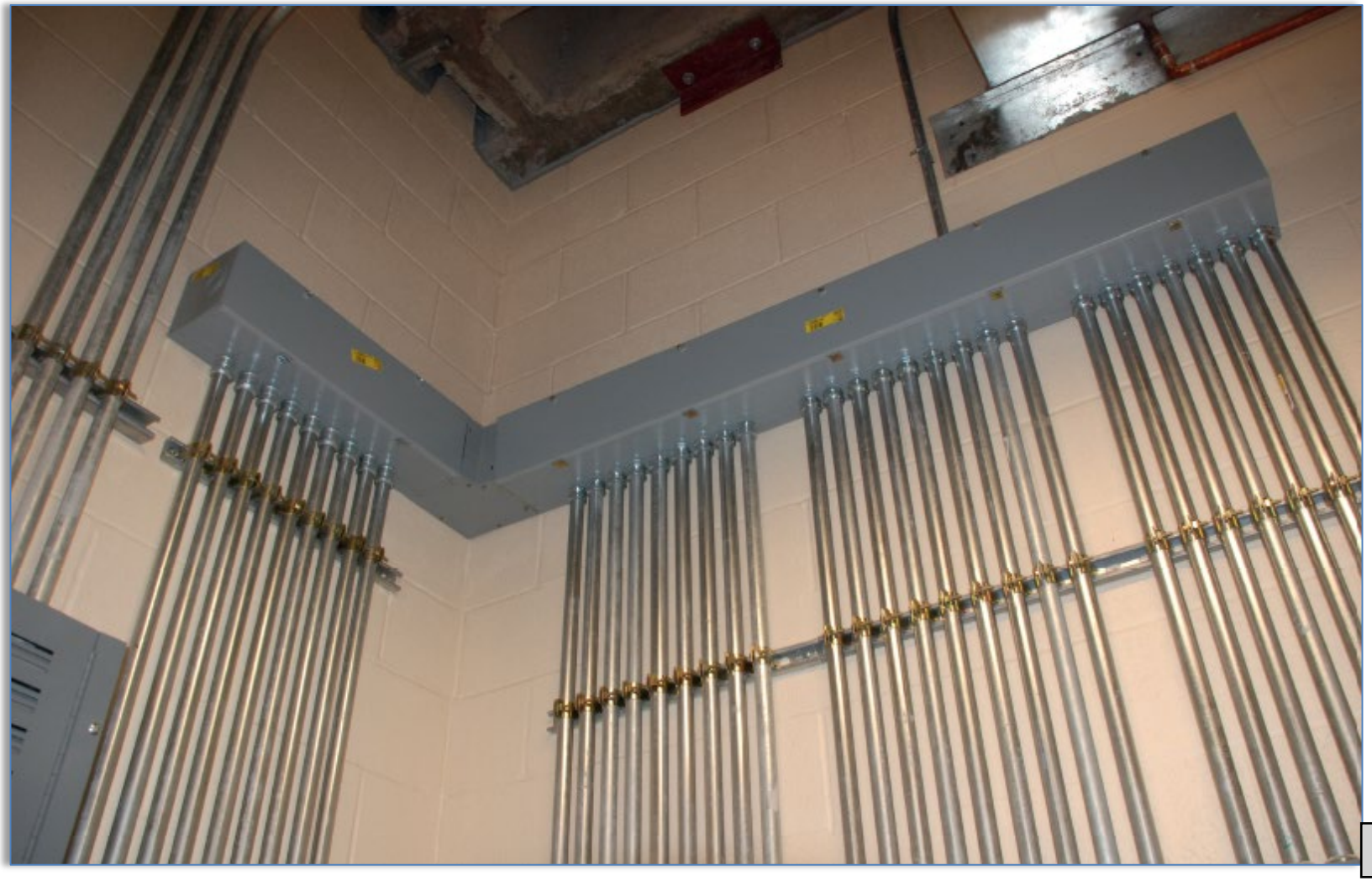
- Article 300 was reorganized to limit it to systems rated 1,000 volts ac, nominal, or less and 1,500 volts dc, nominal, or less.
- Medium- and high-voltage requirements have been moved to the new Article 305.
- This is the first cycle that 1,500 volts dc has been established as a limit.

3176

© 2022 electrical training ALLIANCE

Article 300

REORGANIZE NEW



3177

© 2022 electrical training ALLIANCE

Courtesy of Bill McGovern, City of Plano, TX

300.2 & 300.3

REVISION

Limitations

Change Summary

- Section 300.2 has added a voltage limitation for dc systems that are covered by Article 300.
- Chapter 3 wiring methods apply to systems operating at 1,000 volts ac or less or 1,500 volts dc or less.
- Chapter 3 wiring methods are only permitted on systems operating over 1,000 volts ac and 1,500 volts dc if specifically permitted elsewhere in the *Code*.
- The scope of Article 305 states that it applies to installations exceeding 1,000 volts ac or exceeding 1,500 volts dc.

© 2022 *electrical training ALLIANCE*

300.2 & 300.3

REVISION



3179

© 2022 electrical training ALLIANCE
Courtesy of PDE Total Energy Solutions

300.4(E)

REVISION

Cables, Raceways, or Boxes Under Metal Decking

Change Summary

- Section 300.4(E) will now only apply to installations beneath metal-corrugated roof decking.
- Exception No. 1 was revised to recognize that listed steel or malleable metal fittings and boxes provide protection from nail penetration.
- A new exception was added for corrugated roof decks that have a minimum 2-inch slab installed over the corrugated metal roof deck.

© 2022 electrical training ALLIANCE

300.4(E)

REVISION



3181

© 2022 *electrical training ALLIANCE*

300.7(B)

NEW

Expansion, Expansion-Deflection, Deflection Fittings

Change Summary

- Section 300.7(B) requires raceways to be provided with expansion-deflection or deflection fittings where necessary to compensate for expansion, deflection, and contraction.
- Failure to provide these fittings can result in damage to the installation.
- Informational Note No. 1 provides references to tables that provide expansion information. It also provides information on the rate of expansion.
- A new informational note was added that references NEMA FB 2.40, *Installation Guidelines for Expansion and Expansion/Deflection Fittings.*

© 2022 *electrical training ALLIANCE*

300.7(B)

NEW



3183

© 2022 *electrical training ALLIANCE*

Courtesy of ABB Inc.

300.15

REVISION

Boxes, Conduit Bodies, or Fittings – Where Required

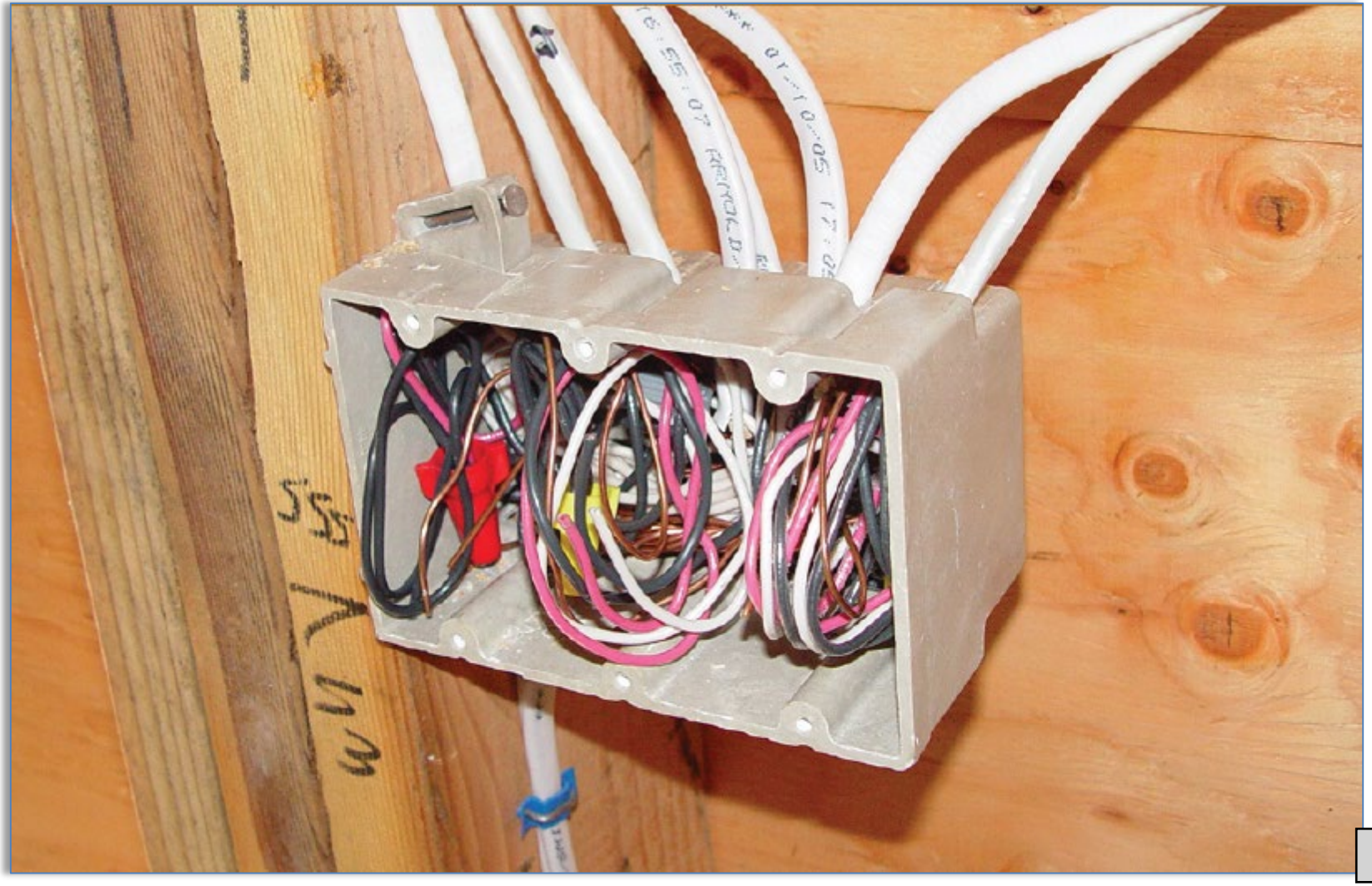
Change Summary

- Section 300.15 was clarified to indicate that a box or conduit body is required at conductor splice, termination, junction, and pull points.
- Wording was added to indicate that boxes or conduit bodies are required at “wiring method transition points,” which indicates a change in wiring method.
- Section 300.15(G) was revised to clarify that it also applies to direct-buried cables in addition to direct-buried conductors.

© 2022 electrical training ALLIANCE

300.15

REVISION



© 2022 *electrical training ALLIANCE*

300.25 & Exception

REVISION

Exit Enclosures (Stair Towers)

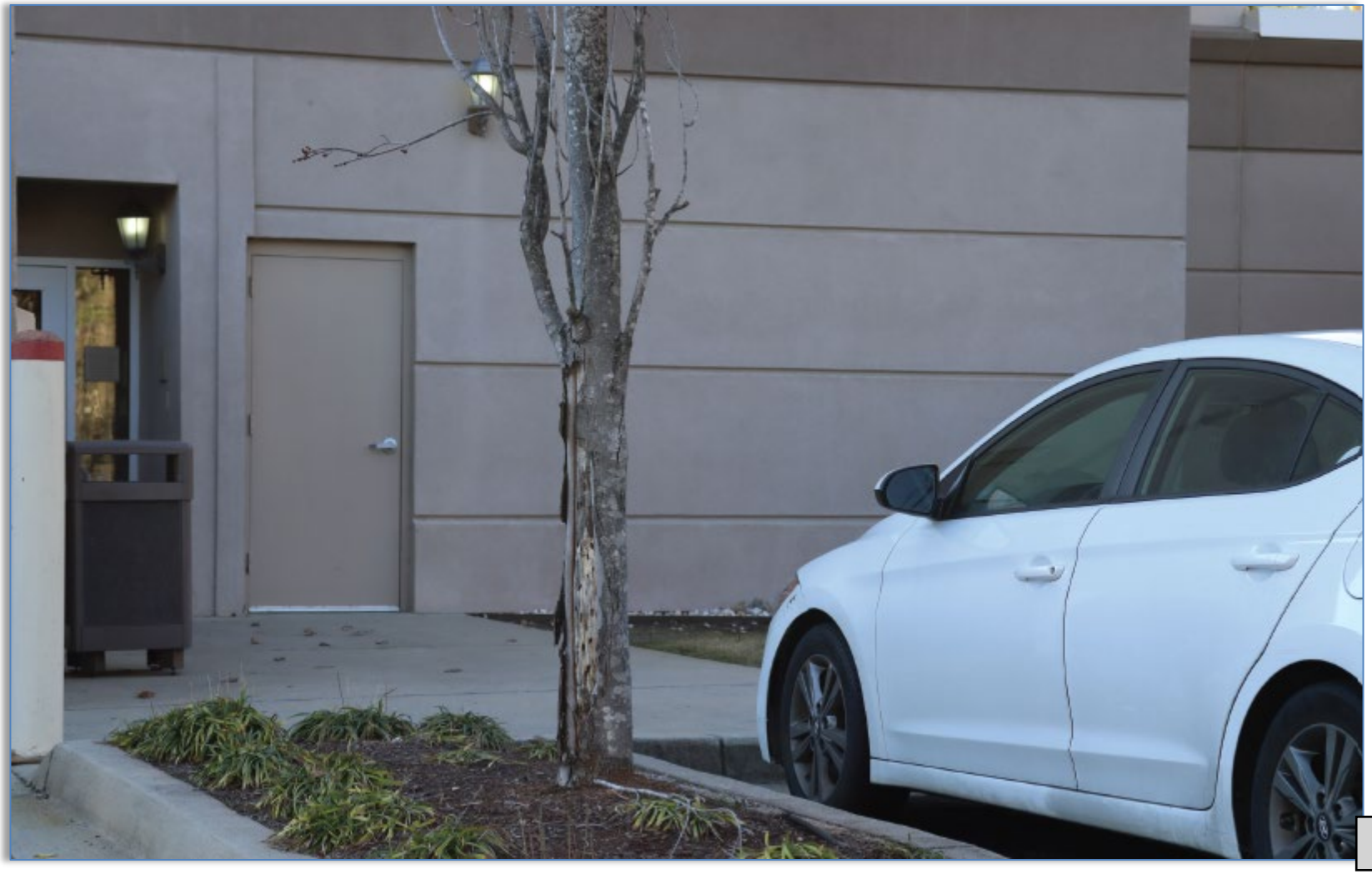
Change Summary

- Many buildings have exit enclosures (stair towers) to protect personnel who need to exit during a fire. These are often supported independently of the building.
- Exit enclosures that are required to have a fire rating must be served only by wiring methods serving equipment that is permitted by the AHJ to be in the stair tower.
- Luminaires for the exterior lighting of exit doors of exit enclosures are permitted to be supplied by a circuit that supplies the inside of the exit enclosure.

© 2022 electrical training ALLIANCE

300.25 & Exception

REVISION



3187

© 2022 *electrical training ALLIANCE*

300.26

NEW

Remote-Control and Signaling Circuits Classification

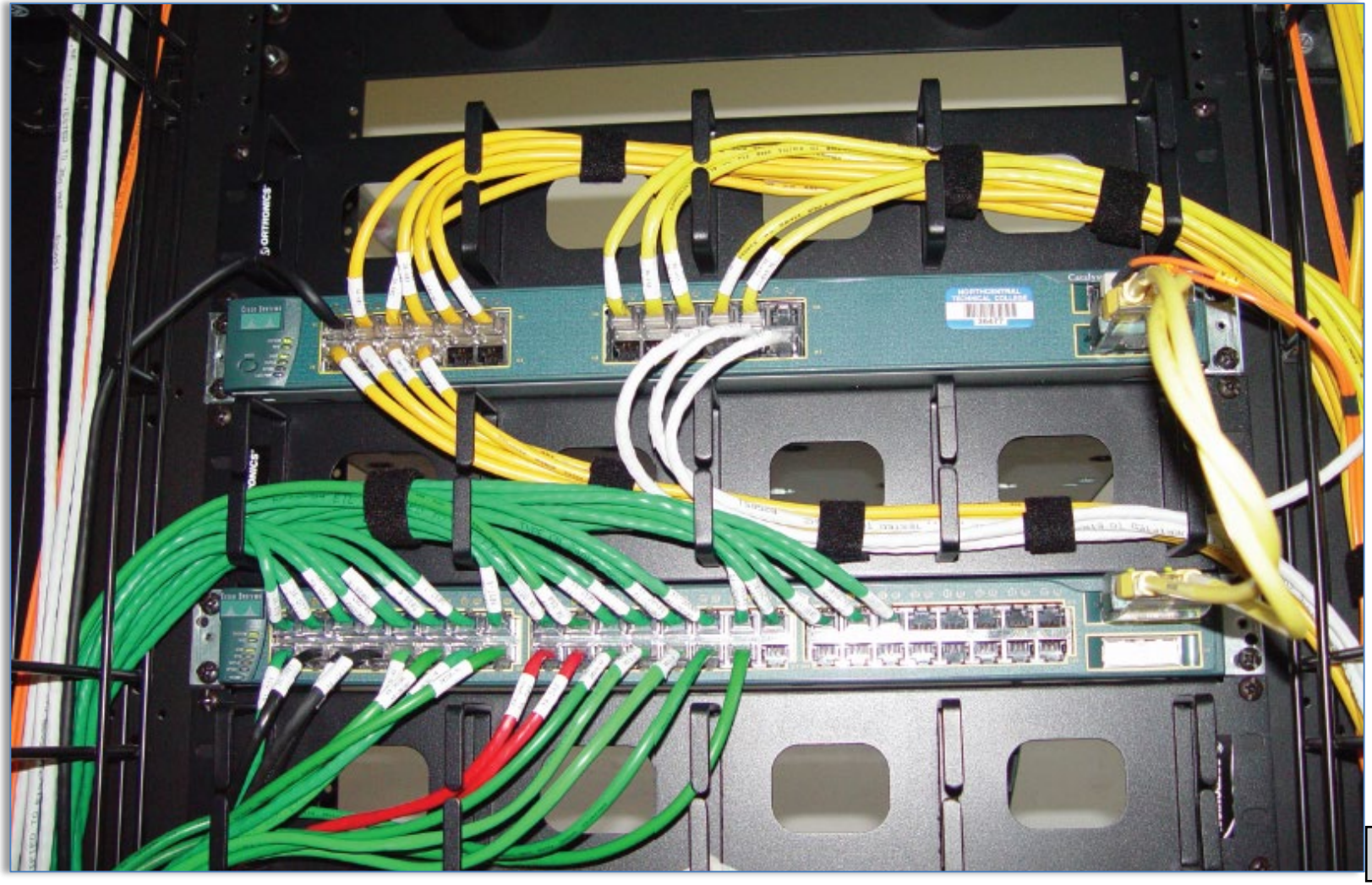
Change Summary

- The scope of Article 725 has been changed, requiring this clarification.
- Class 2 and 3 power-limited remote-control and signaling circuits remain in Article 725.
- Class 1 power-limited remote-control and signaling circuits were relocated to the new Article 724.
- Non–power-limited remote-control and signaling circuits are governed by the requirements of Chapters 1 through 4 of the *Code*.

© 2022 *electrical training ALLIANCE*

300.26

NEW



© 2022 *electrical training ALLIANCE*

Article 305

NEW

Systems Rated Over 1000 V ac, 1500 V dc, Nominal

Change Summary

- Article 305 has been created to separate the requirements for medium-voltage systems from the requirements of systems rated 1,000 volts ac or less and 1,500 volts dc or less.
- The bulk of Article 305 came from Part II of Article 300.
- Section 305.3 references the wiring methods permitted to be used over 1,000 volts ac and 1,500 volts dc.
- Requirements for services, feeders, and branch circuits for systems rated over 1,000 volts ac and over 1,500 volts dc are found in Article 235.

© 2022 *electrical training ALLIANCE*

Article 305

NEW



3191

© 2022 *electrical training ALLIANCE*

Courtesy of Michael J. Johnston

312.8

NEW

Splices, Taps, and Feed-Through Conductors

Change Summary

- A new 312.8(A)(3) has been added to recognize the additional bending space needed for conductors 4 AWG and larger.
- Where splices or where angle or U pulls are made with insulated conductors, 314.28(A)(2) requires the distance between the raceway and the opposite wall to be at least six times the largest trade size in a row.
- The six times rule also applies to straight-through conduit entries if the conductors are spliced.

© 2022 *electrical training ALLIANCE*

312.8

NEW



3193

© 2022 *electrical training ALLIANCE*

Courtesy of Tom Garvey

312.10

NEW

Screws or Other Fasteners

Change Summary

- Screws and other fasteners installed in the field that enter the wiring space are required to be those provided by or specified by the manufacturer.
- If not supplied or specified by the manufacturer, this section provides three criteria that can be used, where applicable.
- An exception allows screws that enter to extend into the enclosure not more than 7/16 inch if located within 3/8 inch of an enclosure wall.
- A similar requirement was added for screws and fasteners in 314.5.

© 2022 *electrical training ALLIANCE*

312.10

NEW



© 2022 *electrical training ALLIANCE*

Courtesy of Michael J. Johnston

314.5

NEW

Screws or Other Fasteners

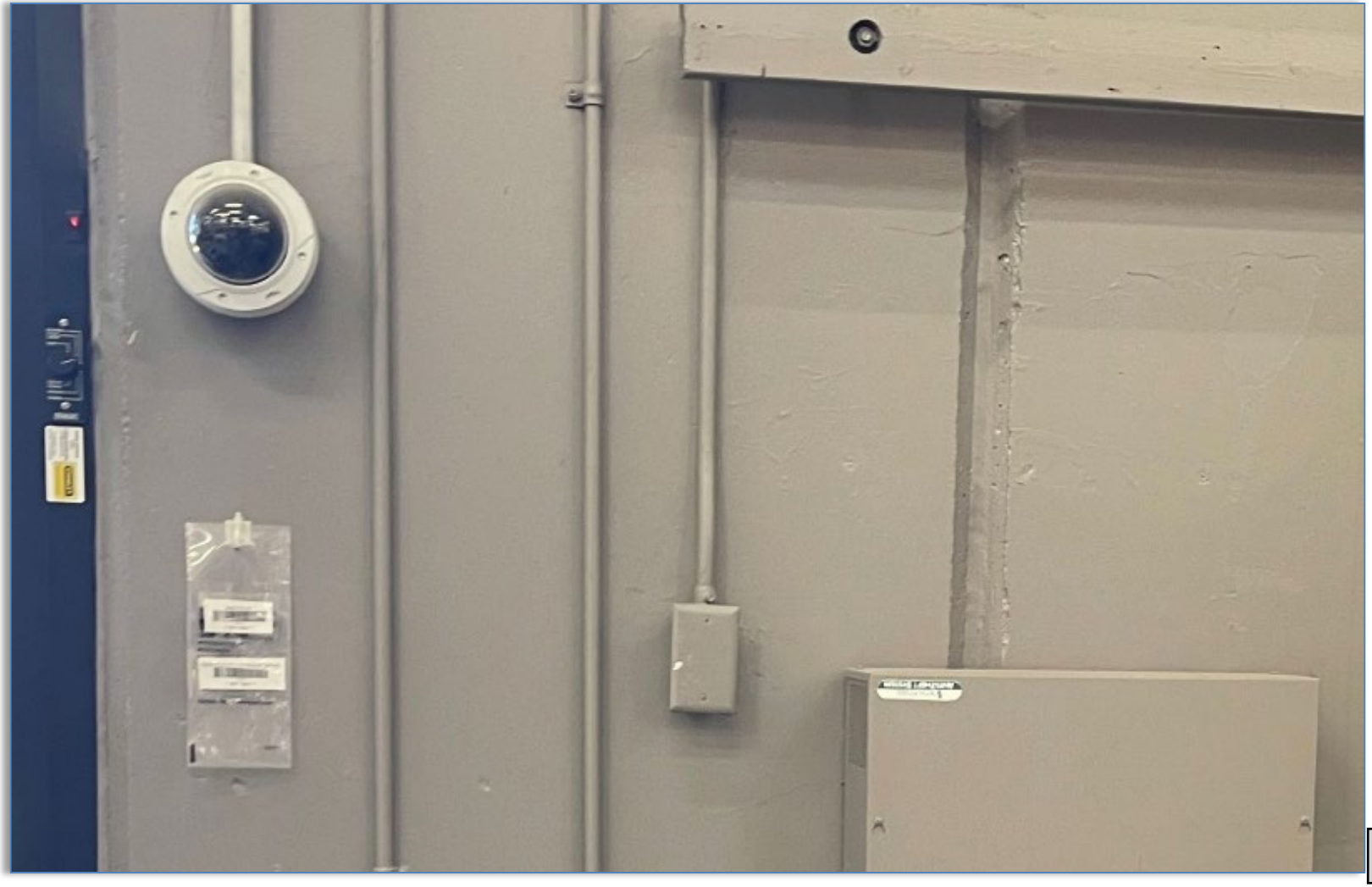
Change Summary

- New requirements for screws and other fasteners have been added to 314.5. Screws and other fasteners are required to have blunt ends.
- Specific requirements are provided for the permitted length, based on where in the box the screw or fastener is used.
- Longer screws are permitted where protected with an approved means.

© 2022 *electrical training ALLIANCE*

314.5

NEW



© 2022 *electrical training ALLIANCE*

314.16(B)

REVISION

Box Fill Calculations

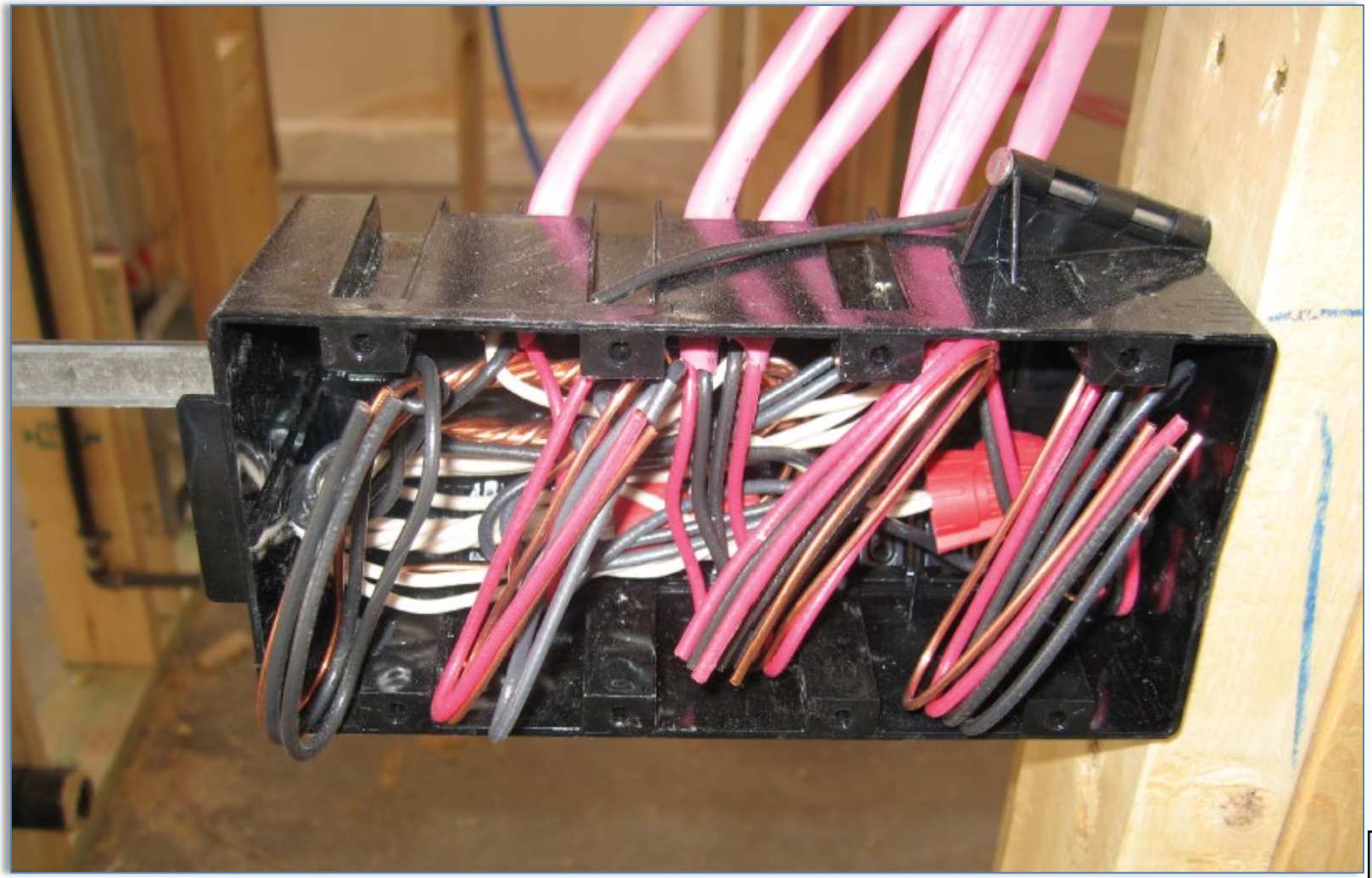
Change Summary

- The second paragraph of 314.16(B)(2) was deleted because the product line that it was intended for is not being produced.
- Equipment bonding jumpers were removed for the conductor fill calculation requirements in 314.16(B)(5). The panel concluded that if equipment bonding jumpers are run within raceways, they are considered an expansion of the equipment grounding conductor.
- 314.16(B)(6) was added to require a single volume allowance for a terminal block assembly based on the largest conductor terminated to the assembly.

© 2022 electrical training ALLIANCE

314.16(B)

REVISION



3199

© 2022 *electrical training ALLIANCE*

314.24

REVISION

Dimensions of Boxes

Change Summary

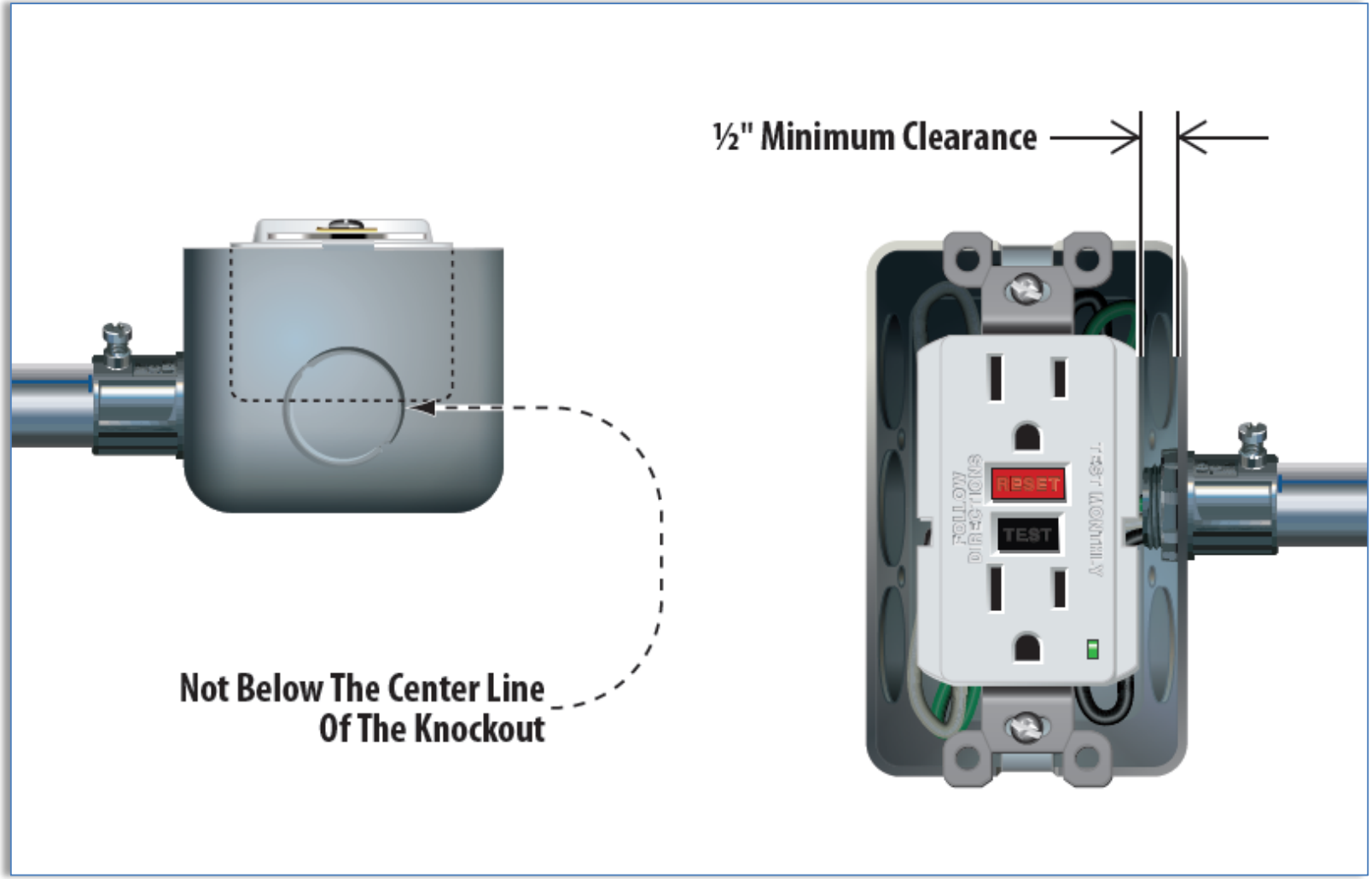
- The title of 314.24 has been changed from “depth of boxes” to “dimensions of boxes” to recognize that this section deals with more than depth.
- The rearward projection of devices or equipment must not be greater than the depth of a knockout used for a side wiring entrance or a ½-inch clearance must be maintained between the device and the sidewall of the box.
- Where wiring enters the center portion of the rear of a box opposite the equipment, the minimum clearance must be increased to ½ inch.

3200

© 2022 *electrical training ALLIANCE*

314.24

REVISION



3201

© 2022 electrical training ALLIANCE

314.25

REVISION

Covers and Canopies

Change Summary

- Section 314.25 was revised to clarify that conduit body enclosures must be enclosed by a cover, a lampholder, or a device.
- Like boxes, conduit bodies can contain splices, terminations, and devices. Therefore, conduit bodies should also be covered.
- The language in 314.25(A) and the informational note were revised to clarify that they apply to equipment grounding conductors.

© 2022 *electrical training ALLIANCE*

314.25

REVISION



3203

© 2022 electrical training ALLIANCE

314.27(C) & (E)

REVISION

Outlet Boxes, Ceiling-Suspended (Paddle Fans)

Change Summary

- Outlet boxes used as the sole support of ceiling-suspended (paddle) fans are now required to be marked on the inside of the box so that the marking can be seen during a rough-in inspection.
- 314.27(C)(2) was simplified to recognize boxes that provide direct access through the box to structural framing capable of supporting a paddle fan, without the need to remove the box.
- The locking support and locking receptacle and the compatible attachment fitting have been renamed as “weight-supporting ceiling receptacle” and “weight-supporting attachment fitting.”

© 2022 *electrical training ALLIANCE*

314.27(C) & (E)

REVISION



3205

© 2022 *electrical training ALLIANCE*

Article 315

REVISION RELOCATE

Medium Voltage Conductors and Cables

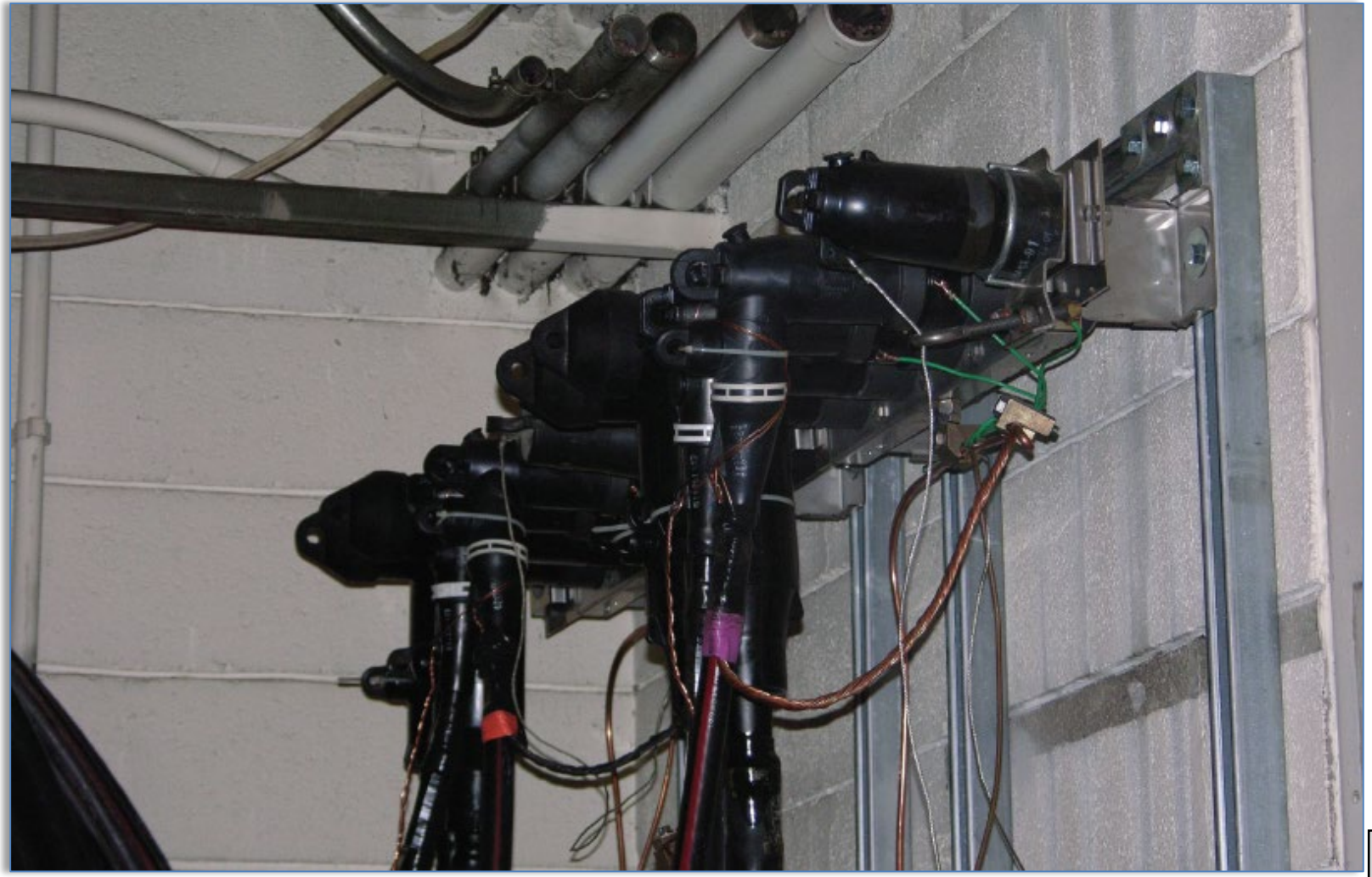
Change Summary

- Article 311 has been relocated to become Article 315, consistent with the numbering scheme for medium-voltage articles.
- The title and scope of Article 315 have been expanded to include cable joints and cable terminations.
- The scope of this article for dc cables is limited to cables rated 2,001 through 2,500 volts.

© 2022 electrical training ALLIANCE

Article 315

REVISION RELOCATE



3207

© 2022 electrical training ALLIANCE

342.24

REVISION REORGANIZE

Bends

Change Summary

- Sections 342.24 and 342.25 have been combined into a 342.25, Bends.
- This now clarifies the total degrees of bends between pull points.
- Since Chapter 3 articles follow the same format, the same change was made in Article 344, 348, 350, 352, 353, 354, 355, 356, 358, 360, and 362.

© 2022 electrical training ALLIANCE

342.24

REVISION **REORGANIZE**



3209

© 2022 *electrical training ALLIANCE*

342.30(A)

NEW

Securing and Supporting

Change Summary

- Section 342.30(A) requires intermediate metal conduit (IMC) to be securely fastened.
- A new exception permits IMC in concealed work to be fished in finished buildings or in prefinished wall panels where secure fastening is impractical.
- This exception only applies to unbroken lengths of IMC without couplings in the concealed space.

© 2022 *electrical training ALLIANCE*

342.30(A)

NEW



© 2022 *electrical training ALLIANCE*

344.28

REVISION

Reaming and Threading

Change Summary

- PVC-coated RMC is often used in areas subject to corrosion.
- New text was added to this section to require that the manufacturer's instructions be followed when threading PVC-coated RMC to prevent damage to the exterior coating.
- A new informational note was added that references NECA 101, *Standard for Installing Steel Conduits (RMC, IMC, EMT)*, which provides information on threading PVC-coated RMC.

© 2022 *electrical training ALLIANCE*

344.28

REVISION



3213

© 2022 electrical training ALLIANCE

Courtesy of Corrosion College

352.10

REVISION REORGANIZE

Insert Uses Permitted

Change Summary

- The uses permitted for PVC conduit have been clarified.
- PVC conduit is permitted to be embedded in concrete.
- Exposure to physical damage requirements have been removed from 352.10(G) and moved to the new 352.10(K), Physical Damage.
- Where subject to physical damage, Schedule 80 PVC conduit, along with listed Schedule 80 PVC conduit fittings, must be used.

© 2022 *electrical training ALLIANCE*

352.10

REVISION **REORGANIZE**



3215

© 2022 electrical training ALLIANCE

Courtesy of Michael J. Johnston and Tom Garvey

358.10

REVISION

Uses Permitted

Change Summary

- Section 358.10 was revised to recognize two new permitted uses for EMT.
- EMT is permitted in direct burial applications where it is used with fittings that are identified for direct burial.
- EMT is recognized for manufactured wiring systems as permitted in 604.100(A)(2).

© 2022 electrical training ALLIANCE

358.10

REVISION



3217

© 2022 electrical training ALLIANCE

Courtesy of Michel J. Johnston

362.10

REVISION

Uses Permitted

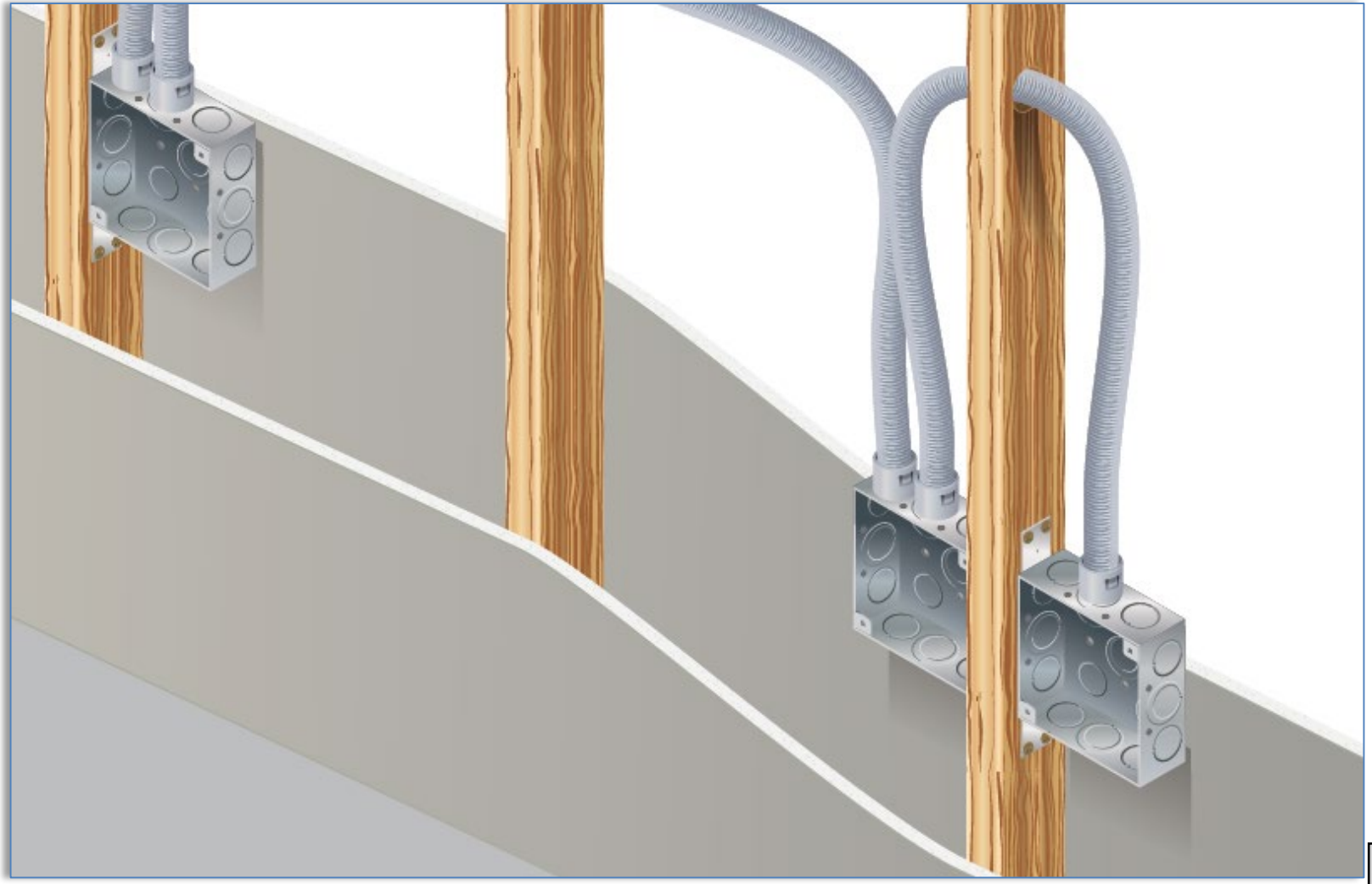
Change Summary

- Section 362.10(2) was revised to clarify that ENT is permitted to be installed in combustible or noncombustible buildings where the walls, floors, and ceilings meet the finish rating.
- The mandatory reference to *NFPA 13* was changed to an informational note reference.
- Section 362.10(6) was split into two sections to separate requirement for installations in poured concrete floors, ceilings, walls, and slabs from those where the ENT is embedded in concrete slabs.

© 2022 *electrical training ALLIANCE*

362.10

REVISION



3219

© 2022 *electrical training ALLIANCE*

Article 369

NEW

Insulated Bus Pipe (IBP)/Tubular Covered Conductors

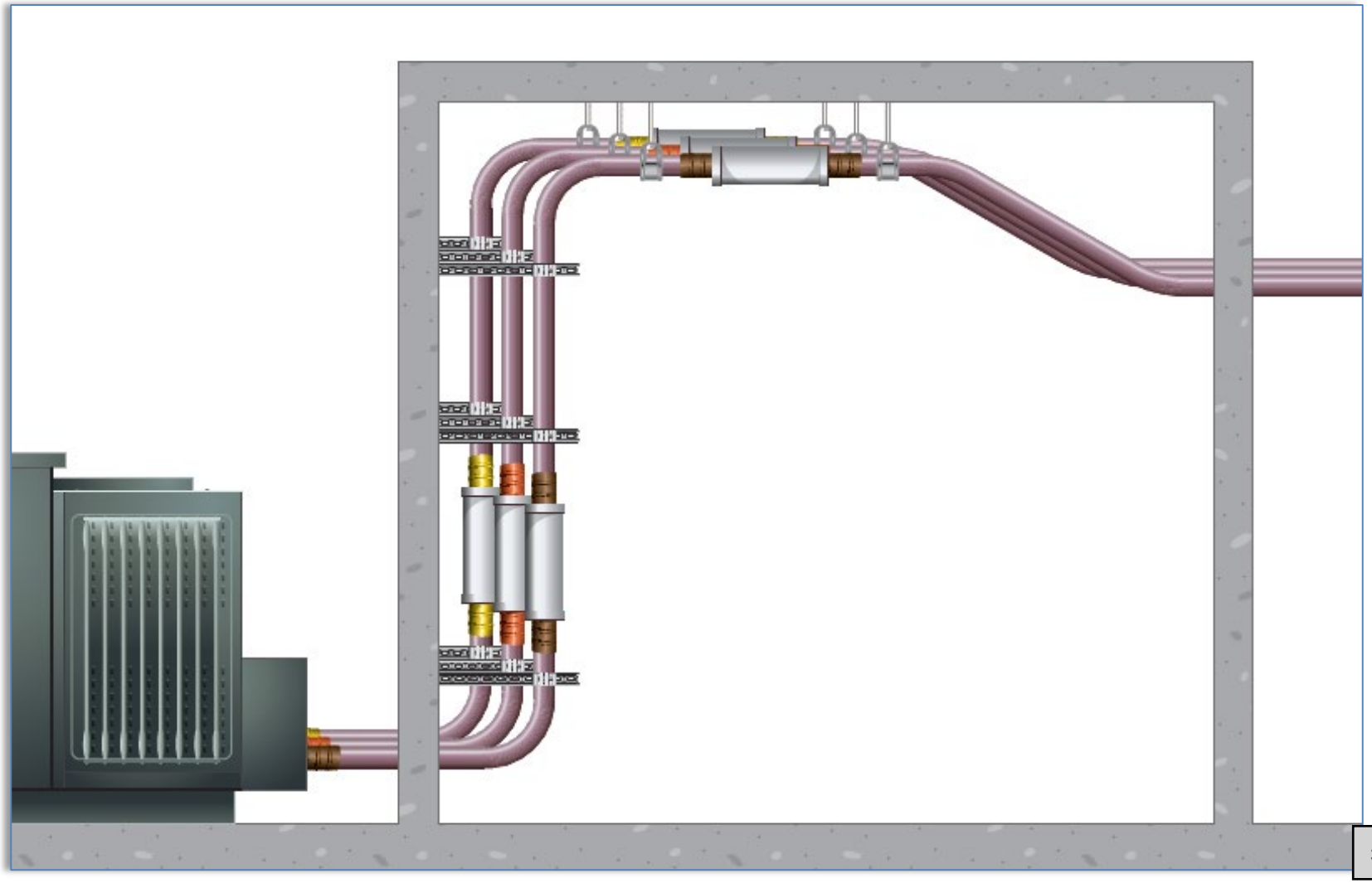
Change Summary

- The new Article 369 covers Insulated Bus Pipe (Type IBP).
- IBP is a cylindrical solid or hollow conductor with a solid insulation system having conductive grading layers and a grounding layer embedded in the insulation that is provided with an overall insulation or metallic material. It is permitted for up to 35 kV.
- IBP is required to be listed.
- IBP is permitted to be used in wet or damp locations when listed for wet or damp locations.
- IBP must not be accessible to unqualified persons.

© 2022 *electrical training ALLIANCE*

Article 369

NEW



3221

© 2022 *electrical training ALLIANCE*

370.18

REVISION

Cablebus Installation

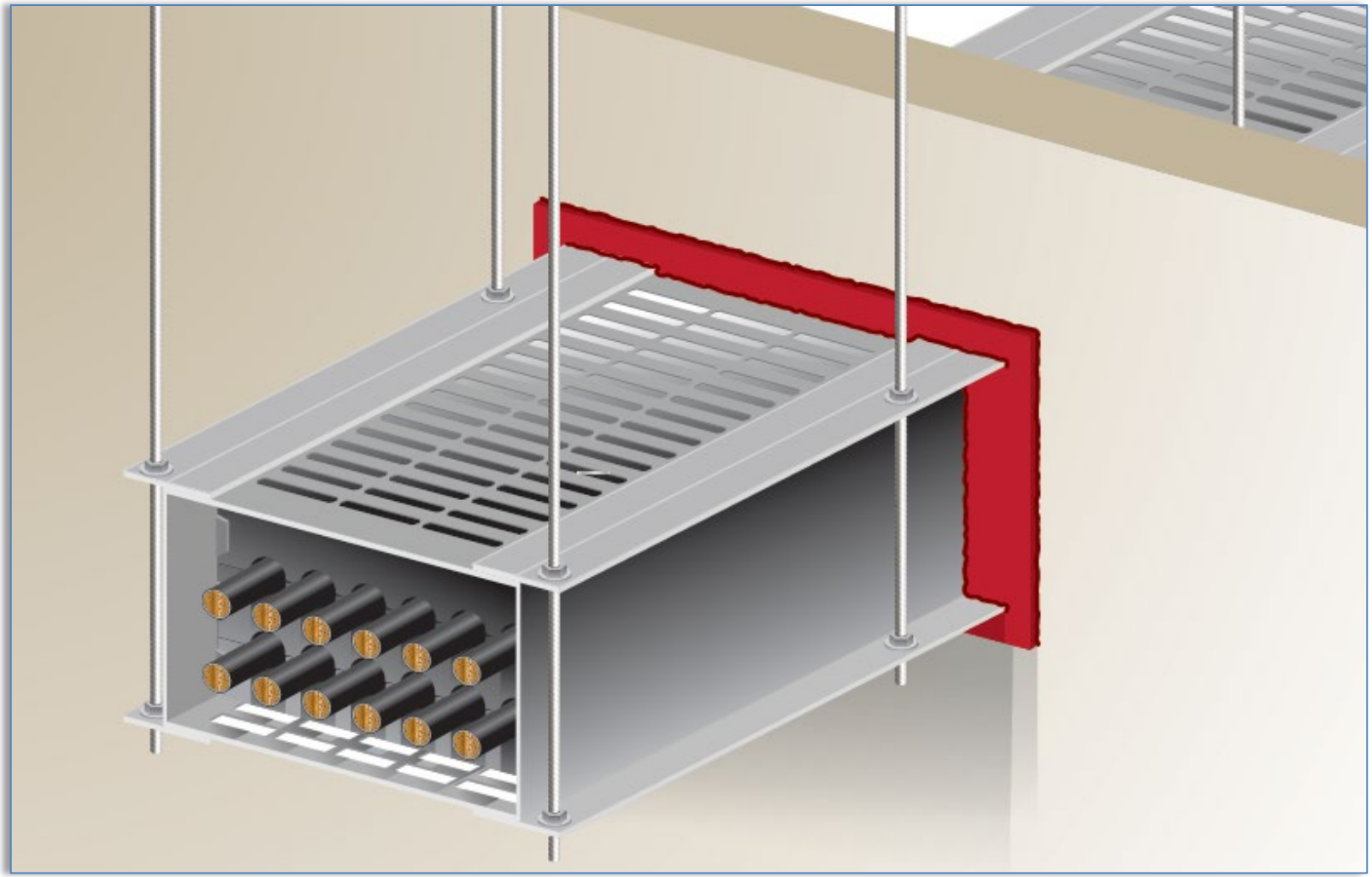
Change Summary

- Cablebus installation requirements have been simplified.
- Flexible bus is permitted to be run through fire walls in accordance with 300.21.
- Since cablebus is a support system, similar to cable trays, the firestop requirements now refer to 300.21.
- The previous requirement for curbs where cablebus penetrates floors has been removed because flexible bus is permitted in wet locations.

© 2022 *electrical training ALLIANCE*

370.18

REVISION



3223

© 2022 electrical training ALLIANCE

370.120

REVISION

Marking

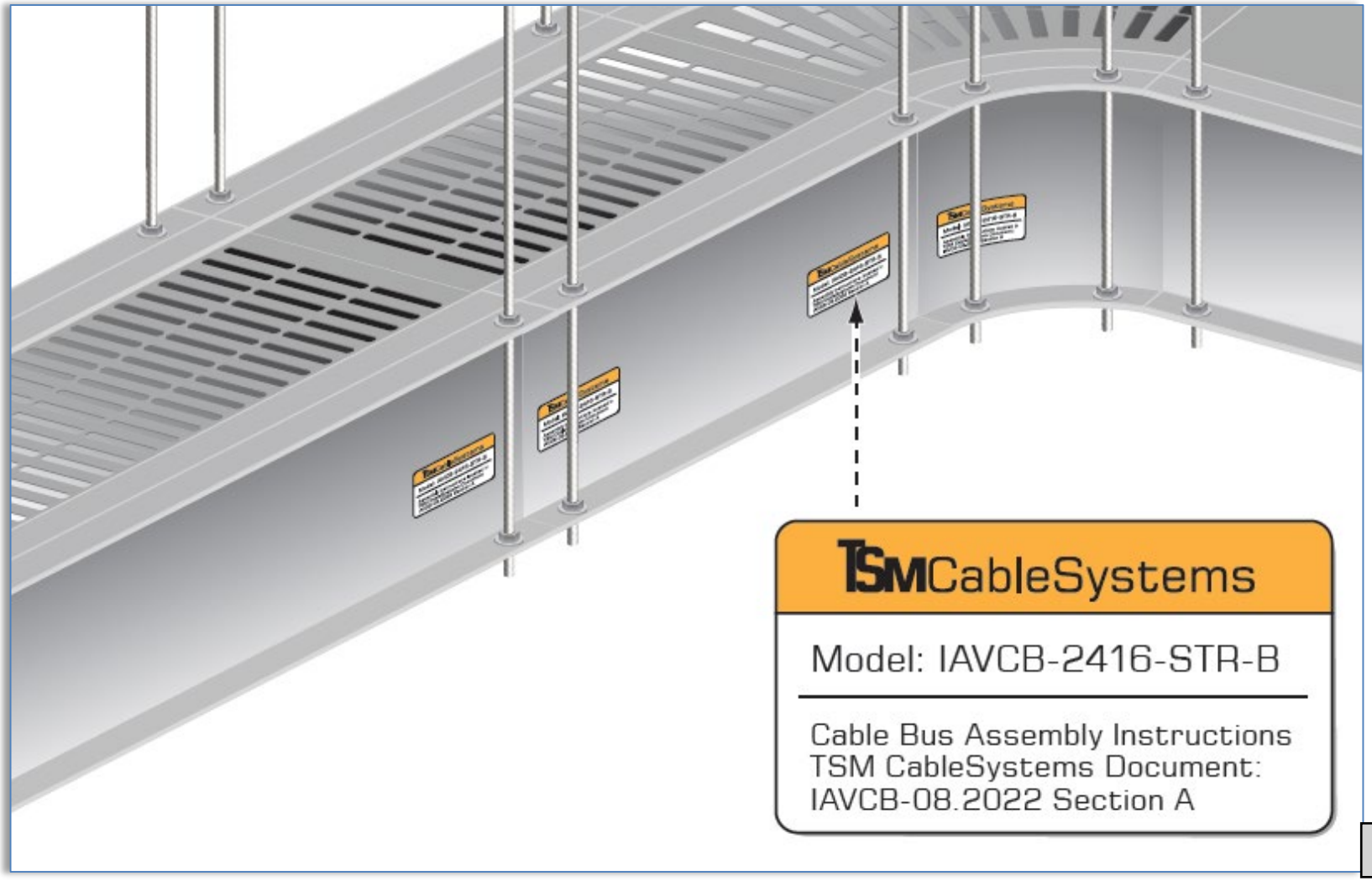
Change Summary

- Section 370.120 was revised to clarify cablebus marking requirements and to harmonize with requirements in Canada.
- Nameplates are required at each terminating end of the system, identifying the manufacturer as well as the ratings.
- Nameplates are required to be visible after installation.
- Each section and fitting of a flexible bus system is required to be identified with a marking that corresponds with the installation instruction.

© 2022 *electrical training ALLIANCE*

370.120

REVISION



3225

© 2022 *electrical training ALLIANCE*

Article 371

NEW

Flexible Bus Systems

Change Summary

- A new Article 371 was created for flexible bus systems, which are assemblies of flexible bus with associated fittings to secure, support, and terminate the bus.
- Flexible bus is permitted for services, feeders, and branch circuits.
- Flexible bus is permitted indoors, or outdoors if identified for outdoor use.
- Flexible bus is permitted to be used exposed or behind access panels as long as the space behind the access panels is not used for air handling.

© 2022 *electrical training ALLIANCE*

Article 371

NEW



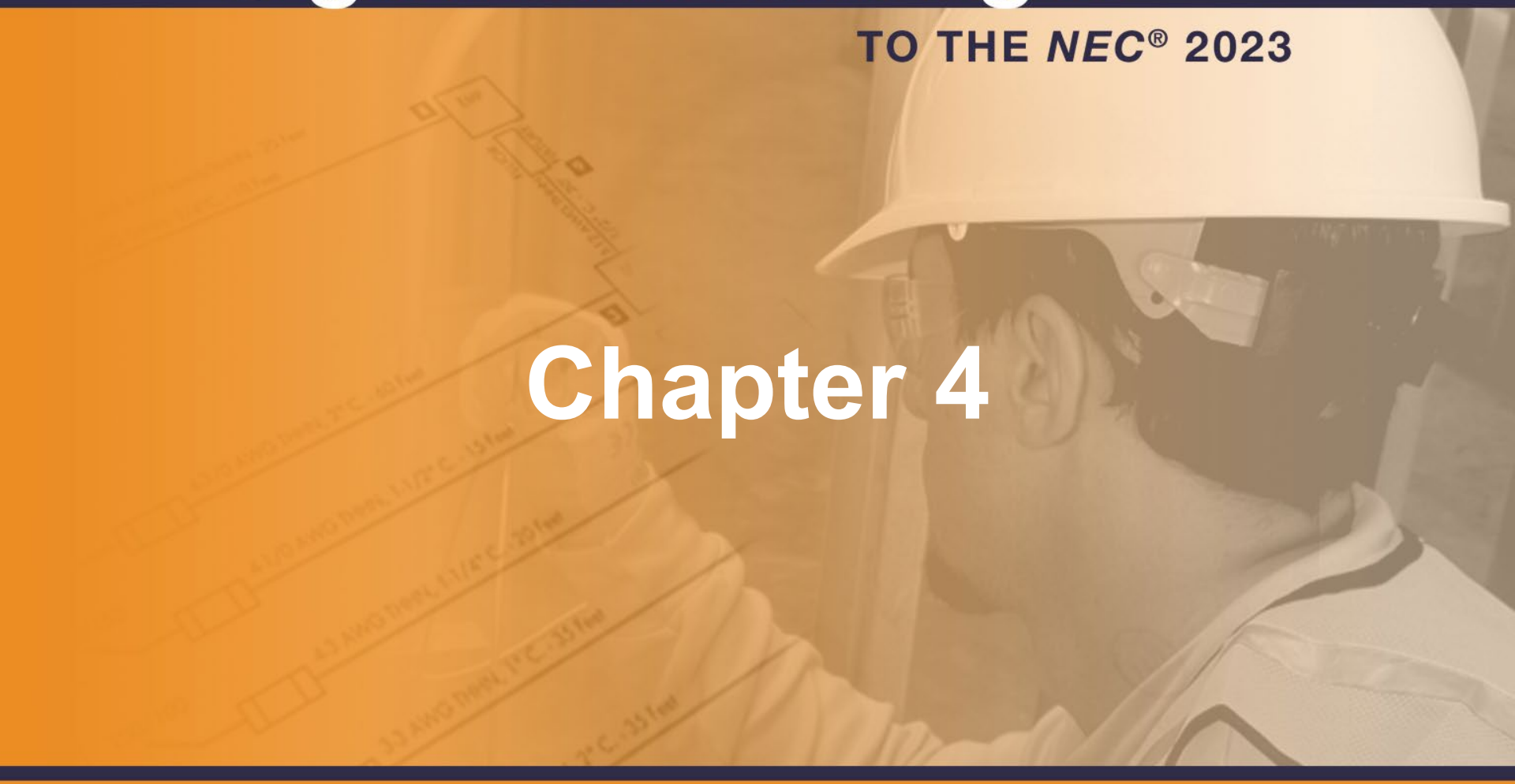
3227

© 2022 *electrical training ALLIANCE*

Courtesy of Ward Judson, nVent

Significant Changes

TO THE *NEC*® 2023



Chapter 4

electrical training ALLIANCE IBEW - NECA IN COLLABORATION WITH NECA NATIONAL ELECTRICAL CONTRACTORS ASSOCIATION

400.40 through 400.52

NEW REVISION

Portable Power Feeder Cables Over 2000 V, Nominal

Change Summary

- Article 400, Part III has a title change. It now covers portable cables of over 600 volts up to 2,000 volts.
- A new Part IV was added on portable power feeder cables over 2,000 volts, nominal.
- Portable power feeder cables can be used for connection of portable equipment and machinery or for wiring of cranes and hoists. Portable power feeder cables can also be used for temporary services and other temporary installations.

© 2022 *electrical training ALLIANCE*

400.40 through 400.52

NEW REVISION



3230

© 2022 *electrical training ALLIANCE*

404.1

REVISION

Scope

Change Summary

- Article 404 applies to all switches, switching devices, and circuit breakers used as switches.
- Article 404 typically applies to switches operating at 1,000 volts or less but can apply to switches operating at higher voltages as specifically referenced elsewhere in the *Code*.
- There is a new generation of wireless control switches that are battery operated. These wireless switches are not covered by Article 404.
- An informational note was added that points to 210.70, which now has requirements that apply to wireless switches.

© 2022 *electrical training ALLIANCE*

404.1

REVISION



3232

© 2022 electrical training ALLIANCE

404.14 & 404.14(D)

NEW REVISION

Snap Switch Terminations

Change Summary

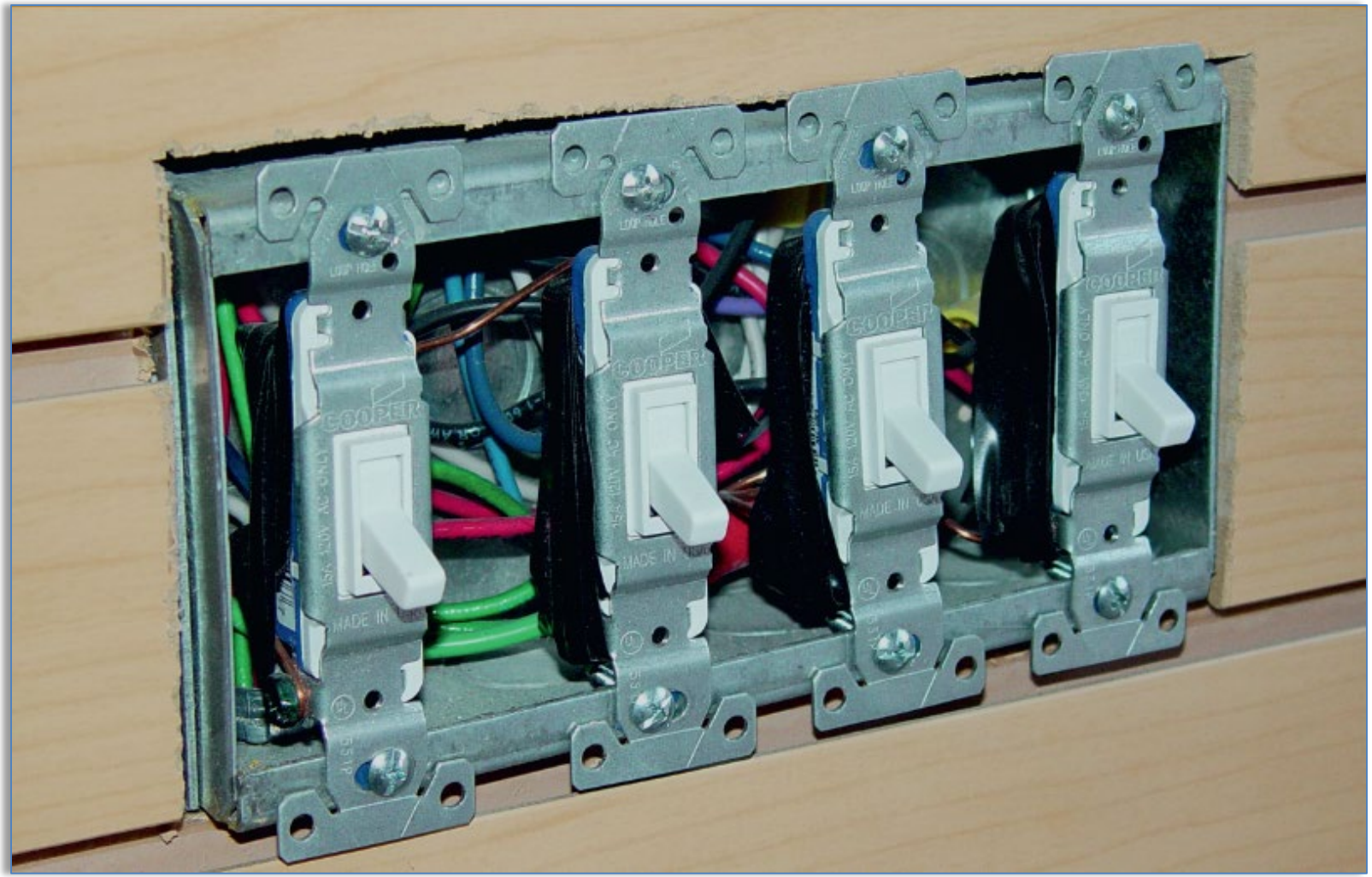
- Section 404.14 has been revised to require that switches be listed and marked with their ratings.
- New 404.14(D) was added to provide requirements for conductors used on the terminals of switches based on the markings of the switches.
- Section 404.14(D)(3) also addresses the limited use of push-in terminals, which are restricted to 14 AWG copper conductors only.

3233

© 2022 *electrical training ALLIANCE*

404.14 & 404.14(D)

NEW | REVISION



3234

© 2022 *electrical training ALLIANCE*

404.16

NEW

Reconditioned Equipment

Change Summary

- Lighting, dimmer, and electronic control switches are not permitted to be reconditioned.
- Snap switches are an inexpensive and easily-replaceable item. Therefore, they are not permitted to be reconditioned.
- Knife switches, switches with butt contacts, and bolted pressure switches are permitted to be reconditioned.

© 2022 *electrical training ALLIANCE*

404.16

NEW



3236

© 2022 *electrical training ALLIANCE*

Courtesy of Leviton

404.30

NEW

Switch Enclosures with Doors

Change Summary

- Doors of enclosures for switches that provide access to live parts when opened must be constructed so that either a tool or other approved means is necessary to open the door if the switch is in the closed position.
- A similar change was made in 690.13(A) and 690.15(A) during the 2020 cycle.
- This does not prohibit the use of a lock to prevent access.
- These changes are intended to restrict access by unqualified persons. The primary intent is to protect children.

© 2022 *electrical training ALLIANCE*

404.30

NEW



3238

© 2022 *electrical training ALLIANCE*

Courtesy of Michael J. Johnston

406.3

REVISION

Receptacle Rating and Type

Change Summary

- The title of 406.3(C) has been changed to CO/ALR Receptacles.
- Section 406.3(D) has been added to cover requirements for termination of conductors to receptacles.
- Push-in terminals are only listed for 14 AWG copper conductors and can only be used to connect receptacles on 15-ampere branch circuits.

© 2022 *electrical training ALLIANCE*

406.3

REVISION



3240

© 2022 *electrical training ALLIANCE*

406.4

REVISION

General Installation Requirements

Change Summary

- Section 406.4(D)(3) now requires replacement GFCI-type receptacles to be listed.
- Section 406.4(D)(5) provides requirements for replacement tamper-resistant receptacles. A tamper-resistant receptacle is not required if a non–grounding-type receptacle is replaced with another non–grounding-type receptacle. A tamper-resistant receptacle is also not required if a CO/ALR receptacle is replaced with another CO/ALR receptacle.
- Replacement receptacles must be provided with GFPE if required elsewhere in the *Code*.
- Floor receptacles must be protected in accordance with 406.4(G).

© 2022 *electrical training ALLIANCE*

406.4

REVISION



3242

© 2022 *electrical training ALLIANCE*

406.9

REVISION

Receptacles in Damp or Wet Locations

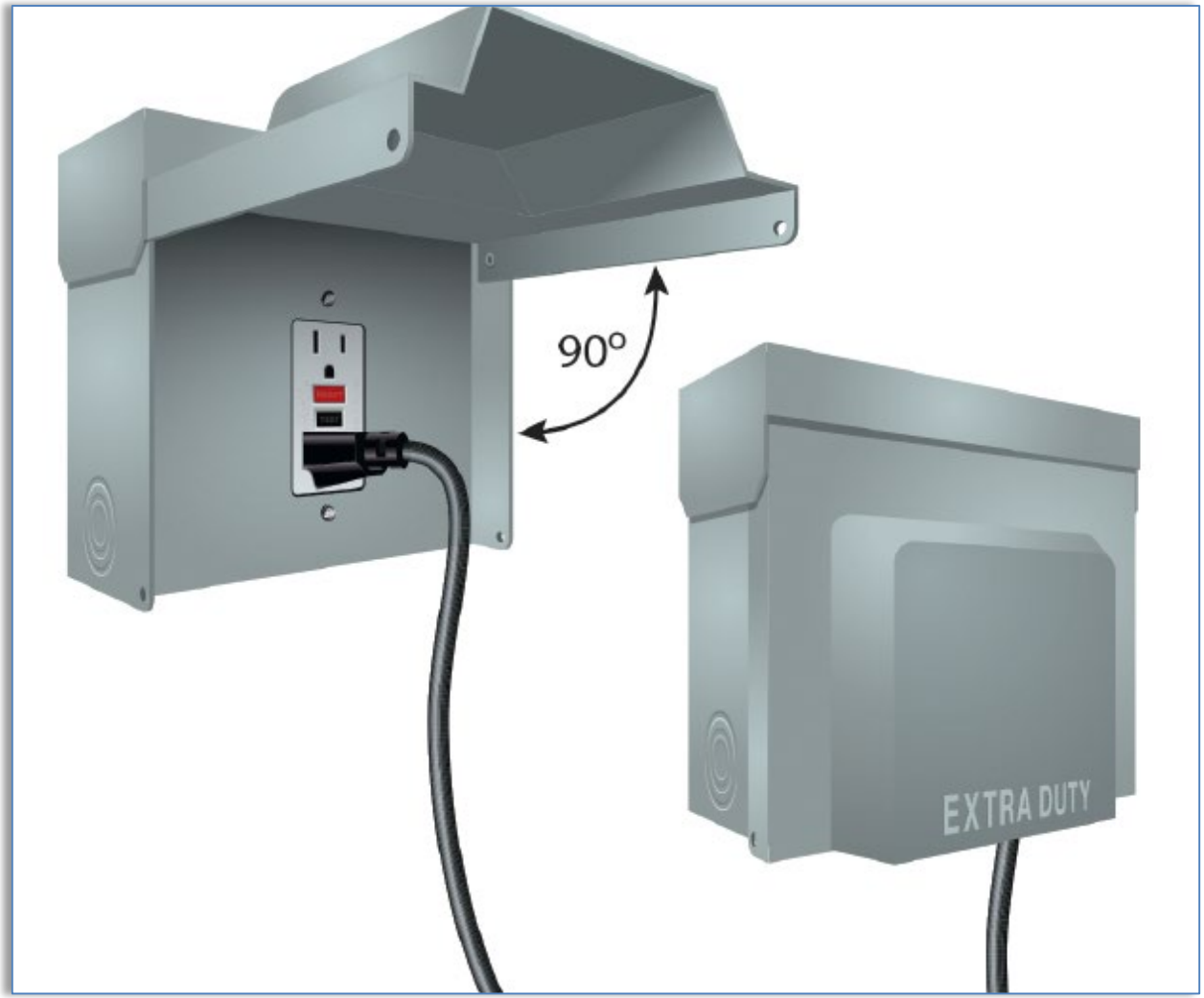
Change Summary

- Hinged covers of outlet box hoods in damp locations must be able to open at least 90° from the open to the closed position.
- If not designed to open 90°, it must be able to open fully.
- All receptacles in wet locations must be listed and identified as weather resistant.
- Other receptacles in wet locations that are attended while in use must be weatherproof with the attachment plug removed.
- The bathtub and shower space zones have been revised.

© 2022 *electrical training ALLIANCE*

406.9

REVISION



3244

© 2022 *electrical training ALLIANCE*

406.12

REVISION

Tamper-Resistant Receptacles

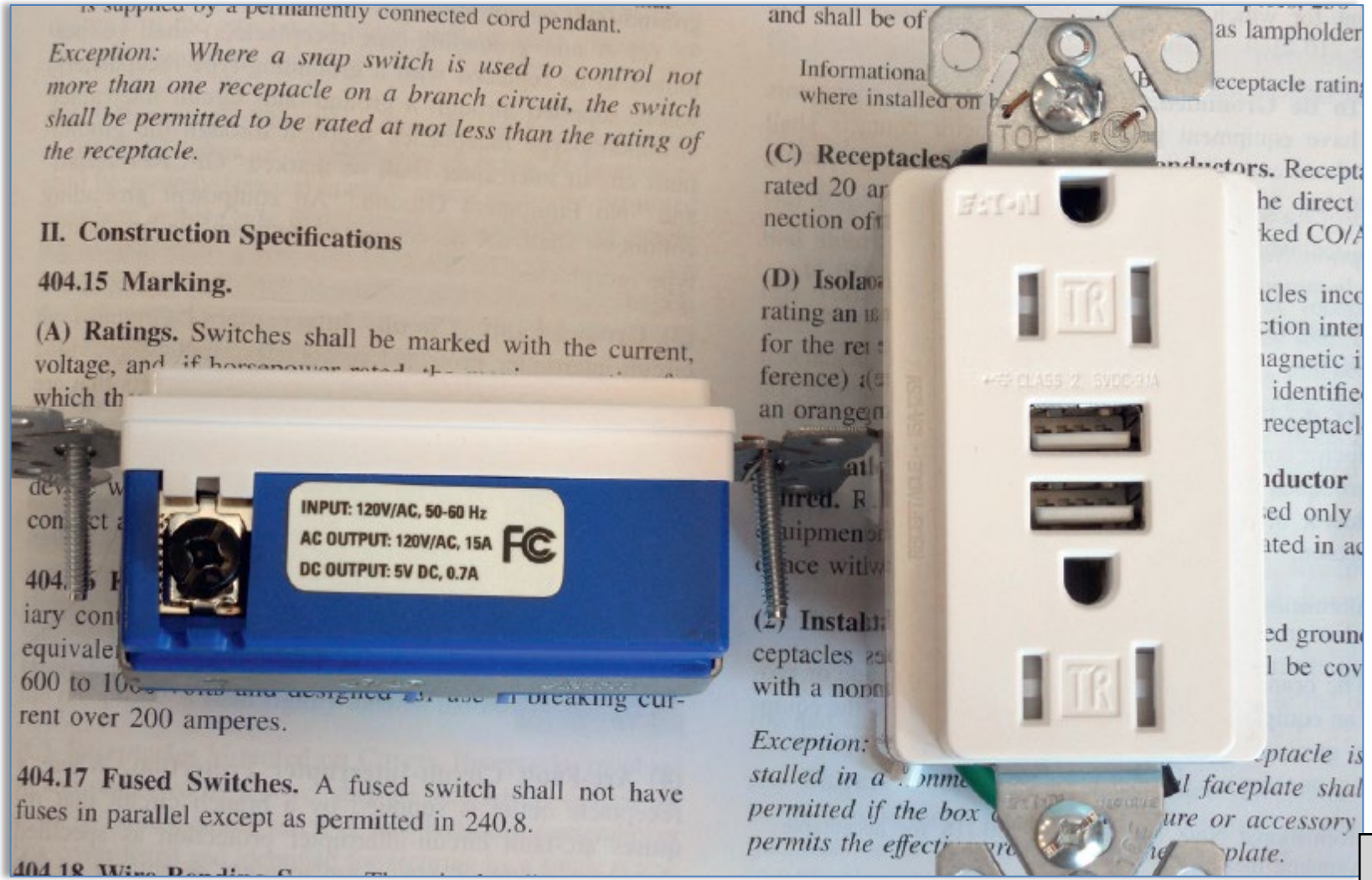
Change Summary

- Tamper-resistant receptacle requirements now include all dwelling units, boathouses, mobile homes, and manufactured homes, including their attached and detached garages.
- Requirements for tamper-resistant receptacles in medical facilities and other types of residential facilities have been revised and clarified.
- The exception has been clarified so that a tamper-resistant receptacle is not required for single receptacles that supply one appliance or duplex receptacles that are not readily accessible. The exception only applies if the receptacle is in the space designated for a specific appliance.

© 2022 *electrical training ALLIANCE*

406.12

REVISION



3246

© 2022 electrical training ALLIANCE

Courtesy of Eaton Corporation

408.4

REVISION

Descriptions Required

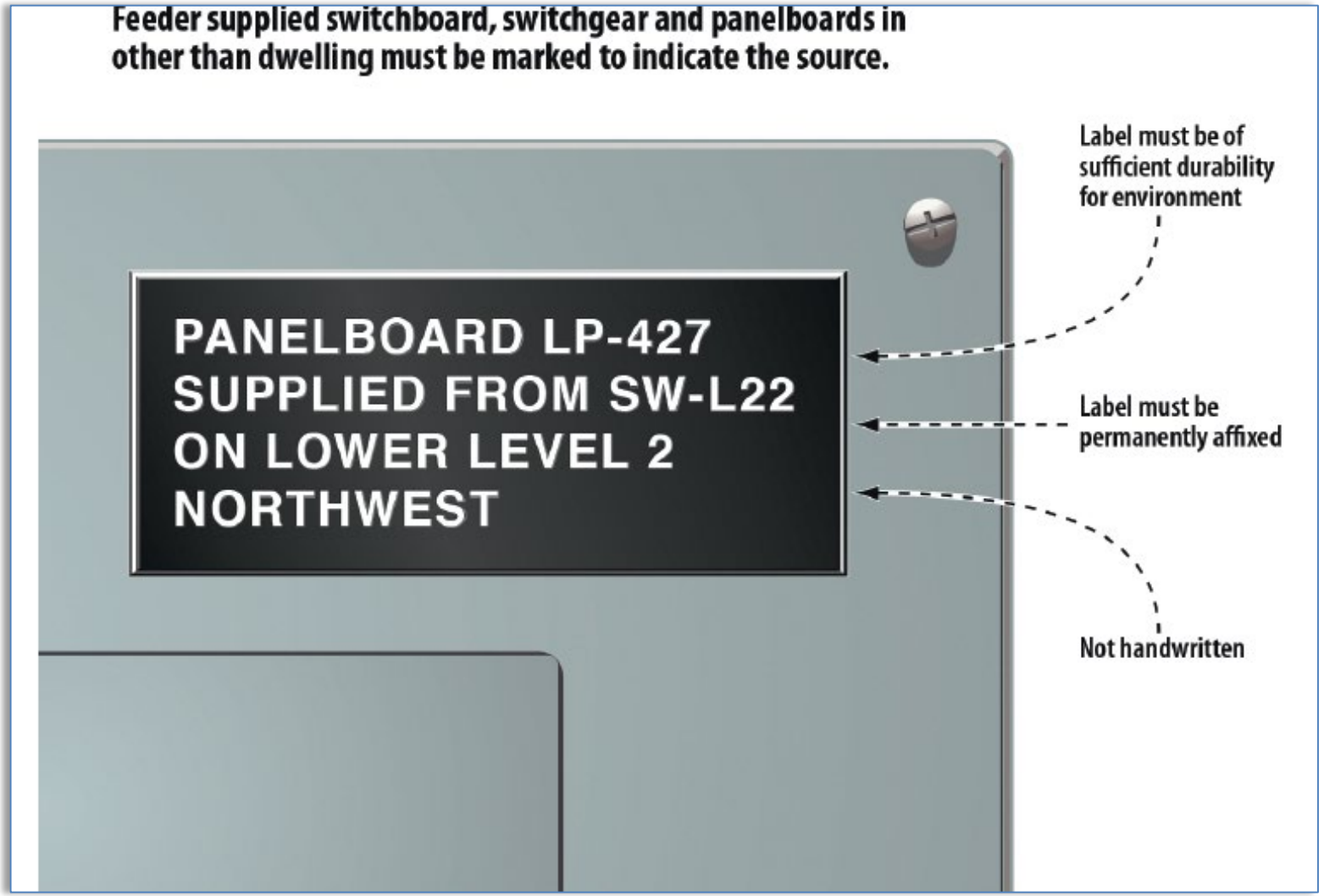
Change Summary

- The title of 408.4 has been changed from “Field Identification” to “Descriptions Required.”
- Every circuit and circuit modification is required to be legibly and permanently described with its clear, evident, and specific purpose or use.
- All switchboards, switchgear, and panelboards supplied by a feeder in other than one- and two-family dwellings must be marked to indicate the location of the power source.

© 2022 *electrical training ALLIANCE*

408.4

REVISION



3248

© 2022 electrical training ALLIANCE

408.9

NEW

Replacement Panelboards

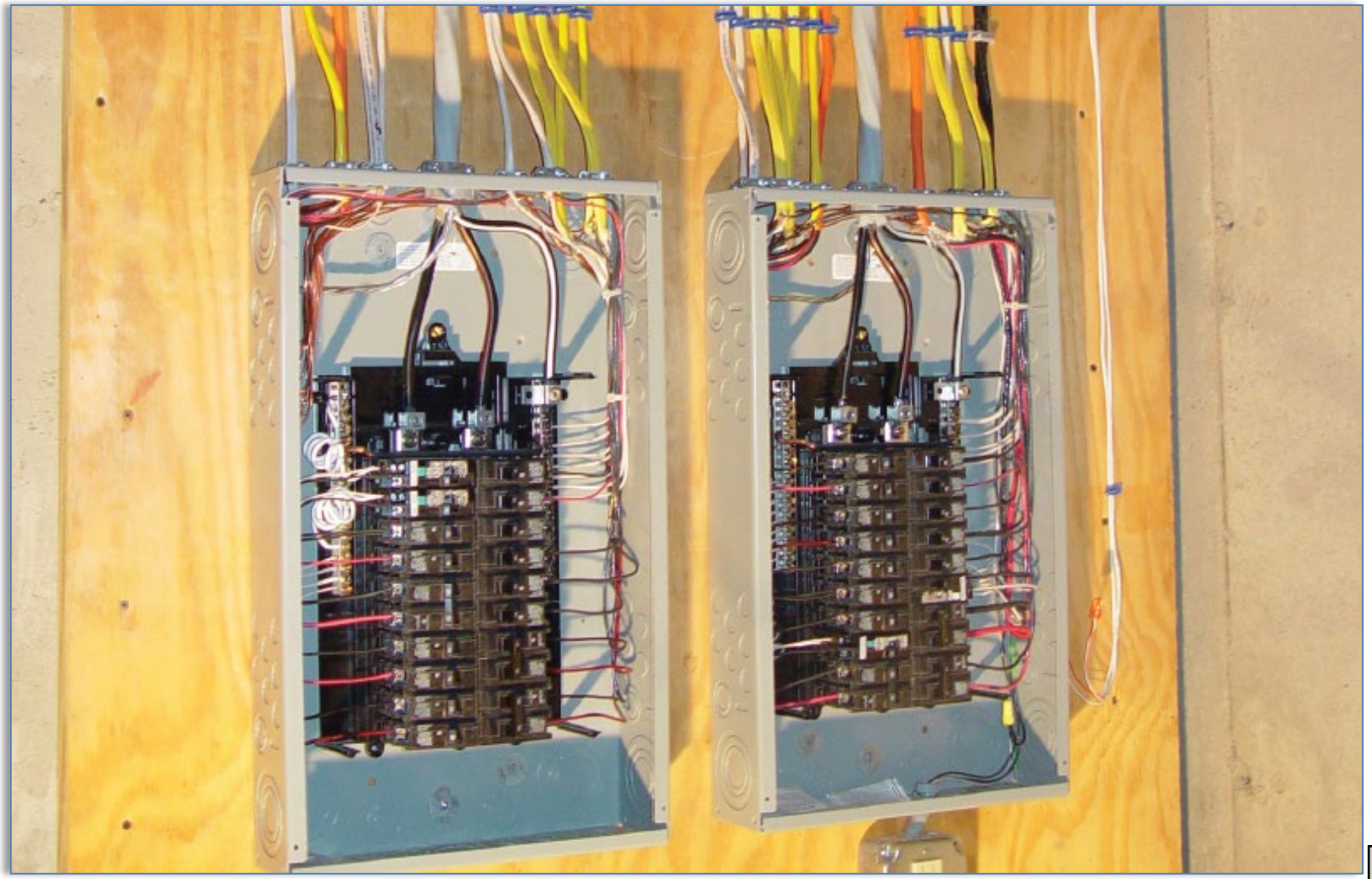
Change Summary

- A new 408.9 has been added to provide requirements for replacement panelboards.
- Panelboards listed for the specific enclosure are permitted to maintain their short-circuit current rating.
- Panelboards not listed for the specific enclosure with fault current over 10,000 amperes require field labeling. If fault current is less than 10,000 amperes, any previous listing marks must be removed.

© 2022 *electrical training ALLIANCE*

408.9

NEW



3250

© 2022 *electrical training ALLIANCE*

Courtesy of Michael J. Johnston

408.43

REVISION

Panelboard Orientation

Change Summary

- The 2020 *Code* prohibited panelboards from being installed in the face-up position because it created an unsafe working position and increased the likelihood that debris could accumulate in the panelboard.
- The requirement has also been modified for the 2023 *Code* to prohibit installation in the face-down position.
- Installation in a face-down position introduces working space concerns. Working on the panelboard would be awkward, increasing the likelihood of injury during an arc flash or arc blast incident.

© 2022 *electrical training ALLIANCE*

408.43

REVISION



3252

© 2022 *electrical training ALLIANCE*

Courtesy of Michael J. Johnston

409.60

REVISION

Bonding

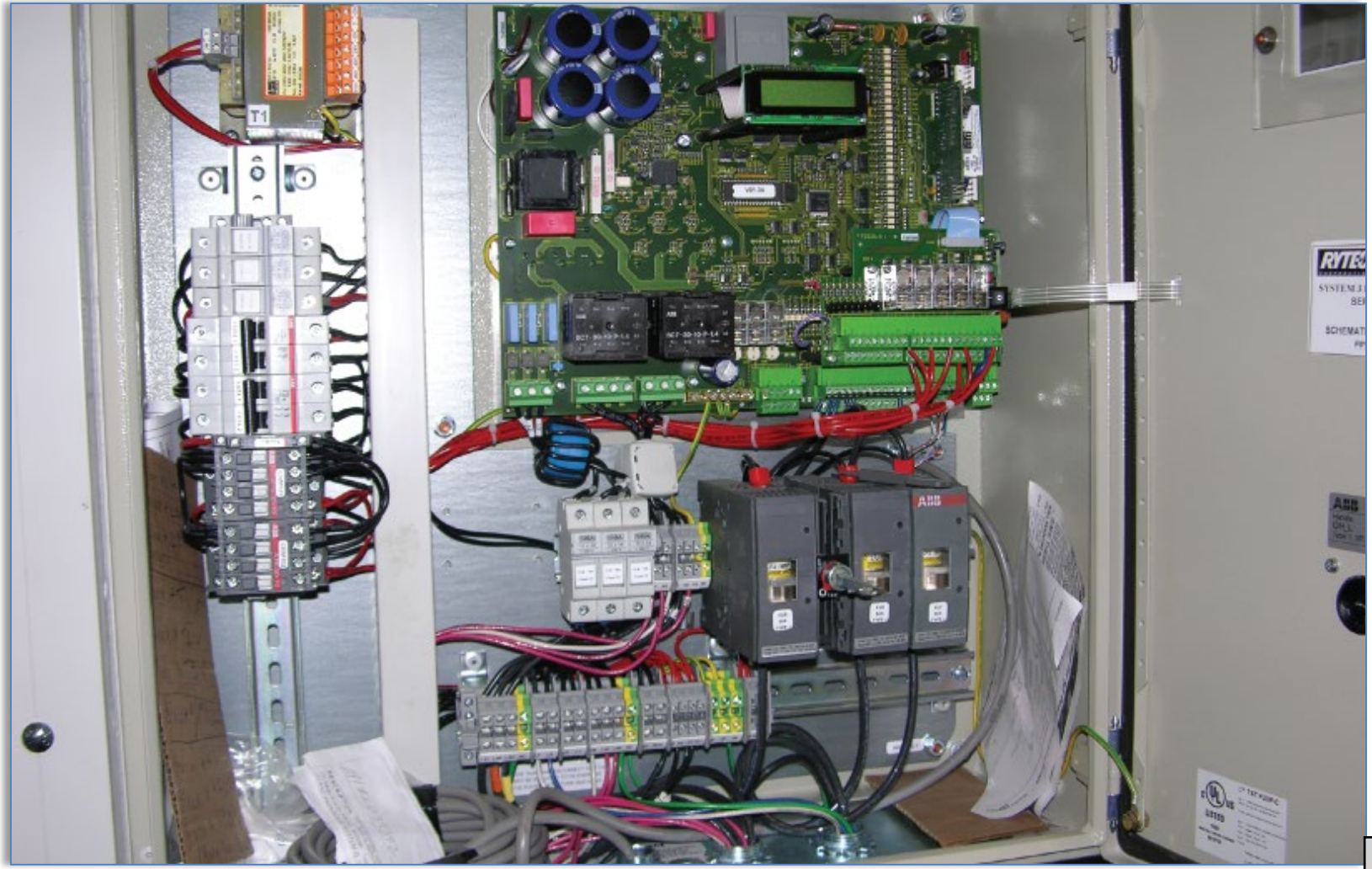
Change Summary

- Section 409.60 has been retitled “Bonding” and has been reorganized into list format for clarity.
- Section 409.60(A), “Grounding,” requires an EGC sized in accordance with 250.122 to be connected to an equipment grounding bus or equipment grounding termination point provided in a single-section industrial control panel.
- Section 409.60(B) requires multisection industrial control panels to be bonded together using a bonding jumper sized in accordance with 250.102(D).

© 2022 *electrical training ALLIANCE*

409.60

REVISION



3254

© 2022 *electrical training ALLIANCE*

409.70

NEW

Surge Protection

Change Summary

- A new Section 409.70 has been added to require surge protection for safety circuits for personnel protection.
- A survey of facility managers in 2013 and 2014 by the Fire Protection Research Foundation found that 26% of safety circuits that were intended to protect personnel had surge damage.
- It was also found that 40% of the surges in industrial facilities were from causes within the plant rather than lightning-caused surges.

© 2022 *electrical training ALLIANCE*

409.70

NEW



© 2022 *electrical training ALLIANCE*

409.110

REVISION

Marking

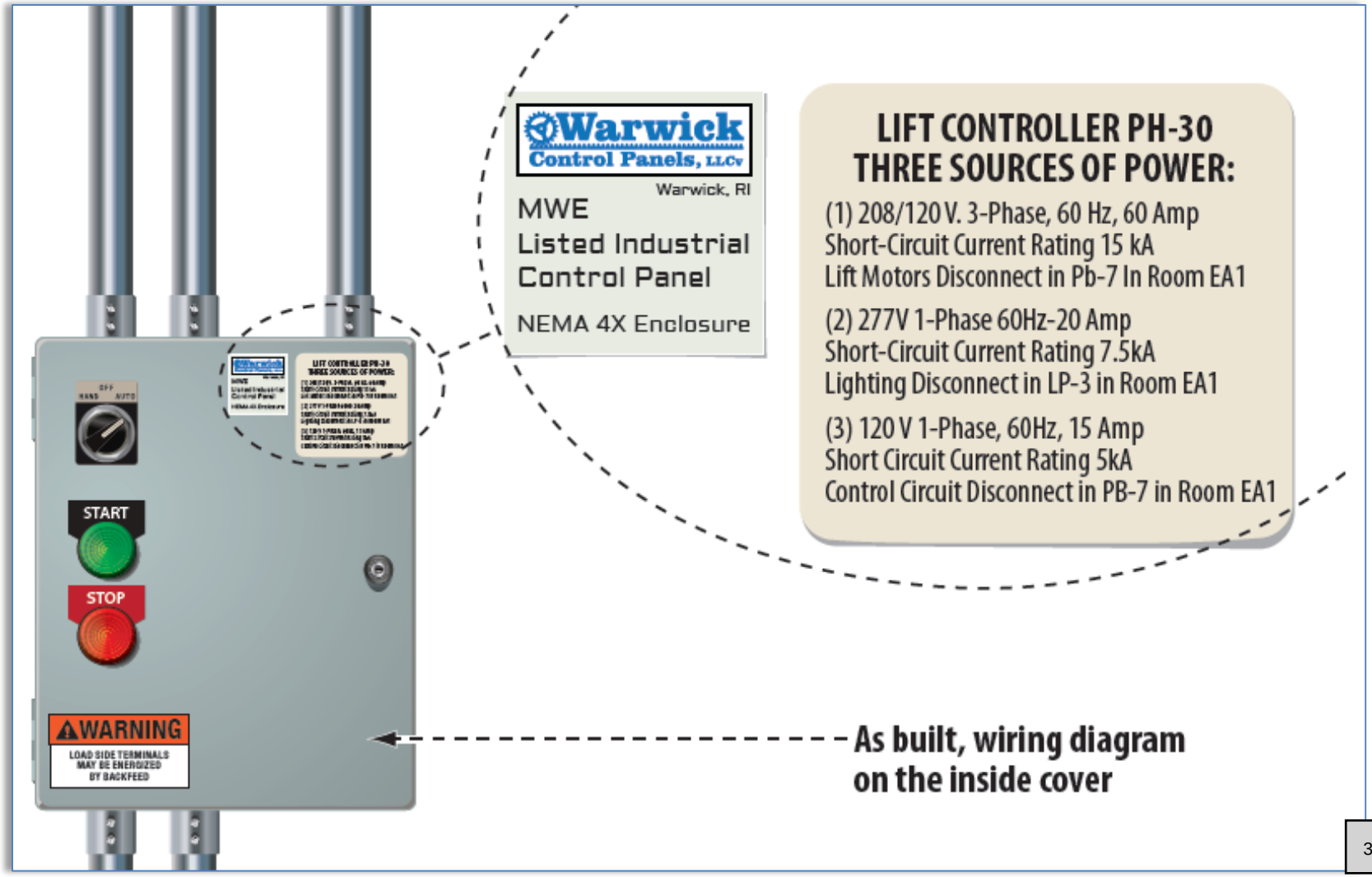
Change Summary

- The marking requirements for industrial control panels have been clarified.
- The voltage, number of phases, and full-load current are required to be marked on the exterior of the enclosure for each supply circuit.
- If the industrial control panel is supplied by multiple sources of supply with multiple disconnecting means, the location of all sources exceeding 50 volts is required to be marked on the exterior.
- The other required markings must be inside or outside of the enclosure.

© 2022 *electrical training ALLIANCE*

409.110

REVISION



3258

© 2022 electrical training ALLIANCE

410.42

REORGANIZE

Luminaires with Exposed Conductive Surfaces

Change Summary

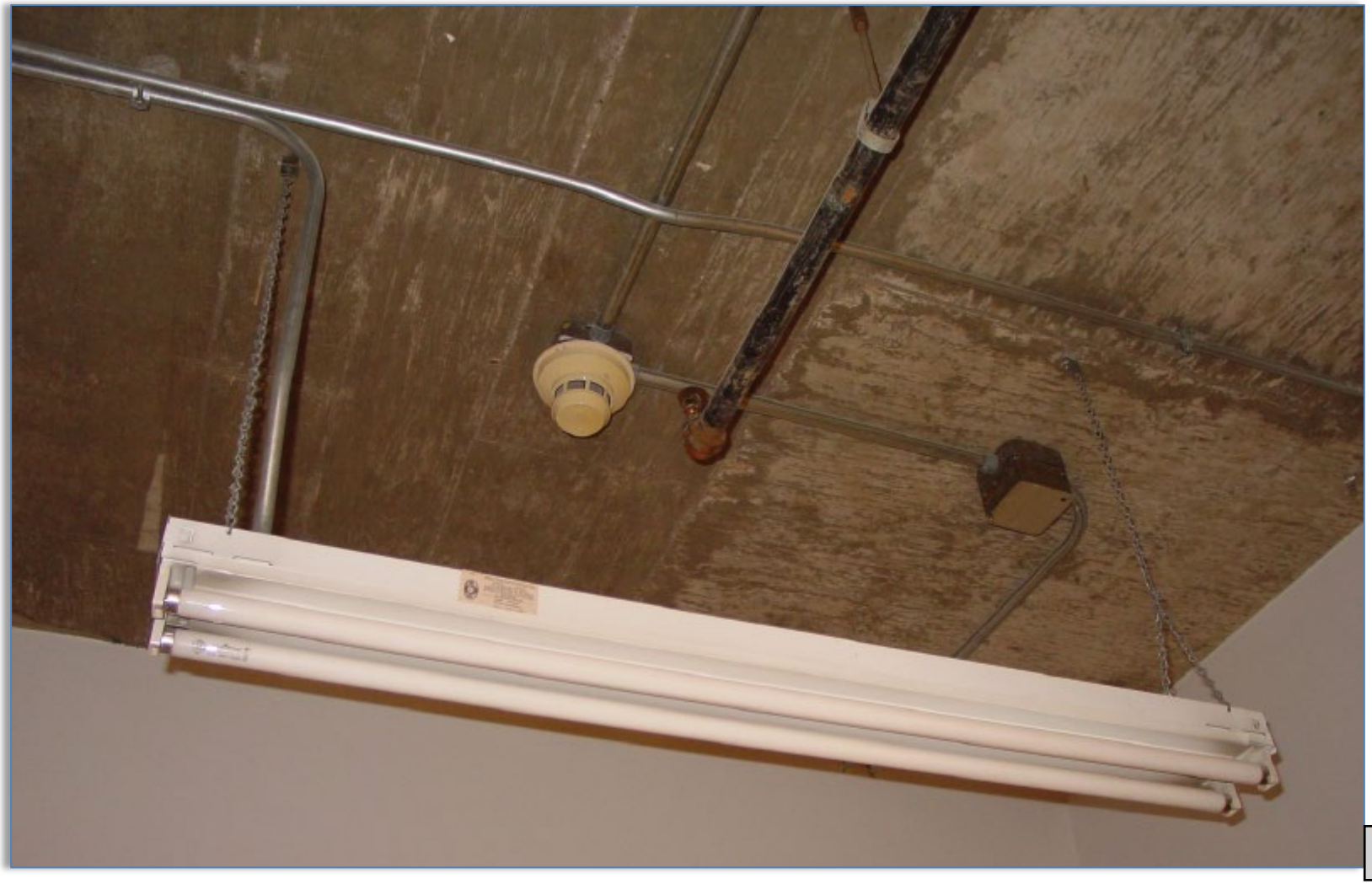
- Section 410.42 was reorganized into a main rule that requires exposed conductive surfaces of a luminaire to be connected to an equipment grounding conductor.
- An exception covers parts that do not require an EGC connection, including:
  - Surfaces that are separated by a listed system of double insulation.
  - Small, isolated parts such as screws, clips, and bands that are separated by at least 1 ½ inches from terminals.
  - Portable luminaires with polarized attachment plugs.

3259

© 2022 *electrical training ALLIANCE*

410.42

REORGANIZE



3260

© 2022 electrical training ALLIANCE

Courtesy of Michael J. Johnston

410.71

REVISION RELOCATE

Disconnecting Means-Fluorescent or LED Luminaires

Change Summary

- Section 410.130(G)(1) was moved into a new 410.71.
- The requirement has been expanded to include LED luminaire drivers that utilize double-ended lamps.
- LED luminaires are more energy-efficient but can still pose the same shock and electrocution hazards to workers.

© 2022 *electrical training ALLIANCE*

410.71

REVISION **RELOCATE**



3262

© 2022 *electrical training ALLIANCE*

Courtesy of Tom Garvey and Michael J. Johnston

410.190 through 197

NEW

Provisions for Germicidal Irradiation Luminaires

Change Summary

- A new Part XVII on germicidal radiation luminaires has been added to Article 410.
- Luminaires intended to emit germicidal radiation are required to be listed.
- Germicidal radiation luminaires must be installed in accordance with the manufacturer's instructions.
- Germicidal luminaires are not permitted in dwellings, unless listed and identified for dwellings.

© 2022 *electrical training ALLIANCE*

410.190 through 197

NEW



3264

© 2022 *electrical training ALLIANCE*

Article 422

DELETION REORGANIZE

Appliances

Change Summary

- Several sections in Article 422 were deleted because they were unnecessary for field applications.
- Section 422.6 requires that all appliances be listed. This eliminated the need for Sections 422.3 and 422.4.
- Sections 422.15 and 422.46 were deleted because they do not address unique field installation problems.
- Section 422.23 was deleted because it provides a redundant reference to the special permission requirement in 90.3.
- The flexible cord requirements in 422.43 were consolidated with other flexible cord requirements in 422.16(A).

© 2022 *electrical training ALLIANCE*

Article 422

DELETION **REORGANIZE**



3266

© 2022 *electrical training ALLIANCE*

422.18

REVISION

Ceiling-Suspended (Paddle) Fans

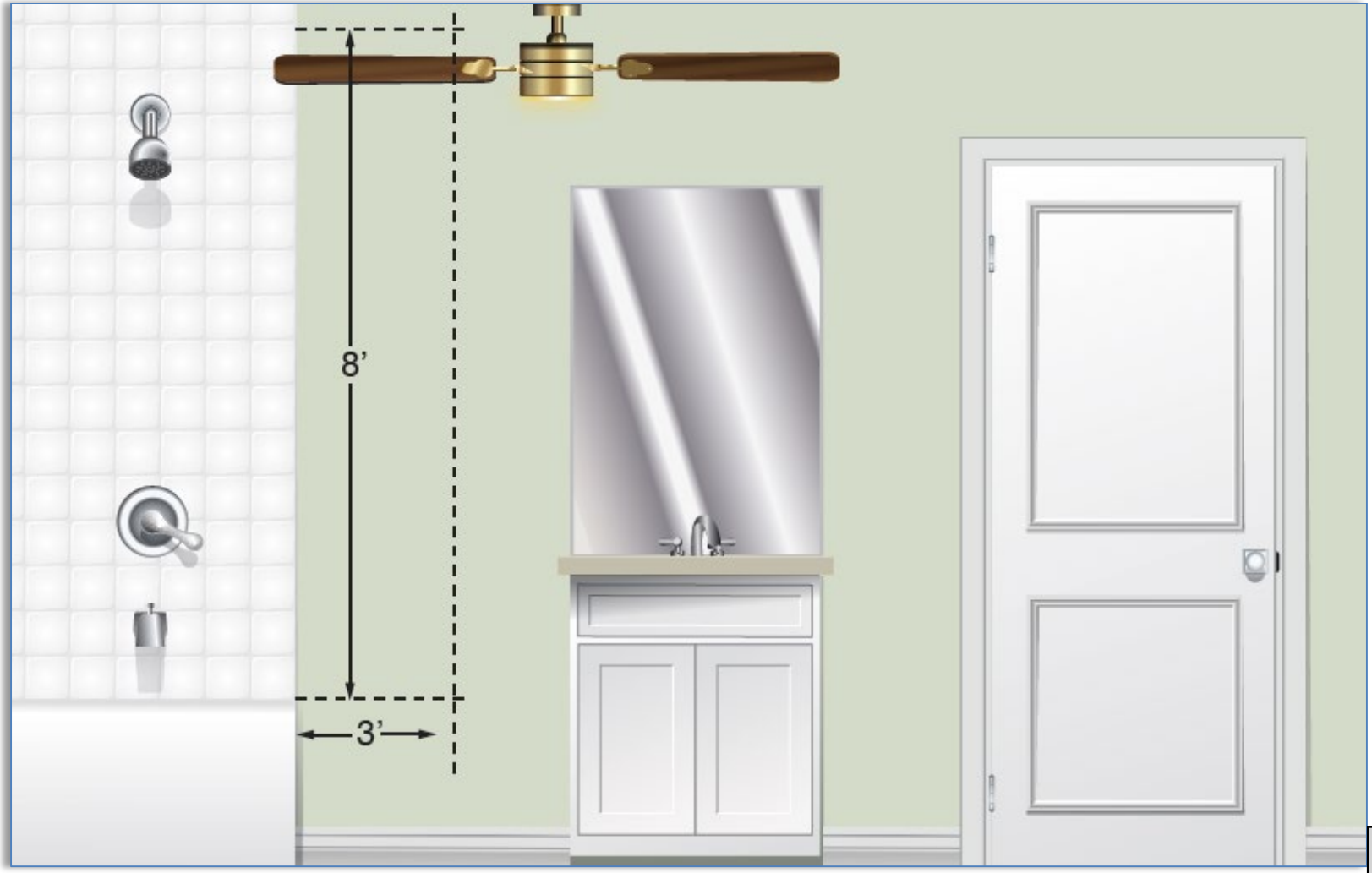
Change Summary

- 422.18(A)(1) was revised to clarify that listed outlet boxes or outlet box systems must be identified for fan support.
- 422.18(A)(2) was revised to use the new terms for weight-supporting ceiling receptacle and weight-supporting attachment fitting.
- 422.18(B) was added to prohibit metal parts of paddle fans from being located within three feet horizontally and eight feet vertically from the top of a bathtub rim or shower threshold.

© 2022 *electrical training ALLIANCE*

422.18

REVISION



3268

© 2022 electrical training ALLIANCE

424.48

NEW

Installation of Cables in Walls

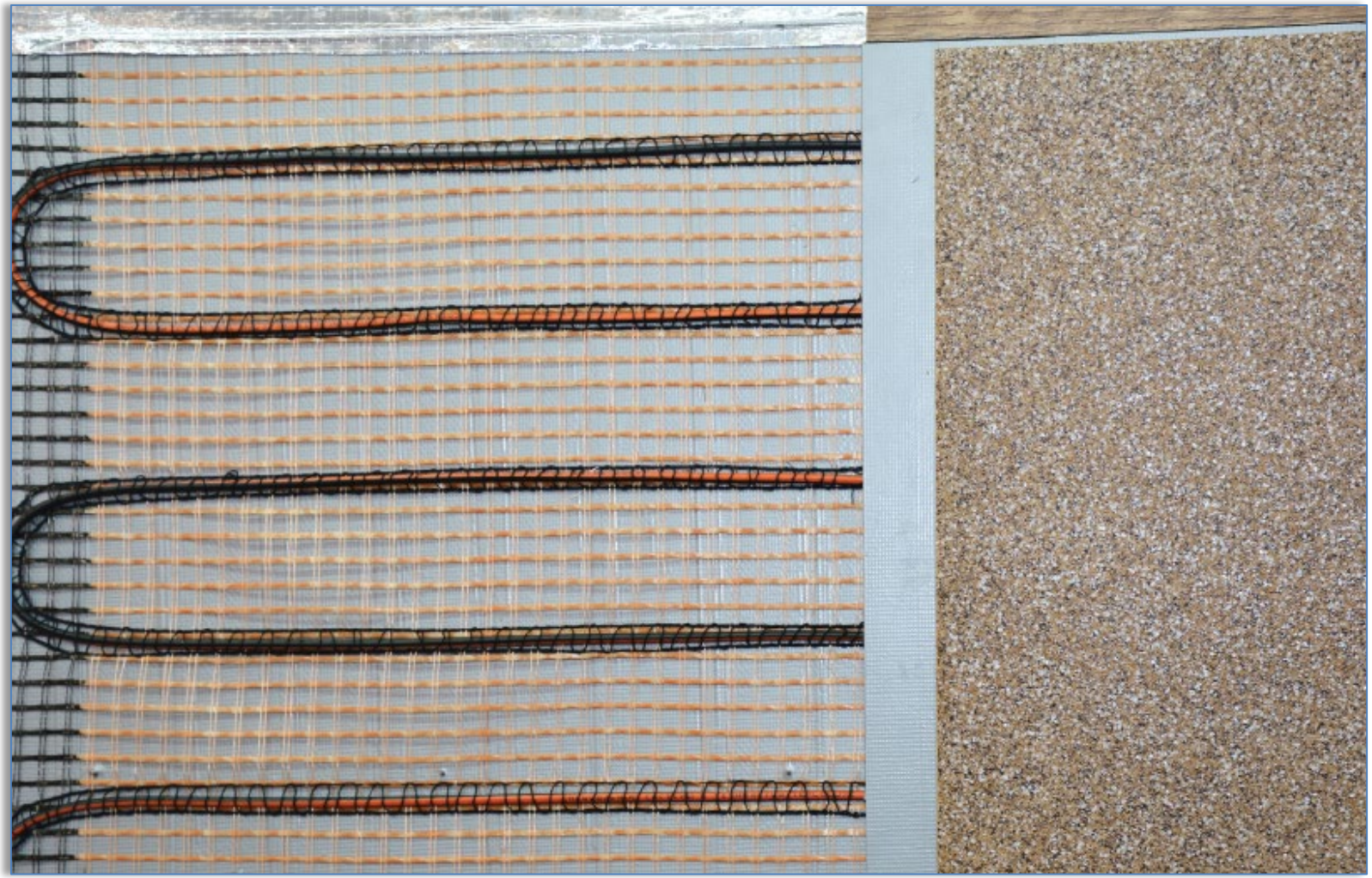
Change Summary

- Section 424.48 recognizes a new heating system that consists of heating cable sets or heating panel sets that can be installed in, on, or behind walls.
- Heating cables and cable sets are required to be GFCI and AFCI protected.
- Heating cables and cable sets are not permitted more than four feet above the floor.

© 2022 *electrical training ALLIANCE*

424.48

NEW



3270

© 2022 *electrical training ALLIANCE*

430.1

REVISION

Scope

Change Summary

- Informational Note Figure 430.1 was revised to make it more useful. The table above the figure remains unchanged.
- For consistency, section numbers were removed from the figure.
- Blocks were added to the diagram indicating feeder overcurrent protection, motor controller disconnecting means, motor branch-circuit conductors, local motor branch-circuit disconnecting means (moved),and grounding.

© 2022 *electrical training ALLIANCE*

430.1

REVISION



3272

© 2022 *electrical training ALLIANCE*

Courtesy of Michael J. Johnston

430.6

REVISION

Conductor Ampacity and Motor Rating Determination

Change Summary

- For most general applications, the current values used for determining the ampacity of conductors, the ampere rating of switches, and the ampere rating of branch-circuit short-circuit and ground-fault protection are based on table values from Article 430, Part IV.
- New 430.6(A)(2)(3) was added to permit the use of nameplate current ratings for motors that exceed the motor sizes in Part XIV.
- Section 430.6 was changed into list format to make it easier to use.

© 2022 *electrical training ALLIANCE*

430.6

REVISION



3274

© 2022 electrical training ALLIANCE

Courtesy of Michael J. Johnston

430.52(C)

REVISION

Rating or Setting

Change Summary

- Section 430.52(C)(3) was revised to recognize the higher available inrush current that is available for Design B premium efficiency motors that are protected by an instantaneous-trip circuit breaker.
- Section 430.52(C)(6) was revised to recognize the higher inrush current for Design B premium efficiency motors supplied by a self-protected combination motor controller.
- Design B premium efficiency motors have been mandated in new federal energy efficiency regulations. Design B and Design B premium efficiency motors have high inrush currents because they are low-impedance equipment.

© 2022 *electrical training ALLIANCE*

430.52(C)

REVISION



3276

© 2022 *electrical training ALLIANCE*

Courtesy of Michael J. Johnston

430.83(F)

NEW

Ratings

Change Summary

- The new 430.83(F) prohibits installing a motor controller on a circuit where the motor controller's short-circuit current rating is exceeded.
- Section 430.8 generally requires motor controllers to be marked with their short-circuit current ratings.
- Section 110.20 requires the equipment short-circuit current ratings and other characteristics of the circuit to be selected and coordinated to permit the circuit protective devices to clear faults without extensive damage to the electrical equipment.

© 2022 *electrical training ALLIANCE*

430.83(F)

NEW



3278

© 2022 *electrical training ALLIANCE*

440.8

REVISION

Single Machine and Location

Change Summary

- Air-conditioning and refrigeration equipment is prohibited from being installed within three feet horizontally and eight feet vertically above a bathtub rim or shower threshold, including the space directly above the shower or tub.
- This requirement primarily affects the installation of mini-split air-conditioning system evaporators.
- Bathrooms are typically very small rooms. A change in bathroom configuration may be necessary to accommodate the equipment of this type of system.

© 2022 *electrical training ALLIANCE*

440.8

REVISION



3280

© 2022 *electrical training ALLIANCE*

440.22(A)

REVISION

Rating or Setting for Individual Motor-Compressor

Change Summary

- Section 440.22(A) was revised by splitting the last sentence and creating two new exceptions. The existing exception became Exception No. 3.
- The first exception addresses installations where the determined value of branch-circuit short-circuit and ground-fault protection does not correspond with the standard sizes of OCPDs.
- The second exception permits the value of an OCPD to be increased in size to as much as 225% if the motor will not start.

© 2022 *electrical training ALLIANCE*

440.22(A)

REVISION



3282

© 2022 *electrical training ALLIANCE*

445.6

REVISION

Listing

Change Summary

- Previously, stationary generators rated 600 volts or less were required to be listed.
- This section now requires all generators to be listed. However, one-of-a-kind custom manufactured generators are permitted to be field labeled.
- UL 2200, Stationary Generator Assemblies, now also covers medium-voltage generators.

© 2022 *electrical training ALLIANCE*

445.6

REVISION



© 2022 *electrical training ALLIANCE*

445.11

REVISION

Marking

Change Summary

- The generator marking requirements were clarified.
- This criterion is needed to ascertain the performance characteristics of the generator and to establish the overcurrent protective device settings.
- A new requirement was added that prohibits mounting equipment on the generator assembly that conceals or obscures the generator nameplate.

© 2022 *electrical training ALLIANCE*

445.11

REVISION



© 2022 *electrical training ALLIANCE*

445.18 & 445.19

NEW REVISION

Disconnecting Means

Change Summary

- Section 445.18 was divided into two sections. Section 445.18 addresses disconnecting means, and new Section 445.19 addresses emergency shutdown of the prime mover.
- Section 445.18(B) was revised to clarify the need for the ability to isolate the generator output terminals from the paralleling system bus.
- A labeling requirement was added to identify the generator emergency shutdown.

© 2022 *electrical training ALLIANCE*

445.18 & 445.19

NEW REVISION



3288

© 2022 *electrical training ALLIANCE*

450.43(C)

REVISION

Accessibility

Change Summary

- The title of 450.43(C) was changed from “Locks” to “Accessibility.”
- Transformer vault doors are required to open in the direction of egress. This has been modified to require that the door be capable of opening at least 90°.
- Similar changes for a 90° opening of egress doors have been implemented in 110.26(C), 110.33(A)(3), and 480.10(E).

© 2022 *electrical training ALLIANCE*

450.43(C)

REVISION



3290

© 2022 *electrical training ALLIANCE*

460.24(A)

REVISION

Load Current

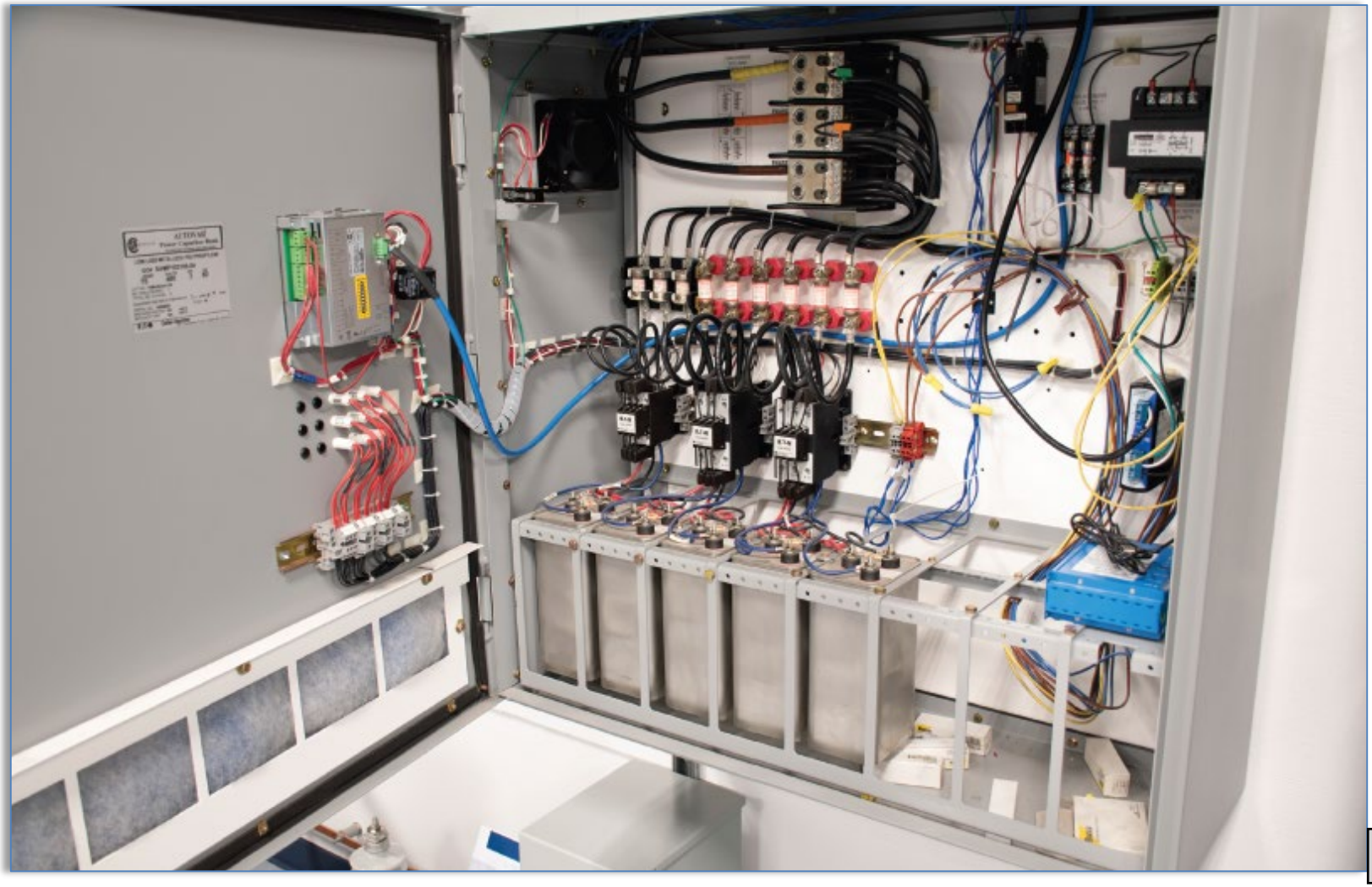
Change Summary

- Switches used to switch capacitive loads on circuits over 1,000 volts, nominal, shall be specifically rated for the switching of capacitive loads.
- Switches are often evaluated for switching inductive loads, but not capacitive loads.
- Capacitive loads can generate recovery voltages of two to three times the rated system voltage, which can cause external equipment flashovers, rupture of capacitors, and damage to surge protective devices.

© 2022 *electrical training ALLIANCE*

460.24(A)

REVISION



3292

© 2022 *electrical training ALLIANCE*

Courtesy of Eaton

Article 480

REVISION

Stationary Standby Batteries

Change Summary

- The title of Article 480 has been changed from “Storage Batteries” to “Stationary Standby Batteries.”
- The scope of Article 480 has been revised to limit it to stationary batteries exceeding one kilowatt-hour.
- A new Informational Note No. 1 points to Article 706 for batteries that do not meet the definition of stationary storage batteries.
- A reference was added in Informational Note No. 2 to point to *NFPA 855*, which is a fire protection standard for energy storage systems.
- *NFPA 111: Stored Energy Systems* also covers battery installations.

© 2022 *electrical training ALLIANCE*

Article 480

REVISION



3294

© 2022 *electrical training ALLIANCE*

Article 495

REVISION RELOCATE

Equipment Over 1000 Volts ac, 1500 Volts dc, Nominal

Change Summary

- Article 490 has been relocated to become Article 495. The scope now covers equipment operating at more than 1,000 volts ac or 1,500 volts dc, nominal.
- Requirements for motors, capacitors, resistors, and reactors remain in Articles 430, 460, and 470, respectively.
- Requirements for transformers remain in Article 450. Moving those requirements may be warranted in the future.

© 2022 *electrical training ALLIANCE*

Article 495

REVISION RELOCATE



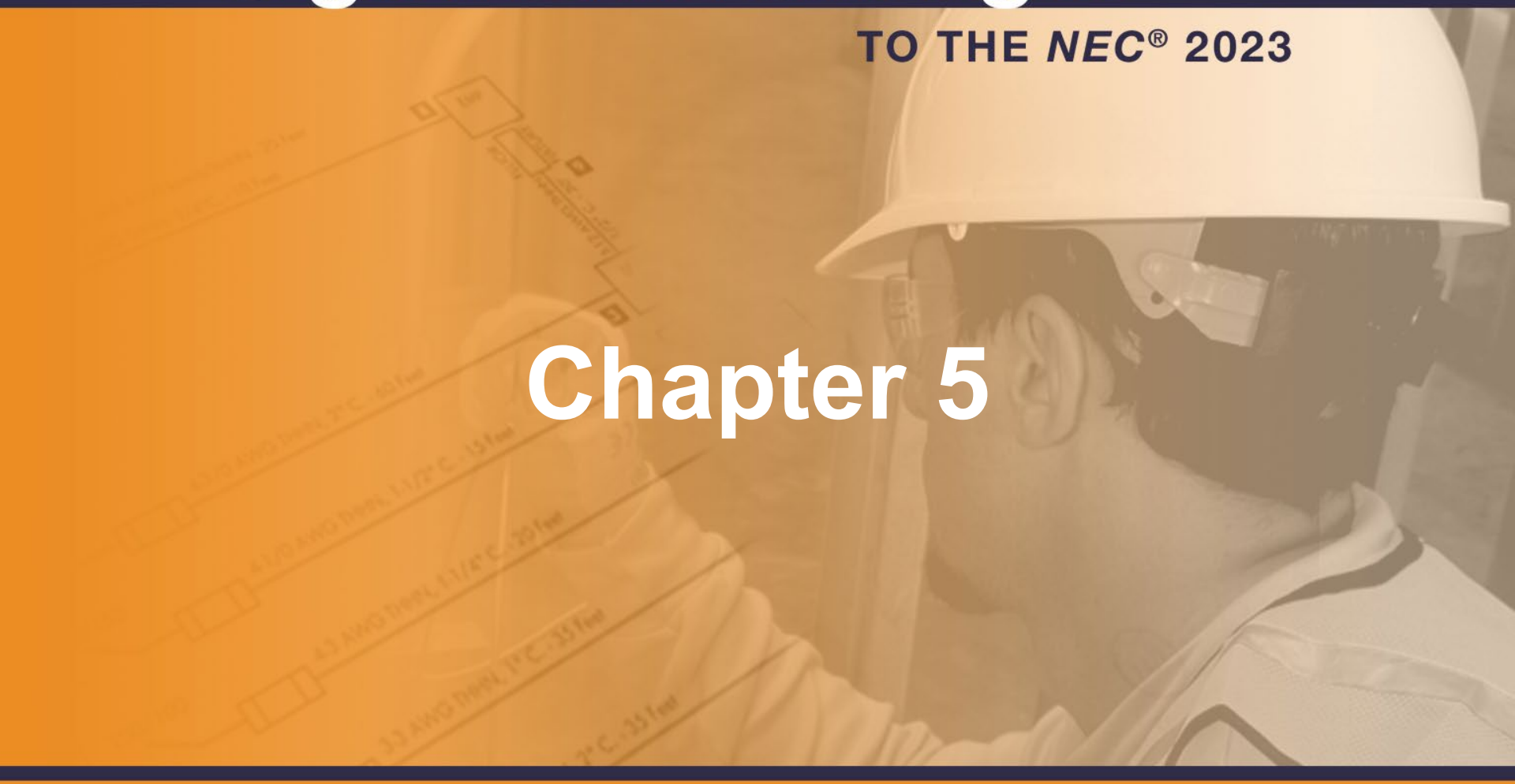
3296

© 2022 electrical training ALLIANCE

Courtesy of Michael J. Johnston

Significant Changes

TO THE *NEC*® 2023



Chapter 5

electrical training ALLIANCE IBEW - NECA IN COLLABORATION WITH NECA NATIONAL ELECTRICAL CONTRACTORS ASSOCIATION

500.1

REVISION

Scope

Change Summary

- The scope of Article 500 was revised. As previously written, it provided a scope for Articles 500 through 504.
- The new scope only covers what is in Article 500.
- Article 500 now only covers the traditional Class I, II, and III locations.
- The zone classification systems are covered in Article 505 for Zones 0, 1, and 2, and Article 506 for Zones 20, 21, and 22.

© 2022 *electrical training ALLIANCE*

500.1

REVISION



3299

© 2022 *electrical training ALLIANCE*

500.4

REVISION

Documentation

Change Summary

- The documentation required by 500.4 now includes areas that have been determined to be unclassified.
- The documentation of the hazardous location must also be available to the authority having jurisdiction.
- The edition dates have been deleted for many of the referenced standards.
- It is important to remember that referenced standards are for information only.

3300

© 2022 *electrical training ALLIANCE*

500.4

REVISION



3301

© 2022 *electrical training ALLIANCE*

500.5(D)

REVISION

Class III Locations

Change Summary

- The definitions of Class III locations have been rewritten.
- The new definitions now align with the definitions of Class II locations.
- A Class III, Division 1 location is one in which combustible fibers/flyings can be present in the air under normal conditions in quantities to produce explosive or ignitible mixtures. Previously, combustible fibers/flyings were considered fast burning fire hazards, rather than explosion hazards.
- A Class III, Division 2 location is one in which nonmetal combustible fibers/flyings can be released through the abnormal operation of equipment and will not interfere with equipment operation.

© 2022 *electrical training ALLIANCE*

500.5(D)

REVISION



3303

© 2022 *electrical training ALLIANCE*

500.6(C) & (D)

NEW

Class III Combustible and Ignitible Fibers/Flyings

Change Summary

- New 500.6(C) and (D) were added to correlate with *NFPA 499: Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas.*
- Combustible fibers/flyings are materials with any dimension that is greater than 500 µm in nominal size that can form an explosible mixture when suspended in air at standard atmospheric pressure and temperature.
- Ignitible fibers/flyings are larger than 500 µm in nominal size, which are not likely to be in suspension in quantities to produce an explosible mixture but could produce an ignitable layer fire hazard.

3304

© 2022 *electrical training ALLIANCE*

500.6(C) & (D)

NEW



2021

NFPA 499

Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas

Origins

Committee Personnel

> Chapter 1 – Administration

> Chapter 2 – Referenced Publications

> Chapter 3 – Definitions

> Chapter 4 – Combustible Dusts

> Chapter 5 – National Electrical Code (NEC) Criteria

> Chapter 6 – Classification of Combustible Dust Locations

> Annex A – Explanatory Material

Annex B – Informational References

© 2022 *electrical training ALLIANCE*

500.7

REVISION

Protection Techniques

Change Summary

- A reference was added for the new Chapter 9, Table 13 on protection techniques.
- Section 500.7(E) was revised to delete references to entire articles.
- New protection techniques were added to this section, including electrical resistance trace heating, impedance heating, enclosed break, non-sparking, sealed, and other techniques that are identified for use in hazardous (classified) locations.

© 2022 *electrical training ALLIANCE*

500.7

REVISION



3307

© 2022 *electrical training ALLIANCE*

500.8(E)(3)

REVISION

Unused Openings

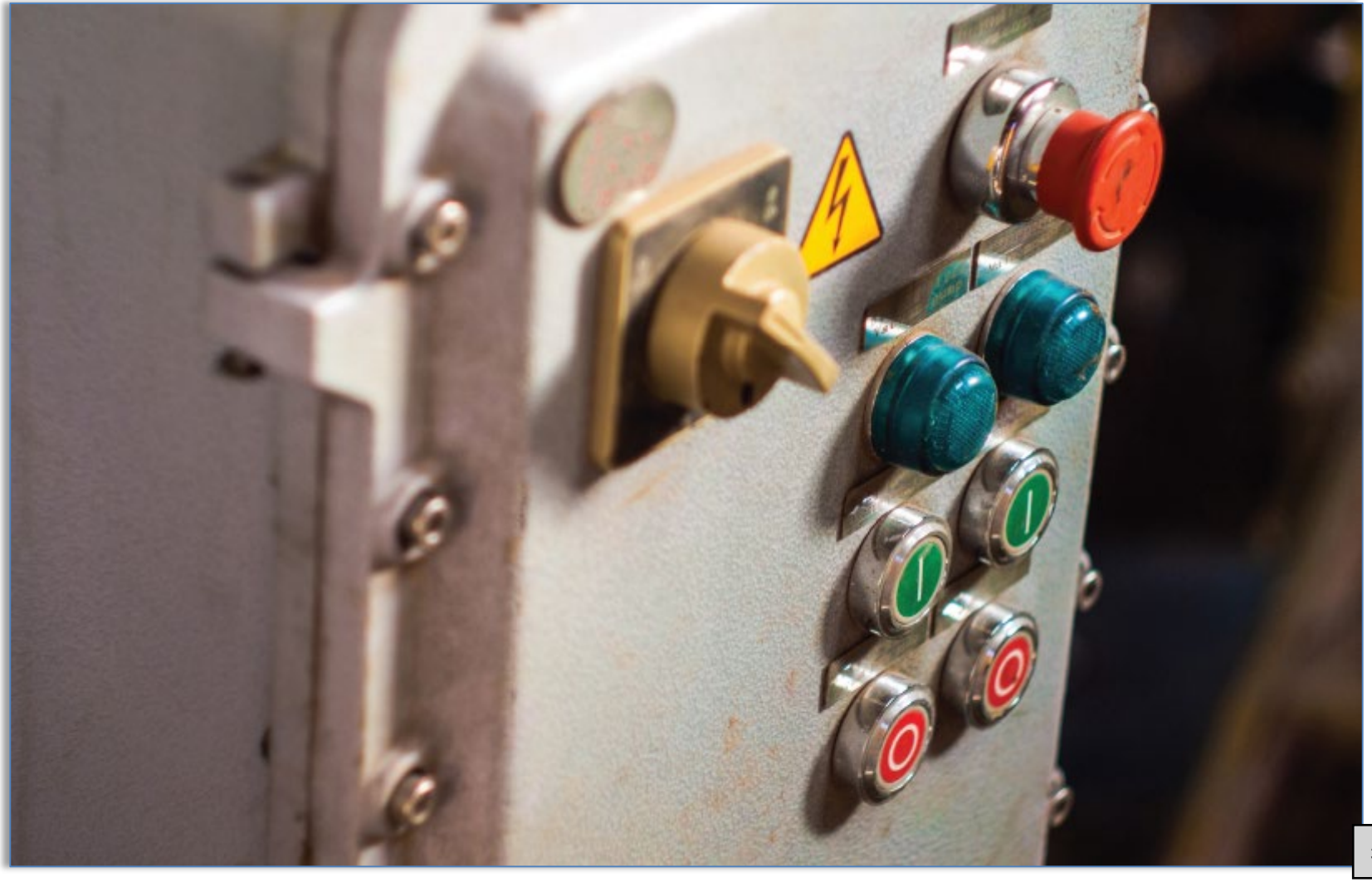
Change Summary

- Unused openings must be closed with blanking elements or close-up plugs that are listed for the location.
- If the equipment has threaded entries of NPT-threaded conduit or fittings, the NPT-threaded entries must be made up with at least five threads fully engaged.
- For listed explosionproof equipment, joints with factory-threaded entries must be made up with at least 4 ½ entries fully engaged.
- For metric threaded entries, either the entry must be listed as being metric or listed adapters must be used.

© 2022 *electrical training ALLIANCE*

500.8(E)(3)

REVISION



3309

© 2022 *electrical training ALLIANCE*

501.10

REVISION

Wiring Methods, Class I

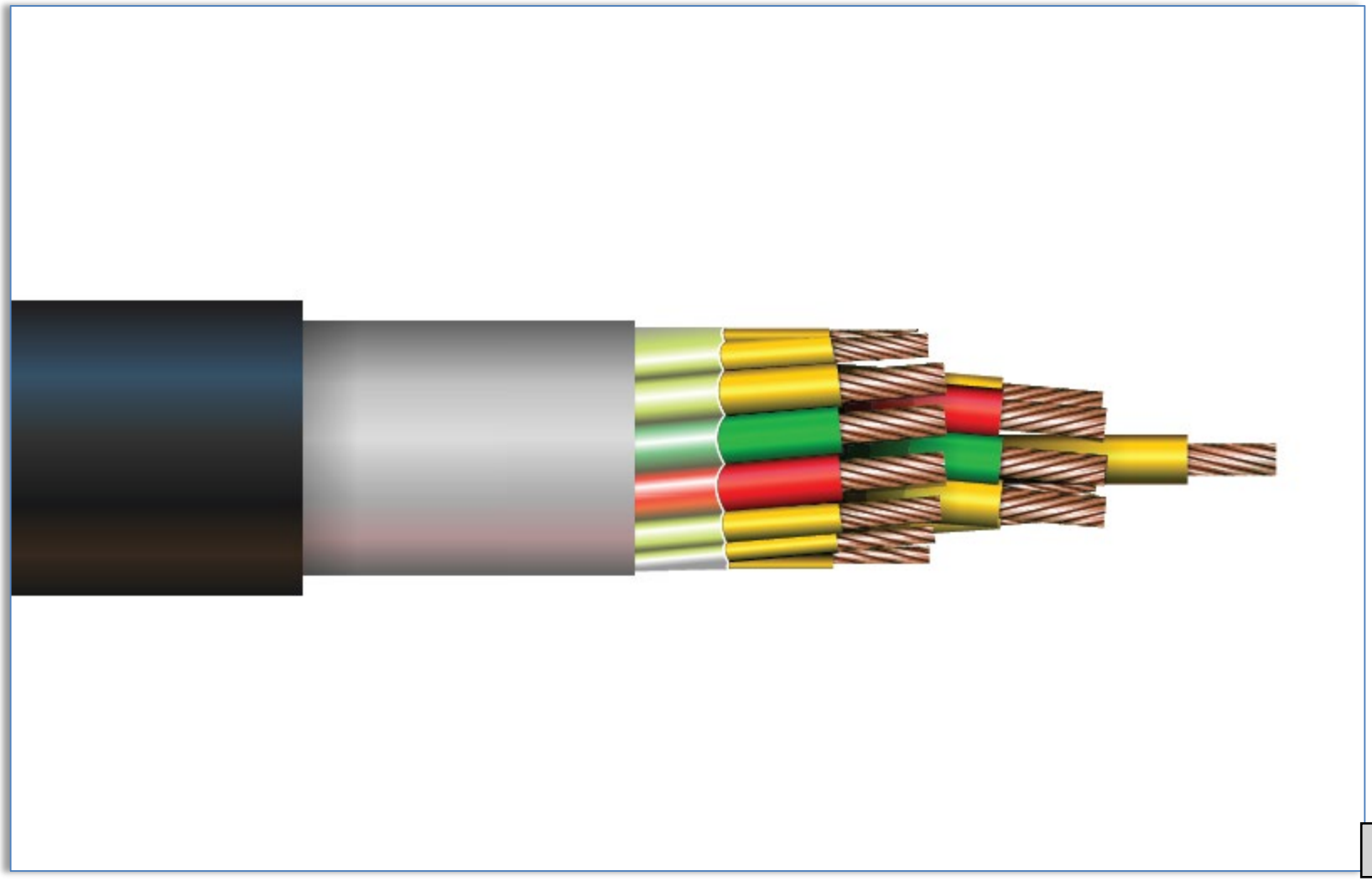
Change Summary

- The previous Exception to 501.10(A)(1)(1) was converted into positive text and now appears as (A)(1)(2).
- The wiring methods in (A)(4), (5), (7), and (8) are for restricted industrial establishments.
- Requirements for cable tray applications have been added to 501.10(B)(3), (6), and (7), which now reference 392.22.
- The reference to 337.10 has been corrected to Article 337, Part II.

© 2022 *electrical training ALLIANCE*

501.10

REVISION



3311

© 2022 *electrical training ALLIANCE*

501.15

REVISION

Sealing and Drainage

Change Summary

- The boundary seal requirement for seals in Division 2 locations has been relocated to 501.15(A)(4). This requires Division 1 wiring methods up to the seal fitting in the Division 2 location.
- A revision to 501.15(B)(2) permits Type RTRC to be used from the boundary conduit seal to the point where it exits the Division 2 location.
- Types TC-ER-HL and Type P cable were inadvertently omitted from the cable seal requirements in 501.15(D)(1) in the 2020 *Code*.

© 2022 *electrical training ALLIANCE*

501.15

REVISION



3313

© 2022 *electrical training ALLIANCE*

Courtesy of Michael J. Johnston

501.141

NEW

Flexible Cables, Class I, Division 2

Change Summary

- A new Section 501.141 was added to provide requirements for flexible cables in Class I, Division 2 locations.
- This new section is primarily focused on permitting the use of Type P cable.
- The means of terminating the cables requires the use of cable connectors that are listed for Class I, Division 2 locations.
- A new definition of “cable connector [as applied to hazardous (classified) locations]” has been added to Article 100.

© 2022 *electrical training ALLIANCE*

501.141

NEW



3315

© 2022 *electrical training ALLIANCE*

501.145

REVISION

Receptacles and Attachment Plugs, Class I Locations

Change Summary

- Section 501.145 now requires receptacles and attachment plugs to be listed for the location, except as permitted by 501.105(B)(6) for meters, instruments, and relays.
- Listing for Class I, Division 2 is not required if the circuit only involves nonincendive wiring.
- Listing is not required in restricted industrial establishments complying with 501.105(B)(6), Exception No. 2, which also requires compliance with 501.6(B)(6)(2) through (4).

© 2022 *electrical training ALLIANCE*

501.145

REVISION



3317

© 2022 *electrical training ALLIANCE*
Courtesy of Michael J. Johnston

502.10

REVISION

Wiring Methods Class II Locations

Change Summary

- PVC-coated metal conduit is permitted in Class II, Division 2 locations, even where there is not an increased level of corrosion.
- EMT with compression-type fittings or connectors is now permitted in Class II, Division 2 Locations.
- Type RTRC-XW conduit is permitted in industrial establishments with restricted public access where conditions of maintenance and supervision ensure that only qualified persons service the installation.

© 2022 *electrical training ALLIANCE*

502.10

REVISION



3319

© 2022 *electrical training ALLIANCE*

502.15

REVISION

Sealing, Class II, Divisions 1 and 2

Change Summary

- The informational note was changed to become 502.15(5). It indicates that electrical sealing putty is a recognized means to prevent the entrance of dust into a dust-ignition-proof enclosure.
- Informational notes cannot be used to provide permissions or recommendations.
- Seal fittings are required to be accessible, but they are not required to be explosionproof.

© 2022 *electrical training ALLIANCE*

502.15

REVISION



© 2022 *electrical training ALLIANCE*

502.30

REVISION

Grounding and Bonding

Change Summary

- References to Article 250 were changed to refer to Article 250, Part VI for grounding and Part V for bonding.
- Cable trays were added to 502.30(B)(1), which addresses specific bonding means, to make it clear that cable trays must be bonded in the same manner as raceways.
- Requirements were added for bonding of metal struts, angles, or channels if used with Types TC-ER, PLTC-ER, or ITC-ER.
- Section 502.30(B)(2)(3) was changed from “not a power utilization load” to “part of a meter, instrument, or relay circuit.”

© 2022 *electrical training ALLIANCE*

502.30

REVISION



© 2022 *electrical training ALLIANCE*

503.10

REVISION

Wiring Methods

Change Summary

- Type P cable is now permitted in Class III, Division 1 locations in restricted industrial establishments.
- Criteria is established for the installation of Type P cable in cable trays.
- Wiring in Class III, Division 2 locations must comply with the Division 1 requirements.
- In sections, compartments, or areas that do not contain machinery and are used solely for storage, open wiring on insulators is permitted.

3324

© 2022 *electrical training ALLIANCE*

503.10

REVISION



3325

© 2022 *electrical training ALLIANCE*

503.30

REVISION

Grounding and Bonding

Change Summary

- References to Article 250 were changed to refer to the general requirements in Part I of Article 250, as well as to Part VI for grounding and Part V for bonding.
- Cable trays were added to 503.30(B)(1), on specific bonding means, to make it clear that cable trays must be bonded in the same manner as raceways.
- Requirements were added for bonding of metal struts, angles, or channels if used with Types TC-ER, PLTC-ER, or ITC-ER.

© 2022 *electrical training ALLIANCE*

503.30

REVISION



3327

© 2022 *electrical training ALLIANCE*

504.30

REVISION

Separation of Intrinsically Safe Conductors

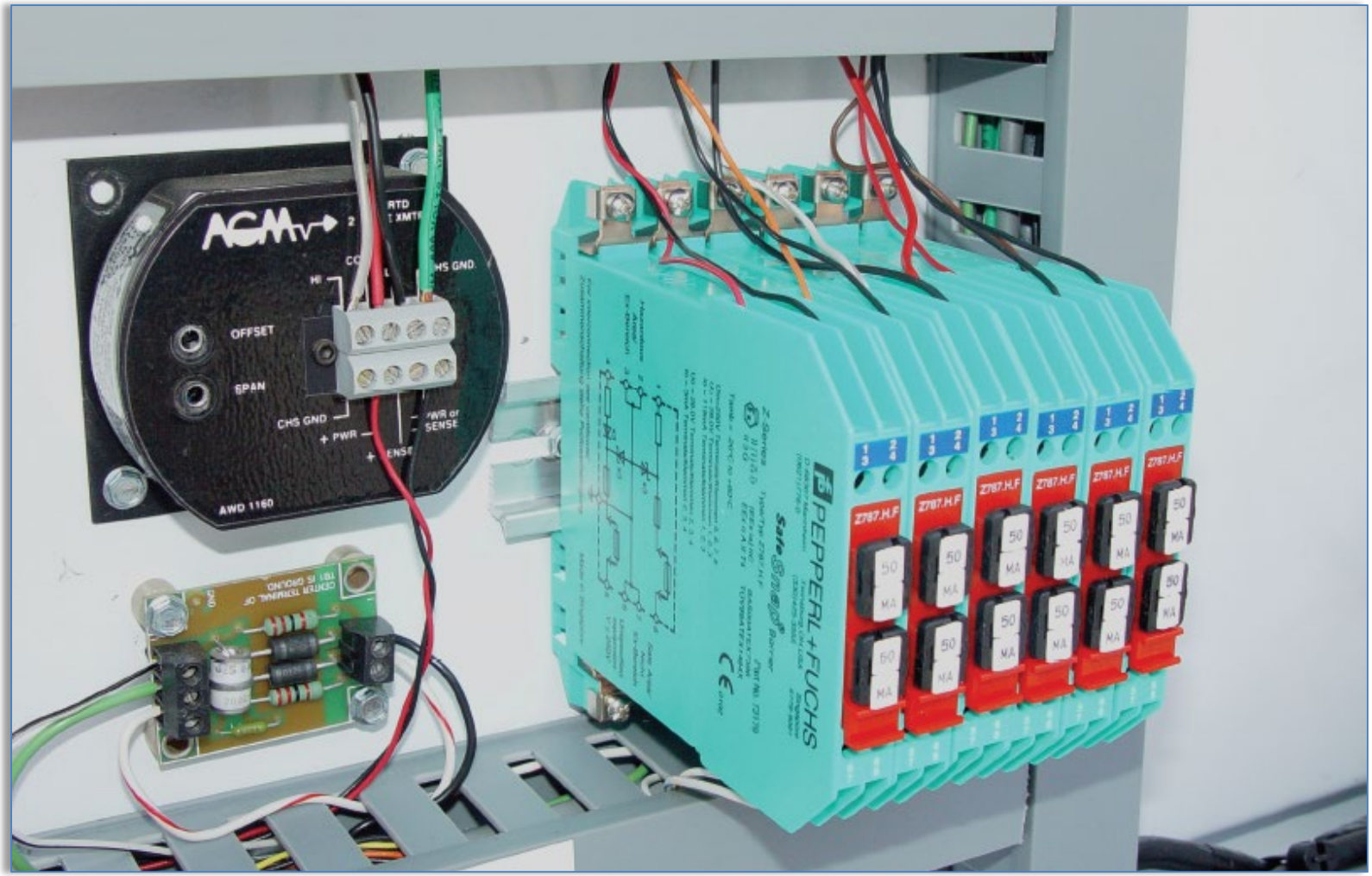
Change Summary

- Section 504.30(A)(1), installations in raceways, cable trays, and cables, had a simple rule, four exceptions, and three informational notes. It has been converted into more usable positive text.
- Section 504.30(A)(2), installations within enclosures, had three informational notes that were incorporated into enforceable *Code* text.
- Section 504.30(A)(3), other installations, contained an exception that was converted into positive text and incorporated into the existing text.

© 2022 *electrical training ALLIANCE*

504.30

REVISION



3329

© 2022 *electrical training ALLIANCE*

Article 505

DELETION REVISION

Zone 0, 1, and 2 Locations

Change Summary

- 505.1 was revised to make it clear that this article does not cover the class/division classification system and that it does not cover explosives, pyrotechnics, or blasting agents.
- Section 505.3 was deleted because 90.3 makes it unnecessary.
- Section 505.4 on documentation was revised for consistency with the requirements for documentation in other articles in Chapter 5.
- Section 505.5(A) was revised for consistency with 500.5(A).

© 2022 *electrical training ALLIANCE*

Article 505

DELETION **REVISION**



© 2022 *electrical training ALLIANCE*

505.8

NEW

Protection Techniques

Change Summary

- Section 505.8 has been revised to recognize new protection techniques.
- Impedance heating is a protection technique that is now recognized. Its design is based on IEEE 844.3.
- A pressurized room “p” is a protection technique that is recognized for Zone 1 or 2 locations.
- Special protection “s” is a protection technique that is recognized for Zones 0, 1, and 2.

© 2022 *electrical training ALLIANCE*

505.8

NEW



3333

© 2022 *electrical training ALLIANCE*

505.16

REVISION

Sealing and Drainage

Change Summary

- Section 505.16(B)(3) has been expanded to include pressurized rooms. An informational note was added to reference the IEC Standard for pressurized rooms.
- Section 505.16(C)(1) was rewritten into list format, and the exceptions were rewritten into positive language.
- New requirements were added to provide sealing requirements for cables that enter breathing-type enclosures “nR.”

© 2022 *electrical training ALLIANCE*

505.16

REVISION



2021

NFPA 496

Standard for Purged and Pressurized Enclosures for Electrical Equipment

Committee Personnel

> Chapter 1 – Administration

> Chapter 2 – Referenced Publications

> Chapter 3 – Definitions

> Chapter 4 – General Requirements for Pressurized Enclosures

> Chapter 5 – Pressurized Enclosures for Class I, or Zone 1, or Zone 2

> Chapter 6 – Pressurized Enclosures for Class II

> Chapter 7 – Pressurized Control Rooms

> Chapter 8 – Pressurized Enclosures Having an Internal Source of Flammable Gas or Vapor

> Chapter 9 – Pressurized Analyzer Rooms Containing a Source of Flammable Gas, Vapor, or Liquid

Annex A – Explanatory Material

Annex B – Informational References

© 2022 *electrical training ALLIANCE*

505.20(C), Exc. Nos. 5 & 6

NEW

Equipment Requirements, Zone 2

Change Summary

- Two new exceptions were added to 505.20(C) to make the requirements for Zone 2 locations consistent with the requirements for Class I, Division 2 locations.
- Exception No. 5 permits the use of certain space heaters in Zone 2 locations where the space heaters are used to reduce condensation during shutdown periods.
- Exception No. 6 permits the use of sliding contact shaft bonding devices that are used on certain motors where the potential discharge is determined to be nonincendive.

3336

© 2022 *electrical training ALLIANCE*

505.20(C), Exc. Nos. 5 & 6

NEW



3337

© 2022 *electrical training ALLIANCE*

Article 506

REVISION

Zone 20, 21, and 22 Locations

Change Summary

- 506.1 was revised to clarify that this article does not cover the class/division classification system and that it does not cover explosives, pyrotechnics, or blasting agents.
- 506.3 was deleted because 90.3 makes it unnecessary.
- 506.4, on documentation, was revised for consistency with similar requirements in other articles in Chapter 5.
- Table 506.9(C)(2)(3) has been deleted. The information is now located in Chapter 9, Table 13.

© 2022 *electrical training ALLIANCE*

Article 506

REVISION



3339

© 2022 *electrical training ALLIANCE*

506.6

REVISION

Material Groups

Change Summary

- The definition of the material groups has been updated for consistency with *NFPA 499: Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*.
- Group IIIC consists of combustible metal dusts and combustible metal fibers/flyings.
- Group IIIB includes combustible dusts other than combustible metal dust.
- Group IIIA, includes combustible fibers/flyings or ignitible fibers/flyings.

© 2022 *electrical training ALLIANCE*

506.6

REVISION



© 2022 *electrical training ALLIANCE*

511.2

NEW

Other Articles

Change Summary

- A new Section 511.2 was created with a table that points to requirements in Articles 500, 501, and 505.
- The table is intended to simplify the use of either the traditional class/division classification system or the zone classification system.
- Articles 511 through 516 provide occupancy-specific requirements that are predicated on the use of Articles 500 and 501, or Article 505.
- Similar tables have been added to 512.2, 513.2, 514.2, 515.2, and 516.2.

© 2022 *electrical training ALLIANCE*

511.2

NEW



3343

© 2022 *electrical training ALLIANCE*

511.7(A)

REVISION

Fixed Wiring Above Hazardous (Classified) Locations

Change Summary

- Section 511.7(A)(1) was converted into list format to make it easier to navigate.
- “Rigid Nonmetallic Conduit” was changed to “PVC Conduit.”
- Reinforced thermosetting resin conduit, RTRC, was added as a permitted fixed wiring method.
- The same changes were made in 514.7 for Wiring Above Hazardous (Classified) locations in Motor Fuel Dispensing Facilities.

© 2022 *electrical training ALLIANCE*

511.7(A)

REVISION



3345

© 2022 *electrical training ALLIANCE*

511.8

REVISION

Underground Wiring Below Hazardous Locations

Change Summary

- The title of this section was changed to “Underground Wiring Below Hazardous (Classified) Locations.”
- The language permitting intermediated metal conduit has been revised to clarify that it must be threaded.
- The exception has been rewritten into positive language.

© 2022 *electrical training ALLIANCE*

511.8

REVISION



3347

© 2022 *electrical training ALLIANCE*

Article 512

NEW

Cannabis Oil Equipment and Cannabis Oil Systems

Change Summary

- A new Article 512 has been created on cannabis oil equipment and cannabis oil systems using flammable materials.
- Flammable materials are used to extract cannabis oil, including butane, ethanol, hexane, pentane, propane, and LPG.
- Article 512 provides detailed classification diagrams to help to evaluate hazardous areas.

3348

© 2022 *electrical training ALLIANCE*

Article 512

NEW



3349

© 2022 *electrical training ALLIANCE*

516.7(A)

REVISION

Wiring & Equipment Not Within Hazardous Locations

Change Summary

- Section 516.7(A) was converted into a list format to make it easier to navigate.
- “Rigid Nonmetallic Conduit” was changed to “PVC Conduit.”
- Reinforced thermosetting resin conduit, RTRC, was added as a permitted fixed wiring method.
- Similar changes were made in 511.7(A) and 514.7(A).

© 2022 *electrical training ALLIANCE*

516.7(A)

REVISION



3351

© 2022 *electrical training ALLIANCE*

517.6

NEW

Patient Care-Related Electrical Equipment

Change Summary

- A new requirement has been added that indicates that patient care-related equipment is not subject to the reconditioning requirements in the *Code*.
- Patient care-related equipment is subject to a recertification process after it is reconditioned.
- Patient care-related equipment is also subject to recommissioning or recertification when it is relocated.

© 2022 *electrical training ALLIANCE*

517.6

NEW



3353

© 2022 *electrical training ALLIANCE*

Courtesy of Michael J. Johnston

517.10(B)

REVISION

Not Covered

Change Summary

- Informational Note No. 1 was added to point to certain receptacles in health care business offices that are required to be tamper-resistant.
- Informational Note No. 2 was added to point to requirements for AFCI protection for branch-circuit outlets in patient sleeping rooms that are required to be AFCI protected.
- A new list item (3) was added to exempt pharmacy services not contiguous to health care facilities from the requirements of Article 517.

© 2022 *electrical training ALLIANCE*

517.10(B)

REVISION



3355

© 2022 *electrical training ALLIANCE*

Photo from iStock

517.13

REVISION

Equipment Grounding Conductor

Change Summary

- 517.13(B)(1), Exception No. 2 was relocated to 517.13 following the main rule.
- The requirement for grounding and bonding of metal faceplates was relocated from 517.13(B)(1)(3) to 517.13(B)(1), Exception No. 2. Faceplates are normally grounded through the attachment screws that connect them to the yoke of the switch or receptacle.
- All branch-circuit wiring for a patient care space must comply with 517.13, including wiring that originates outside of the patient care space.

3356

© 2022 *electrical training ALLIANCE*

517.13

REVISION



© 2022 *electrical training ALLIANCE*

517.14

REVISION

Panelboard Bonding

Change Summary

- An exception was added to 517.14 on panelboard bonding to permit an insulated copper conductor not smaller than 10 AWG to be terminated on listed connections to an aluminum or copper busbar.
- The busbar must be at least ¼ inch thick by two inches wide and of sufficient length to accommodate the number of terminations necessary for the bonding of the panelboards.
- The busbar must be securely fastened and installed in an accessible location.

© 2022 *electrical training ALLIANCE*

517.14

REVISION



© 2022 *electrical training ALLIANCE*

517.20(A)

REVISION

Wet Procedure Locations

Change Summary

- Wet procedure locations are required to be provided with protection against electric shock.
- 517.20(A)(1) was clarified to indicate that it applies to isolated power systems that remain in operation in the event of a single line-to-ground fault.
- The informational note was revised to clarify that isolated power systems can eliminate the danger of electric shock.

© 2022 *electrical training ALLIANCE*

517.20(A)

REVISION



3361

© 2022 *electrical training ALLIANCE*

517.22

NEW

Demand Factors

Change Summary

- New demand factors have been added for general-use receptacles and individual branch circuits not exceeding 150 volts to ground.
- This information is based on hospital load studies and a study by the Fire Protection Research Foundation.
- For cord-connected equipment, the table provides two sets of demand factors. One set applies to Category 1 and 2 spaces. The second applies to Category 3 and 4 spaces.
- For receptacle loads, the first 5 kVA is calculated at 100%, the next 5–10 kVA is calculated at 50%, and the remainder is calculated at 25%.

3362

© 2022 *electrical training ALLIANCE*

517.22

NEW



3363

© 2022 *electrical training ALLIANCE*

517.30

REVISION

Sources of Power

Change Summary

- 517.30 requires that essential electrical systems (EES) have two or more independent sources or sets of sources.
- At least one source or set of sources must be entirely onsite and it must be capable of serving the entire EES load.
- 517.30(B) now provides a list of power sources for the EES, which includes utility supply power, generating units, fuel cell systems, energy storage systems, and health care microgrids.

© 2022 *electrical training ALLIANCE*

517.30

REVISION



3365

© 2022 *electrical training ALLIANCE*

517.41

REVISION

Required Power Sources

Change Summary

- Section 517.41 requires that the essential electrical system (EES) have two or more independent sources or sets of sources, one of which must be onsite and capable of supplying the entire EES load.
- At least one source or one set of sources must be entirely onsite.
- EES components are required so that they are not exposed to interruptions from storms, floods, earthquakes, or hazards from adjoining structures or nearby activities.

© 2022 *electrical training ALLIANCE*

517.41

REVISION



© 2022 *electrical training ALLIANCE*

Article 517, Part V.

REVISION

Diagnostic Imaging and Treatment Equipment

Change Summary

- The title of Part V has been changed to “Diagnostic Imaging and Treatment Equipment.”
- A new Informational Note No. 3 has been added that provides examples of 12 types of diagnostic imaging equipment covered by Part V.
- A new Informational Note No. 4 was added that provides examples of five types of treatment equipment covered by Part V.

© 2022 *electrical training ALLIANCE*

Article 517, Part V.

REVISION



3369

© 2022 *electrical training ALLIANCE*

517.80

REVISION

Patient Care Spaces

Change Summary

- Section 517.80 was revised to recognize that Class 2 circuits that transmit power and data to a powered device do not need to comply with the grounding requirements in 517.13.
- Power over Ethernet (PoE) is an example of a Class 2 circuit that can transmit power for applications, such as wireless access points and lighting, while also transmitting data.
- A new informational note was added to reference a NEMA standard on PoE lighting.

© 2022 *electrical training ALLIANCE*

517.80

REVISION



3371

© 2022 *electrical training ALLIANCE*

518.2(A)

REVISION

Examples

Change Summary

- Casinos and gaming facilities have been added to the list of examples of assembly occupancies that are covered by Article 518.
- Casinos can have transient crowds of people hovering over machines and table games that can grow larger than in traditional places of assembly.
- Many casinos also have entertainment to retain customers at the machines.

© 2022 *electrical training ALLIANCE*

518.2(A)

REVISION



3373

© 2022 *electrical training ALLIANCE*

518.4

REVISION

Wiring Methods-General

Change Summary

- Section 518.4 was reformatted into list format.
- Section 518.4(B)(4) was added to recognize power over Ethernet (PoE) supplying lighting.
- A new informational note was added to 518.4(B)(4) that references a NEMA standard for the installation of PoE lighting.
- The wiring methods for buildings or portions of buildings of non-fire rated construction were expanded to include the permitted Chapter 3 wiring methods.

© 2022 *electrical training ALLIANCE*

518.4

REVISION



© 2022 *electrical training ALLIANCE*

520.53(C)

REVISION

Construction

Change Summary

- A new sentence was added to the main rule to clarify that the requirements of 408.18(C) do not apply to portable stage switchboards.
- In the 2020 *Code*, single-pole separable connectors were relocated into 406.13.
- This section has been revised to point to 406.13. Since the general requirements would continue to apply to this section, there is no reason to repeat the requirements here.
- Section 520.53(C) now only covers those requirements that are unique to occupancies that are covered by Article 520.

© 2022 *electrical training ALLIANCE*

520.53(C)

REVISION



© 2022 *electrical training ALLIANCE*

520.68(D)

NEW

Special-Purpose Multi-Circuit Cable Systems

Change Summary

- A new 520.68(D) was created to provide requirements for multi-circuit cable systems.
- These circuits are limited to not more than 20 amperes and not more than 150 volts to ground.
- Trunk cables, breakout assemblies, and multi-circuit enclosures are required to be listed.
- Installation and operation of special-purpose multi-circuit cable systems requires qualified persons.

© 2022 *electrical training ALLIANCE*

520.68(D)

NEW



3379

© 2022 *electrical training ALLIANCE*

Article 530

REVISION

Motion Picture and TV Studios and Remote Locations

Change Summary

- Article 530 has been rewritten and updated.
- Several technologies have disappeared or are being phased out, including carbon arc luminaires, tungsten luminaires, fused extension cables, video tape, and film.
- Several newer technologies are being used, including the use of generators, AC enclosed arc luminaires, and digital cameras.

© 2022 *electrical training ALLIANCE*

Article 530

REVISION



3381

© 2022 *electrical training ALLIANCE*

545.22

REVISION

Power Supply

Change Summary

- This section was revised to clarify that relocatable structures must be supplied by a feeder.
- This correlates with Article 550, which does not allow service equipment on a structure without a permanent foundation.
- Two or more relocatable structures joined into a single unit are permitted to use a chassis bonding conductor as the tap conductor.

© 2022 *electrical training ALLIANCE*

545.22

REVISION



3383

© 2022 *electrical training ALLIANCE*

547.26

REVISION

Physical Protection

Change Summary

- Section 547.26 has been revised to prohibit nonmetallic sheathed cable from being concealed within walls and above ceilings of buildings or portions thereof which are contiguous with or physically adjoined with livestock areas.
- Rodents and other pests frequently chew through cables.
- The requirement also provides examples of areas where this commonly happens, including within walls and ceilings of offices, lunchrooms, and ancillary areas adjoining animal confinement areas.

© 2022 *electrical training ALLIANCE*

547.26

REVISION



© 2022 *electrical training ALLIANCE*

547.44(B)

REVISION

Bonding of Equipotential Planes

Change Summary

- The bonding requirements in agricultural buildings have been clarified.
- Equipotential planes must be bonded to the grounding electrode system or an equipment grounding terminal in any panelboard associated with the equipotential plane.
- The bonding conductor must be an insulated, covered, or bare solid copper conductor that is not smaller than 8 AWG.

3386

© 2022 *electrical training ALLIANCE*

547.44(B)

REVISION



3387

© 2022 *electrical training ALLIANCE*

550.10(I)

REVISION

Mast Weatherhead or Raceway

Change Summary

- The reference to Article 230 has been clarified to indicate that Part II applies.
- This section previously permitted metal raceways. It has been clarified to indicate that the permitted metal raceways are rigid metal conduit or intermediate metal conduit.
- Previously, this section permitted rigid nonmetallic conduit. It now recognizes rigid polyvinyl conduit or other raceways suitable for the location.

© 2022 *electrical training ALLIANCE*

550.10(I)

REVISION



3389

© 2022 *electrical training ALLIANCE*

550.16(C)(1)

REVISION

Exposed Non-Current-Carrying Metal Parts

Change Summary

- Mobile homes often consist of multiple units that are joined together.
- Multiple sections of a mobile home are now required to be bonded with a solid copper conductor that is at least 8 AWG. It can be insulated or bare.
- Bonding conductor terminations must be in accordance with 250.8 and 250.12.

© 2022 *electrical training ALLIANCE*

550.16(C)(1)

REVISION



3391

© 2022 *electrical training ALLIANCE*

550.32(A)

REVISION

Mobile Home Service Equipment

Change Summary

- Section 550.32(A) was revised to make it clear that mobile home service equipment is not permitted to be mounted in or on the mobile home.
- The service equipment must be mounted in a readily accessible outdoor location, and it must be visible from the mobile home it serves.
- The mobile home service disconnect is permitted to serve as the emergency disconnect specified in 230.85.

© 2022 *electrical training ALLIANCE*

550.32(A)

REVISION



3393

© 2022 *electrical training ALLIANCE*

550.33(A)

NEW

Feeder Equipment

Change Summary

- A new 550.33(A) has been added. The previous 550.33(A) has become 550.33(B).
- Service equipment is not permitted to be mounted in or on a mobile home.
- The feeder assembly is not permitted to be mounted in or on the mobile home.
- Manufactured home feeder disconnecting means are permitted to be installed in or on the manufactured home in accordance with 550.33(B).

3394

© 2022 *electrical training ALLIANCE*

550.33(A)

NEW



© 2022 *electrical training ALLIANCE*

551.3

NEW

Electrical Datum Plane Distances

Change Summary

- Electrical datum plane requirements were added to Article 551 because RV parks often border bodies of water.
- In areas subject to tidal fluctuations, the datum plane is two feet above the highest high-tide level under normal conditions.
- In areas not subject to tidal fluctuation, the plane is two feet above the normal high-tide level.

© 2022 *electrical training ALLIANCE*

551.3

NEW



3397

© 2022 *electrical training ALLIANCE*

551.40(D)

NEW DELETION

Loss of Ground Device

Change Summary

- The previous 551.40(D), titled “Reverse Polarity Device,” was deleted.
- The reverse polarity device may only indicate that the pedestal is mis-wired but may not interrupt power.
- A new 551.40(D) was added to require a listed grounding monitor interrupter to be installed between the feeder assembly connection to the vehicle and before either a transfer switch (if installed) or the panelboard.

© 2022 *electrical training ALLIANCE*

551.40(D)

NEW **DELETION**



3399

© 2022 *electrical training ALLIANCE*

551.72

REVISION

Distribution System

Change Summary

- Section 551.72(A) was revised to recognize 208Y/120 three-phase distribution systems in RV parks.
- The prohibition against reducing the size of the neutral conductor was moved from 551.72(C) to (D).
- An informational note was added indicating that RV loads are line-to-neutral and non-permanently connected loads.
- The prohibition of the use of cord- and plug-connected autotransformers used on RV park distribution systems has been deleted.

© 2022 *electrical training ALLIANCE*

551.72

REVISION



3401

© 2022 *electrical training ALLIANCE*

552.4

REVISION

General Requirements

Change Summary

- Park trailers are designed for seasonal use. They are not permitted as permanent dwelling units.
- Section 552.4 makes it clear that trailers used as banks, clinics, offices, or similar applications are considered relocatable structures and are covered in Part II of Article 545.
- This change correlates with the action of CMP 7 to create a new Part II in Article 545 on relocatable structures.

© 2022 *electrical training ALLIANCE*

552.4

REVISION



© 2022 *electrical training ALLIANCE*

555.4

REVISION

Location of Service Equipment

Change Summary

- Service equipment for a floating building, dock, or marina must be no closer than five feet horizontally from and adjacent to the structure.
- Service equipment must also be located a minimum of 12 inches above the datum plane.
- An electrical datum plane is a specified vertical distance above the normal high-water level at which electrical equipment can be installed and connections can be made.

© 2022 *electrical training ALLIANCE*

555.4

REVISION



3405

© 2022 *electrical training ALLIANCE*

555.14

NEW

Equipotential Planes and Bonding of the Planes

Change Summary

- Articles 555 and 682 have overlaps in coverage. This change is intended to improve correlation between the articles.
- A new 555.14 has been added to correlate requirements for equipotential planes and bonding of equipotential planes with Article 682.
- This section is intended to reduce step and touch potentials. It is also intended to reduce the hazards that have resulted in electric shock drownings.

© 2022 *electrical training ALLIANCE*

555.14

NEW



© 2022 *electrical training ALLIANCE*

555.15

NEW

Replacement of Equipment

Change Summary

- A new requirement has been added titled “replacement of equipment,” which addresses modification of equipment as well as repairs.
- This new requirement recognizes the harsh environment that exists at marinas. The intent is to ensure that the installation remains in compliance.
- *NFPA 303* requires annual inspections of marinas. Periodic inspections are outside the scope of the *NEC*.

© 2022 *electrical training ALLIANCE*

555.15

NEW



3409

© 2022 *electrical training ALLIANCE*

555.30

REVISION

Electrical Equipment and Connections

Change Summary

- The term *pier* has been replaced with the term *structure* to apply to all fixed and floating structures.
- The separate section on fixed piers has been deleted as the requirements apply to both fixed and floating piers.
- Electrical components within electrical equipment and connections that are not intended for use while submerged are required to be located at least 12 inches above the deck of the structure.

© 2022 *electrical training ALLIANCE*

555.30

REVISION



© 2022 *electrical training ALLIANCE*

555.35

REVISION

GFPE and GFCI

Change Summary

- The requirements for GFPE of feeder-supplied installations have been rewritten. Coordination with downstream GFPE is permitted.
- Requirements for GFCI protection of boat hoist receptacles have been relocated from 555.9 to 555.35(C).
- The requirements for GFCI protection have been expanded to include all docking facilities, not just those at dwelling unit docks.
- A new requirement was added in 555.35(B)(2) for GFCI protection of outlets for other than shore power not exceeding 150 volts and 60 amperes and 100 amperes or less, three-phase.

© 2022 *electrical training ALLIANCE*

555.35

REVISION



© 2022 *electrical training ALLIANCE*

555.36(C)

NEW

Disconnecting Means for Shore Power Connection(s)

Change Summary

- A new requirement has been added for an emergency disconnect for each power outlet or enclosure that provides shore power to boats.
- The emergency disconnect must be a listed emergency shutoff device or disconnect that is clearly marked “emergency shutoff.”
- The emergency shutoff must be located within sight of the marina power outlet or other device that provides shore power.

© 2022 *electrical training ALLIANCE*

555.36(C)

NEW



© 2022 *electrical training ALLIANCE*

555.37

REVISION

Equipment Grounding Conductor

Change Summary

- Section 555.37(B) and (C) were consolidated to require that the EGCs be insulated wire-type EGCs, sized in accordance with 250.122, but not smaller than 12 AWG.
- Section 555.37(E) has been added to provide requirements for EGCs for equipment that is not double-insulated.
- An exception was added to (E) that permits the EGC to be uninsulated if it is part of a listed cable assembly that is identified for the environment.

© 2022 *electrical training ALLIANCE*

555.37

REVISION



© 2022 *electrical training ALLIANCE*

555.38

NEW

Luminaires

Change Summary

- New requirements have been added for luminaires in marinas, boatyards, and docking facilities.
- Luminaires and retrofit kits are required to be listed and identified for use in the environment.
- Luminaires and their supply connectors must be secured to the structural elements of the marina in a manner that limits damage from watercraft impacts and from marine life.

© 2022 *electrical training ALLIANCE*

555.38

NEW



© 2022 *electrical training ALLIANCE*

590.8

REVISION

Overcurrent Protective Devices

Change Summary

- A new requirement has been added for wye-connected temporary service installations of more than 150 volts to ground, but not more than 1,000 volts phase-to-phase.
- If the available fault current exceeds 10,000 amperes, the overcurrent protection is required to be current-limiting.
- Where available fault current is less than 10 kA, conventional OCPDs will operate quickly enough to clear a fault before damage occurs.

© 2022 *electrical training ALLIANCE*

590.8

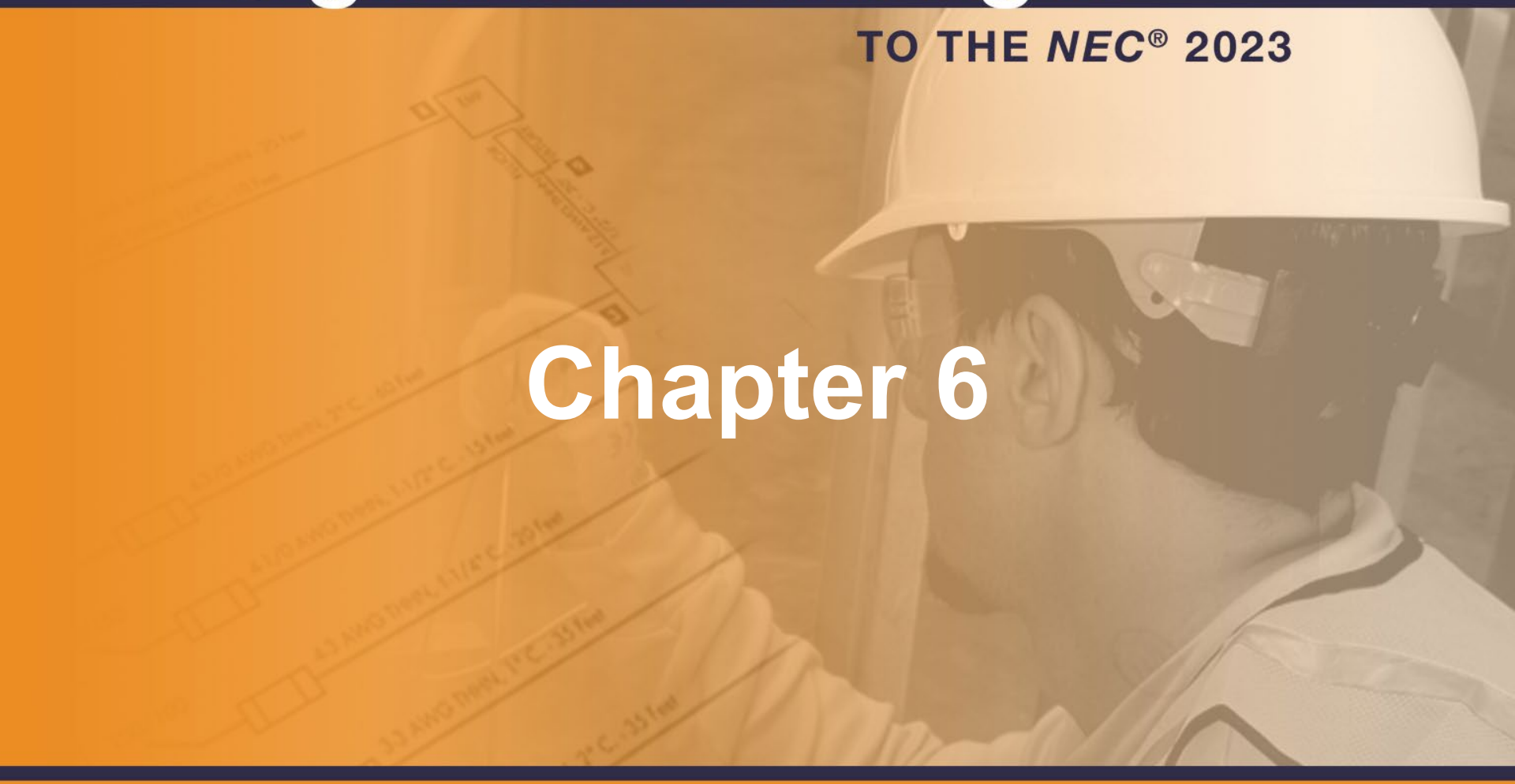
REVISION



© 2022 *electrical training ALLIANCE*

Significant Changes

TO THE *NEC*® 2023



Chapter 6

electrical training ALLIANCE IBEW - NECA IN COLLABORATION WITH NECA NATIONAL ELECTRICAL CONTRACTORS ASSOCIATION

600.5

REVISION

Branch Circuits

Change Summary

- The last sentence of 600.5(A) was converted into an exception that exempts some entrances, corridors, and hallways.
- A second exception was added that permits the branch circuit to supply other loads that are directly related to the control of the sign.
- Section 600.5(D)(2) now permits electrical enclosures integral to the sign that are listed and labeled as electrical enclosures to be used as pull or junction boxes for up to 600 volts.

© 2022 electrical training ALLIANCE

600.5

REVISION



3424

© 2022 *electrical training ALLIANCE*

600.6

REVISION

Disconnects

Change Summary

- The general requirements of Chapters 1 through 4 of the *Code* apply, including the requirements of 404.7, requiring disconnects to indicate whether they are open or closed.
- The disconnecting means is required to be accessible and located at the point of entry to the sign, within sight of the sign, or within sight of the controller.
- If the disconnecting means is remote from the sign, it must be mounted at an accessible location that is available to first responders and service personnel.

© 2022 *electrical training ALLIANCE*

600.6

REVISION



© 2022 *electrical training ALLIANCE*

620.12(A)

REVISION

Traveling Cables

Change Summary

- A new 620.12(A)(2) has been added to recognize Class 2 and communications cables used on Class 2 circuits, including power over Ethernet, in traveling cables.
- The minimum size of Class 2 and communications circuit conductors is 24 AWG.
- New requirements were added to require parallel conductors of traveling cables to be not smaller than 20 AWG.

© 2022 *electrical training ALLIANCE*

620.12(A)

REVISION



3428

© 2022 *electrical training ALLIANCE*

620.22

REVISION

Branch Circuits for Car Lighting, Receptacles, HVAC

Change Summary

- Section 620.22(A) permits car lighting branch circuits to supply additional loads.
- The lighting circuit is now permitted to supply emergency responder radio coverage circuits, car ventilation purification systems, car emergency signaling, and communications devices, including charging circuits.
- The permitted location of the OCPD for the circuit for the air conditioning and heating source has been revised to correlate with the OCPD locations permitted for other branch circuits in 620.22(A).

© 2022 *electrical training ALLIANCE*

620.22

REVISION



3430

© 2022 electrical training ALLIANCE

NECA Photo – © 2010 Rob Colgan

620.23

REVISION

Branch Circuits for Machine Room, Control Room…

Change Summary

- The title of 620.23 was revised to include truss interior lighting.
- Truss interiors are the structure of moving walkways and escalators.
- At least one 125-volt, single-phase, 15- or 20-ampere duplex receptacle is now required for truss interiors.

© 2022 electrical training ALLIANCE

620.23

REVISION



3432

© 2022 *electrical training ALLIANCE*

Courtesy of Tom Garvey

625.1 Info. Notes

NEW

Scope

Change Summary

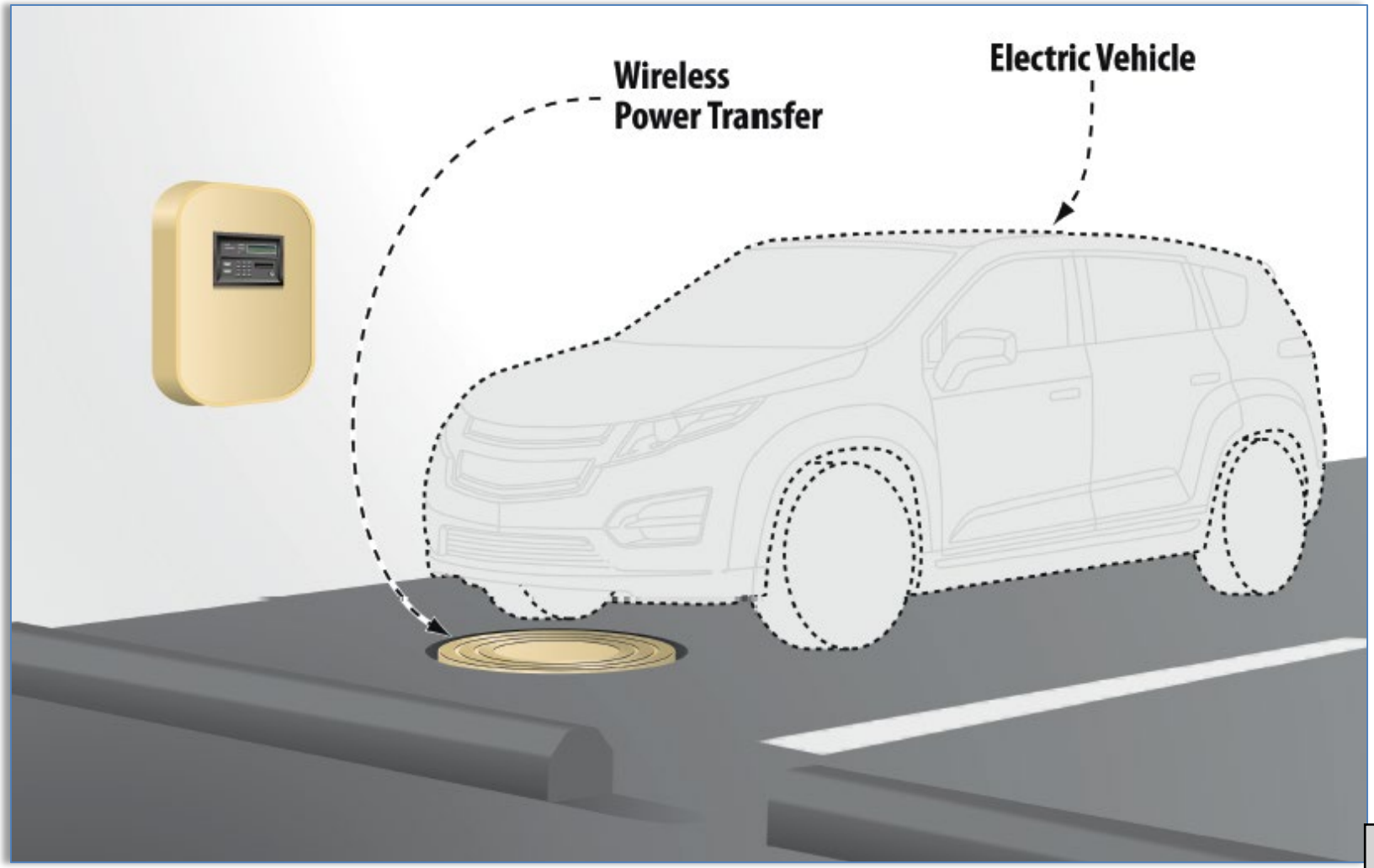
- Two new informational notes were added to 625.1 to provide additional information for installation of electric vehicle infrastructure.
- UL 2750 provides information that was developed by UL when they were investigating wireless power transfer equipment.
- NECA 413 provides information on installation and maintenance of AC Level 1 and 2 and fast-charging dc EVSE.

3433

© 2022 *electrical training ALLIANCE*

625.1 Info. Notes

NEW



3434

© 2022 *electrical training ALLIANCE*

625.17

REVISION

Cords and Cables

Change Summary

- “Stationary equipment” was changed to “fastened-in-place equipment” for consistency with 625.44(B).
- The overall cord and cable length is not permitted to exceed 25 feet unless equipped with a cable management system.
- Section 625.17(C) has been revised to indicate how the power supply cords for the output cable is measured.

© 2022 *electrical training ALLIANCE*

625.17

REVISION



3436

© 2022 *electrical training ALLIANCE*

625.40

REVISION

Electric Vehicle Circuit

Change Summary

- Section 625.40 requires each outlet installed for supplying EVSE to be supplied by an individual branch circuit.
- The requirement for an individual branch circuit applies to outlets greater than 16 amperes or 120 volts.
- A new exception has been added that permits branch circuits to supply multiple EVSEs in accordance with 625.42(A) or (B).

© 2022 *electrical training ALLIANCE*

625.40

REVISION



3438

© 2022 *electrical training ALLIANCE*

625.42

REVISION

Rating

Change Summary

- Section 624.42 was split into two subsections to clearly provide separate requirements for load management systems and EVSE with adjustable settings.
- Energy management systems are permitted to be integral to one piece of equipment or to a listed system. If integral load management is provided, the system must be marked to indicate that control is provided.
- EVSE with adjustable settings is permitted if access to the settings is restricted.

© 2022 *electrical training ALLIANCE*

625.42

REVISION



© 2022 *electrical training ALLIANCE*

625.43

REVISION

Disconnecting Means

Change Summary

- Section 625.43 was revised so that it applies to EVSE and WPTE rather than to all equipment.
- The disconnect must be installed in a readily accessible location.
- If the disconnect is in a remote location, a plaque must be installed on the equipment indicating the location of the disconnecting means.

© 2022 *electrical training ALLIANCE*

625.43

REVISION



3442

© 2022 *electrical training ALLIANCE*

625.49

NEW

Island Mode

Change Summary

- EVPE and EVSE with a power export function is now permitted to be part of an interconnected power system that operates in island mode.
- Some electric vehicle installations can function as optional standby power systems.
- The rest of the connected system must be capable of operating in island mode.

3443

© 2022 *electrical training ALLIANCE*

625.49

NEW



3444

© 2022 *electrical training ALLIANCE*

625.102

REVISION

Installation

Change Summary

- Changes were made to 625.102 to better integrate wireless power transfer into the *Code*.
- The title of 625.102(B) was changed to “Control Box.” The term *charger power converter* is no longer used.
- The title of 625.102(D) has been changed from “Protection of Cables” to “Protection of Cords and Cables to the Primary Pad.”
- If there is not a control box, the cord or cable supplying power to the primary pad must be secured in place to restrict movement and prevent strain at the connection points.

© 2022 *electrical training ALLIANCE*

625.102

REVISION



3446

© 2022 *electrical training ALLIANCE*

630.8

NEW

Ground-Fault Circuit-Interrupter Protection

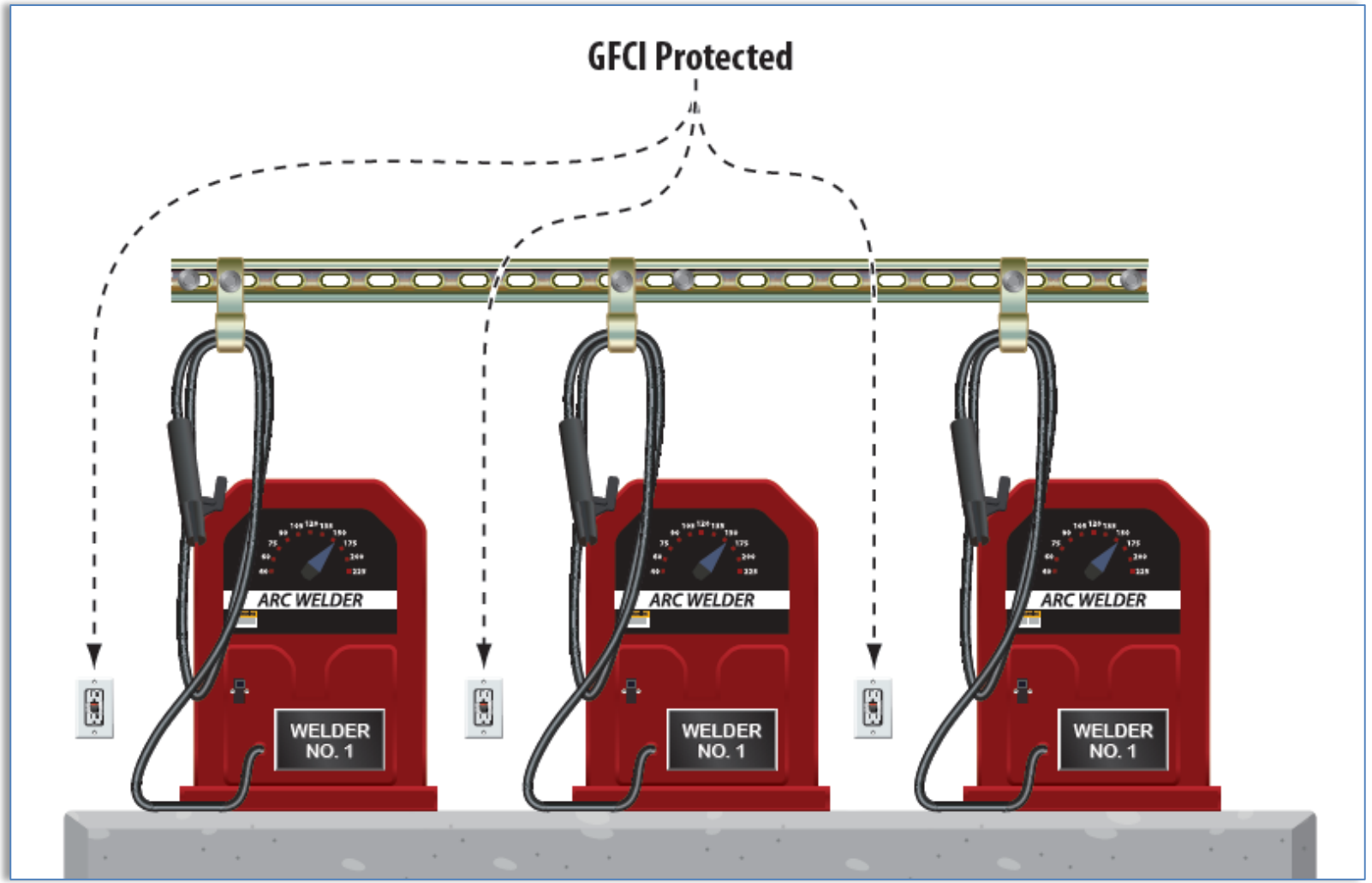
Change Summary

- All 125-volt, single-phase, 15- and 20-ampere receptacles installed in work areas where welders are operated are required to be GFCI protected.
- This requirement is to protect workers who are using electric hand tools or portable lighting equipment.
- The work area is not defined in this requirement.

© 2022 *electrical training ALLIANCE*

630.8

NEW



3448

© 2022 *electrical training ALLIANCE*

645.5

REVISION

Supply Circuits and Interconnecting Cables

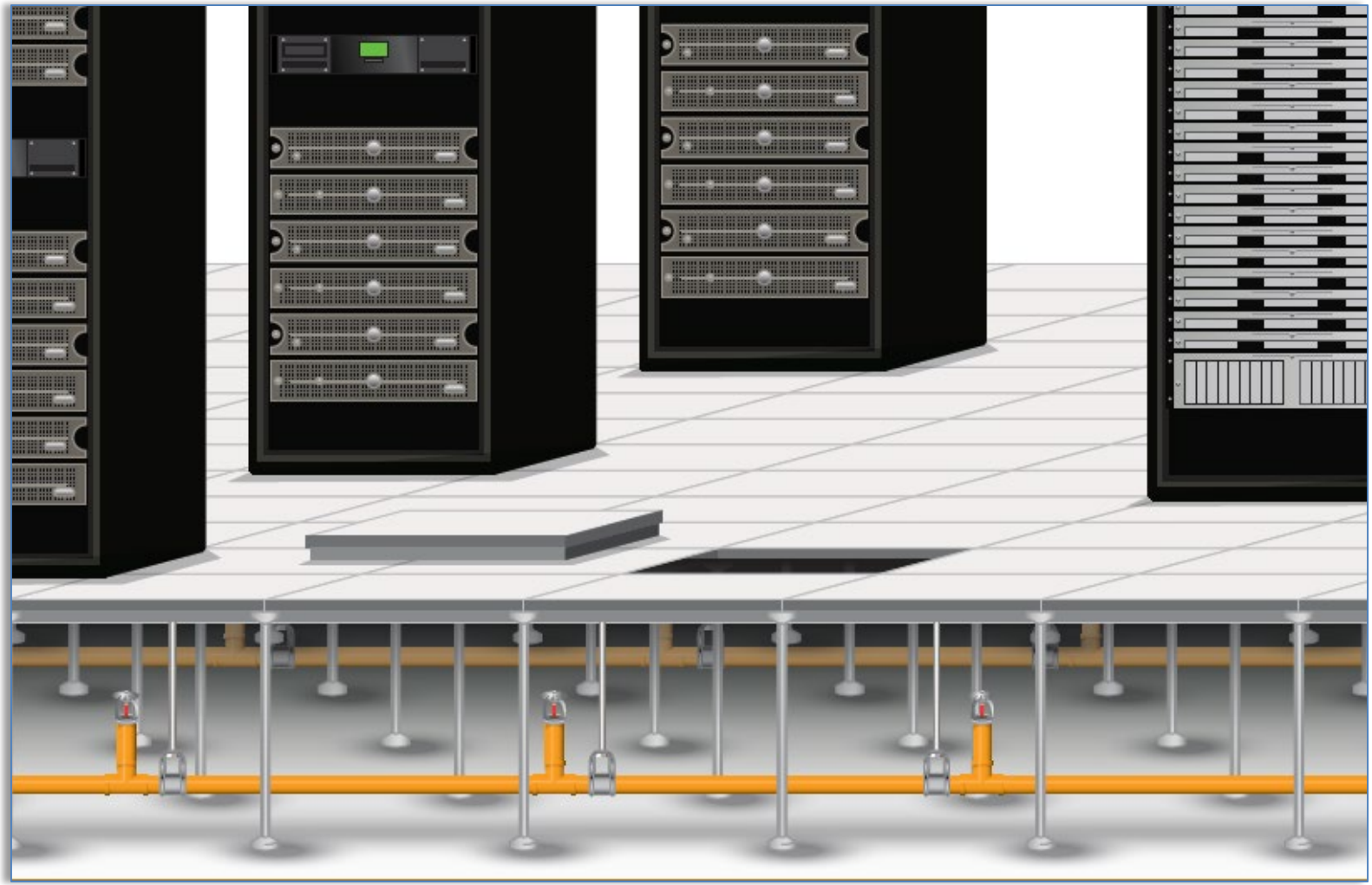
Change Summary

- New 645.5(B)(3) was added to ensure that the plugs and receptacles that connect power supply cords are listed and have properly-mated components.
- Sections 645.5(D), (E), and (F) were modified to use properly descriptive terminology.
- Section 645.5(H) was rearranged into list format to improve clarity.

© 2022 *electrical training ALLIANCE*

645.5

REVISION



3450

© 2022 *electrical training ALLIANCE*

670.3(A)

REVISION

Permanent Nameplate

Change Summary

- The requirements for nameplates on industrial machinery were revised for consistency with *NFPA 79* regarding industrial machinery.
- The nameplate must be attached to the outside of the control equipment enclosure or on the machine immediately adjacent to the main control equipment enclosure so that it is visible after installation.
- The requirement previously required that the nameplate be “plainly visible,” which was unenforceable.

© 2022 *electrical training ALLIANCE*

670.3(A)

REVISION



3452

© 2022 *electrical training ALLIANCE*

680.5

REVISION

GFCI and SPGFCI Protection

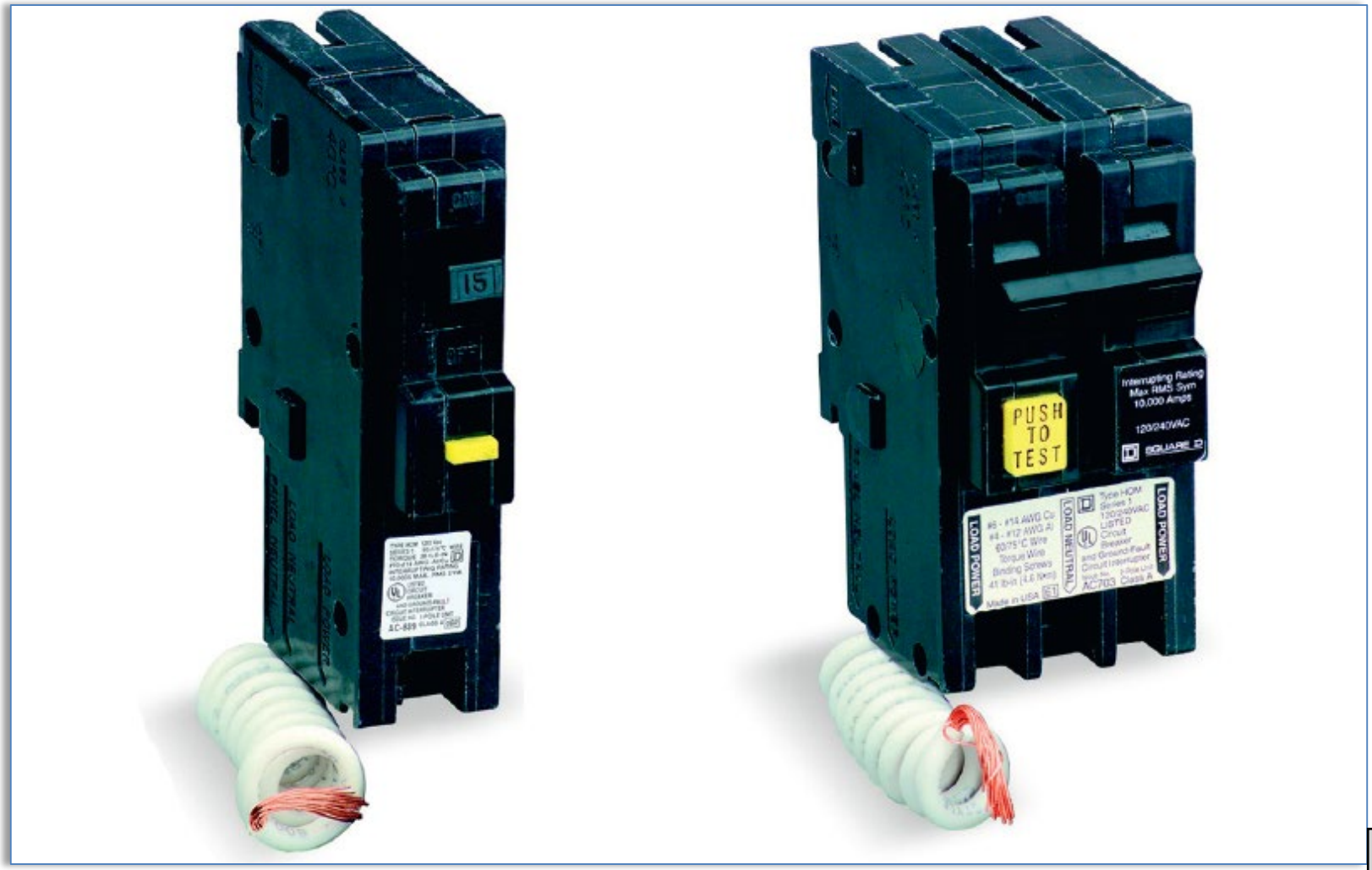
Change Summary

- The first sentence of 680.8 was deleted because it described the types of devices used for GFCI protection, which was not needed.
- Some GFCI requirements from other parts of Article 680 were consolidated into 680.5.
- The informational note to 680.5(B) points out that the high leg of a 120/240-volt, 4-wire, delta-connected system exceeds the limits for Class A GFCIs.
- A new 680.5(C) has been added to address ground-fault protection of receptacles and outlets on single- and 3-phase circuits exceeding 150 volts to ground.

© 2022 electrical training ALLIANCE

680.5

REVISION



3454

© 2022 *electrical training ALLIANCE*

Courtesy of Schneider Electric

680.6 & 680.7

DELETION REVISION

Grounding and Bonding

Change Summary

- Section 680.6, Bonding and Equipment Grounding, was deleted as it was redundant with requirements in Article 250.
- Section 680.7 was retitled “Grounding and Bonding.” The previously existing text was revised and relocated to 680.7(C).
- The requirements for cord- and plug-connected equipment were relocated to 680.7(B) from 680.21(A)(3) and 680.8(B).
- Requirements for feeders and branch circuits were relocated into 680.7(A) from 680.21(A)(3) and 680.8(B).

© 2022 electrical training ALLIANCE

680.6 & 680.7

DELETION **REVISION**



3456

© 2022 *electrical training ALLIANCE*

680.10

REVISION

Electric Pool Water Heater

Change Summary

- The title of 680.10 has been changed to indicate that it applies to heaters incorporating resistive heating elements and electrically-powered swimming pool heat pumps and chillers.
- Section 680.10(A) only applies to heaters incorporating the traditional resistive heating elements.
- Section 680.10(B) recognizes the newer technology of electric heat pumps and chillers to heat or cool the pool water. They may do both.

© 2022 *electrical training ALLIANCE*

680.10

REVISION



3458

© 2022 *electrical training ALLIANCE*

680.12

REVISION

Equipment Rooms, Vaults, and Pits

Change Summary

- The title of the section and 680.12(A) have been revised so that the requirements also apply to equipment in vaults.
- Equipment in rooms or vaults that do not have drainage that prevents water accumulation must be identified for submersion.
- A new 680.12(B) has been added to require at least one GFCI-protected, 125-volt, 15- or 20-ampere receptacle in the equipment room or vault.
- All other receptacles rated 150 volts or less to ground must be GFCI protected.

© 2022 *electrical training ALLIANCE*

680.12

REVISION



3460

© 2022 electrical training ALLIANCE

Courtesy of Mark Ode

680.14

REVISION

Corrosive Environments

Change Summary

- Section 680.14 now covers wiring methods and other equipment in corrosive environments.
- Liquidtight flexible nonmetallic conduit is now permitted to be used in corrosive environments.
- Aluminum conduit and tubing are not permitted for use in corrosive environments.
- Other equipment in corrosive environments must be installed in identified corrosion-resistant enclosures.
- Equipment listed for spa and pool use is suitable.

© 2022 *electrical training ALLIANCE*

680.14

REVISION



3462

© 2022 *electrical training ALLIANCE*

680.21

REVISION

Motors

Change Summary

- The requirements for corrosive environments were removed from this section because they are covered by 680.14.
- The title of 680.21(C) has been changed to “Ground-Fault Protection,” which now refers to 680.5(B) or (C).
- Section 680.21(D) has been revised to require that pool pump motors that are replaced or repaired be provided with ground-fault protection in accordance with 680.5.

© 2022 electrical training ALLIANCE

680.21

REVISION



3464

© 2022 *electrical training ALLIANCE*

680.41

REVISION

Location of Other Equipment

Change Summary

- This section was retitled “Location of Other Equipment.”
- The emergency switch for spas and hot tubs has been relocated to 680.41(A). It will not apply to installations in one- and two-family dwellings.
- A new 680.41(B) was added to provide requirements for equipment exceeding the low-voltage contact limit.

© 2022 *electrical training ALLIANCE*

680.41

REVISION



3466

© 2022 *electrical training ALLIANCE*

680.43(A)

REVISION

Ground-Fault Protection for Receptacles

Change Summary

- The requirements for ground-fault protection for receptacles have been revised.
- All receptacles rated 125 through 250 volts, 60 amperes or less, that are located within 10 feet of the inside walls of a spa or hot tub must have ground-fault protection complying with 680.5(B) or (C).
- Receptacles that provide power for spas and hot tubs are not permitted to exceed 150 volts to ground.

© 2022 *electrical training ALLIANCE*

680.43(A)

REVISION



3468

© 2022 electrical training ALLIANCE

I-Stock Photo, Courtesy of NECA

680.44

REVISION

GFCI and SPGFCI Protection

Change Summary

- The first sentence of this section has been relocated to become 680.44(A), and has been revised so that it requires the outlet that supplies a self-contained spa or hot tub, a packaged spa or hot tub equipment assembly, or a field-assembled spa or hot tub to have ground-fault protection in accordance with 680.5(B) or (C), as applicable.
- Section 680.44(C), “Other Units,” has been deleted because the reference to 680.5(C) covers ground-fault protection for 3-phase units.
- The new 680.44(C) provides requirements for gas-fired water heaters operating above the low-voltage contact limit.

© 2022 electrical training ALLIANCE

680.44

REVISION



3470

© 2022 *electrical training ALLIANCE*

680.54

REVISION

Bonding

Change Summary

- Section 680.54(B) was revised to require that a conductor used for bonding be a minimum 8 AWG solid copper conductor.
- Section 680.54(B)(6) was revised by replacing *devices and controls* with the more general term *equipment*.
- A new first-level subdivision 680.54(C) was added to require equipotential bonding of splash pads.

© 2022 *electrical training ALLIANCE*

680.54

REVISION



3472

© 2022 *electrical training ALLIANCE*

680.58

REVISION

GFCI and SPGFCI Protection for Receptacles

Change Summary

- The requirements for ground-fault protection for adjacent receptacle outlets have been expanded to apply to all receptacles rated 125 through 250 volts, 60 amperes or less.
- The requirements apply to single-phase and 3-phase receptacles within 20 feet of the edge of the fountain.
- The protection will be GFCI or SPGFCI protection, in accordance with 680.5(B) or (C), as applicable.

© 2022 *electrical training ALLIANCE*

680.58

REVISION



3474

© 2022 *electrical training ALLIANCE*

680.59

REVISION

Ground-Fault Protection for Nonsubmersible Pumps

Change Summary

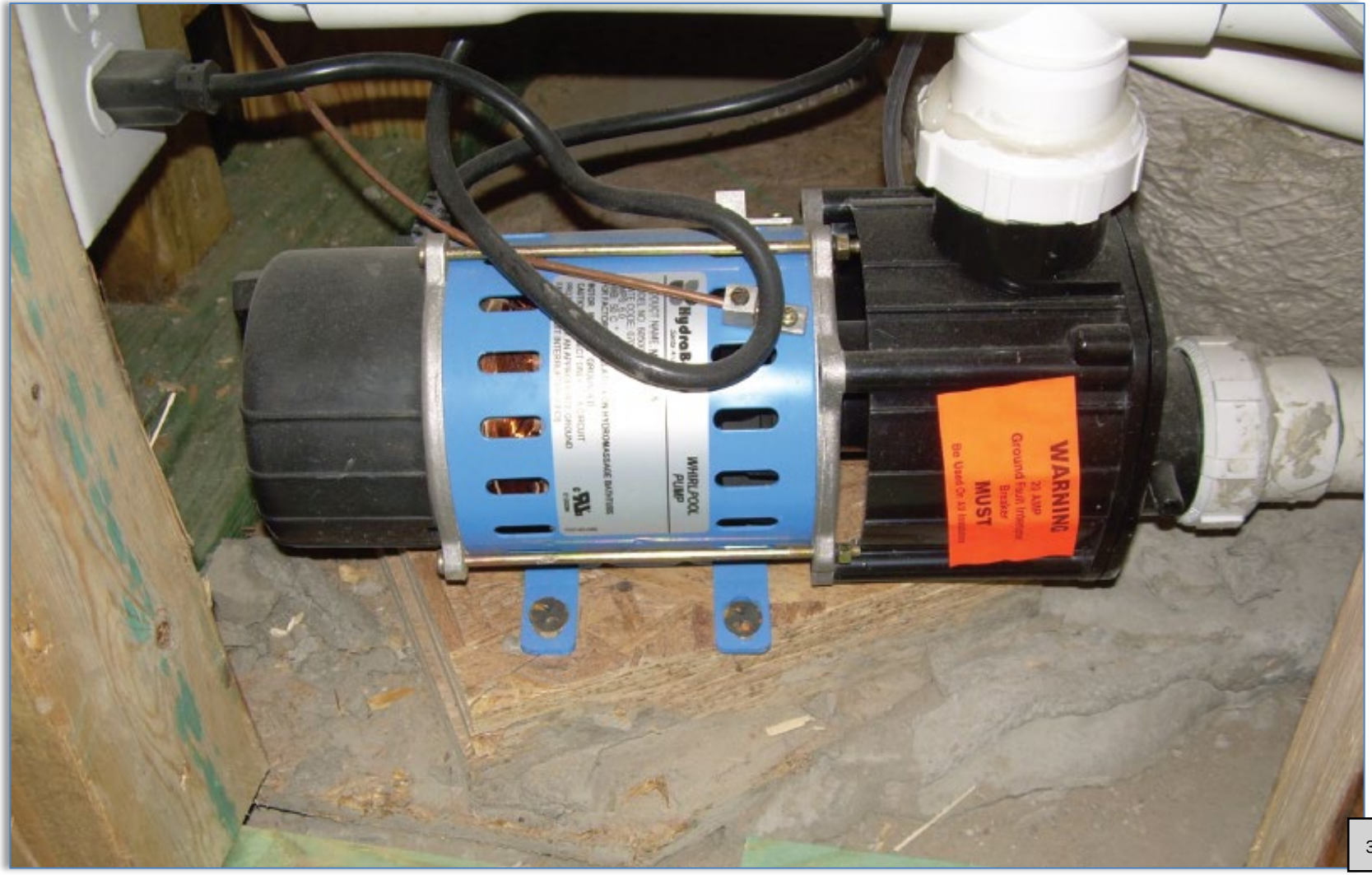
- The title of 680.59 has been revised to recognize that it applies to GFCI and SPGFCI protection for permanently installed nonsubmersible pumps.
- If the voltage to ground is 150 volts or less, GFCI protection is required.
- If the voltage to ground exceeds 150 volts, SPGFCI protection is required.
- An exception was added for listed low-voltage motors not requiring grounding that do not exceed the low-voltage contact limit, if the motor is supplied by listed transformers or power supplies that comply with 680.23(A)(2).

3475

© 2022 *electrical training ALLIANCE*

680.59

REVISION



3476

© 2022 *electrical training ALLIANCE*

680.83

REVISION

Equipotential Bonding

Change Summary

- Equipotential bonding of pool lift equipment must use solid copper conductors that are not smaller than 8 AWG and may be covered, insulated, or bare.
- Connection to bonded parts must comply with 250.8.
- The bonding jumpers in the pool area are not required to be extended to remote panelboards, service equipment, or electrodes.

© 2022 *electrical training ALLIANCE*

680.83

REVISION



3478

© 2022 *electrical training ALLIANCE*

682.11

REVISION

Location of Electrical Distribution Equipment

Change Summary

- Section 682.11 has been revised to apply to electrical distribution equipment. It previously applied only to service equipment. It now provides two options for the location of the installation.
- Electrical distribution equipment can be located at least five feet horizontally from the shoreline where live parts of the equipment are located at least 12 inches above the datum plane.
- Electrical equipment can be located no closer than the shoreline where live parts of equipment are located at least 10 feet above the datum plane.

© 2022 *electrical training ALLIANCE*

682.11

REVISION



3480

© 2022 *electrical training ALLIANCE*

682.12

REVISION

Electrical Connections

Change Summary

- Section 682.12, Electrical Connections, was divided into two subsections.
- Conductor splices located above the waterline but below the datum plane must be in junction boxes identified for wet locations, using sealed wire connector systems listed and identified for submersion.
- Replacement electrical connections that are located below the electrical datum plane and above the waterline must be listed and identified for submersion.

© 2022 *electrical training ALLIANCE*

682.12

REVISION



© 2022 *electrical training ALLIANCE*

Article 690

REVISION

Solar Photovoltaic (PV) Systems

Change Summary

- The three informational note figures in 690.1 have been combined into a single figure.
- Requirements for stand-alone systems were deleted from 690.10. Article 710 covers stand-alone systems.
- Parts VI and VIII were deleted. Part VII, Connection to Other Sources, became Part VI, Source Connections. Part VIII, Energy Storage Systems, was deleted because that is covered in Article 706.

© 2022 electrical training ALLIANCE

Article 690

REVISION



3484

© 2022 *electrical training ALLIANCE*

690.4

REVISION

General Requirements

Change Summary

- There is a new definition of “electronic power converter” in Article 100, which includes inverters and dc-to-dc converters. Electronic power converters were added to the list of equipment in 690.4(B) to replace inverters and dc-to-dc converters. PV hazard control equipment and PV hazard control systems were also added.
- Acronyms were added for rapid shutdown (PVRSE), hazard control system (PVHCS), and hazard control equipment (PVHCE).
- New requirements were added for PV equipment floating on or attached to structures floating on bodies of water.

© 2022 *electrical training ALLIANCE*

690.4

REVISION



3486

© 2022 *electrical training ALLIANCE*

690.7

REVISION

Maximum Voltage

Change Summary

- Section 690.7 was revised for clarity and to remove requirements for systems over 1,000 volts.
- Section 690.7(A) through (D) were revised to eliminate the terminology *source and output* and to add the defined term *PV string circuit* in 690.7(B).
- Section 690.7(B) was also updated by deleting “source and output” from the term *dc-to-dc converter circuits*.
- The marking requirements for dc PV circuits were relocated to 690.7(D) from 690.53.

© 2022 electrical training ALLIANCE

690.7

REVISION



3488

© 2022 *electrical training ALLIANCE*

690.8

REVISION

Circuit Sizing and Current

Change Summary

- An informational note was added to 690.8(A)(1) noting that some modules can produce electricity when exposed to light on multiple surfaces.
- Section 690.8(B) requires a minimum conductor size without adjustment and correction factors based on an ampacity not less than the current calculated in 690.8(A) multiplied by 125%.
- Section 680.8(D) was updated to use the term *PV string circuits*, which describes how some PV circuits are arranged.

3489

© 2022 *electrical training ALLIANCE*

690.8

REVISION



3490

© 2022 *electrical training ALLIANCE*

690.9(D)

REVISION

Transformers

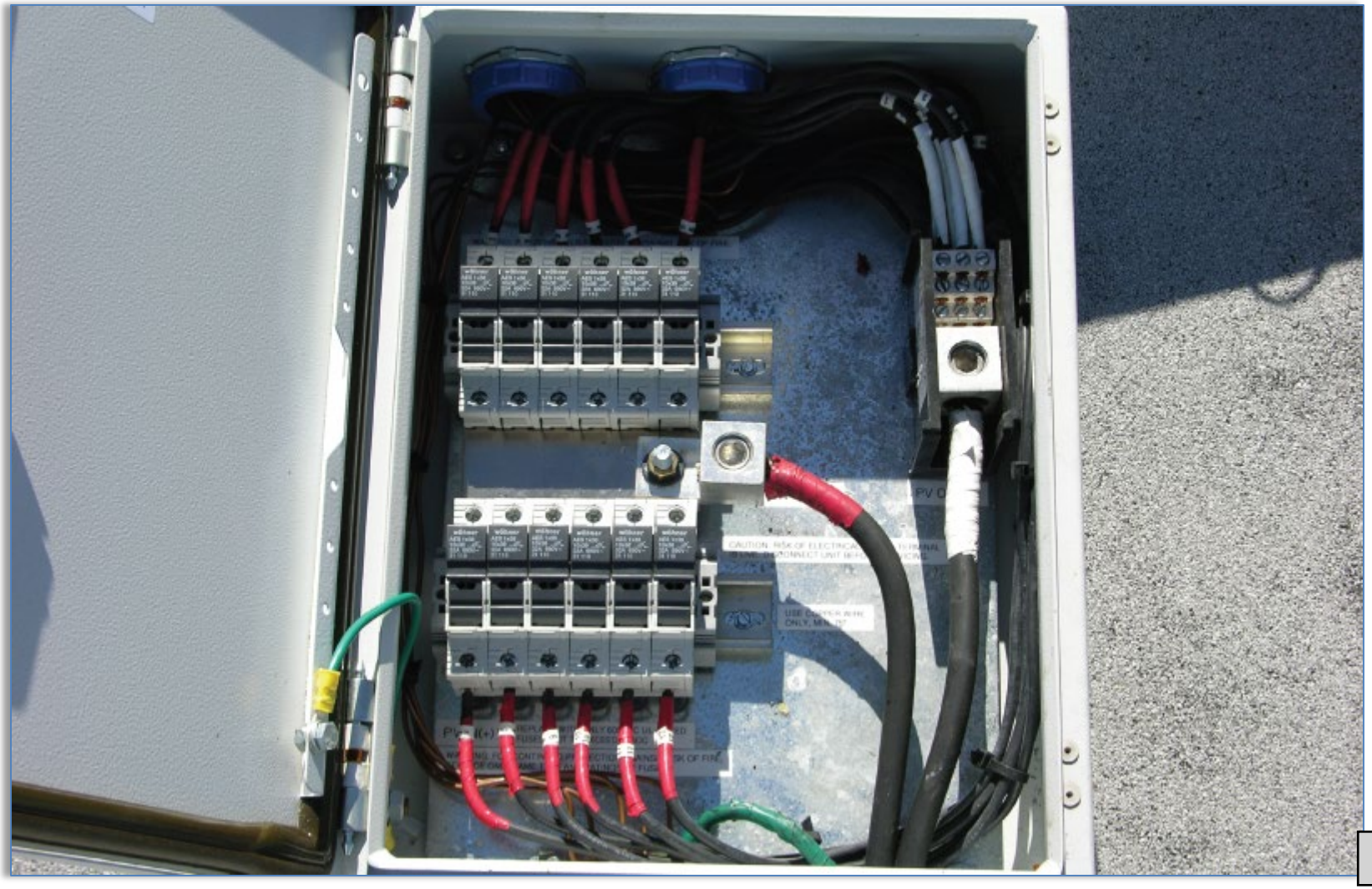
Change Summary

- The requirements for protection of transformers are now covered in 705.30(C).
- The requirements in 450.3 are based on the primary being one side at a time.
- Section 705.30(F) is based on interconnected power production sources. It is applicable to installations where there can be multiple sources.

© 2022 electrical training ALLIANCE

690.9(D)

REVISION



3492

© 2022 *electrical training ALLIANCE*

690.12, Exception

REVISION

Rapid Shutdown of PV Systems on Buildings

Change Summary

- Section 690.12 establishes requirements for rapid shutdown of PV systems on buildings.
- A new exception was added to exempt non-enclosed detached structures, such as those that provide parking shade, carports, solar trellises, and similar structures.
- The exception aligns with requirements for firefighter rooftop access in the building and fire codes.

© 2022 *electrical training ALLIANCE*

690.12, Exception

REVISION



3494

© 2022 *electrical training ALLIANCE*

690.15

REVISION

Disconnecting Means for Isolating PV Equipment

Change Summary

- 690.15(D), Type of Disconnecting Means, has been relocated to 690.15(A). Revised wording clarifies that disconnecting means complying with 690.15(C) are permitted in any circuit, regardless of current rating.
- 690.15(A)(2) was revised to permit an isolating device that is part of listed equipment where an interlock prevents opening the isolating switch under load.
- 690.15(D) was rewritten to remove the distances and to replace them with the terms *readily accessible* and *in sight from*.

© 2022 *electrical training ALLIANCE*

690.15

REVISION



3496

© 2022 *electrical training ALLIANCE*

690.31

REVISION

Wiring Methods

Change Summary

- Section 690.31(A)(2) has been expanded to cover all PV dc circuits, and it has been clarified to indicate the conditions to which it applies.
- Section 690.31(B)(1) has been rewritten into list format and clarified regarding which conductors can be intermingled.
- Requirements have been added that provide more detail on cable tray installations.

© 2022 *electrical training ALLIANCE*

690.31

REVISION



3498

© 2022 *electrical training ALLIANCE*

691.1 & 691.4

REVISION

Large-Scale Photovoltaic (PV) Electric Supply Stations

Change Summary

- Large-scale PV systems are those that have an inverter generating capacity of 5,000 kW or larger that are not under exclusive utility control.
- The 5,000 kW lower limit was moved from the scope to 691.4(7).
- Section 691.4(6) now requires large-scale PV systems to be monitored from a central command center.

© 2022 electrical training ALLIANCE

691.1 & 691.4

REVISION



3500

© 2022 *electrical training ALLIANCE*

Article 692

REVISION

Fuel Cell Systems

Change Summary

- Section 692.4(B) now points to the requirement of a plaque or directory in 705.10.
- Part V, Grounding, was deleted because it did not modify the general rules of Article 250.
- Part VI, Marking, became Part V, Marking.
- Sections 692.60 through 692.65 were deleted in order to remove sections that did not modify the requirements of Chapters 1 through 4. In addition, requirements that are addressed during product listing were also deleted.

© 2022 *electrical training ALLIANCE*

Article 692

REVISION



3502

© 2022 *electrical training ALLIANCE*

694.50 & 694.68

DELETION

Interactive System Point of Interconnection

Change Summary

- The marking requirement for interactive points of interconnection with other sources that was in Section 694.50 was deleted. The new requirement is located in 705.14, which is a more general requirement for labeling an interactive point of connection to other sources.
- The requirement for points of connection was deleted from 694.68. The intent is that all sources combined with other sources must comply with Article 705.
- Requirements for identification of power sources in 694.54 requires a plaque or directory installed in accordance with 705.10.

© 2022 *electrical training ALLIANCE*

694.50 & 694.68

DELETION



3504

© 2022 *electrical training ALLIANCE*

695.1(B)

NEW

Not Covered

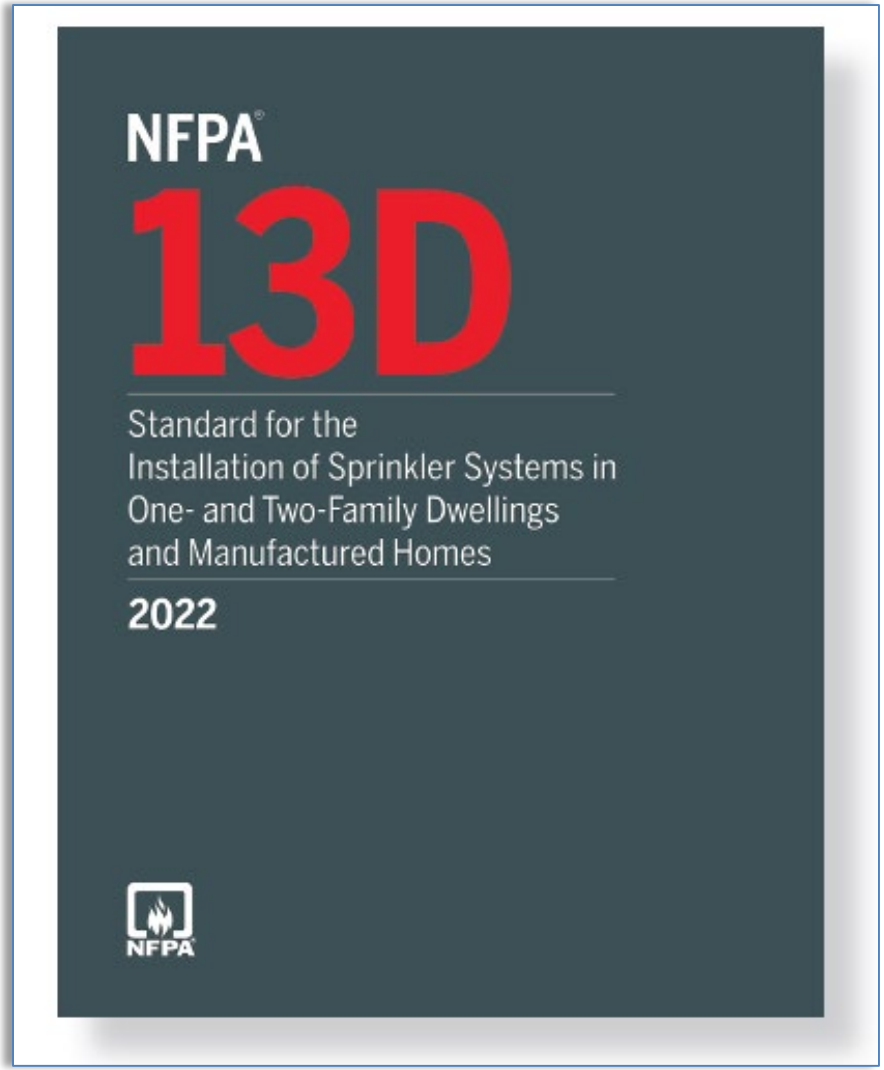
Change Summary

- The small water pumps that may be installed in one- and two-family dwellings for fire suppression are not the fire pumps covered by Article 695.
- These water pumps would have to comply with Article 430 rather than Article 695.
- Larger homes may have a sprinkler system in accordance with *NFPA 13* or *NFPA 13R*, which could require a fire pump in accordance with *NFPA 20* and Article 695.

© 2022 *electrical training ALLIANCE*

695.1(B)

NEW



3506

© 2022 *electrical training ALLIANCE*

695.7

NEW

Voltage Drop

Change Summary

- The exception to 695.7(A) which permits the voltage to drop more than 15% below normal is now 695.7(B), Emergency Run.
- A new 697.5(C) has been added to recognize bypass mode.
- Both emergency run mode and bypass mode are permitted to exceed 15% voltage drop, provided the pump can still be started while supplied by a generator.

© 2022 *electrical training ALLIANCE*

695.7

NEW

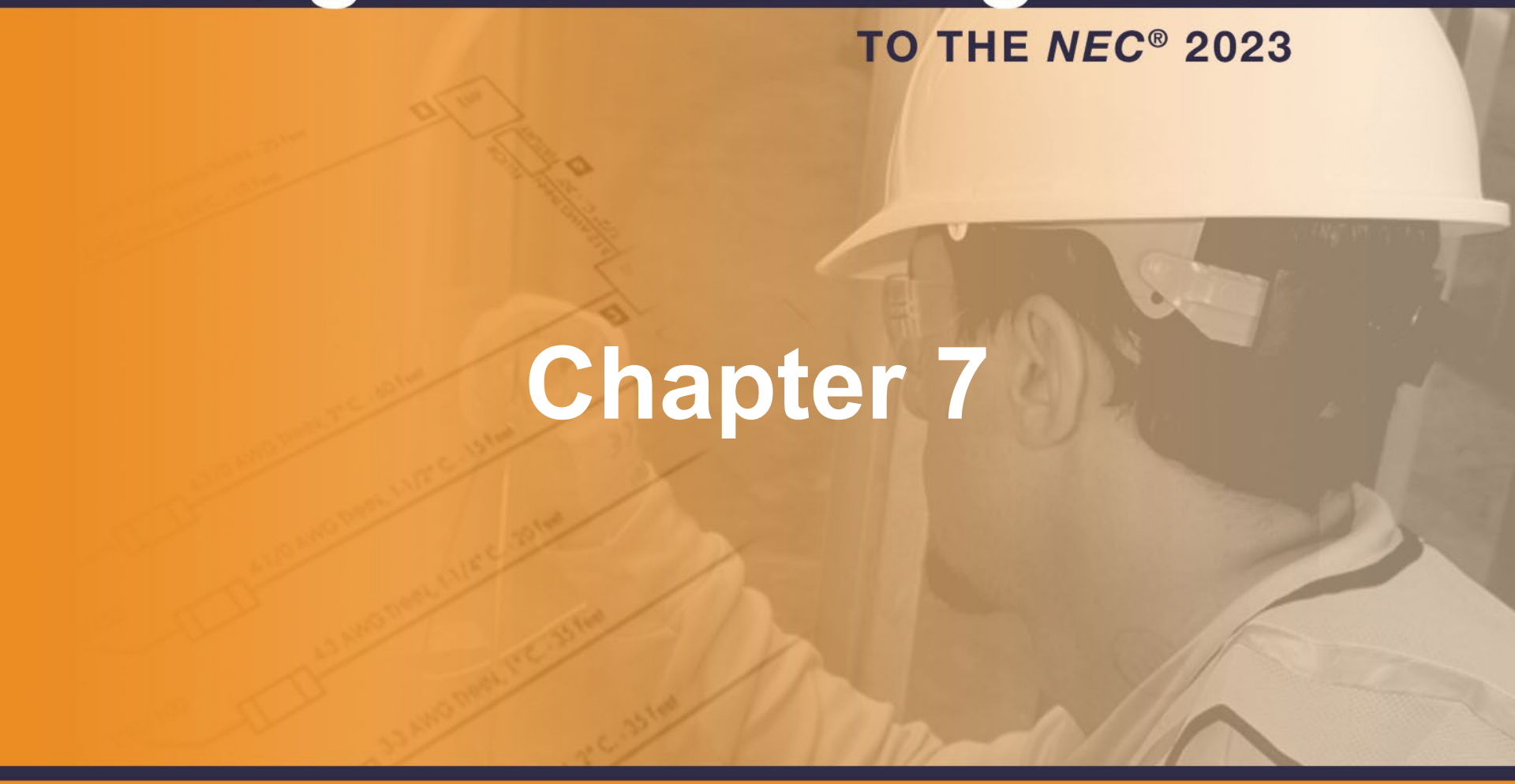


3508

© 2022 *electrical training ALLIANCE*

Significant Changes

TO THE *NEC*® 2023



Chapter 7

electrical training ALLIANCE IBEW - NECA IN COLLABORATION WITH NECA NATIONAL ELECTRICAL CONTRACTORS ASSOCIATION

700.3

REVISION

Tests and Maintenance

Change Summary

- The permanent connection point for the temporary generator must be located outdoors. Cables must not be run through exterior windows, doors, or similar openings.
- The switching means, including the interlocks, are required to be listed to prevent inadvertent interconnection of power sources.
- A permanent label must be field-applied at the permanent connection point that indicates the system voltage, maximum load, and short-circuit current rating of the load-side equipment.

© 2022 *electrical training ALLIANCE*

700.3

REVISION



3511

© 2022 *electrical training ALLIANCE*

700.4

REVISION

Capacity and Rating

Change Summary

- Section 700.4(A) was deleted because this is a general requirement covered by 110.9 and 110.10.
- Emergency systems are now required to have sufficient capacity for rapid load changes and transient energy requirements associated with expected loads.
- Peak load shaving requirements are now covered in 700.4(C), Parallel Operations.
- A new 700.4(C) addresses requirements for the two types of parallel operations. Section 700.4(C)(1) covers parallel operation of normal and emergency sources, while 700.4(C)(2) covers emergency sources that operate in parallel.

© 2022 *electrical training ALLIANCE*

700.4

REVISION



3513

© 2022 *electrical training ALLIANCE*

700.5

REVISION

Transfer Equipment

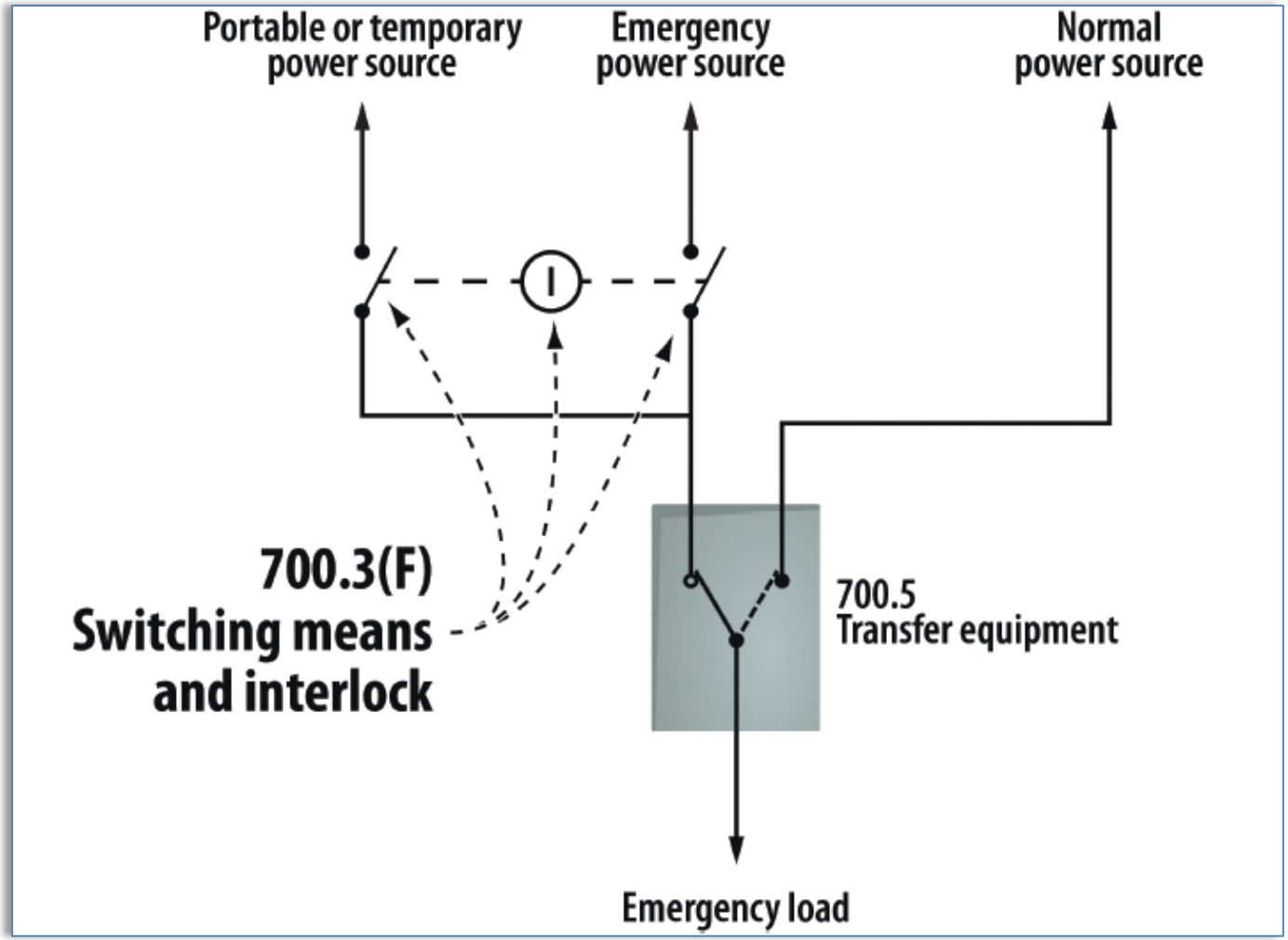
Change Summary

- The requirement in 700.5(A) for approval by the AHJ of transfer equipment was deleted.
- The prohibition of reconditioning emergency transfer switches has been relocated to 700.2.
- A new 700.5(D), Redundant Transfer Equipment, has been added to require emergency loads that are supplied by a single feeder to have a redundant transfer switch or a bypass isolation switch.
- Where the redundant transfer switch or bypass isolation switch is manual or not automatic, it must be supervised when the primary is out of service.

© 2022 *electrical training ALLIANCE*

700.5

REVISION



© 2022 *electrical training ALLIANCE*

700.11

NEW

Wiring, Class-2-Powered Emergency Lighting Systems

Change Summary

- New Section 700.11 recognizes Class 2 emergency lighting systems that could use power over ethernet technology or low-power LED luminaires.
- These are directly-controlled luminaires and must comply with 700.24.
- In addition to other separation requirements, Class 2 emergency circuits must be separated from nonemergency Class 2 circuit conductors. If bundled, they must be bundled separately.
- Wiring must comply with 300.4 and be installed in a raceway, armored or metal-clad cable, or cable tray.

© 2022 *electrical training ALLIANCE*

700.11

NEW



3517

© 2022 *electrical training ALLIANCE*

Courtesy of Electronic Theatre Controls Incorporated

700.12

REVISION

General Requirements

Change Summary

- Section 700.12(B) was revised to correlate with the occupancy requirements in 700.10(D)(1).
- The title of 700.12(C) has been changed from “storage battery” to “supply duration” to cover the duration of all supplies. Battery and UPS durations are covered under 700.10(C)(4).
- The exception to 700.10(C)(3) recognizes that where the AHJ approves a public gas system to supply an emergency source, an onsite fuel supply is not required.

© 2022 *electrical training ALLIANCE*

700.12

REVISION



3519

© 2022 *electrical training ALLIANCE*
Courtesy of Eaton

700.24

REVISION

Directly Controlled Emergency Luminaires

Change Summary

- Directly controlled luminaires can be energized in two different ways.
- An active control signal can be sent from a listed external control system. This requires the controller and the luminaire to be listed for use in emergency systems.
- Systems that are activated by disconnection of the control input by a listed control device, such as an automatic load control relay, would not require the luminaire to be listed for use in emergency systems.

© 2022 *electrical training ALLIANCE*

700.24

REVISION



3521

© 2022 *electrical training ALLIANCE*

700.32

NEW

Selective Coordination

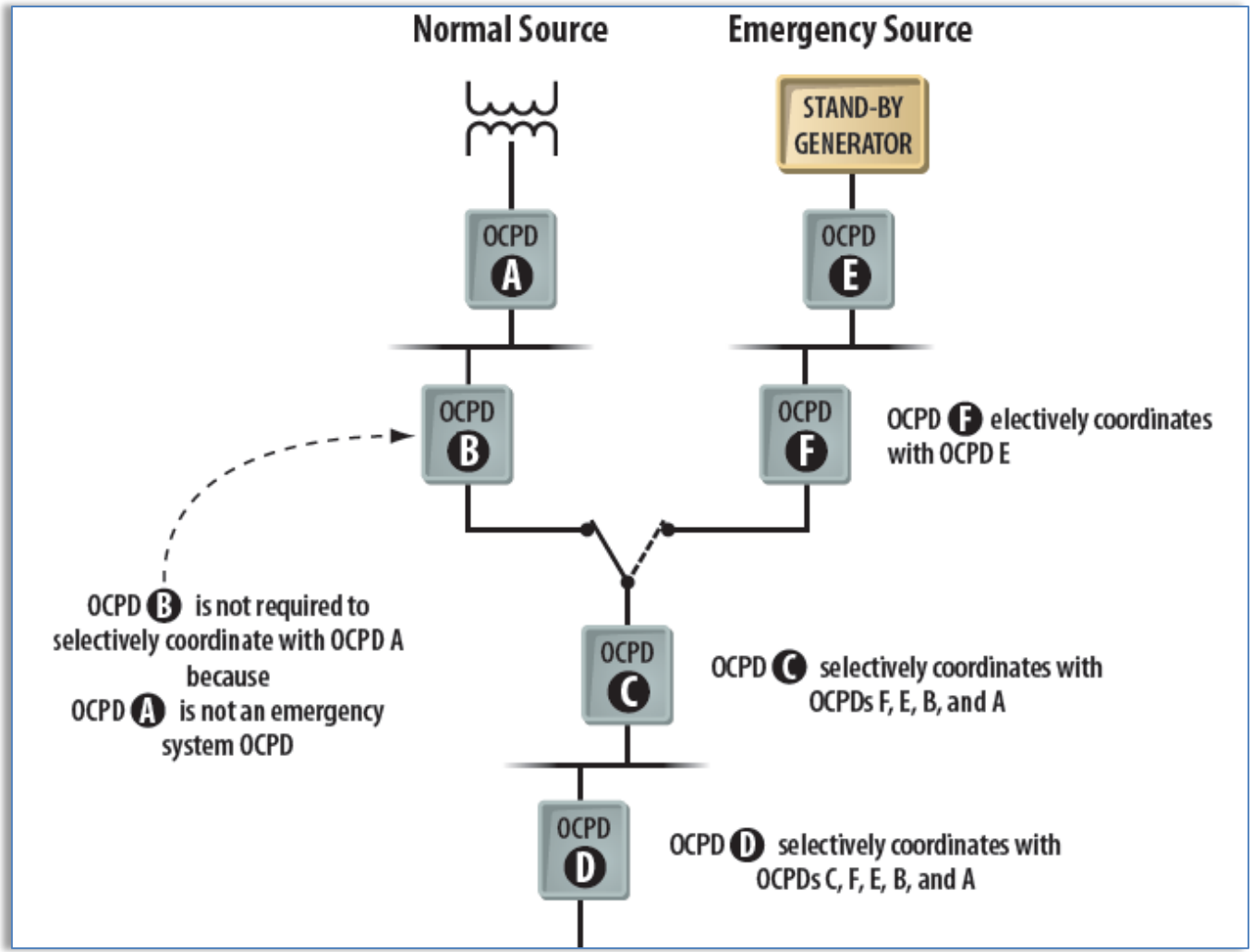
Change Summary

- Selective coordination of emergency systems is required to ensure that overcurrent protective device operation does not affect other loads supplied by the emergency systems.
- The text has been revised by adding “load-side” to ensure that coordination applies upstream and downstream.
- New text states that if OCPDs are replaced, modified, deleted, or added, coordination must be reevaluated.

© 2022 *electrical training ALLIANCE*

700.32

NEW



© 2022 *electrical training ALLIANCE*

705.5

REVISION

Parallel Operation

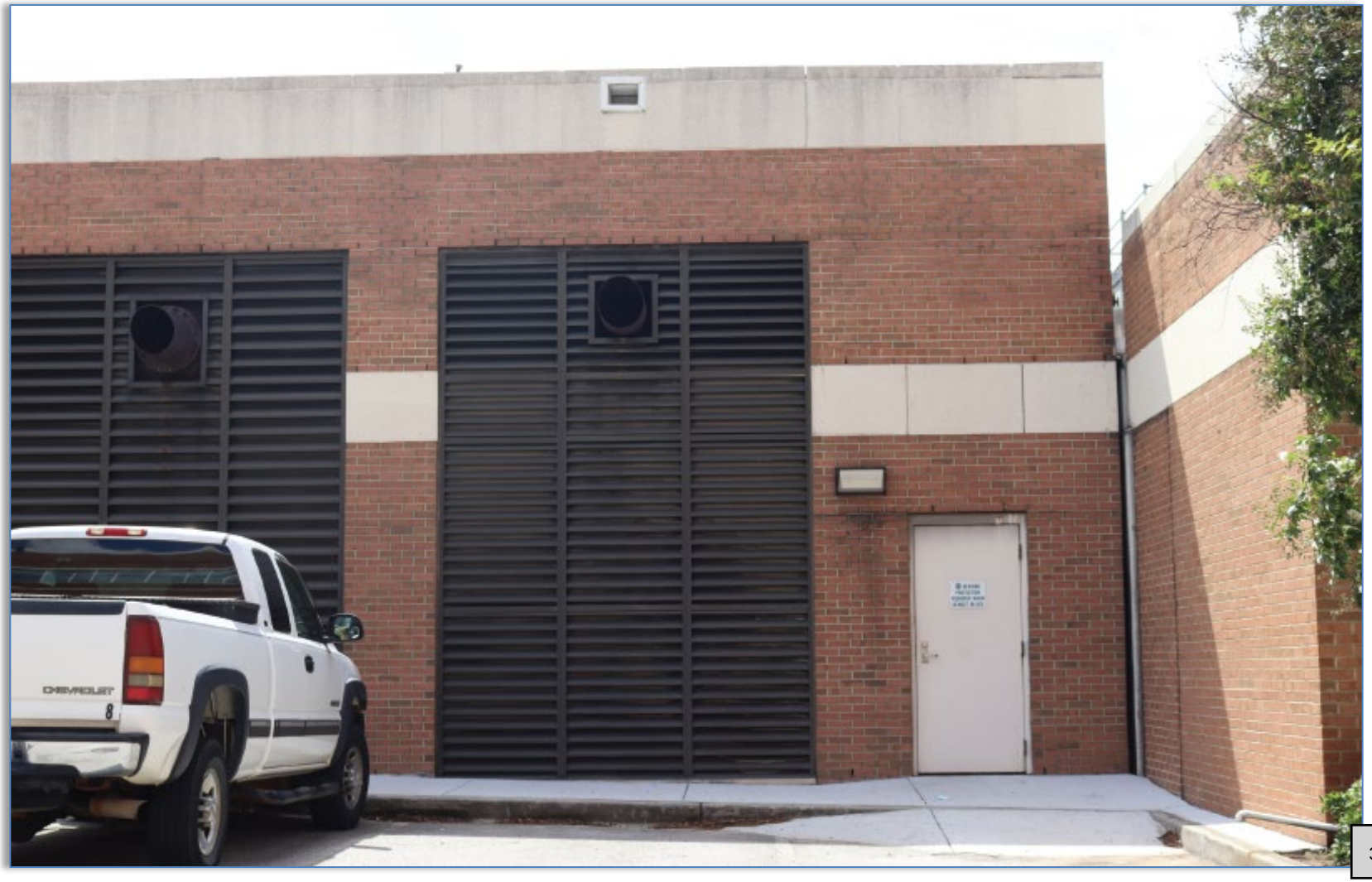
Change Summary

- Section 705.14 has been relocated to become 705.5.
- The title was changed from “Output Characteristics” to “Parallel Operation.”
- The previous first sentence of 705.14 has become 705.5(A).
- The marking requirements from 705.14 were deleted because listed equipment is required, which addresses the marking requirements.
- The last sentence of 705.14 has become 705.5(B).

© 2022 *electrical training ALLIANCE*

705.5

REVISION



3525

© 2022 *electrical training ALLIANCE*

705.10

NEW

Identification of Power Sources

Change Summary

- The identification requirements have been reorganized into list format.
- The plaques, labels, or directories are now required to indicate the emergency telephone numbers of off-site entities that service the installation.
- A reference was added to *NFPA 1: Fire Prevention Code*, which provides installer information.

© 2022 *electrical training ALLIANCE*

705.10

NEW



3527

© 2022 *electrical training ALLIANCE*

Courtesy of Michael J. Johnston

705.11

REVISION

Source Connections to a Service

Change Summary

- The title of 705.11 was revised to make it clear that it refers to any connection of an interconnected source to a service.
- The requirements for service conductors were moved to 705.11(B).
- The former 705.11(D) was relocated to (C) and was completely rewritten.
- The new 705.11(E) was added to provide requirements for bonding and grounding.

© 2022 *electrical training ALLIANCE*

705.11

REVISION



3529

© 2022 electrical training ALLIANCE
Courtesy of the National Renewable Energy Laboratory

705.12

REVISION

Load-Side Source Connections

Change Summary

- The first paragraph was revised for clarity by deleting unnecessary words.
- 705.12(A) was deleted because disconnecting requirements are covered in 705.20 and overcurrent protection is covered in 705.30.
- Requirements were revised for ampere ratings of busbars for connection to distribution equipment with no specific listing and instructions for combining multiple loads.

© 2022 *electrical training ALLIANCE*

705.12

REVISION



3531

© 2022 *electrical training ALLIANCE*

705.20

NEW

Source Disconnecting Means

Change Summary

- Section 705.20 provides requirements for disconnecting means for interconnected electric power production sources.
- Most articles that cover power sources also include disconnecting means requirements.
- If an installation complies with 705.20, a single disconnecting means is permitted to disconnect multiple sources.

© 2022 *electrical training ALLIANCE*

705.20

NEW



3533

© 2022 *electrical training ALLIANCE*

705.80 through 705.82

NEW

Interconnected Systems Operating in Island Mode

Change Summary

- A new Part III has been added to provide requirements for operating an interconnected electric power production source in island mode.
- The three categories of operation are automatic load management, manual load management, and no-load management.
- Operation in island mode requires voltage and frequency to be controlled within limits.

© 2022 *electrical training ALLIANCE*

705.80 through 705.82

NEW



3535

© 2022 *electrical training ALLIANCE*

706.1 & 706.8

REVISION

Scope

Change Summary

- Informational Note No. 1 points out that Article 480 covers installation of stationary-standby batteries.
- Other battery applications that are not stationary standby batteries are covered by Article 706.
- *NFPA 1* and *NFPA 855* were added to the list of reference standards because some battery chemistries require special fire protection precautions.

© 2022 *electrical training ALLIANCE*

706.1 & 706.8

REVISION



3537

© 2022 *electrical training ALLIANCE*

Courtesy of Tesla Energy

706.7

REVISION

Commissioning and Maintenance

Change Summary

- Section 706.7 has been expanded to require that energy storage systems be commissioned before being placed into service.
- This does not apply to ESS installations in one- and two-family dwellings.
- An informational note was added to point to *NFPA 855* for information on commissioning of energy storage systems.

© 2022 *electrical training ALLIANCE*

706.7

REVISION



3539

© 2022 electrical training ALLIANCE
Courtesy of Michael J. Johnston

706.15

REVISION

Disconnecting Means

Change Summary

- Requirements for disconnecting means for energy storage systems have been expanded.
- For one- and two-family dwellings, an emergency shutdown function must cease export of power from the ESS to the premises wiring of other systems.
- New requirements have been added for disconnecting means for batteries where the battery is separate from the ESS electronics and is subject to field servicing.

© 2022 *electrical training ALLIANCE*

706.15

REVISION



3541

© 2022 *electrical training ALLIANCE*
Courtesy of Tesla Energy

Article 722

NEW

Cables for Power-Limited Circuits

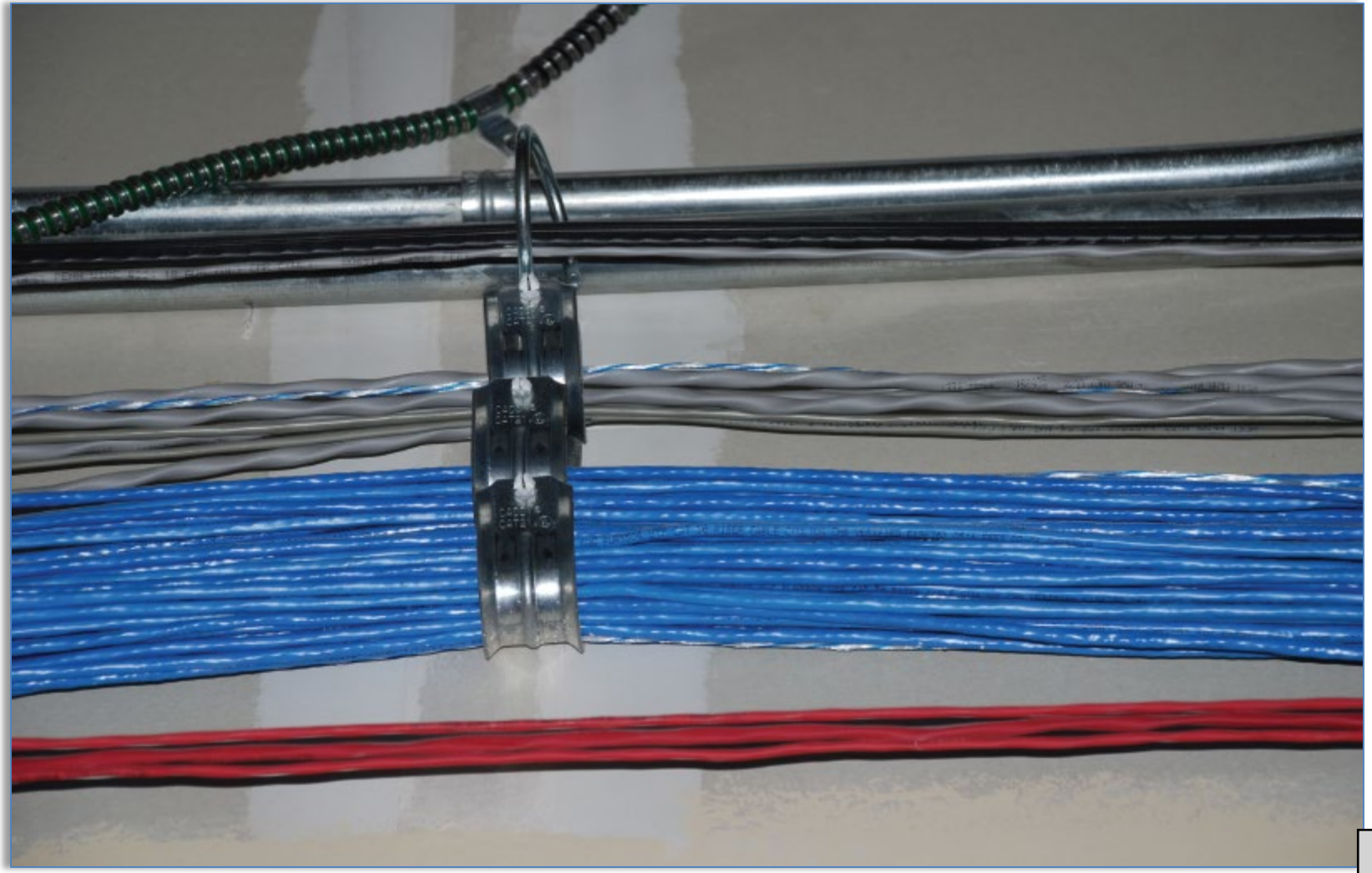
Change Summary

- A new Article 722 has been created to cover cable requirements for Class 2 and 3 power-limited circuits, power-limited fire alarm circuits, and Class 4 fault-managed power systems.
- Many of the installation requirements for these types of cables were repeated in Articles 725 and 760.
- Part I provides general requirements for power-limited circuit conductors and cables.
- Part II covers listing requirements for conductors and cables.
- The requirements for Class 4 circuits are new for this cycle.

© 2022 *electrical training ALLIANCE*

Article 722

NEW



3543

© 2022 *electrical training ALLIANCE*

Courtesy of Michael J. Johnston

722.10

NEW

Hazardous (Classified) Locations

Change Summary

- Class 4 cables are permitted in hazardous (classified) locations where specifically permitted in the applicable article elsewhere in the *Code*.
- Similar language permitting wiring and applicable equipment has also been added to 725.10, 726.10, and 760.10 to provide a consistent approach in each of these articles.
- All of these sections have been rewritten into positive language by the *NEC* Correlating Committee.

© 2022 *electrical training ALLIANCE*

722.10

NEW



3545

© 2022 *electrical training ALLIANCE*

Courtesy of Cisco

Article 724

NEW

Class 1 Power-Limited Circuits

Change Summary

- Class 1 circuit requirements have been moved from Article 725 to the new Article 724.
- Class 1 circuits are now limited to not more than 30 volts and 1,000 volt-amperes.
- The remote control and signaling circuits that are not power-limited are no longer considered to be Class 1 circuits. They are now covered by the first four chapters of the *Code*.

3546

© 2022 *electrical training ALLIANCE*

Article 724

NEW



3547

© 2022 *electrical training ALLIANCE*

Article 725

NEW

Class 2 and 3 Power-Limited Circuits

Change Summary

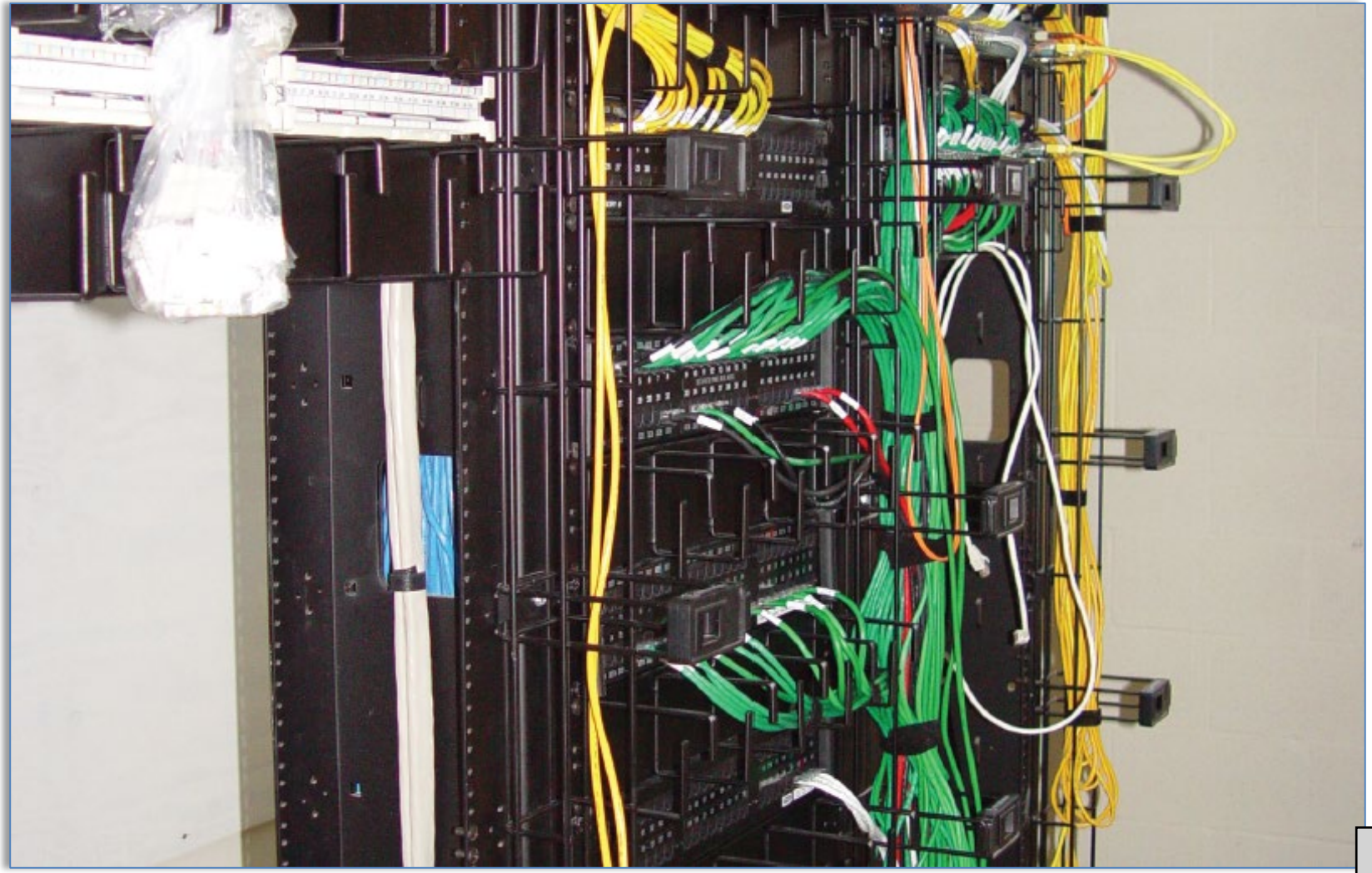
- Requirements for Class 1 circuits have been removed from Article 725, which now only applies to Class 2 and 3 power-limited remote control and signaling circuits.
- General requirements for wiring of Class 2 and 3 circuits have been relocated to new Article 722, Cables for Power-Limited Circuits.
- The relocated material includes substitution tables, abandoned cables, mechanical execution of work, and other requirements that are common to Articles 725, 760, and 770.

3548

© 2022 *electrical training ALLIANCE*

Article 725

NEW



3549

© 2022 *electrical training ALLIANCE*

725.31

REVISION

Safety-Control Equipment

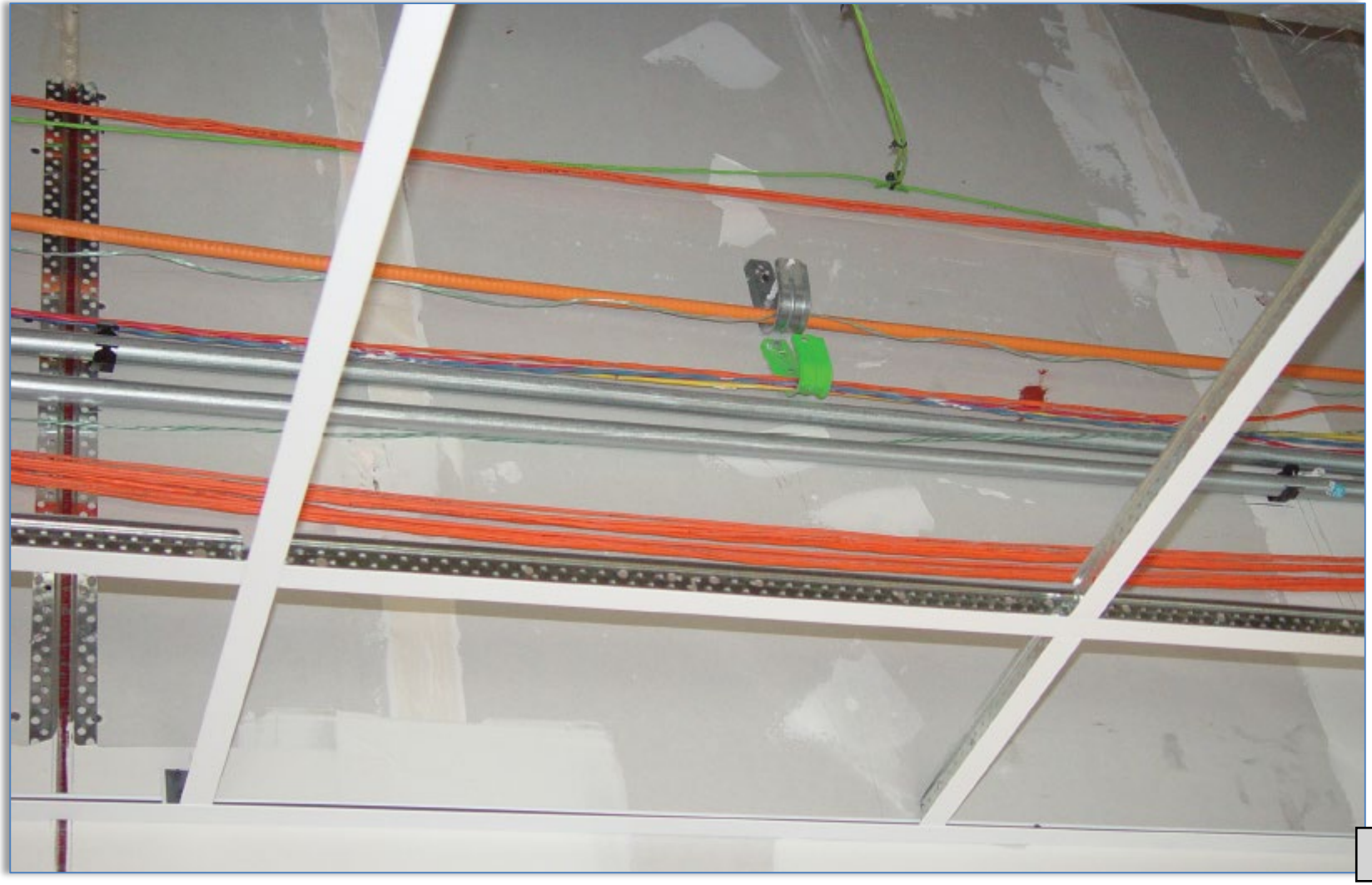
Change Summary

- If damage to Class 2 and 3 power-limited safety-control equipment can result in a direct fire or life safety hazard, the power-limited circuit must be installed in accordance with 724.31.
- Such circuits are no longer permitted to be reclassified as Class 1, but are required to be installed using Class 1 wiring methods.
- Reclassifying the wiring as Class 1 would require recertification of the source and load equipment as Class 1 equipment.

© 2022 *electrical training ALLIANCE*

725.31

REVISION



3551

© 2022 *electrical training ALLIANCE*

Courtesy of Michael J. Johnston

Article 726

NEW

Class 4 Power Systems

Change Summary

- A new Article 726, Class 4 Power-Limited Circuits, has been created to provide requirements for fault-managed power systems.
- Fault-managed power systems monitor the circuit for faults and control power delivery to ensure that fault energy is limited.
- Class 4 circuits can have a peak output voltage of 450 volts dc line-to-line or 225 volts line-to-ground.

© 2022 *electrical training ALLIANCE*

Article 726

NEW



3553

© 2022 *electrical training ALLIANCE*
Courtesy of Michael J. Johnston

Article 750

REVISION

Energy Management Systems

Change Summary

- Energy management systems are required to be listed.
- Three options are provided for listing, including a complete listed system, a field installation kit, or listed components assembled as a system.
- 750.30(C) was expanded to provide requirements for current set point, system malfunction, settings, and marking requirements.

© 2022 *electrical training ALLIANCE*

Article 750

REVISION



3555

© 2022 *electrical training ALLIANCE*

760.24

REVISION

Mechanical Execution of Work

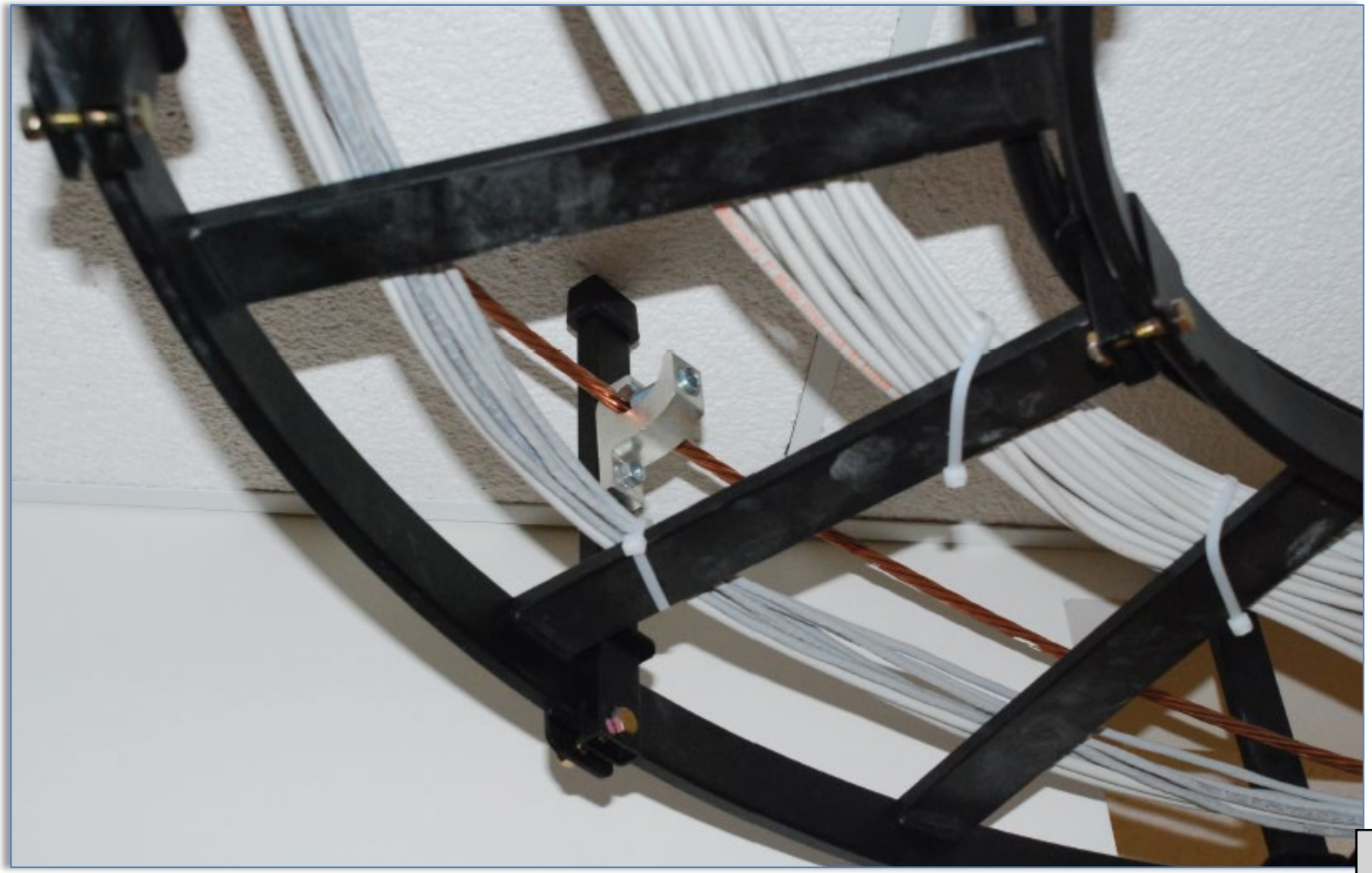
Change Summary

- Fire alarm circuit cables and conductors must be supported by hardware, including straps, hangers, and cable ties, that are listed and identified for securement and support.
- This correlates with requirements in 320.30, 330.30, 334.30, and 337.30, which all require mounting hardware that is listed for securement and support.
- A similar requirement in 722.24 covers Class 2, 3, and 4 wiring.

© 2022 *electrical training ALLIANCE*

760.24

REVISION



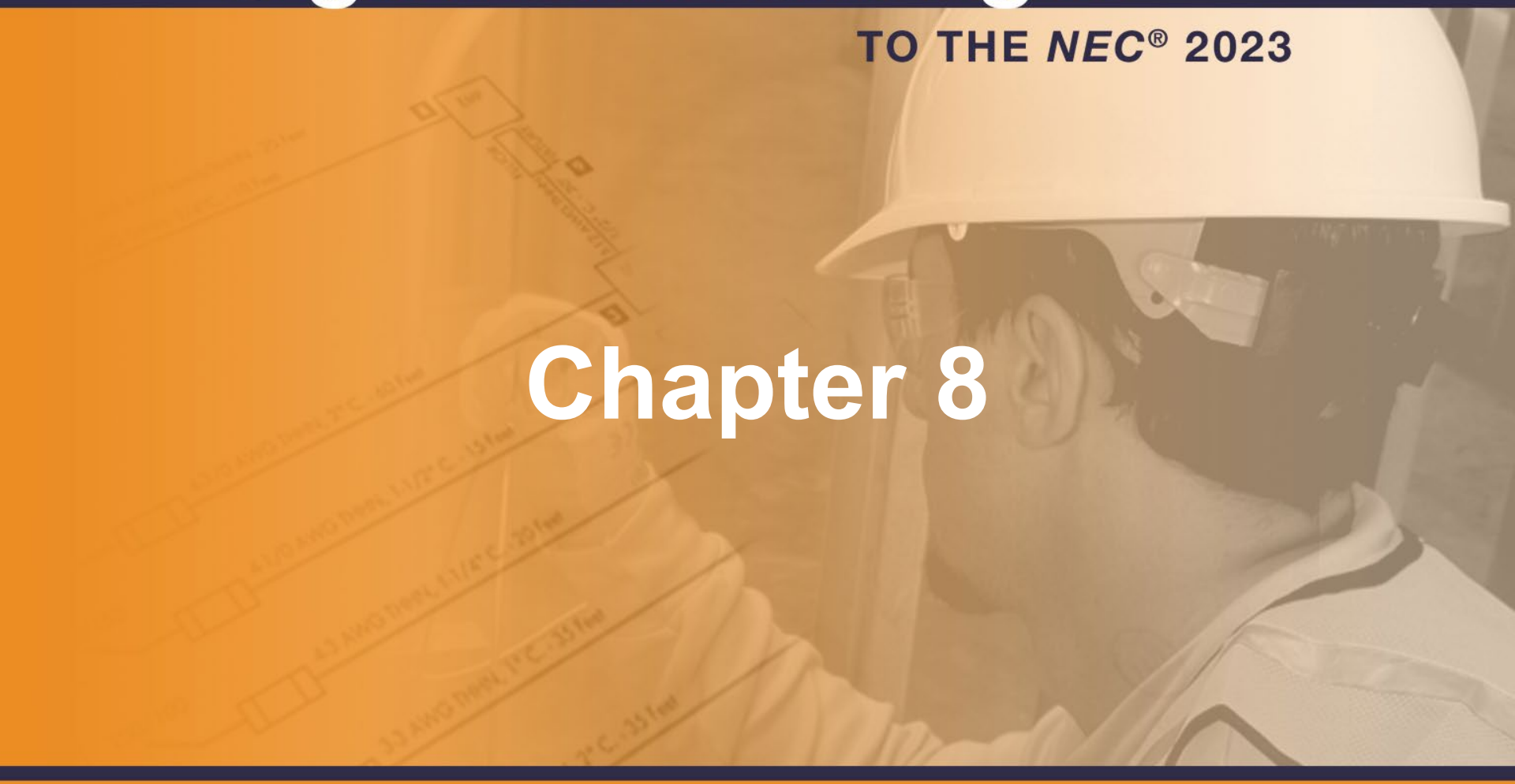
3557

© 2022 *electrical training ALLIANCE*

Courtesy of Michael J. Johnston

Significant Changes

TO THE *NEC*® 2023



Chapter 8

electrical training ALLIANCE IBEW - NECA IN COLLABORATION WITH NECA NATIONAL ELECTRICAL CONTRACTORS ASSOCIATION

Article 800

REVISION

General Requirements for Communications Systems

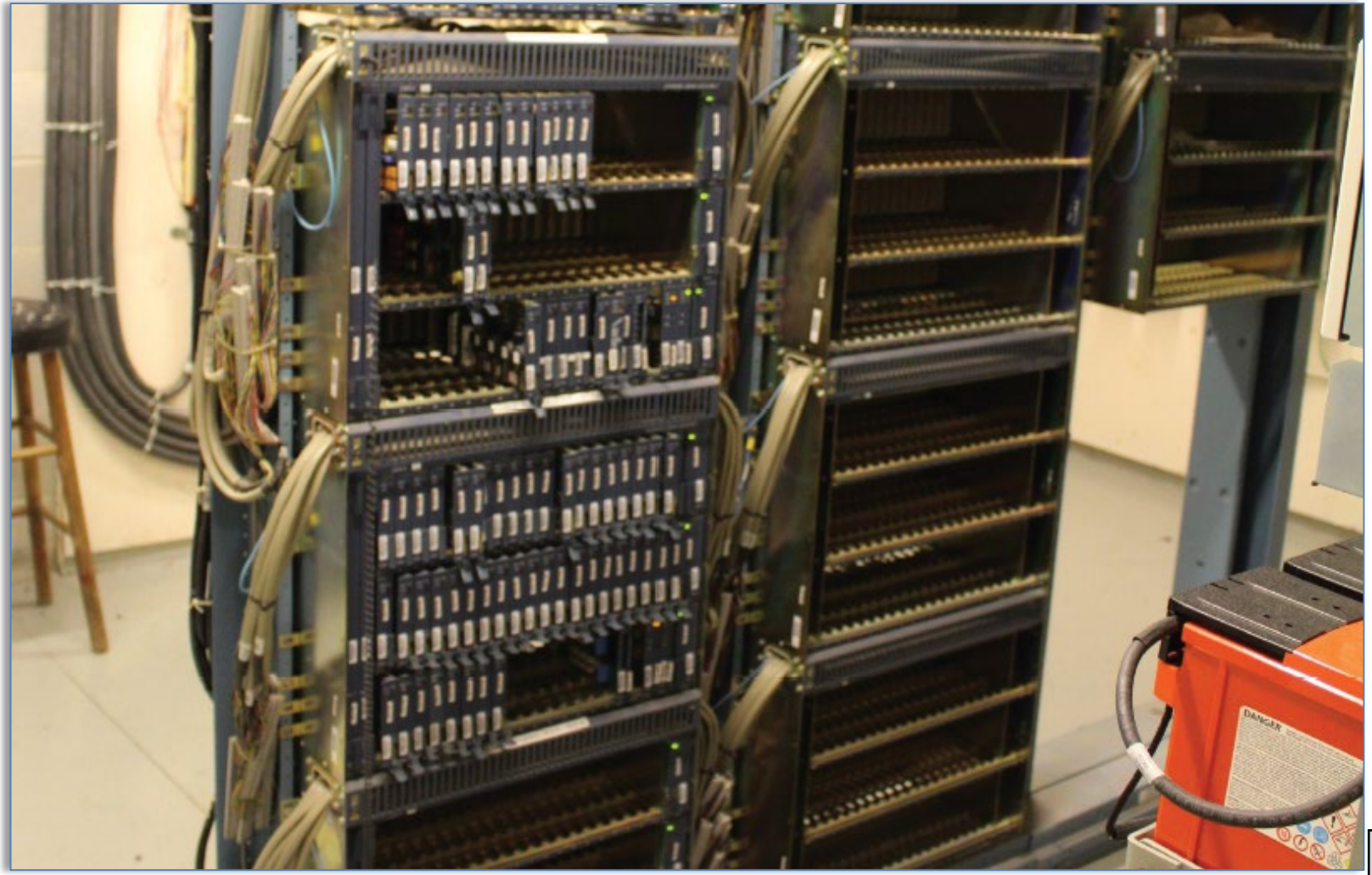
Change Summary

- During the 2020 cycle, communications circuit requirements were moved from Article 800 to Article 805.
- A new Article 800, General Requirements for Communications Circuits, was created as a location for the Chapter 8 articles.
- The task was incomplete in the 2020 cycle. This cycle, several additional sections have been moved into Article 800.

© 2022 *electrical training ALLIANCE*

Article 800

REVISION



3560

© 2022 *electrical training ALLIANCE*

Article 810

REVISION

Antenna Systems

Change Summary

- The title of Article 810 has been changed from “Radio and Television Equipment” to “Antenna Systems.”
- Most radio receiving equipment covered by Article 810 is cord- and plug connected to branch-circuit wiring.
- This article covers all radio receiving equipment.
- The only radio transmitting equipment covered by Article 810 is transmitters used for amateur radio and citizens band radio.

© 2022 *electrical training ALLIANCE*

Article 810

REVISION



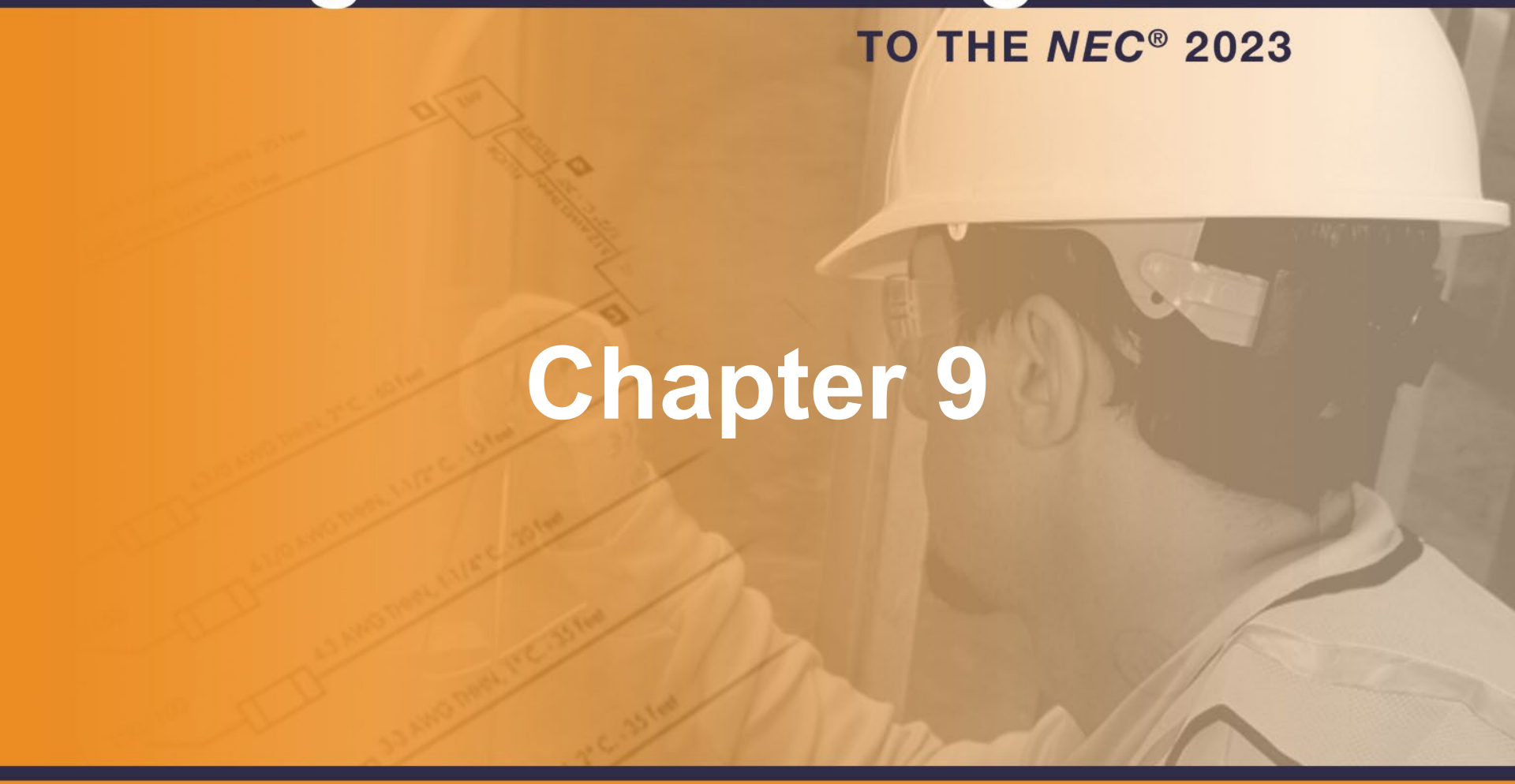
3562

© 2022 *electrical training ALLIANCE*

Courtesy of David Nelson, WV1H

Significant Changes

TO THE *NEC*® 2023



Chapter 9

electrical training ALLIANCE IBEW - NECA IN COLLABORATION WITH NECA NATIONAL ELECTRICAL CONTRACTORS ASSOCIATION

Chapter 9, Table 13

NEW

Equipment Suitable for Hazardous Locations

Change Summary

- Tables 505.9(C)(2)(4) and 506.9(C)(2)(3) were deleted.
- These tables were used for equipment selection where the zone classification systems are used.
- These tables have been replaced by Chapter 9, Table 13, which can be used for both the traditional class/division classification system and the zone classification system.

© 2022 *electrical training ALLIANCE*

Chapter 9, Table 13

NEW



3565

© 2022 *electrical training ALLIANCE*

File Attachments for Item:

EC-25 Sizing Building Drains and Stacks (Richardson)

All certifications (2 hours)

Sizing Building Drains and Stacks Learning Objectives

1. Familiarize participants with the sizing charts in chapter 7.
2. Familiarize participants with referenced definitions in he code sections.
3. Familiarize participants with the proper sequence for sizing building drains.
4. Familiarize participants participants with the proper sequence for sizing stacks and branches connected to stacks.
5. Familiarize participants with identifying the number of branch intervals and how this corresponds to sizing table 710.1(2).
6. Familiarize participants with other referenced code sections pertinent to sizing in chapter 7.

APPLICATION FOR CONTINUING EDUCATION APPROVAL
COURSE CONDITIONS AND GUIDELINES

The Ohio Board of Building Standards is committed to the ongoing education and professional development of board-certified personnel through the delivery of high-quality, accurate and engaging professional continuing education content. To this end, the Board reviews and approves Continuing Education Courses for building department personnel.

Board approval is granted for course instruction on current codes and standards, including the OBC, OMC, OPC, and RCO, and any other content areas directly related to the responsibilities of the certification for which credit is being requested.

Promotion: Any person or organization promoting an approved course is required to make full and accurate disclosure regarding course title, course approval number, number of credit hours, categories for which the BBS has approved the class, and fees in promotion materials and advertising. ***The Board does not grant retroactive approval. It is recommended that courses be submitted for approval well in advance of any scheduling of classes and advertising***. Advertising may not falsely state BBS approval before approval is granted. Course providers may state that BBS approval is pending.

Application Submission: All Applications and associated materials shall be submitted by email in .pdf format. Instructions for completing the application are attached.

Certificate of Completion: Course providers shall provide participants a certificate of completion containing the following information:

- Name of participant
- Title of approved courses
- BBS approval #
- BBS approved certifications
- Date of the continuing education program
- Number of approved credit hours awarded, and
- Signature of authorized sponsor or instructor.

Any person or organization administering an approved course shall return a completed BBS Course Attendance form by email.

Participants: Participants must attend the complete course as presented by the instructor to receive credit hours approved by the Board. The organization or instructor of online courses shall plan and execute methods to verify the individual's attendance and completion of the course. No partial credit will be given to any participant who failed to complete the entire course as approved.

Board approval: All courses are approved for the calendar year in which application is made. Courses may be renewed so long as the referenced code is in effect, and the CEUs, certification and content remain unchanged. When the referenced code is updated, courses must be updated, and new approvals obtained.

Facility/training area: BBS Course may be delivered in person or online, or both, at the sponsor's option.
Course facilities shall include the following:

In Person Classes:

Sufficient seating capacity
ADA accessible facilities
Appropriate Audio/Visual devices for delivery
Writing surfaces for participants

Online Classes:

Web-accessible
ADA accessible delivery
Tech support available
Live and recorded courses permitted

In-person facilities shall comfortably and safely seat at least the number of attendees present in the room and shall be climate controlled, non-smoking, and sound controlled so that outside noise will not interfere with the training.

Ohio | Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: James A. Richardson Jr.

Organization: James A. Richardson Jr.

Address:

E-mail: jarichardson@columbus.gov Telephone: 6147744855

Website:

Conference Sponsor (if applicable) Conference Email:

Check here if Course Renewal: ☐ Prior course number _____ (*i.e. BBS2018-429*)

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: Sizing Building Drains and Stacks

Course instructor: James A. Richardson Jr.

Course description:

This course will cover the proper steps for sizing building drains, stacks, and branches connected to stacks.

Instructional hours per session: 2 Number of Sessions: 1

Course Date(s) and Location: TBD

Special Content:

Code Administration ☐
Existing Buildings: ☐
Electrical Instruction: ☐
Plumbing Instruction: ✔

Conference Course:
Conference Name:
Conference location:

Course to be offered online? ✔ **On Demand** ✔ **Webinar** ✔

Course Website: TBD

Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation)*:
Online/On Demand - exit questions, Webinar - monitored by IT proctor

Course applicable for the following certifications

Residential Certifications Only: ☐ Commercial Certifications: ✔
Administrative Course, All Certifications: ☐

Application materials included:

✔ Course Outline or Course Learning Objectives
✔ Presentation Materials/Slides (not required for roundtable courses)
✔ Assessment Materials (for online courses)
✔ Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

Instructions for new Continuing Education Approval form

Provider Information

1. Please include all contact information.
2. If course is not part of a conference, leave conference sponsor and email blank.

Course Renewal

1. Indicate if the course is being submitted for renewal. Include prior approval letter and write in prior course number.
2. Certification approval for courses has now changed: all existing courses being renewed will be approved within the new classification system.
    a. Courses previously approved for only residential certifications will be approved for all residential certifications.
    b. Courses previously approved for at least on commercial certification will now be approved for all commercial certifications and all residential certifications.
    c. Courses on required instruction topics, Ohio Ethics, Code Administration and Existing Buildings, will be noted as Administrative Courses and be approved for all certifications.
3. Courses being renewed should skip the New Course information section and are not required to submit outline, agenda, slides or other instructional materials for review. Skip to Special Content, and mark any item that applies to the course.

New Course Information

1. Enter course title, name of instructor, and a brief description of the course content. Learning objectives may be substituted for course description, if desired.
2. Number of instructional hours per session is the length of instructional time.
3. Number of sessions: can be 1 or the number of sessions planned.
4. Course date(s) and location: not necessary at this time, enter if known.

Special Content

1. Indicate if the course will meet instructional time in Code Administration or Existing Buildings.
2. Indicate if the course is a plumbing or electrical course, for ESIAC review and trainee course tracking.
3. If the course is associated with a conference, indicate the conference name and location, as this will allow BBS to coordinate approvals with the conference provider.
4. If the course will be offered online, specify whether it will be on demand or offered as a virtual webinar, or both. Include website where the course will be provided.

Course applicable for the following certifications

This section represents a major change from previous BBS course approval forms.

1. If the course is only for residential certifications, check 'Residential Certifications Only'. The course, if approved, will be approved for all residential certifications.
2. If the course is appropriate for any commercial certifications, check Commercial Certifications. The course, if approved, will be approved for all commercial certification **AND** all residential certifications.
3. If the course is intended to meet required instruction in Code Administration (Chapter 1) or Existing Buildings (commercial or residential) check 'Administrative Course, All Certifications'.

Application Materials Included

This is a checklist for the course submitter's use, to be sure all materials necessary for review are included with the application. All materials should be submitted in .pdf format, along with the application, via email to Michael.Lane@com.ohio.gov or BBS@com.ohio.gov

SIZING BUILDING DRAINS & STACKS

710.1 MAXIMUM FIXTURE UNIT LOAD

THE MAXIMUM NUMBER OF *DRAINAGE FIXTURE UNITS* CONNECTED TO A GIVEN SIZE OF *BUILDING SEWER*, BUILDING DRAIN OR HORIZONTAL BRANCH OF THE BUILDING DRAIN SHALL BE DETERMINED USING TABLE 710.1(1). THE MAXIMUM NUMBER OF *DRAINAGE FIXTURE UNITS* CONNECTED TO A GIVEN SIZE OF HORIZONTAL *BRANCH* OR VERTICAL SOIL OR WASTE *STACK* SHALL BE DETERMINED USING TABLE 710.1(2).

710.1 BREAKDOWN

- Establishes the maximum number of DFUs that can discharge to a given size pipe can be found:
  - In table 710.1(1) for *building drains* and *branches* of *building drains*, or
  - In table 710.1(2) for *stacks* and horizontal *branches* from *stacks*.

BUILDING DRAIN

That part of the lowest piping of a drainage system that receives the discharge from soil, waste and other drainage pipes inside and that extends 30 inches in developed length of pipe beyond the exterior walls of the building and conveys the drainage to the building sewer.

BRANCH

Any part of the piping system except a *riser*, *main* or *stack*.

STACK

A general term for any vertical line of soil, waste, vent or inside conductor piping that extends through at least one story with or without offsets.

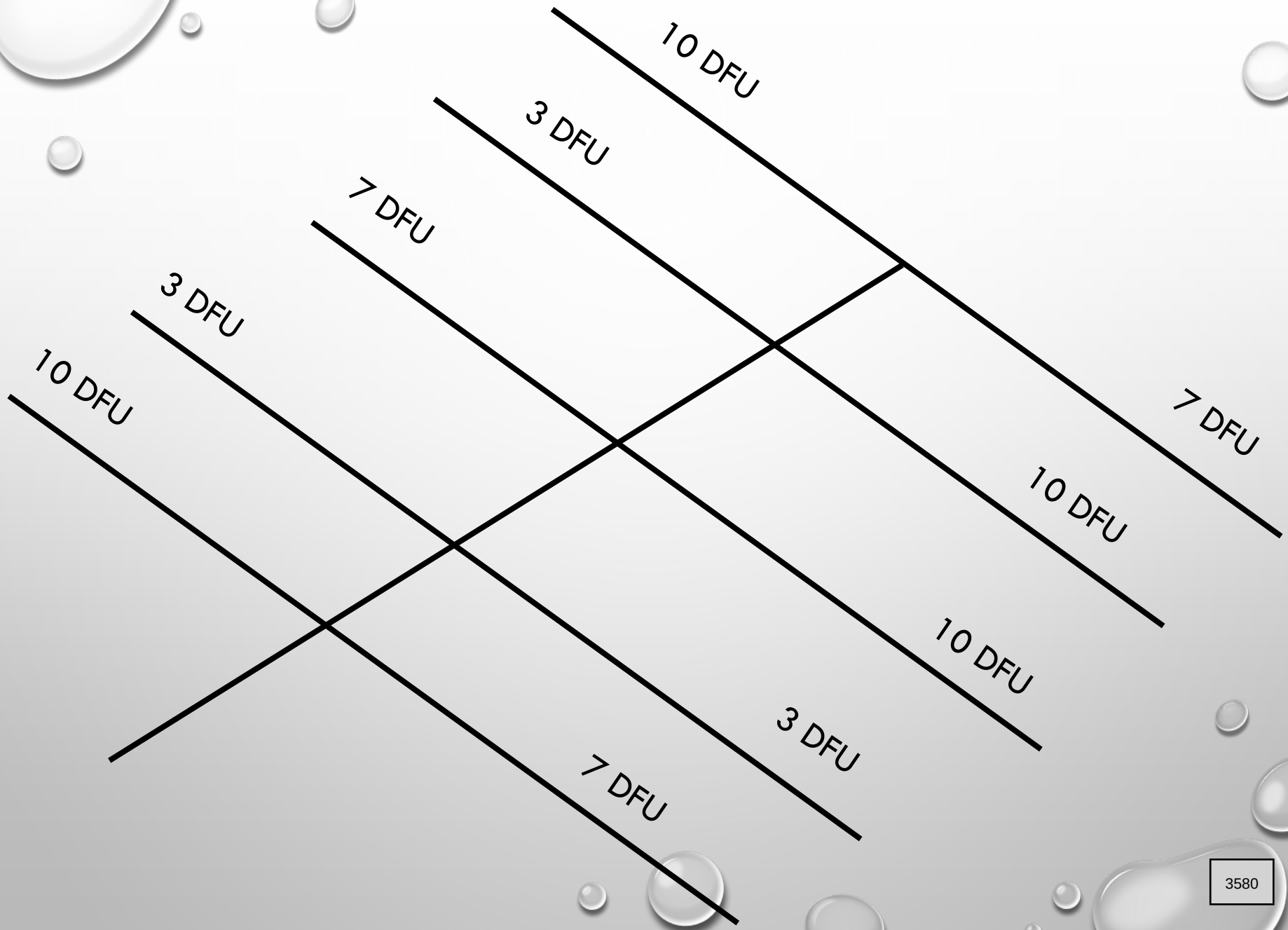
TABLE 710.1(1)BUILDING DRAINS AND SEWERS

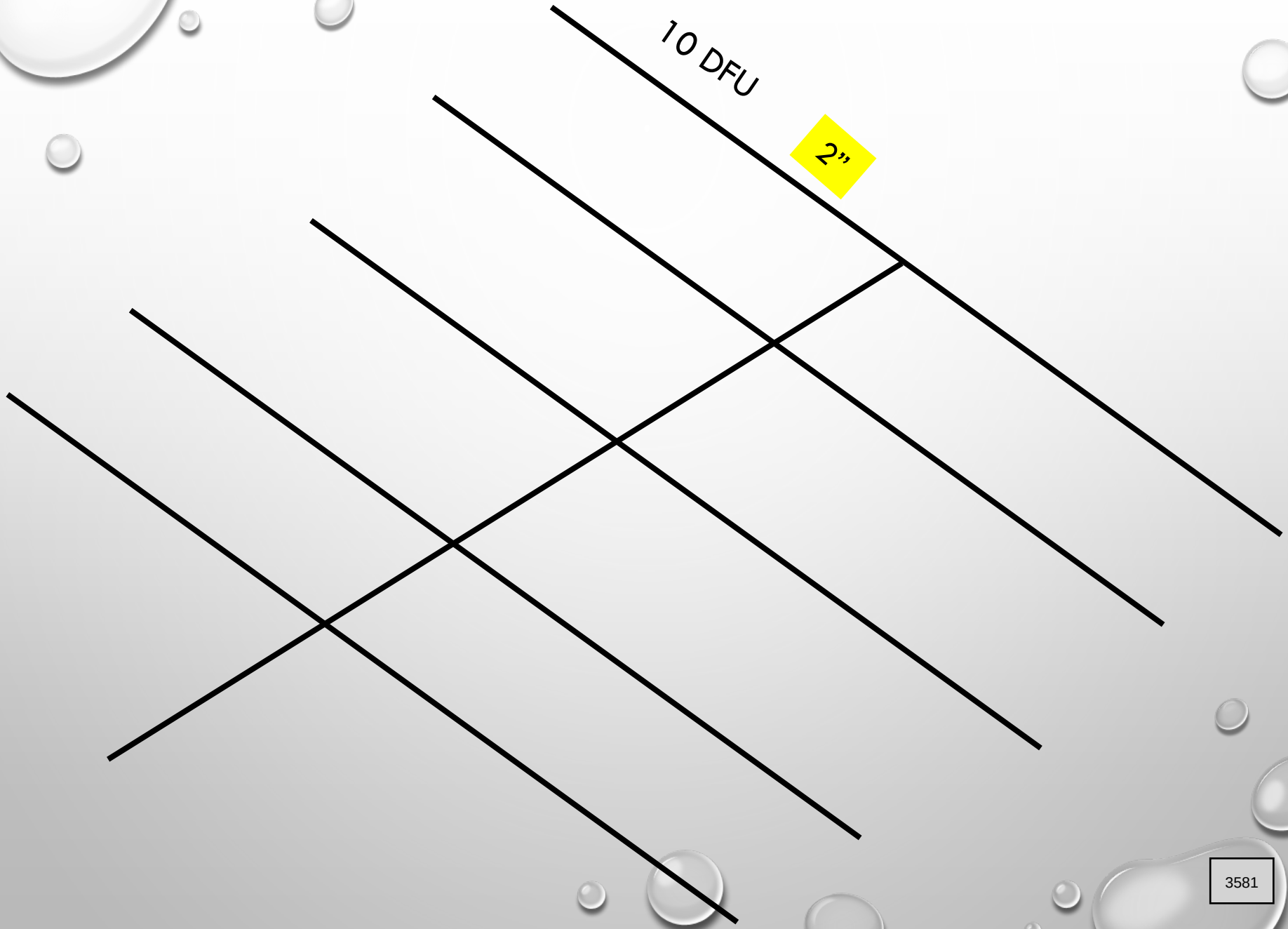
DIAMETER OF PIPE (inches)	MAXIMUM NUMBER OF DRAINAGE FIXTURE UNITS CONNECTED TO ANY PORTION OF THE BUILDING DRAIN OR THE BUILDING SEWER, INCLUDING BRANCHES OF THE BUILDING DRAIN[a]			
	Slope per foot			
	1/16 inch	1/8 inch	1/4 inch	1/2 inch
1 1/4	—	—	1	1
1 1/2	—	—	3	3
2	—	—	21	26
2 1/2	—	—	24	31
3	—	36	42	50
4	—	180	216	250
5	—	390	480	575
6	—	700	840	1,000
8	1,400	1,600	1,920	2,300
10	2,500	2,900	3,500	4,200
12	3,900	4,600	5,600	6,700
15	7,000	8,300	10,000	12,000

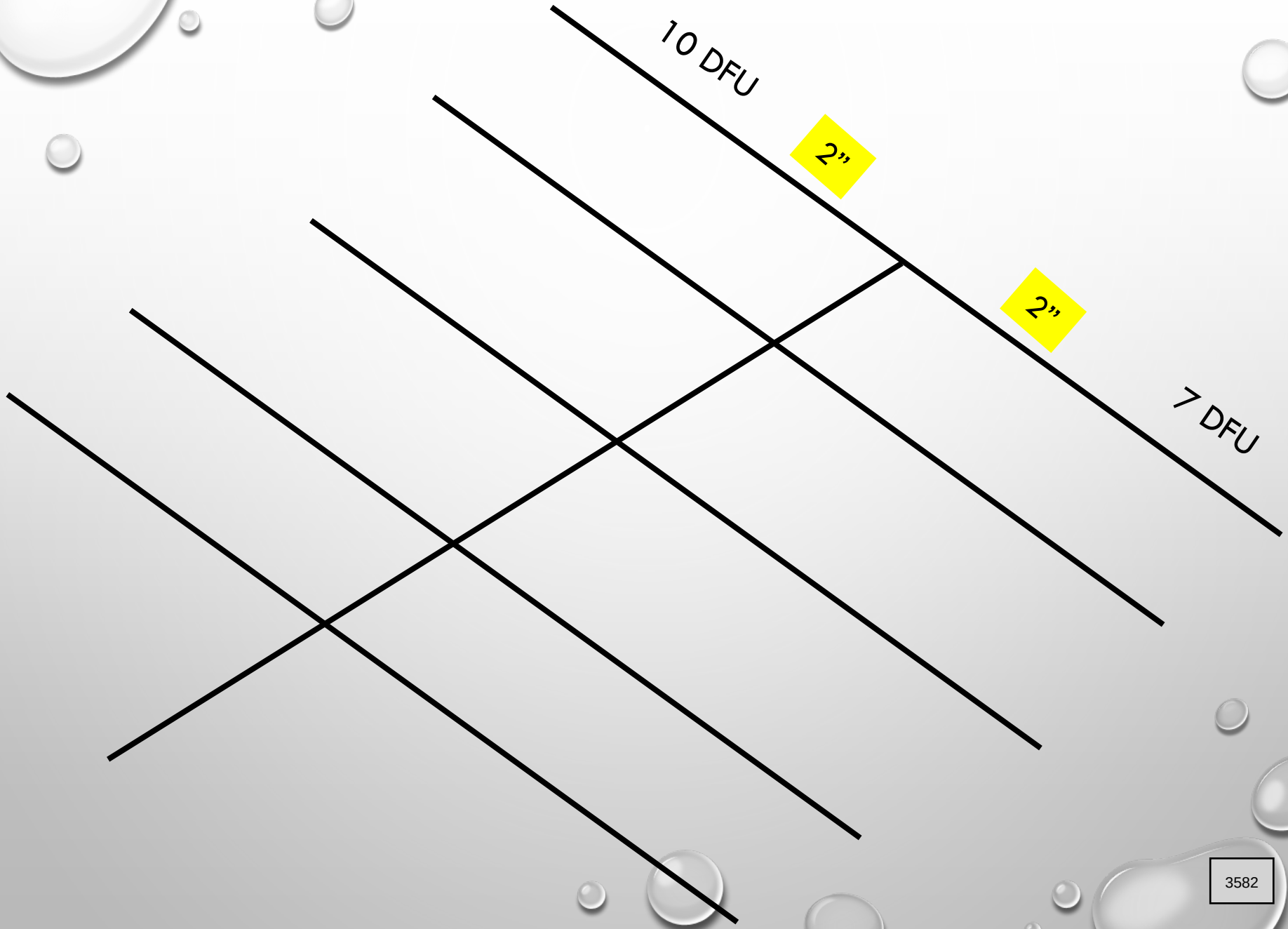
a. The minimum size of any building drain serving a water closet shall be 3 inches.

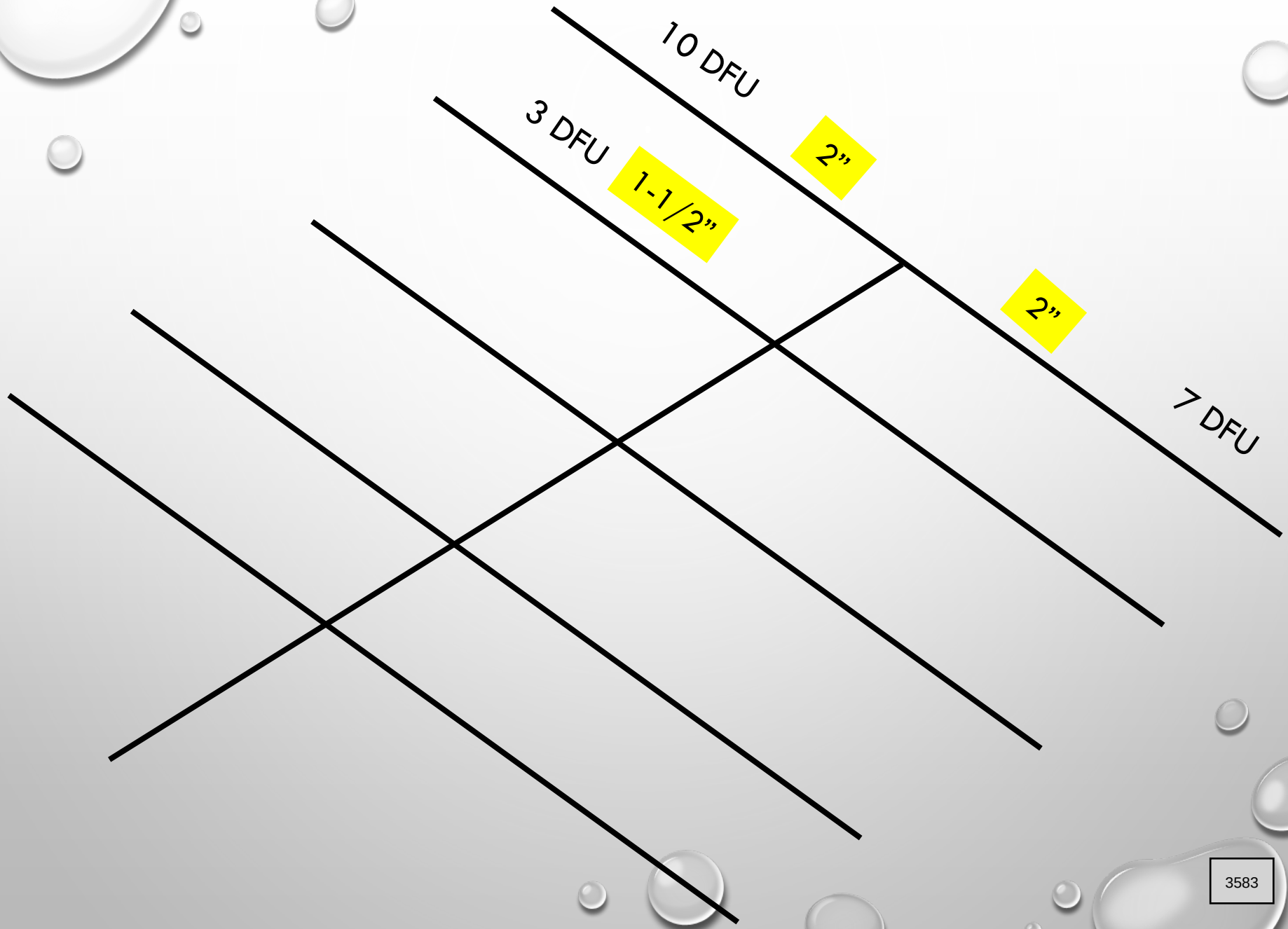
BEFORE WE MOVE ONTO SIZING FOR STACKS AND BRANCHES FROM STACKS…

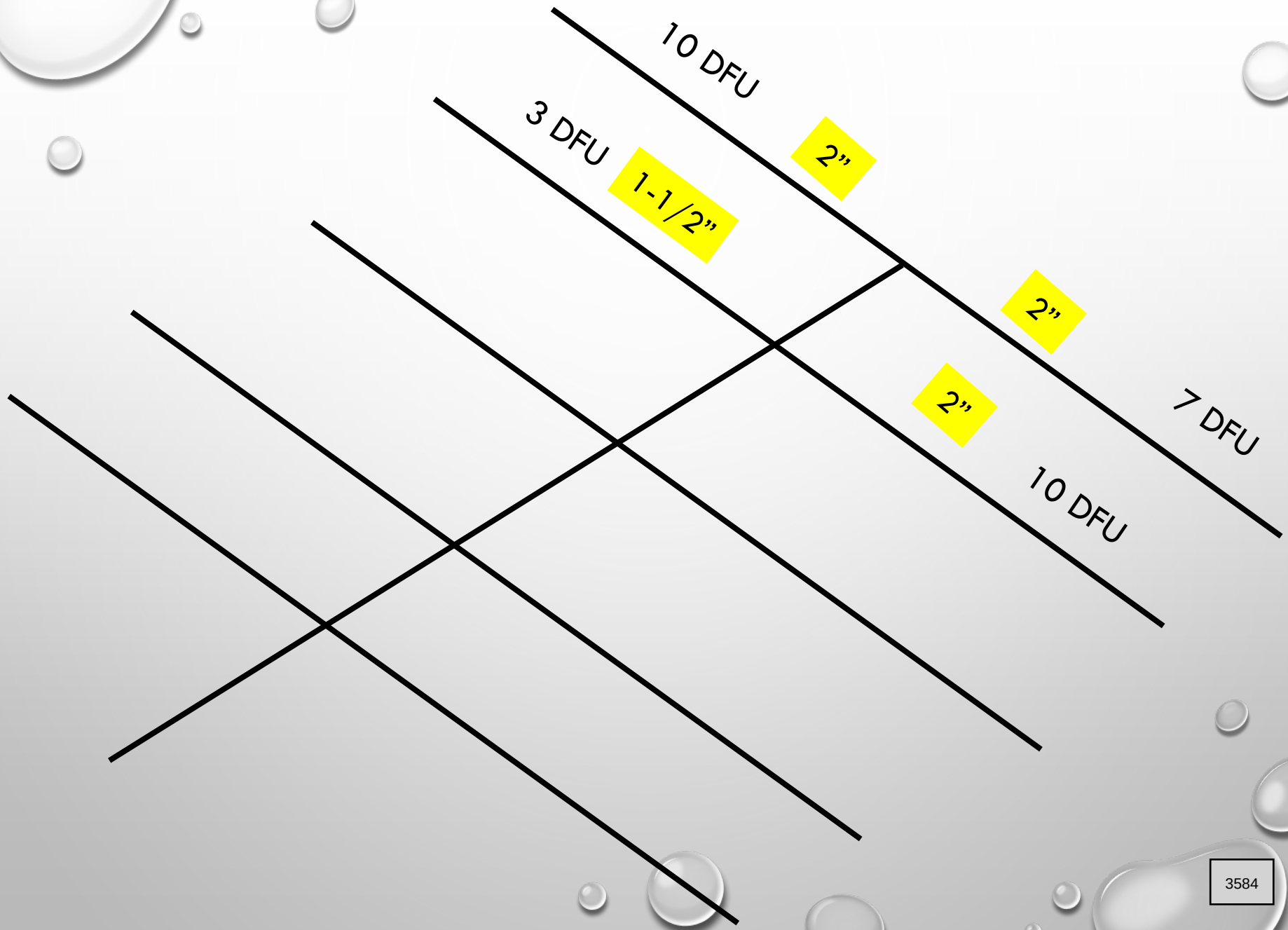
Let’s take a moment to size a building drain based on the DFU discharge connected.

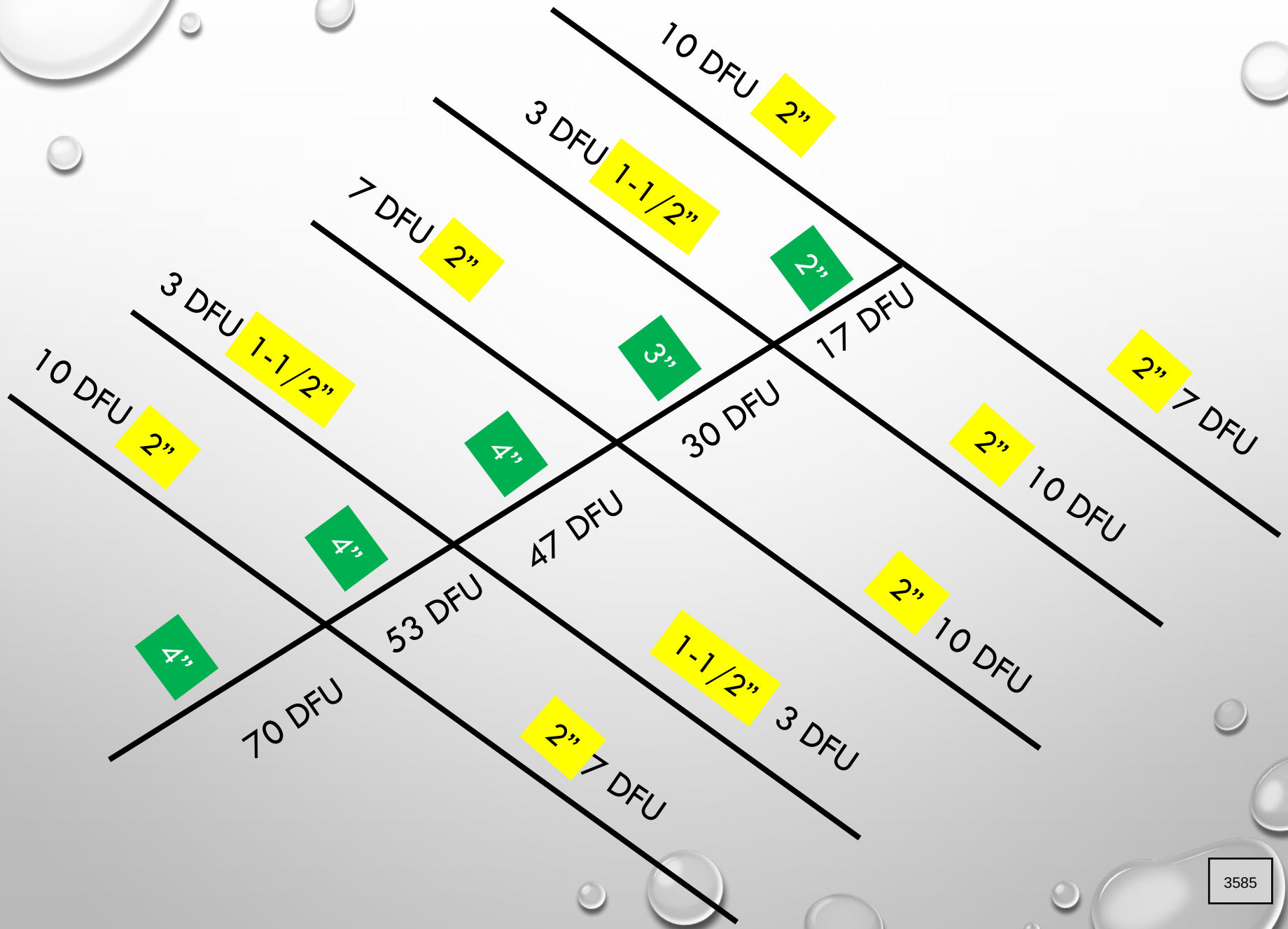

10 DFU
3 DFU
7 DFU
10 DFU
7 DFU
3 DFU
10 DFU
10 DFU
3 DFU
7 DFU


10 DFU
2”


10 DFU
2"
2"
7 DFU


10 DFU
2”
3 DFU
1-1/2”
2”
7 DFU


10 DFU
2”
3 DFU
1-1/2”
2”
2”
7 DFU
10 DFU


10 DFU
2”
3 DFU
1-1/2”
2”
7 DFU
2”
3”
17 DFU
2”
7 DFU
10 DFU
2”
4”
30 DFU
2”
10 DFU
3 DFU
1-1/2”
4”
47 DFU
2”
10 DFU
4”
53 DFU
1-1/2”
3 DFU
70 DFU
2”
7 DFU

710.1 MAXIMUM FIXTURE UNIT LOAD

THE MAXIMUM NUMBER OF *DRAINAGE FIXTURE UNITS* CONNECTED TO A GIVEN SIZE OF *BUILDING SEWER*, BUILDING DRAIN OR HORIZONTAL BRANCH OF THE BUILDING DRAIN SHALL BE DETERMINED USING TABLE 710.1(1). THE MAXIMUM NUMBER OF *DRAINAGE FIXTURE UNITS* CONNECTED TO A GIVEN SIZE OF HORIZONTAL *BRANCH* OR VERTICAL SOIL OR WASTE *STACK* SHALL BE DETERMINED USING TABLE 710.1(2).

710.1 BREAKDOWN

- Establishes the maximum number of DFUs that can discharge to a given size pipe can be found:
  - In table 710.1(1) for *building drains* and *branches* of *building drains*, or
  - In table 710.1(2) for *stacks* and horizontal *branches* from *stacks*.

TABLE 710.1(2)HORIZONTAL FIXTURE BRANCHES AND STACKS*a*				
DIAMETER OF PIPE (inches)	MAXIMUM NUMBER OF DRAINAGE FIXTURE UNITS (dfu)			
	Total for horizontal branch	Stacks[b]		
		Total discharge into one branch interval	Total for stack of three branch Intervals or less	Total for stack greater than three branch intervals
$1^1/_2$	3	2	4	8
2	6	6	10	24
$2^1/_2$	12	9	20	42
3	20	20	48	72
4	160	90	240	500
5	360	200	540	1,100
6	620	350	960	1,900
8	1,400	600	2,200	3,600
10	2,500	1,000	3,800	5,600
12	3,900	1,500	6,000	8,400
15	7,000	Note c	Note c	Note c

a. Does not include branches of the building drain. Refer to Table 710.1(1).

b. Stacks shall be sized based on the total accumulated connected load at each story or branch interval. As the total accumulated connected load decreases, stacks are permitted to be reduced in size. Stack diameters shall not be reduced to less than one-half of the diameter of the largest stack size required.

c. Sizing load based on design criteria.

SIZING FOR STACKS AND BRANCHES CONNECTED TO STACKS

When sizing stacks and branches connected to stacks, the best place to start is with the branches. In order to do this, we will need the DFU load on the system, and which column to reference in table 710.1(2).

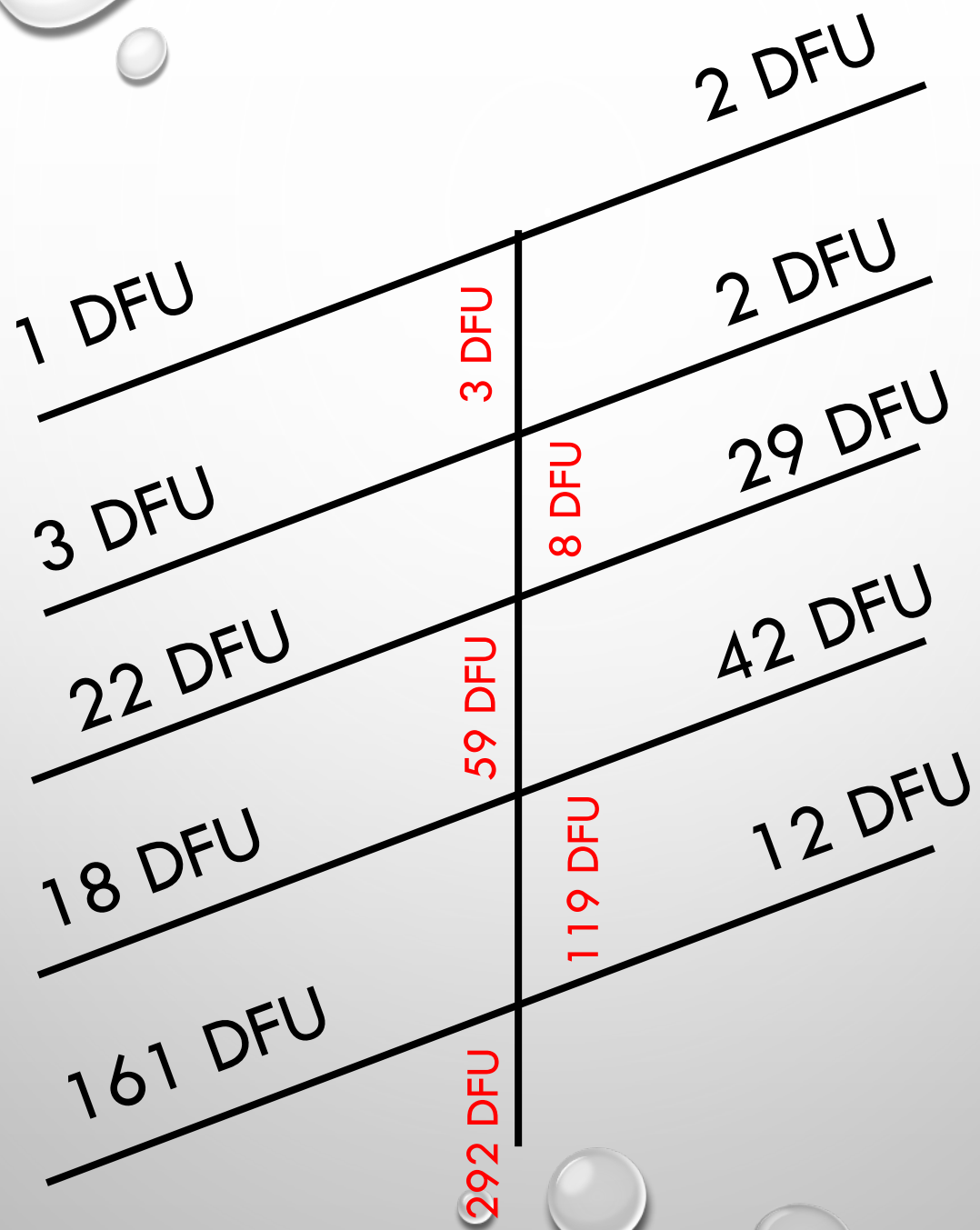

1 DFU
2 DFU
3 DFU
2 DFU
22 DFU
29 DFU
18 DFU
42 DFU
161 DFU
12 DFU
3 DFU
8 DFU
59 DFU
119 DFU
292 DFU

TABLE 710.1(2)HORIZONTAL FIXTURE BRANCHES AND STACKS*a*

DIAMETER OF PIPE (inches)	MAXIMUM NUMBER OF DRAINAGE FIXTURE UNITS (dfu)			
	Total for horizontal branch	Stacks[b]		
		[illegible] interval	intervals or less	[illegible] branch intervals
$1^1/_2$	3	2	4	8
2	6	6	10	24
$2^1/_2$	12	9	20	42
3	20	20	48	72
4	160	90	240	500
5	360	200	540	1,100
6	620	350	960	1,900
8	1,400	600	2,200	3,600
10	2,500	1,000	3,800	5,600
12	3,900	1,500	6,000	8,400
15	7,000	Note c	Note c	Note c


1-1/2"
1 DFU
1-1/2"
3 DFU
4"
22 DFU
3"
18 DFU
5"
161 DFU
1-1/2"
2 DFU
1-1/2"
2 DFU
4"
29 DFU
4"
42 DFU
2-1/2"
12 DFU

SIZING THE STACK

Before we do this, we must identify the type of stack we are sizing, and the DFU load at each interval. It is also best to size from the top down.

How many branch intervals?

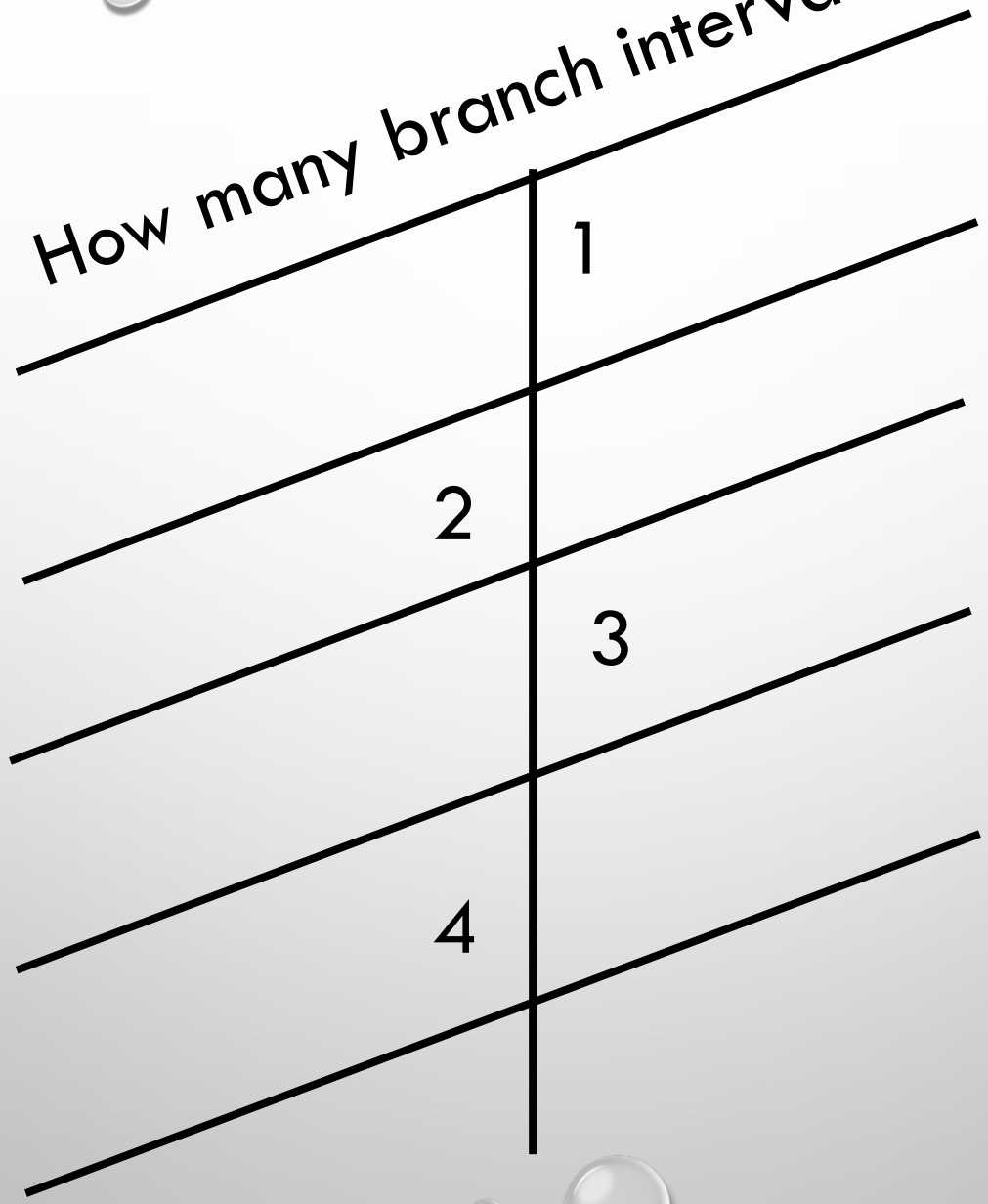


TABLE 710.1(2)HORIZONTAL FIXTURE BRANCHES AND STACKS*a*

DIAMETER OF PIPE (inches)	MAXIMUM NUMBER OF DRAINAGE FIXTURE UNITS (dfu)			
		Stacks[b]		
	[illegible] branch	Total discharge into one branch interval	Total for [illegible]ack less	Total for stack greater than three branch intervals
$1^1/_2$	3	2	4	8
2	6	6	10	24
$2^1/_2$	12	9	20	42
3	20	20	48	72
4	160	90	240	500
5	360	200	540	1,100
6	620	350	960	1,900
8	1,400	600	2,200	3,600
10	2,500	1,000	3,800	5,600
12	3,900	1,500	6,000	8,400
15	7,000	Note c	Note c	Note c

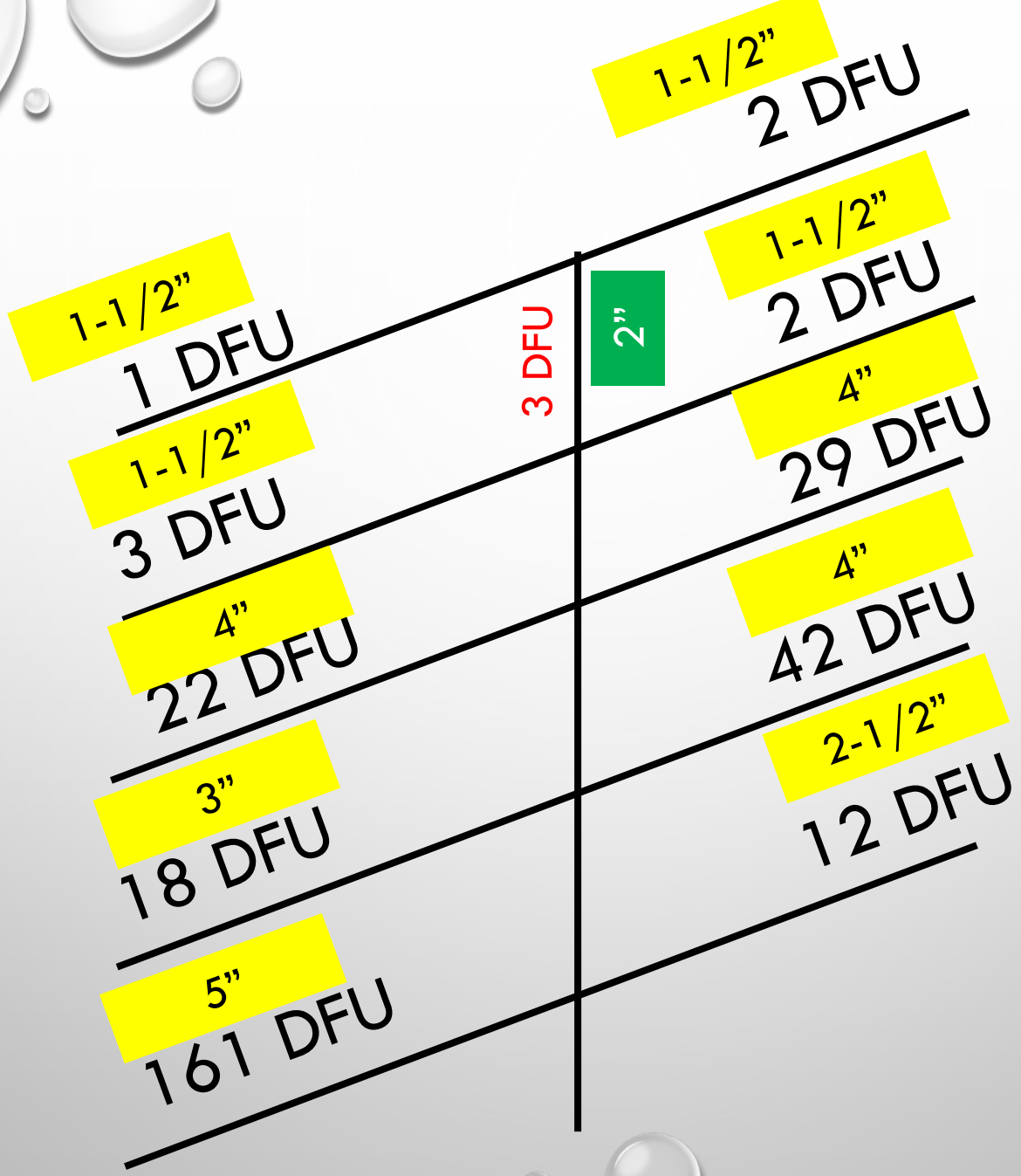
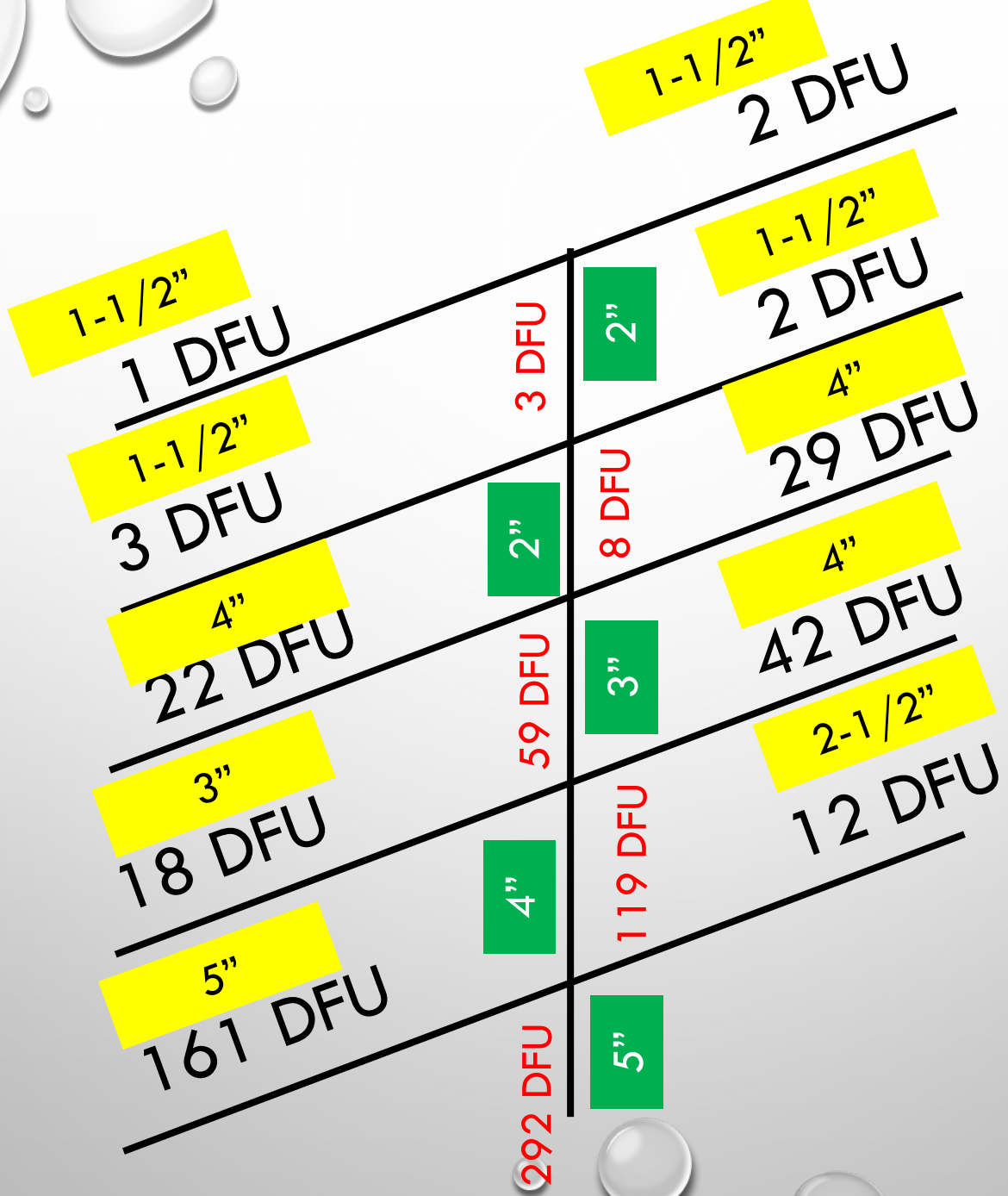

1-1/2"
1 DFU
1-1/2"
3 DFU
4"
22 DFU
3"
18 DFU
5"
161 DFU
3 DFU
2"
1-1/2"
2 DFU
1-1/2"
2 DFU
4"
29 DFU
4"
42 DFU
2-1/2"
12 DFU

TABLE 710.1(2)HORIZONTAL FIXTURE BRANCHES AND STACKS*a*

DIAMETER OF PIPE (inches)	MAXIMUM NUMBER OF DRAINAGE FIXTURE UNITS (dfu)			
		Stacks[b]		
	Any horizontal branch	Total discharge into one branch interval	Total for stack less	Total for stack greater than three branch intervals
$1^1/_2$	3	2	4	8
2	6		10	24
$2^1/_2$	12		20	42
3	20		48	72
4	160		240	500
5	360	2	540	1,100
6	620	3	960	1,900
8	1,400	6	2,200	3,600
10	2,500	1,	3,800	5,600
12	3,900	1,	6,000	8,400
15	7,000	Note c	Note c	Note c

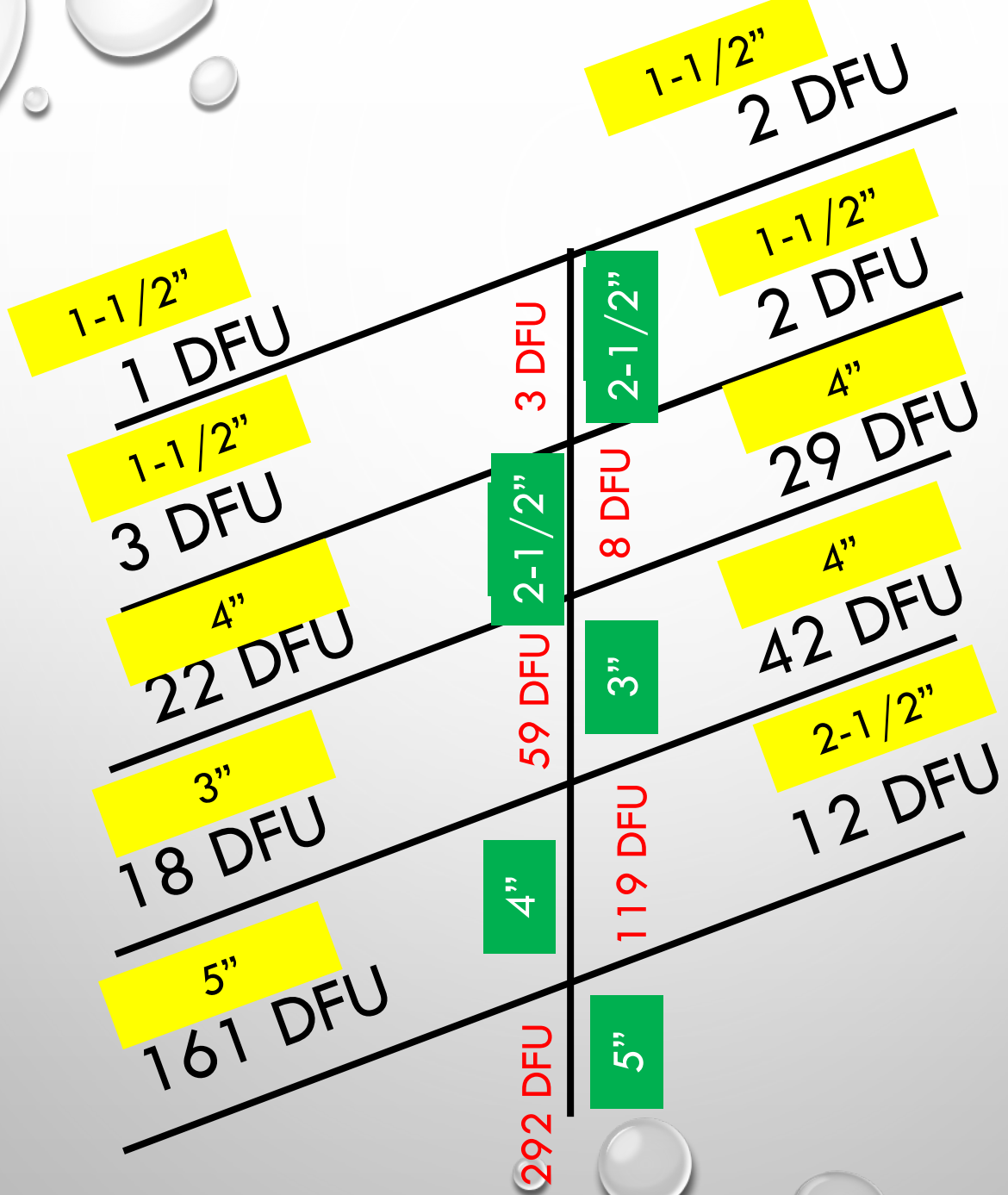

1-1/2"
1 DFU
1-1/2"
3 DFU
4"
22 DFU
3"
18 DFU
5"
161 DFU
3 DFU
2"
8 DFU
2"
59 DFU
4"
119 DFU
3"
292 DFU
5"
1-1/2"
2 DFU
1-1/2"
2 DFU
4"
29 DFU
4"
42 DFU
2-1/2"
12 DFU

REMEMBER THIS?

a. DOES NOT INCLUDE BRANCHES OF THE BUILDING DRAIN. REFER TO TABLE 710.1(1).

b. STACKS SHALL BE SIZED BASED ON THE TOTAL ACCUMULATED CONNECTED LOAD AT EACH STORY OR BRANCH INTERVAL. AS THE TOTAL ACCUMULATED CONNECTED LOAD DECREASES, STACKS ARE PERMITTED TO BE REDUCED IN SIZE. STACK DIAMETERS SHALL NOT BE REDUCED TO LESS THAN ONE-HALF OF THE DIAMETER OF THE LARGEST STACK SIZE REQUIRED.

c. SIZING LOAD BASED ON DESIGN CRITERIA.


1-1/2"
1 DFU
1-1/2"
3 DFU
4"
22 DFU
3"
18 DFU
5"
161 DFU
3 DFU
2-1/2"
8 DFU
59 DFU
4"
119 DFU
292 DFU
5"
1-1/2"
2 DFU
1-1/2"
2 DFU
4"
29 DFU
4"
42 DFU
2-1/2"
12 DFU

710.1.1 HORIZONTAL STACK OFFSETS

HORIZONTAL *STACK* OFFSETS SHALL BE SIZED AS REQUIRED FOR BUILDING DRAINS IN ACCORDANCE WITH TABLE 710.1(1), EXCEPT AS REQUIRED BY SECTION 711.3.

711.3 OFFSETS BELOW LOWEST BRANCH

WHERE A VERTICAL OFFSET OCCURS IN A SOIL OR WASTE *STACK* BELOW THE LOWEST HORIZONTAL *BRANCH*, A CHANGE IN DIAMETER OF THE *STACK* BECAUSE OF THE OFFSET SHALL NOT BE REQUIRED. IF A HORIZONTAL OFFSET OCCURS IN A SOIL OR WASTE *STACK* BELOW THE LOWEST HORIZONTAL *BRANCH*, THE REQUIRED DIAMETER OF THE OFFSET AND THE *STACK* BELOW IT SHALL BE DETERMINED AS FOR A *BUILDING DRAIN* IN ACCORDANCE WITH TABLE 710.1(1).

710.1.2 VERTICAL STACK OFFSETS

VERTICAL *STACK* OFFSETS SHALL BE SIZED AS REQUIRED FOR STRAIGHT STACKS IN ACCORDANCE WITH TABLE 710.1(2), EXCEPT WHERE REQUIRED TO BE SIZED AS A *BUILDING DRAIN* IN ACCORDANCE WITH SECTION 711.1.1.

711.1.1 OMISSION OF VENTS FOR VERTICAL STACK OFFSETS

VENTS FOR VERTICAL OFFSETS REQUIRED BY SECTION 711.1 SHALL NOT BE REQUIRED WHERE THE *STACK* AND ITS OFFSET ARE SIZED AS A *BUILDING DRAIN* [SEE TABLE 710.1(1)].

BUT, WHEN DOES SECTION 711.1 APPLY?

SECTION 711 OFFSETS IN DRAINAGE PIPING IN BUILDINGS OF FIVE STORIES OR MORE

711.1 HORIZONTAL BRANCH CONNECTIONS ABOVE OR BELOW VERTICAL STACK OFFSETS

IF A HORIZONTAL *BRANCH* CONNECTS TO THE *STACK* WITHIN 2 FEET (610 MM) ABOVE OR BELOW A VERTICAL *STACK* OFFSET, AND THE OFFSET IS LOCATED MORE THAN FOUR *BRANCH INTERVALS* BELOW THE TOP OF THE *STACK*, THE OFFSET SHALL BE VENTED IN ACCORDANCE WITH SECTION 907.

AND, LASTLY…
710.2 FUTURE FIXTURES

WHERE PROVISION IS MADE FOR THE FUTURE INSTALLATION OF FIXTURES, THOSE PROVIDED FOR SHALL BE CONSIDERED IN DETERMINING THE REQUIRED SIZES OF DRAIN PIPES.

QUESTIONS?

THANK YOU

File Attachments for Item:

EC-26 Understanding the Residential Mid-Rise Fire Problem from a Fire Protection Perspective (Fire Code Academy)

All certifications (1 hour)

Ohio | Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: Randy Hormann

Organization: Fire Code Academy

Address: 81 Mill Street - Suite 300 Gahanna, Ohio 43230

E-mail: RandyH@FireCodeAcademy.com Telephone: 614-416-8077

Website: www.FireCodeAcademy.com

Conference Sponsor (if applicable)_____ Conference Email:_____

Check here if Course Renewal:_____Prior course number _____ (*i.e. BBS2018-429*)

Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: Understanding the Residential Mid-Rise Fire Problem from a Fire Protection Perspective

Course instructor: Terin Hopkins - National Fire Sprinkler Association (NFSA),

Course description:
This program will discuss the design criteria for buildings designed with combined systems, meeting the requirements of 13R Standard for the Installation of Fire Sprinkler Systems and NFPA 14 Standard for the Installation of Standpipes and Hose Systems, in Low-Rise Residential Occupancies

Instructional hours per session: 1.0 Hours Number of Sessions:_____

Course Date(s) and Location:_____

Special Content:

Code Administration:_____ Conference Course: _____

Existing Buildings: _____ Conference Name: _____

Electrical Instruction: _____ Conference location:_____

Plumbing Instruction:_____

Course to be offered online? No **On Demand**_____ **Webinar**_____

Course Website: _____

Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation*):

_____

Course applicable for the following certifications

Residential Certifications Only: _____ Commercial Certifications: _____

Administrative Course, All Certifications: _____

Application materials included:

X Course Outline or Course Learning Objectives

X Presentation Materials/Slides (not required for roundtable courses)

_____ Assessment Materials (for online courses)

X Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

020. Understanding the Residential Mid-Rise Fire Problem from a Fire Protection and Code Enforcement Perspective

Presented by: The National Fire Sprinkler Association

Join me for a tail board talk on the residential fire problem in mid-rise apartment buildings. We are experiencing large apartment fires every day in the United States and continue to misunderstand how to use the fire protection design to our advantage. This program will discuss the design criteria for buildings designed with combined systems, meeting the requirements of 13R Standard for the Installation of Fire Sprinkler Systems and NFPA 14 Standard for the Installation of Standpipes and Hose Systems, in Low-Rise Residential Occupancies and how we can use them to our tactical advantage. It will also cover the challenges and misnomers commonly associated with this design.

Learning Objectives:
1. Examples and expectations of the 13R design
2. Understanding combined water-base fire protection design
3. Identifying and utilizing NFPA 13R sprinkler systems to your tactical advantage
4. Understanding the commonly misunderstood NFPA 13R design

Terin Hopkins

Terin is currently the Public Fire Protection Specialist in Codes, Standards, Public Fire Protection and Training Department, for the National Fire Sprinkler Association (NFSA), headquartered in Baltimore, Maryland. - The Associations mission is "to protect lives and property from fire though the widespread acceptance of the fire sprinkler concept."

Terin has 34 years in public safety beginning his public safety career in 1981 as a Volunteer Firefighter/EMT and then serving 25 years with the Prince George's County Maryland Fire/EMS Department, retiring in 2009. He then went to work for the Howard County Department of Fire Rescue Service, Office of the Fire Marshal. In 2018 he was hired as the Mid-Atlantic Field Service Coordinator with NFSA. Terin is currently the Public Fire Protection Specialist at NFSA and represents NFSA on several technical committees including, NFPA 1 *Fire Code,* NFPA 14 *Standard for the Installation of Standpipes and Hose Systems* and the eight fire service training standards covered by NFPA 13E *Recommended Practice for Fire Department Operations in Properties Protected by Sprinkler and Standpipe Systems* and UL 47 Standpipe Equipment Technical Committee.

Understanding the Residential Mid-Rise Fire Problem



NFSA
NATIONAL FIRE SPRINKLER ASSOCIATION
The Voice of the Fire Sprinkler Industry

FIRE CODE ACADEMY

CAMPUS FireSafety.com

3614

Photo credit to The Oklahommen

COPYRIGHT

All course related content, including the presentation, is the property of the National Fire Sprinkler Association and protected by U.S. and international copyright laws. You may not copy, reproduce, modify, record, distribute, transmit, display, publish, broadcast, create derivative works, or in any way use any part of the copyrighted material without the prior written permission of the National Fire Sprinkler Association.

©National Fire Sprinkler Association 2023

Presenter – Terin Hopkins

Terin Hopkins

Terin is currently the Public Fire Protection Specialist in Codes, Standards, Public Fire Protection and Training Department, for the National Fire Sprinkler Association (NFSA), headquartered in Baltimore, Maryland. The Associations mission is “to protect lives and property from fire though the widespread acceptance of the fire sprinkler concept.” Terin has 34 years in public safety beginning his public safety career in 1981 as a Volunteer Firefighter/EMT and then serving 25 years with the Prince George’s County Maryland Fire/EMS Department, retiring in 2009. He then went to work for the Howard County Department of Fire Rescue Service, Office of the Fire Marshal.

In 2018 he was hired as the Mid-Atlantic Field Service Coordinator with NFSA. Terin represents NFSA on several NFPA technical committees including, NFPA 1 *Fire Code,* NFPA 14 *Standard for the Installation of Standpipes and Hose Systems, UL 47UL Standard for Safety Standpipe Devices* and the eight fire service training standards covered by NFPA 13E *Recommended Practice for Fire Department Operations in Properties Protected by Sprinkler and Standpipe Systems*.



LEARNING OBJECTIVES

1. Examples and expectations of the 13/13R design
2. Understanding combined water-base fire protection design
3. Identifying and utilizing NFPA 13R sprinkler systems to your tactical advantage
4. Understanding the commonly misunderstood NFPA 13R design

Problem – Big Fires










Owens Landing 2018 Easter morning Fire







“Fire injures 4, destroys condo building in Perryville”







2500 Block of Shelley Circle - Fredrick, Maryland 2020



Multi-Family Dwelling

4:51 am

Arrived on scene with fire showing though the roof

12 condos damaged from heavy fire

No Injuries



Omaha Fire Department battles massive blaze









The 4-alarm fire on Applied Pkwy has been declared "**under control" (11hr 30 mins) No Injuries!**

Fire Growth - Modern Day vs. Legacy Materials

Modern day materials reach flashover in 3-5 minutes

Shortest time to flashover in Legacy day materials 29 minutes

Faster Fire Propagation in modern materials

Modern windows and doors fail faster than legacy counter parts

Open Concept

Ventilation systems

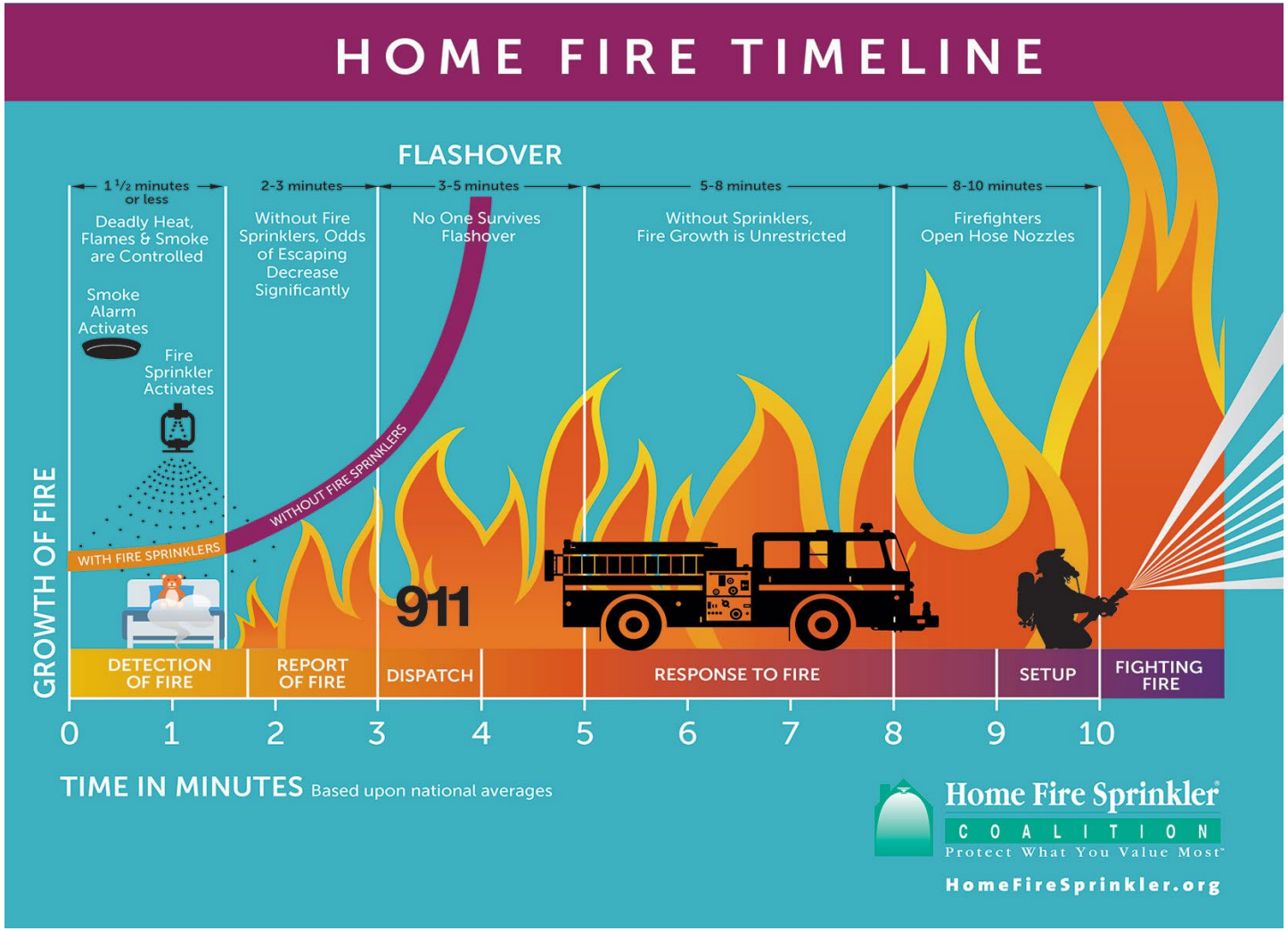
Modern construction methods removed components that prolonged collapse

Collapse is possible as early as 1 minute 30 seconds after arrival compared to 40 minutes in legacy

Home Fire Sprinkler Coalition – Fire Timeline

- NFPA 1710
  - Suburban area response 10 mins
  - Urban area response 9 minutes

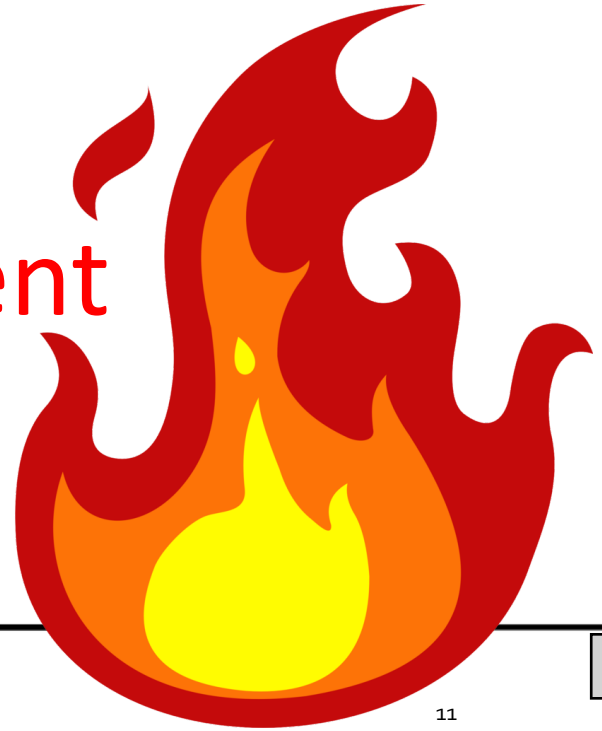
Unchanged in the standard



FLASHOVER

- **Flashover** is the simultaneous ignition of most of the directly exposed combustible material in an enclosed area
- NFPA 555 A stage in the development of a contained fire in which all exposed surfaces reach ignition temperatures more or simultaneously and fire spreads rapidly through the space.

Flashover is **non** a **survivable** event



Modern

Involving recent techniques, methods, or ideas from a relevant remote past to the present time

Lithium Ion Li+

Electric bike sales $26 billion 2022 (US Population 333 Million)

Structural Composite Lumber

CLT, NLT, D-LT, G-LT, LVL, PSL, LSL, and OSL

3D Volumetric Construction (Modular)

Polyethylene Terephthalate PET/PETE

High-Density Polyethylene HDPE

Polystyrene

Modern construction techniques



2000



2022

Fifty years – High-rise

Jeddah Tower (Kingdom Tower)

Saudi Arabia

3281+? feet.

Observation deck at 2500



Willis (Sears) Tower 1729 feet

10 high-rises in one building

4.5 million sf

Built 1974



NFPA 13/13R SPRINKLER SYSTEMS

NFPA 13R To provide a sprinkler system that aids in the detection and control of residential fires and thus provides improved protection against injury, life loss, and property damage





NFPA 13 To provide a reasonable degree of protection for life and property from fire through standardization of design, installation, and testing requirements for sprinkler systems based on sound engineering principles, test data, and field experience

NFSA
NATIONAL FIRE SPRINKLER ASSOCIATION
The Voice of the Fire Sprinkler Industry

3627

NFPA 13 VS. NFPA 13R IN PODIUM AND MIXED-USE CONSTRUCTION

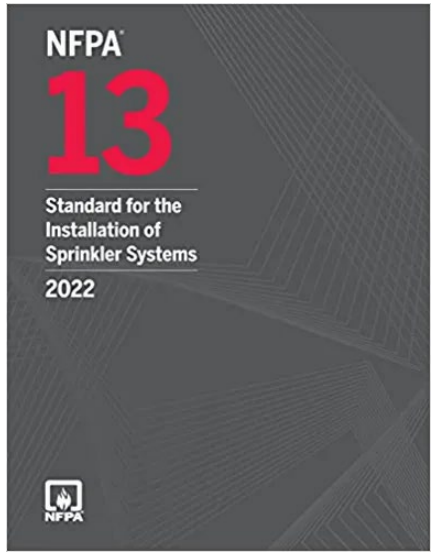
November 17, 2020



NFPA 13
Standard for Sprinkler Systems



1896

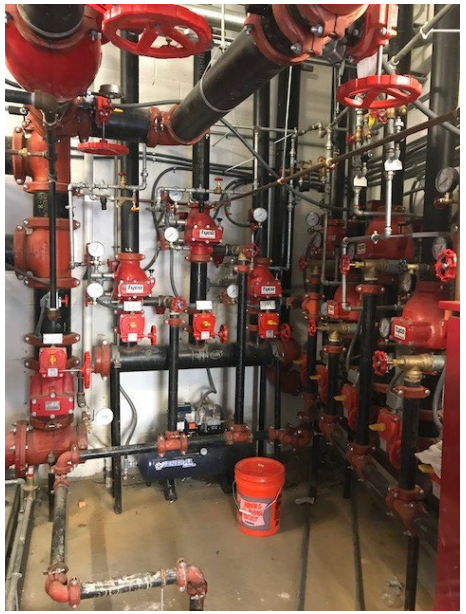




NFPA 13 System

- Property Protection Design
- Designed to Occupancy/Hazard type
- water supply
  - Hydraulically designed demand
  - Municipal water
- Requires Fire Alarm System
- Requires a 2 x 2 ½ in. FDC







NFPA 13R

1989

Standard for Residential Mid-Rise Occupancies - Four stories or less

Cannot exceed 60 feet in height

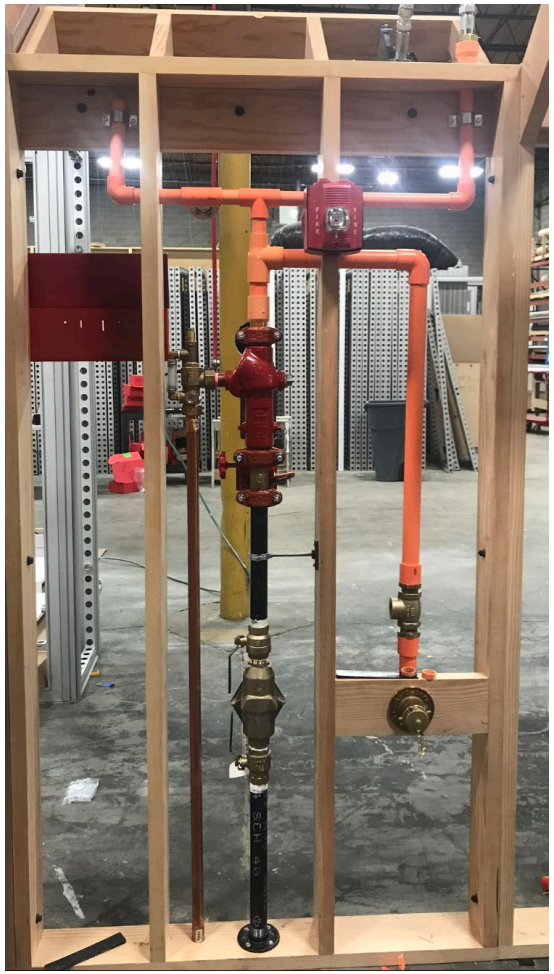
Unless????







NFPA 13R System



- Life safety System Design
- 4 Head Design
- 30 Minute water supply
  - Hydraulically designed demand
  - Municipal water
- Requires a **minimum** 1 ½” Fire Department Connection FDC
- Requires Fire Alarm System



PEDESTAL MIXED-USE

Exception for pedestal-type construction = 4-stories above the horizontal assembly





WHAT DOES THE IBC SAY ABOUT NFPA 13R?

December 15, 2022



SIN

NFPA 13, FM and UL listings require **Sprinkler Identification Number (SIN)**

1. One or two letters – Manufacturer
2. Three or four numbers - Model



Provides uniformed modeling system

Reliable®

F1Res Series Residential Sprinkler

Sprinklers

Standard Response

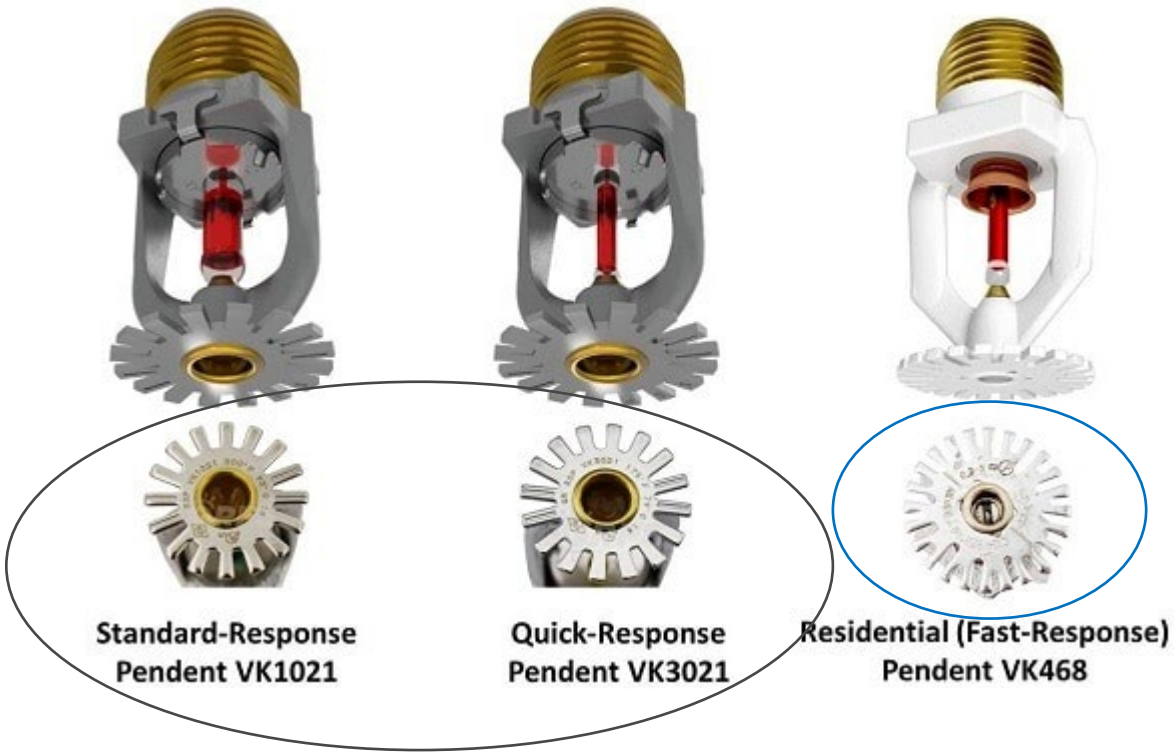
Quick-Response

Residential Fast-Response



EVOLUTION OF SPRINKLERS (RTI) RESPONSE TIME INDEX

Standard response
5mm glass blub
Standard spray pattern
Wetting/cooling fire



Higher spray pattern
Wall wetting
Limited water supply
Survivability design

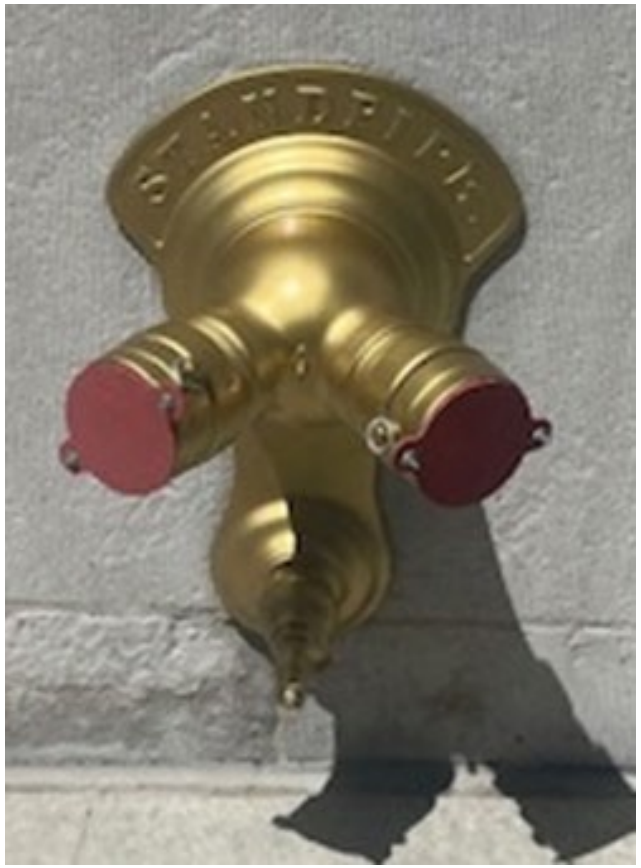
Residential (Fast Response)
3mm glass blub
Residential use –Late 1990's
Higher spray pattern
Wall wetting
Slowing flash over

Same deflector
Umbrella pattern

Quick response
3mm glass blub
Light or ordinary hazard
Standard spray pattern
Wetting/cooling fire

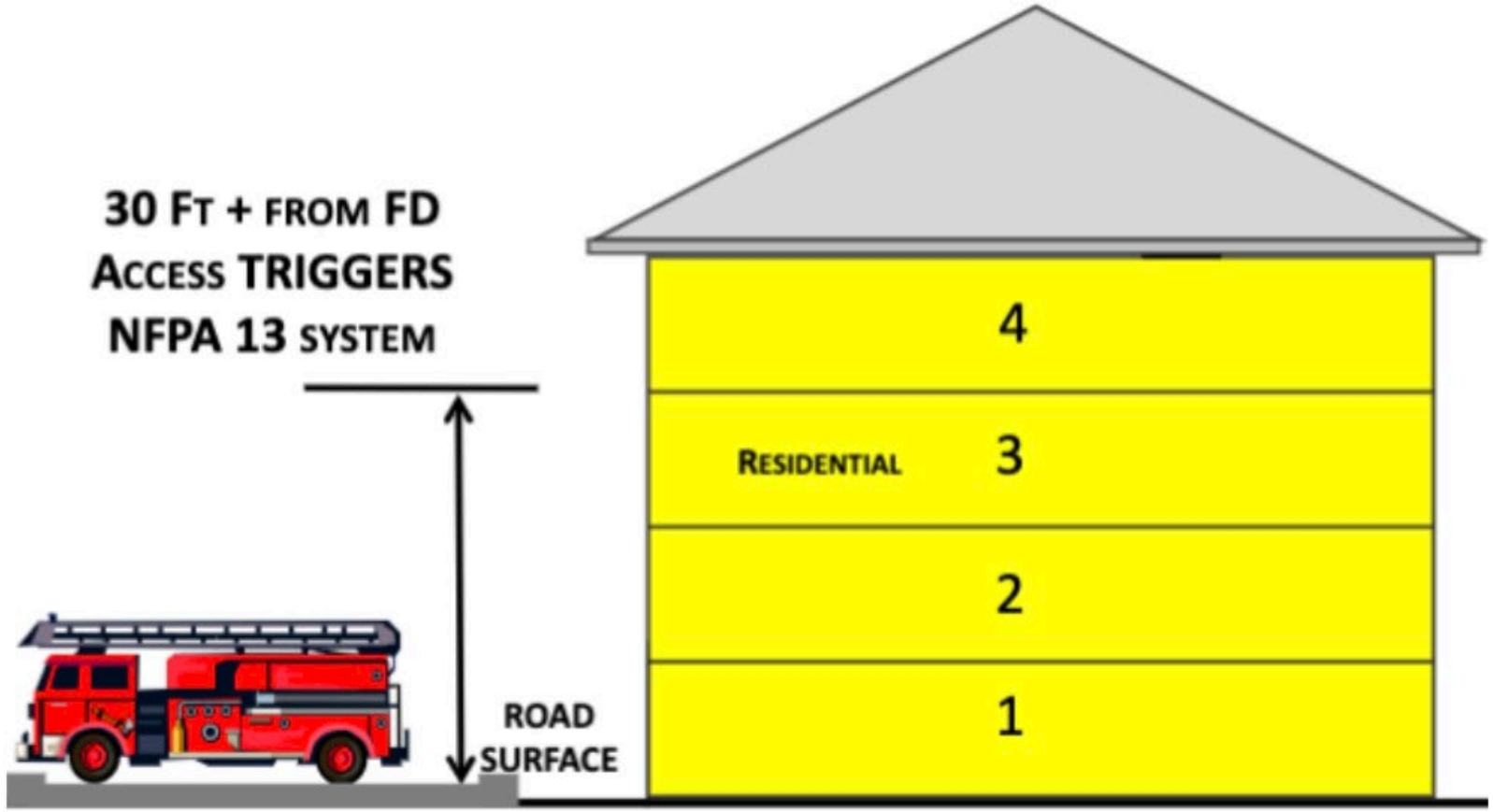
STANDPIPES

When are standpipes required?



IBC 905 Standpipes

Height



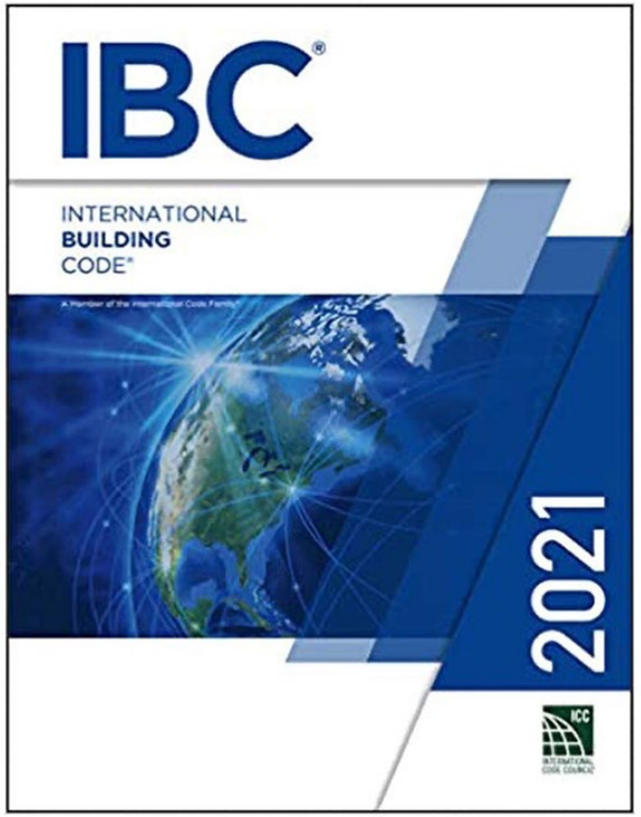
STANDPIPES

Class III required the IBC

7 Exception allowing only the Class I

Sprinklered buildings with 2 ½ x 1 ½ reducer cap and chain





COMBINED OR COMBINATION SYSTEMS AUTOSPKR/STANDPIPE

Combination systems share a common water supply between sprinkler and standpipe system

Standpipe can be:

- Manual Wet (Required signage)
- Automatic





AUTOMATIC FIRE SPRINKLER/MANUAL WET STANDPIPES

Manual Wet Standpipe - A standpipe system containing water at all times that relies exclusively on the fire department connection to supply the system demand

MANUAL WET STANDPIPES

Four stories or >30 Ft. to the highest floor
Manual Wet Standpipe



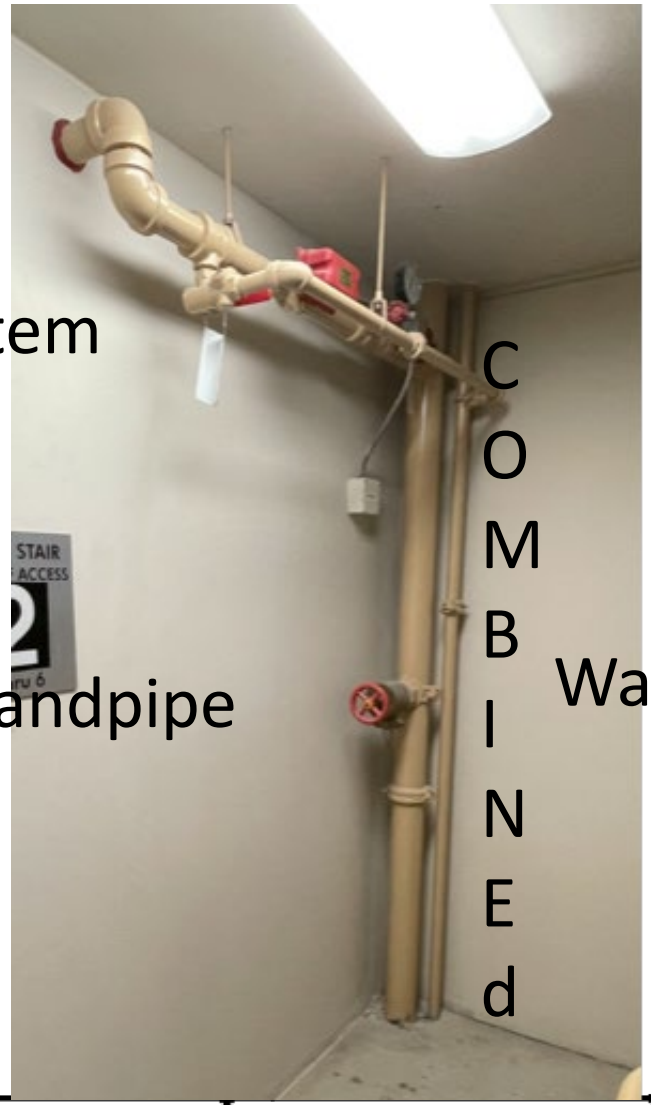


High-rise building >75 ft to the highest floor
Automatic wet standpipe

COMBINED SYSTEM (AUTOMATIC SPRINKLER/STANDPIPE)

Automatic Fire Sprinkler System

Manual Wet Standpipe



COMBINED

Water supply

Four Components of a Sprinkler System

- Water supply
- Control Valve
- Waterflow Device/switch
- Drain



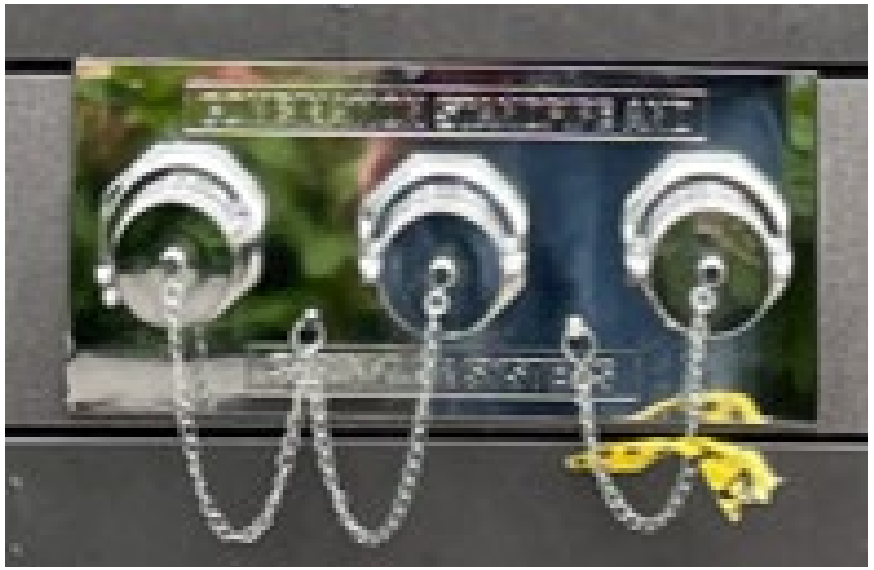


COMBINED SYSTEM - 13R SPRINKLER/STANDPIPE

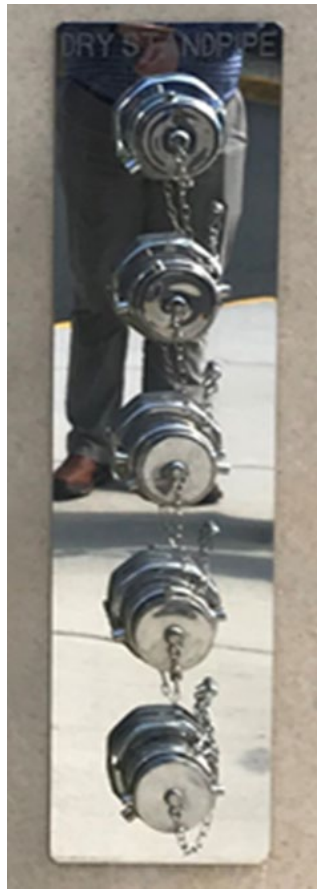
Fire Department Connection on combined system

- Minimum 2-2 ½” FDC sized for 500gpm for each 2 ½’
- Maximum of 5- 2 ½” (1250gpm)









Will the System Work?

Automatic Sprinkler System

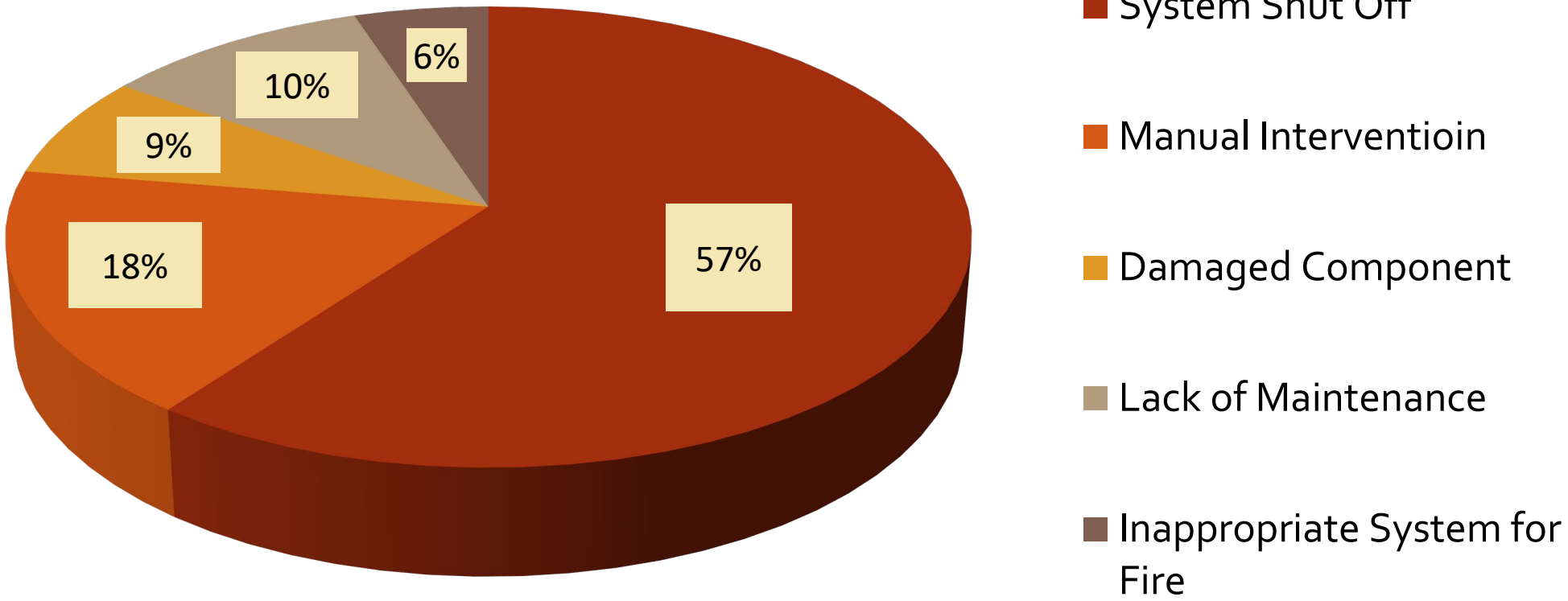
97% Effective in **controlling** residential fires

89% of activations operated only **one** sprinkler

99.5% <6 sprinklers activated



3% of Sprinklers that fail to Operate



SUPPLYING/SUPPLEMENTING THE FDC

Charge Fire Department Connection (FDC)

- 150psi and **maintain** automatic sprinkler systems

Combination systems – considerations

- Manual/Automatic
- +/- elevation



THE GOLDEN RULE

FIREFIGHTING TACTICS FOR SPRINKLERED BUILDINGS





Prince George's County Maryland

15 Year study on residential fire sprinklers 1992-2007

January 1, 1989, Prince Georges County Maryland Requires all new one-and two-Family structure

- 13,494 residential fires annually
- 1992—2007 **191** fire fatalities/**328** injuries
- 89% occurred in residential dwellings
- 245 fire sprinkler activations

0 fire fatalities/ only 6 injuries

in homes with fire sprinklers


BENEFITS of RESIDENTIAL FIRE SPRINKLERS:

Prince George's County
15-Year History with its
Single-Family Residential Dwelling
Fire Sprinkler Ordinance

PRINCE GEORGE'S COUNTY MARYLAND

Prepared by Steve Weatherby
August 2009

Produced in cooperation with the Home Fire Sprinkler Coalition, University of Maryland University College, Prince George's County Fire Department and the Maryland State Fire Marshal's Office.

Home Fire Sprinkler COALITION
Protect What You Value Most
HomeFireSprinkler.org

BENEFITS of RESIDENTIAL FIRE SPRINKLERS: Prince George's County 15-Year History

Prince George's County, Maryland

Prince George's County, Maryland, has not had a fatality in a protected area of a home, equipped with residential automatic fire sprinklers since the adoption of the residential requirement 30+ years ago.

Approximately 150,000 calls for service, protecting 1 million citizens and 15,000 residential fires annually

UNDER CONTROL



NFSA
NATIONAL FIRE SPRINKLER ASSOCIATION
The Voice of the Fire Sprinkler Industry

THANK YOU!!

Any questions/answers?



Terin Hopkins
Public Fire Protection Specialist at
National Fire Sprinkler Association

twitter @NFSAPFP
@thop264



thopkins@nfsa.org
(c) 443.745.4142

3654

File Attachments for Item:

EC-27 Updates to the 2022 Edition of NFPA 13 (Fire Code Academy)

All certifications (1 hour)

Ohio | Department of Commerce

Mike DeWine, Governor
Jon Husted, Lt. Governor

Sheryl Maxfield, Director

Board of Building Standards

Application for Continuing Education Course Approval

Provider Information:

Name: Randy Hormann
Organization: Fire Code Academy
Address: 81 Mill Street - Suite 300 Gahanna, Ohio 43230
E-mail: RandyH@FireCodeAcademy.com Telephone: 614-416-8077
Website: www.FireCodeAcademy.com
Conference Sponsor (if applicable)_____ Conference Email:_____

Check here if Course Renewal:_____Prior course number _____ (*i.e. BBS2018-429*)
Renewals will only be granted for identical content and certifications, within the current code cycle.
Attach a copy of prior course approval letter for confirmation. No further information is required.

New Course Information:

Course title: Updates to the 2022 Edition of NFPA 13
Course instructor: Kevin Hall
Course description:
This seminar will review the changes to the 2022 edition of NFPA 13. The content will summarize the actions of the four technical committees responsible for revising NFPA 13 and include topics on installation, discharge, hanging and bracing, and water supply requirements.
Instructional hours per session: 1.0 Hours Number of Sessions:_____
Course Date(s) and Location:_____

Special Content:

Code Administration:_____ Conference Course: _____
Existing Buildings: _____ Conference Name: _____
Electrical Instruction: _____ Conference location:_____
Plumbing Instruction:_____

Course to be offered online? No **On Demand**_____ **Webinar**_____
Course Website: _____
Detail online course participation confirmation method *(i.e. test, quizlets, participant activity confirmation)*:
_____

Course applicable for the following certifications

Residential Certifications Only: _____ Commercial Certifications: _____
Administrative Course, All Certifications: _____

Application materials included:

X Course Outline or Course Learning Objectives
X Presentation Materials/Slides (not required for roundtable courses)
_____ Assessment Materials (for online courses)
X Presenter Bio

Please submit application and materials in .pdf format to: michael.lane@com.ohio.gov or BBS@com.ohio.gov

Seminar Description

Updates to the 2022 Edition of NFPA 13
0.1 CEU | 0.1 CPD | 1.0 Contact Hours
Standards Referenced: NFPA 13, 2022 edition

Description: This seminar will review the changes to the 2022 edition of NFPA 13. The content will summarize the actions of the four technical committees responsible for revising NFPA 13 and include topics on installation, discharge, hanging and bracing, and water supply requirements.

Learning Objectives:

Upon completion of this webinar, attendees will be able to:

1. Identify the scopes and applicable chapters of each technical committee
2. Identify new options for determining seismic protection requirements
3. Understand new definitions added for new technologies in the sprinkler industry
4. Identify new obstruction rules for Ordinary Hazard occupancies and ESFR systems
5. Apply single point density designs
6. Identify new requirements for the protection of rack storage
7. Apply the appropriate C Value when utilizing nitrogen
8. Apply appropriate flows and equivalent lengths in hydraulic calculation

AFSA Technical Services Seminar Instructor Information

John August Denhardt, P.E., ET, CWBSP, FSFPE • American Fire Sprinkler Association
1410 East Renner Rd, Suite 150 | Richardson, TX 75028 | 214-349-5965 | jdenhardt@firesprinkler.org

John August Denhardt, P.E., ET, CWBSP, FSFPE, is the vice president of engineering and technical services for the American Fire Sprinkler Association (AFSA). He is responsible for strengthening AFSA's engineering and technical approaches to meeting member, industry, and operational priorities, with an emphasis on service, quality, and integrity. Denhardt is a registered professional engineer (P.E.) in the District of Columbia as well as the states of Delaware, Maryland, Pennsylvania, and Virginia. He is NICET Level III certified in water-based systems layout, NICET Level III certified in inspection and testing of bater-based systems, and a certified water-based system professional through NFPA. Denhardt is a member of the NFPA 13 technical committee on sprinkler system discharge criteria, a fellow in the Society of Fire Protection Engineers (SFPE), a member of the SFPE Board of Directors, a member of the Board of Trustees for NFPA's Fire Protection Research Foundation and sits on the University of Maryland Department of Fire Protection Engineering's Board of Visitors. A native of Maryland, Denhardt holds a Bachelor of Science degree from the University of Maryland, College Park in fire protection engineering. Prior to this role, Denhardt was employed by Strickland Fire Protection in Forestville, Maryland since 1994, overseeing large-scale projects and assisting with design and installation technical issues.

Kevin Hall, M.Eng., P.E., ET, CWBSP, PMSFPE • American Fire Sprinkler Association
1410 East Renner Rd, Suite 150 | Richardson, TX 75028 | 214-349-5965 | khall@firesprinkler.org

Kevin Hall, M.Eng., P.E., ET, CWBSP, PMSFPE is the senior manager of engineering and technical services for the American Fire Sprinkler Association (AFSA). He is a member of several National Fire Protection Association (NFPA) technical committees responsible for developing the model codes and standards including, NFPA 1 *Fire Code*, NFPA 13/13R/13D *Installation of Sprinkler Systems*, NFPA 20 *Installation of Stationary Fire Pumps for Fire Protection*, NFPA 30 *Flammable and Combustible Liquids Code*, and NFPA 915 *Remote Inspections*. He also represents AFSA on numerous UL standard technical panels responsible for revising and maintaining the product standards used in the sprinkler industry. He is a registered professional engineer in Delaware and Maryland, NICET III certified in water-based system layout, a certified water-based system professional through NFPA, and a professional member of the Society of Fire Protection Engineers (SFPE). He earned his Bachelor of Science and Master of Engineering degrees from the University of Maryland, College Park in fire protection engineering. In 2021, he was recognized as one of SFPE's "5 Under 35" award recipients. Prior to his association and committee work, he worked for Reliance Fire Protection in Baltimore, Maryland as a project manager overseeing projects of various sizes and complexity for the Contracts Division.

Updates to NFPA 13, 2022 Edition

Instructor:
Kevin Hall, M.Eng., P.E., PMSFPE

AFSA
American Fire Sprinkler Association

No individual or entity - including a presenting author - may electronically record or broadcast any portion of the AFSA training without prior written consent of AFSA. Unauthorized recording (audio, video, still photography, etc.) of this presentation without the express written consent of AFSA is strictly prohibited.

1



Kevin Hall, M.Eng., P.E., ET, CWBSP, PMSFPE

AMERICAN FIRE SPRINKLER ASSOCIATION

Kevin Hall, M.Eng., P.E., ET, CWBSP, PMSFPE, is the coordinator of engineering and technical services for the American Fire Sprinkler Association (AFSA). He is a member of, and involved in, several National Fire Protection Association (NFPA) technical committees responsible for developing the model codes and standards including, NFPA 1 Fire Code, NFPA 13/13R/13D Installation of Sprinkler Systems, NFPA 20 Installation of Stationary Fire Pumps for Fire Protection, NFPA 30 Flammable and Combustible Liquids Code, and NFPA 915 Remote Inspections. He also represents AFSA on numerous UL standard technical panels responsible for revising and maintaining the product standards used in the sprinkler industry. He is a registered professional engineer in Delaware and Maryland, NICET III certified in water-based system layout, a certified water-based system professional (NFPA), and a professional member of the Society of Fire Protection Engineers. He earned his Bachelor of Science and Master of Engineering degrees from the University of Maryland, College Park in fire protection engineering. Prior to his association and committee work, he worked for Reliance Fire Protection in Baltimore, Maryland as a project manager overseeing projects of various sizes and complexity for the Contracts Division.

khall@firesprinkler.org | P: 214-349-5971 | American Fire Sprinkler Association

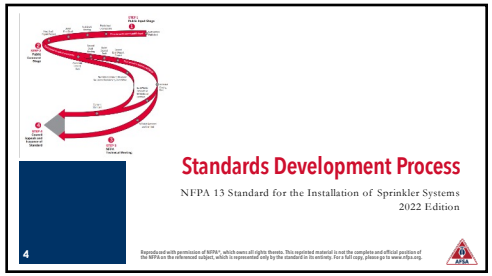
2

NFPA
IT'S A BIG WORLD.
LET'S PROTECT IT TOGETHER.

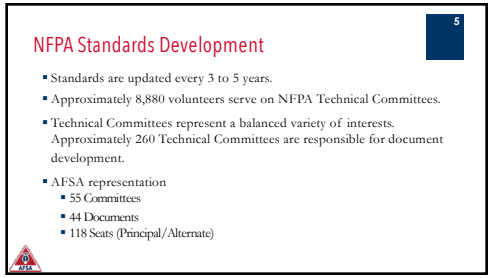
DISCLAIMER

This seminar and its content is not a formal interpretation issued pursuant to NFPA regulations. Any opinion expressed is the personal opinion of the author and presenter and does not necessarily present the official position of the NFPA and its Technical Committees.

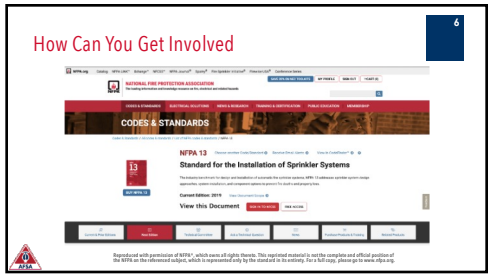
3


Standards Development Process
NFPA 13 Standard for the Installation of Sprinkler Systems
2022 Edition
4

4


NFPA Standards Development
5
Standards are updated every 3 to 5 years.
Approximately 8,880 volunteers serve on NFPA Technical Committees.
Technical Committees represent a balanced variety of interests. Approximately 260 Technical Committees are responsible for document development.
AFSA representation
55 Committees
44 Documents
118 Seats (Principal/Alternate)

5


How Can You Get Involved
6
CODES & STANDARDS
NFPA 13
Standard for the Installation of Sprinkler Systems
View this Document

6

NFPA 13 Technical Committees

7

- Corelating Committee (AUT-AAC)
- Hanging and Bracing of Water-Based Fire Protection Systems (AUT-HBS)
  - Chapter 3-Definitions
  - Chapter 17- Installation Requirements for Hanging and Support of System Piping
  - Chapter 18- Installation Requirements for Seismic Protection
- Private Water Supply Piping (AUT-PRI)
  - NFPA 291
  - NFPA 24
  - Chapter 3- Definitions
  - Chapter 6- Installation Underground Piping

7

NFPA 13 Technical Committees

8

Sprinkler System Discharge Criteria (AUT-SSD)

Chapter	Topic
3	Definitions
4	General Requirements
5	Water Supplies
19	Design Approaches
20	General Requirements for Storage
21	Protection of High-Piled Storage Using CMDA Sprinklers
22	CMSA Requirements for Storage Applications
23	ESFR Requirements for Storage Applications
24	Alternative Sprinkler System Designs
25	Protection of Rack Storage Using In-Rack Sprinklers
26	Special Occupancy Requirements
27	Plans and Calculations
28	Existing System Modifications

8

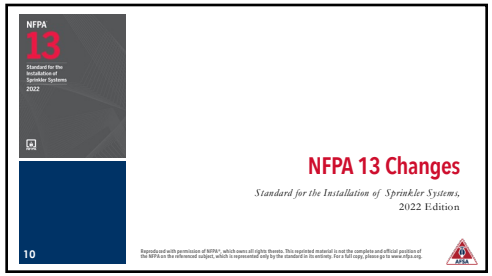
NFPA 13 Technical Committees

9

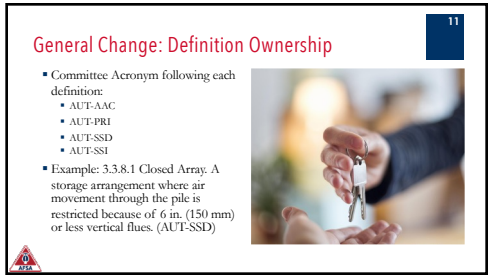
Chapter	Topic
1	Administrations
2	Referenced Publications
3	Definitions
10	Req'ts for Standard Pendent, Upright, and Sidewall Spray Sprinklers
11	Req'ts for EC Upright, Pendent, and Sidewall Spray Sprinklers
12	Req'ts for Residential Sprinklers
13	Req'ts for CMSA Sprinklers
14	Req'ts for ESFR Sprinklers
15	Req'ts for Special Sprinklers
16	Installation of Piping, Valves, and Appurtenances
29	Existing System Modifications
30	Marine Systems
Annex F	Informational References

Sprinkler System Installation Criteria (AUT-SSI)

9


NFPA
13
Standard for the Installation of Sprinkler Systems
2022
NFPA 13 Changes
Standard for the Installation of Sprinkler Systems,
2022 Edition
10
Reproduced with permission of NFPA®, which owns all rights thereto. This reprinted material is not the complete and official position of the NFPA on the referenced subject, which is represented only by the standard in its entirety. For a full copy, please go to www.nfpa.org.

10


11
General Change: Definition Ownership
Committee Acronym following each definition:
AUT-AAC
AUT-PRI
AUT-SSD
AUT-SSI
Example: 3.3.8.1 Closed Array. A storage arrangement where air movement through the pile is restricted because of 6 in. (150 mm) or less vertical flues. (AUT-SSD)

11

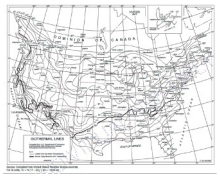

CORRELATE
Correlating Committee
AUT-AAC
12

12

Protecting Pipe Against Freezing

13

The weather temperature used to determine if an unheated portion of a system is subject to freezing and required to be protected in accordance with 16.4.1.1 shall be the lowest mean temperature for one day, obtained from an approved source.



Section 16.4.1.1.1

13



Hanging and Bracing of Water-Based Fire Protection Systems

AUT-HBS

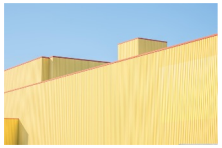
14

14

Building Height

15

- For the purposes of seismic protection, the vertical distance from the grade plane to the average elevation of the highest roof surface. (AUT-HBS)



Section 3.3.21

15

Grade Plane

16

- A reference plane upon which vertical measurements of a building are based representing the average of the finished ground level adjoining the building at all exterior walls. [See also 3.3.222, Finished Ground Level (Grade), of NFPA 5000.] [5000, 2021] (AUT-HBS)



Section 3.3.92

16

Site Class

17



- A classification assigned to a site based on the types of soils present and their engineering properties as defined in Chapter 20 of ASCE/SEI 7, Minimum Design Loads and Associated Criteria for Buildings and Other Structures. [ASCE/SEI 7:11.2] (AUT-HBS)

Section 3.3.201

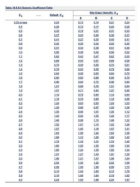
17

Seismic Coefficients

18

- Site class specific and acquired by AHJ
- AHJ may not be sprinkler AHJ
- Linear interpolation allowed (A.18.5.9.3.3):

$$C_P = C_{P\text{-low}} + \frac{C_{P\text{-high}} - C_{P\text{-low}}}{S_{1\text{-high}} - S_{1\text{-low}}}\left(S_1 - S_{1\text{-low}}\right)$$



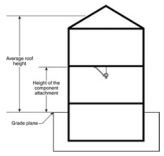
Reproduced with permission of NFPA®, which owns all rights thereto. This reprinted material is not the complete and official position of the NFPA on the referenced subject, which is represented only by the standard in its entirety. For a full copy, please go to www.nfpa.org.

Section 18.5.9.3

18

Seismic Coefficients (Cont.)

19



- Height of component attachment to the structure to the average roof height:
  - 51-75%: C_p x .875
  - >50%: C_p x .75

Section 18.5.9.3.4

19



Sprinkler System Installation Committee

AUT-SSI

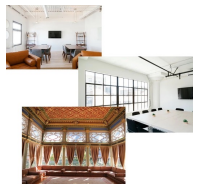
20

20

Smooth Ceiling

21

- A continuous ceiling free from significant irregularities, lumps, or indentations greater than 4 in. (100 mm) in depth . (AUT-SSI)



Section 3.3.28.4

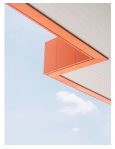
21

Exterior Projection

22

- ~~Construction attached to the primary structure.~~ An extension beyond an exterior wall capable of collecting heat below. (AUT-SSI)





Section 3.3.73

22

Electrically Operated Sprinkler

23

- A sprinkler equipped with an integral means of activation using electricity. (AUT-SSI)





Photo Credit: JCI

Section 3.3.215.4.6

23

Electrically Operated Sprinkler

24

- Permitted when evaluated and listed under the following conditions:
  - Fire tests related to the intended hazard
  - Distribution of spray pattern:
    - Floor and wall wetting
    - Respect to obstructions
  - Performance under horizontal and sloped ceilings
  - Area of design
  - Allowable clearance to ceilings





Photo Credit: JCI

Section 15.6

24

3666

Shadow Area

25

- The floor area within the protection area of a sprinkler created by the portion of sprinkler discharge that is blocked by a wall, partition, or other obstruction. (AUT-SSI)



Section 3.3.195

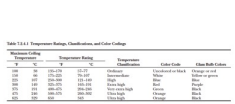
25

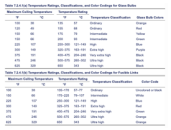
Temperature Rating Table

26

Old

New





Reproduced with permission of NFPA®, which owns all rights thereto. This reprinted material is not the complete and official position of the NFPA on the referenced subject, which is represented only by the standard in its entirety. For a full copy, please go to www.nfpa.org.

Table 7.2.4.1(a) & (b)

26

Ordinary or Intermediate Temperature

27





Section 9.4.2.1

27

Weld Repairs

28



Section 7.5.2.2.1

28

System Air Pressure

29

- Low pressure at least 5 psi above trip pressure
- High pressure 5 psi above system pressure
- Notification:
  - Audible at location
  - FACP supervisory condition



Photo Credit: Viking

Section 8.2.6.7

29

Porte-cocheres

30

- Sprinklers are required when located directly below floors intended for occupancy



Section 9.2.3.2.1

30

Bathrooms Under Stairs

31



- Do not require sprinklers when separated from the stairs by fire-resistive construction

Section 9.2.4.1.1.1

31

Balconies and Decks Serving Dwelling Units

32

- Added a section to aligns with IBC and 13R
- Type V construction



Section 9.3.20

32

Small Temporarily Occupied Enclosures

33

- Do not require sprinklers when:
  - Do not extend to the ceiling
  - No storage
  - Maximum: 24 ft²



Section 9.3.21

33

3669

Combustible Stairways

34

- Clarification of intent
- Protect the entire footprint of the shaft



Section 9.3.4.1.1

34

Partitions in OH Occupancies

35



Reproduced with permission of NFPA®, which owns all rights thereto. This reprinted material is not the complete and official position of the NFPA on the referenced subject, which is represented only by the standard in its entirety. For a full copy, please go to www.nfpa.org.

Section 10.2.7.3.2.3 & 10.2.7.3.2.4

35

Sidewall Spray Sprinklers

36

- Annex language added for car stackers
- Allowance to install sidewall sprinklers:
  - Under cars in car stackers
  - Cars stacked vertically placed under each level of cars

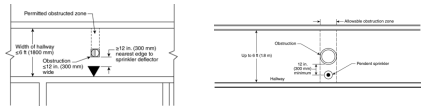


Section 10.3.2

36

Sprinkler Obstructions in Hallways

37



Reproduced with permission of NFPA®, which owns all rights thereto. This reprinted material is not the complete and official position of the NFPA on the referenced subject, which is represented only by the standard in its entirety. For a full copy, please go to www.nfpa.org.

Section 10.3.6.1.7 & 12.1.10.1.2

37

Clearance to Storage

38

- Rubber tire storage: 36 in.



Section 10.2.8.3 & 11.2.6.3

38

Concealed Sprinklers in Beams

39

- Concealed sprinklers:
  - Increased from 4 in. to 14 in.-deep beam



Photo credit: Globe

Section 12.1.8.1.2

39

Upright ESFR on Branch lines

40

- Attached directly to branch lines ≤ 4 in. (nominal)
- Offset horizontally minimum of 12 in. from the pipe
- Supplied by a riser nipple to elevate the sprinkler 12 in. from centerline of pipe > 4 in. (nominal)



Photo credit: Viking Group Inc.

Section 14.2.11.3.3

40

Piping Subject to Mechanical Damage

41

- Must provide nail plates when pipe other than steel is run through wood or metal studs:
- Steel shield plates:
  - Where the face of piping is less than 1.25 in from nearest edge of member
  - Minimum thickness of .0575 in. (No. 16 gauge)
  - Cover the area of the pipe where the member is notched and bored



Section 16.4.4

41

Pipe Schedule Nameplate

42

- Installing contractor must provide
- Permanently marked weatherproof or rigid plastic sign
- Corrosion-resistant wire, chain, or other approved means
- Placed at the corresponding system riser

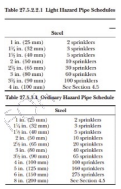


Table 27.5.2.2.1 Light Hazard Pipe Schedules

Steel
1 in. (25 mm) — 2 sprinklers
1¼ in. (32 mm) — 3 sprinklers
1½ in. (40 mm) — 5 sprinklers
2 in. (50 mm) — 10 sprinklers
2½ in. (65 mm) — 30 sprinklers
3 in. (80 mm) — 60 sprinklers
3½ in. (90 mm) — 100 sprinklers
4 in. (100 mm) — See Section 4.5

Table 27.5.3.3 Ordinary Hazard Pipe Schedule

Steel
1 in. (25 mm) — 2 sprinklers
1¼ in. (32 mm) — 3 sprinklers
1½ in. (40 mm) — 5 sprinklers
2 in. (50 mm) — 10 sprinklers
2½ in. (65 mm) — 30 sprinklers
3 in. (80 mm) — 60 sprinklers
3½ in. (90 mm) — 100 sprinklers
4 in. (100 mm) — 100 sprinklers
5 in. (125 mm) — 160 sprinklers
6 in. (150 mm) — 275 sprinklers
8 in. (200 mm) — See Section 4.3

Reproduced with permission of NFPA®, which owns all rights thereto. This reprinted material is not the complete and official position of the NFPA on the referenced subject, which is represented only by the standard in its entirety. For a full copy, please go to www.nfpa.org.

Section 29.5

42

Waterflow Alarm Devices

43

Mechanical

- 5 minutes



Electrical

- 100 seconds



Section 7.7

43

Dwelling Delivery Time

44

Table 8.2.3.6.1 Dry Pipe System Water Delivery

Hazard	Number of Most Remote Sprinklers Initially Open	Maximum Time of Water Delivery (seconds)
~~Residential~~ Dwelling unit	1	15
Light	1	60
Ordinary I	2	50
Ordinary II	2	50
Extra I	4	45
Extra II	4	45
High piled	4	40

Reproduced with permission of NFPA®, which owns all rights thereto. This reprinted material is not the complete and official position of the NFPA on the referenced subject, which is represented only by the standard in its entirety. For a full copy, please go to www.nfpa.org.

Section 8.2.3.6.1

44

Nitrogen Supply for Increased C-factor

45

- Restore air pressure withing 30-60 minutes
- Listed and permanently installed
- Maintain 98% at minimum leakage rate of 1.5 psi/hr
- Installed per manufacturer's instructions



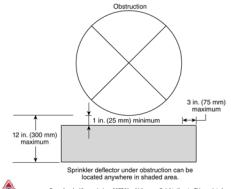
Photo credit: General Air Products

Section 8.2.6.9

45

Circular Obstructions

46







Reproduced with permission of NFPA®, which owns all rights thereto. This reprinted material is not the complete and official position of the NFPA on the referenced subject, which is represented only by the standard in its entirety. For a full copy, please go to www.nfpa.org.

Section 8.2.6.9

46

ESFR in Light and Ordinary Hazard

47

- For retrofits
- Light and Ordinary Hazard
- Utilize Spray Sprinkler Guidance for:
  - Protection Areas and Maximum Spacing for Light Hazard
  - Spacing
  - Obstruction Criteria



Section 14.2.7

47

ESFR Isolated Obstructions

48

- Sprinklers not required for isolated noncontiguous obstruction :
  - ≤ 1.5 in. in width located horizontally a minimum of 12 in. below deflector
  - ≤ 6 in. in width and located a minimum of 6 in. horizontally from the sprinkler
  - ≤24 in. in width and a minimum of 12 in. horizontally from the sprinkler
- High-piled storage is not physically separated from an adjacent light or ordinary hazard area:
  - Criteria applies to sprinkler located 6 ft. horizontally of any high-piled storage



Section 14.2.11.2

48

ESFR General Continuous Obstructions

49

- Sprinklers not required for isolated noncontiguous obstruction :
  - ≤ 1.5 in. in width located horizontally a minimum of 12 in. below deflector
  - ≤ 6 in. in width and located a minimum of 6 in. horizontally from the sprinkler
  - ≤24 in. in width and a minimum of 12 in. horizontally from the sprinkler
- ESFRs shall be arranged with respect to the bottom chord of bar joist or open truss:
  - Bottom cord is ≤ 6 in. in width, located a minimum of 6 in. horizontally from nearest edge of bottom cord
  - Bottom cord is ≤ 24 in. in width, located a minimum of 12 in. horizontally from nearest edge of bottom cord



Reproduced with permission of NFPA®, which owns all rights thereto. This reprinted material is not the complete and official position of the NFPA on the referenced subject, which is represented only by the standard in its entirety. For a full copy, please go to www.nfpa.org.

Section 14.2.11.3

49

Beam Rule

50

Table 14.2.11.1.1(a) Positioning of Sprinklers to Avoid Obstructions to Discharge (ESFR Sprinklers)

Distance from Sprinkler to Side of Obstruction (A) (ft)	Allowable Distance of Deflector Above Bottom of Obstruction (B) (in.)
Less than 1	0
1 or more	1½ or less
1½ or more	3 or less
2 or more	5½ or less
2½ or more	8 or less
3 or more	10 or less
3½ or more	12 or less
4 or more	15 or less
4½ or more	18 or less
5 or more	22 or less
5½ or more	26 or less
6 or more	31 or less

Reproduced with permission of NFPA®, which owns all rights thereto. This reprinted material is not the complete and official position of the NFPA on the referenced subject, which is represented only by the standard in its entirety. For a full copy, please go to www.nfpa.org.

Table 14.2.11.1.1(a)

50

Campus Arrangement of Spare Sprinklers

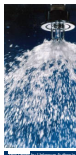
51



- Sprinklers and wrenches do not need to be stored at individual systems locations
- Hospitals
- Multifamily complexes
- Schools

Section 16.2.7.1

51



Committee on Sprinkler System Discharge Criteria

AUT-SSD

52

52

Single Point Densities

53

- New systems use Table 19.2.3.1.1:

Table 19.2.3.1.1 Density/Area

Hazard	Density/Area {{gpm/ft²} (mm/min/m²)}
Light	0.1/1500 or 0.07/3000* (4.1/140 or 2.9/280)
Ordinary Group 1	0.15/1500 or 0.12/3000* (6.1/140 or 4.9/280)
Ordinary Group 2	0.2/1500 or 0.17/3000* (8.1/140 or 6.9/280)
Extra Group 1	0.3/2500 or 0.28/3000* (12.2/230 or 11.4/280)
Extra Group 2	0.4/2500 or 0.38/3000* (16.3/230 or 15.5/280)

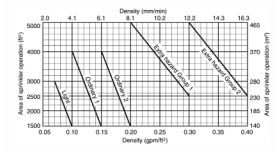
Reproduced with permission of NFPA®, which owns all rights thereto. This reprinted material is not the complete and official position of the NFPA on the referenced subject, which is represented only by the standard in its entirety. For a full copy, please go to www.nfpa.org.

Table 19.2.3.1.1

53

Evaluating Existing Systems

54



Reproduced with permission of NFPA®, which owns all rights thereto. This reprinted material is not the complete and official position of the NFPA on the referenced subject, which is represented only by the standard in its entirety. For a full copy, please go to www.nfpa.org.

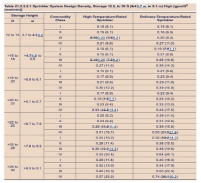
Figure 19.2.3.1.1

54

CMDA Single Point Densities

55

- Curves still exist for existing systems
- Adjustments for single point densities throughout Chapter 21



Reproduced with permission of NFPA®, which owns all rights thereto. This reprinted material is not the complete and official position of the NFPA on the referenced subject, which is represented only by the standard in its entirety. For a full copy, please go to www.nfpa.org.

Table 21.2.2.2.1

55

Chapter Reorganization

56

Topic	2019	2022
Special Designs for Storage Applications	24	26
Special Occupancies	26	27
Plans and Calculations	27	28
Systems Acceptance	28	29
Existing System Modifications	29	30
Marine Systems	30	31
System Inspection Testing and Maintenance	31	32

56

Owner's Certificate Addition

57

4.2 Owner's Certificate The owner(s) of a building or structure where the fire sprinkler system is going to be installed or their authorized agent shall provide the sprinkler system installer with the following information prior to the layout and detailing of the fire sprinkler system [see Figure A.28.1(b)]:

1) Intended use of the building, including the materials within the building and the maximum height of any storage
2) A preliminary plan of the building or structure along with the design concepts necessary to perform the layout and detail for the fire sprinkler system
3) Water supply information as identified in 5.2.2
4) *Any special knowledge of the water supply, including known environmental conditions that might be responsible for corrosion, including microbiologically influenced corrosion (MIC)
5) Whether seismic protection is required and the applicable short period response parameter.

Section 4.2

57

Design Approach

58

More than one design approach can be selected for a single building or system. It is the designer's discretion as to which design approaches or methods to utilize; prior approval by the authority having jurisdiction is not required.



Section 19.1.1

58

Unsprinklered Combustible Concealed Space

59

- Addition to the list of items that shall not require minimum area of sprinkler operation of 3,000 ft^2:
  - 12. Exterior soffits, eaves, overhangs, and decorative frame elements complying with 9.2.1.19.



Section 19.2.3.1.5.2

59

Room Design Method Using Light Hazard

60

- Light hazard criteria for residential sprinklers applicable



Section 19.3.1.1.1

60

3678

Commodity Classification Ranking:

61



1. Class I
2. Class II
3. Class III
4. Class IV
5. Cartoned nonexpanded plastic
6. Cartoned expanded plastic
7. Exposed nonexpanded plastic
8. Exposed expanded plastic

Section 20.3.1.3 & 20.3.1.4

61

Open Racks

62

Double-row

- No solid shelves
- Storage height does not exceed 25 ft.
- Transverse flues maximum of 5 ft. intervals

Multi-row

- No solid shelves
- Both transverse and longitudinal flue spaces at maximum of 5 ft. intervals

OR

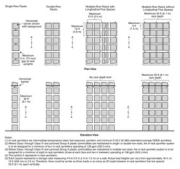
- Transverse flues at maximum of 5 ft and rack depth does not exceed 20 ft. between aisles at least 3.5 ft.

Section 20.5.3.1.2 & 20.5.3.1.3

62

Revised Rack Figures

63



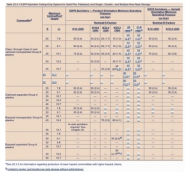
Reproduced with permission of NFPA®, which owns all rights thereto. This reprinted material is not the complete and official position of the NFPA on the referenced subject, which is represented only by the standard in its entirety. For a full copy, please go to www.nfpa.org.

Figures 25.6.2.3.1 (a) through (f)

63

Condensed ESFR Protection Table

64



Reproduced with permission of NFPA®, which owns all rights thereto. This reprinted material is not the complete and official position of the NFPA on the referenced subject, which is represented only by the standard in its entirety. For a full copy, please go to www.nfpa.org.

Table 23.3.1

64

Working Plans List

65

- Reorganized
- Added information
- Provides comprehensive plans for:
  - AHJ
  - Installation Crew



Section 28.1.3

65

Working Plans

66

- Name, telephone number, and address of installing contractor
- Location of all fire-rated partitions, fire barriers, draft stops, and draft curtains
- Location and identification of all major structural members, and identification and labeling of construction types (i.e., obstructed or unobstructed) for each space or portion thereof in the building, as applicable
- Location and identification of spaces, regardless of combustibility, and of architectural and/or structural features not shown or easily identifiable in the floor plan or reflected ceiling plan views
- Water source(s) supply information, including the following:
  - a. Location
  - b. Type
  - c. Size
  - d. Dimensions
  - e. Capacity
  - f. Configuration
  - g. Elevation
  - h. Static pressure
  - i. Flow rate
  - j. Residual pressure
  - k. Flow test locations, dates, and sources (i.e., city or private)
  - l. Any adjustments from the raw data required by the engineer of record (i.e., owner's certificate) or the water authority, if applicable

Section 28.1.3

66

Friction Loss

67

- Fitting with a bushing same as similarly sized and configured reducing fitting
- Excluded for tapered reducers
- Included for Listed fittings



Section 28.2.4.8.1

67

Friction Loss for Systems Using Nitrogen

68



Reproduced with permission of NFPA®, which owns all rights therein. This reprinted material is not the complete and official position of the NFPA on the referenced subject, which is represented only by the standard in its entirety. For a full copy, please go to www.nfpa.org.

Table 28.2.4.8.1

68

Parking Garages

69

- Automobile material have changed
- No longer an example of OH 1
  - Moved to OH2
- Need more data (FPRF)

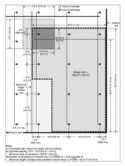


69

Area of Discharge

70

- Where defined by full-height wall assembly
- Other side of the wall is not counted towards total design area



Reproduced with permission of NFPA®, which owns all rights thereto. This reprinted material is not the complete and official position of the NFPA on the referenced subject, which is represented only by the standard in its entirety. For a full copy, please go to www.nfpa.org.

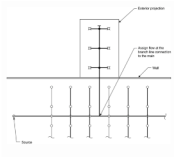
Section 28.2.4.2.6

70

Phantom Flow

71

- Added annex added
- Reworded



Reproduced with permission of NFPA®, which owns all rights thereto. This reprinted material is not the complete and official position of the NFPA on the referenced subject, which is represented only by the standard in its entirety. For a full copy, please go to www.nfpa.org.

Section 28.2.4.2.5

71



For additional questions regarding the content in today's presentation, please contact:

Kevin Hall, M.Eng., P.E., ET, CWBSP, PMSFPE
Sr. Manager of Engineering and Technical Services
American Fire Sprinkler Association
khall@firesprinkler.org
214-349-5965 x128

You can contact the AFSA Technical Services staff at technical@firesprinkler.org

72

File Attachments for Item:

EC-28 Victaulic VicFlex Sprinklers (Victaulic)

All certifications (1 hour)

CRITERIA FOR SUBMITTING CONTINUING EDUCATION COURSES FOR BOARD OF BUILDING STANDARDS CERTIFICATIONS

The Ohio Board of Building Standards approves Continuing Education Courses for building department personnel. The courses may be used for the attainment of goals that are connected with technical and professional development as they relate to enforcing and interpreting the Ohio State Building Codes. Board approval is granted only on course instruction pertaining to OBC, OMC, OPC, and RCO requirements and such other content areas directly related to the responsibilities of the certification for which credit is being requested.

Instructors: Anyone or any organization promoting an approved course, is required to make full and accurate disclosure regarding course title, course approval number, number of credit hours, certifications for which the BBS has approved the class, and fees in promotion materials and advertising. ***The Board does not grant retroactive approval. It is recommended that courses be submitted for approval well in advance of any scheduling of classes and advertising***. Advertising shall not disclose improper approval information to the public.

Course sponsors/co-sponsors: provide participants a certificate of completion containing the following information: name of participant, title of approved courses, BBS approval #, BBS approved certifications, date of the continuing education program, number of approved credit hours awarded and signature of authorized sponsor or instructor.

Anyone or any organization administering an approved course shall provide the Board with advanced written information on scheduling of the course(s) (date and place) and provide to the Board a legible list of participants who completed the course with the name of course, date, and location.

Participants: Must attend the complete course as presented by the instructor to receive credit hours approved by the Board. No partial credit shall be given to any participant who failed to complete the entire course as approved. The sponsor/co-sponsor or instructor shall formulate a method to verify the individual's attendance and completion of the course.

Board approval: Remains in effect through the calendar year of approval. The course may be renewed administratively by sponsor application in subsequent years so long as it references current codes and standards Upon the Board's adoption of a new edition of the codes, course sponsors must update their course and submit to the Board for approval. The Board does not grant retroactive approval for courses presented prior to approval date.

Facility/training area: Shall be capable of comfortably and safely seating at least the number of attendees with writing surfaces for each attendee; accessible to/and usable for people with disabilities; sized and provided with audio/visual equipment adequate so that each attendee can see the instructor(s) and overhead screen and hear the content of the training programs; illuminated for writing and that the content on an overhead screen can be seen easily by all attendees; non-smoking in the training room; sound controlled so that outside noise will not interfere with the training.

APPLICATION

FOR

Continuing Education Course Approval

Continuing education programs approved for education credit by the Ohio Board of Building Standards may be used for compliance with certification requirements related to code enforcement, plan review, and inspection responsibilities. The credit is to be used to renew the certifications issued by the Ohio Board of Building Standards pursuant to section 3781.10(E) ORC.

Board of Building Standards
6606 Tussing Road, P.O. Box 4009
Reynoldsburg, Ohio 43068-9009
(614) 644-2613 Fax: (614) 644-3147
dic.bbs@com.state.oh.us
www.com.state.oh.us/dic/dicbbs.htm

COURSE SUBMITTER:

Course Submitter: Lyndsay Coyle
(Contact Name)
Organization: Victaulic
(Organization/Company)
Address: 4901 Kesslersville Road
(Include Room Number, Suite, etc.)
City: Easton State: PA Zip: 18040
E-Mail: lyndsay.coyle@victaulic.com
Telephone: 484 541 1460 Fax: _____
Course Sponsor: NA

COURSE INFORMATION:

Course Title: Victaulic VicFlex Sprinklers

New Course Submittal: ☒ Update Course: ☐ Prior Approval Number: _____

Purpose and Objective:
The purpose of this course is to build awareness and understanding of flexible sprinkler technology. Authorities having jurisdiction (AHJs) and consulting engineers will learn about the use of k-factored flexible sprinklers in wet and dry applications as compared to flexible sprinkler fitting systems and traditional hard-pipe armovers.

Number of Instructional Contact Hours that can be obtained upon completion: 1

If Multi-Session, Number of Instructional Contact Hours Per Session: _____

Program Applicable for the Following Participants:

Building Official ☒	Master Plans Examiner ☒	Building Inspector ☒	Fire Protection Inspector ☒	Mechanical Inspector ☒	
	Building Plans Exam. ☒			Plumbing Inspector ☒	
	Plumbing Plans Exam. ☒			Non-Res IU Inspector ☒	
	Electrical Plans Exam. ☒				
	Mechanical Plans Exam. ☒				
	Fire Protect. Plans Exam. ☒				
Res Building Official ☒	Res Plans Examiner ☒	Res Building Inspector ☒	Res Mechanical Inspector ☒	Res IU Inspector ☒	

Electrical Safety Inspectors ☐
Location of ESI Course: _____ Date(s) of ESI Course(s): _____

SUBMITTAL CHECKLIST: **Make Sure** all of the Following Information is **Submitted**:		Check Off
Course Submitter:	Name of contact person and their certification numbers, organization, address, fax, phone	X
	Organization sponsoring or requesting the program (if any)	X
Course Title:	Name of course (related to content)	X
Purpose/Objective:	Describe purpose and how course will improve competency of certification(s) listed	X
Contact Hours:	Indicate instructional time and credit requested in hours (e.g.: 0.5 hr, 1 hr, 3.5 hrs)	X
Participants:	Check off each certification for which credit is requested (for which course relates to certification)	X
Content of Program:	Include collated agenda, time schedule, course outline; list specific sections of code, references, and topics covered	X
Course Materials:	Collated workbooks, handouts, hard copy or electronic versions of program is available	X
Instructor(s) Info.:	Resume of professional/educational qualifications & teaching/training experience/BBS certifications	X
Test Materials:		X
Completed Application:		X

NOTE: The Board does NOT grant retroactive approval for courses presented prior to approval date.

Victaulic® University Continuing Education Course Instructor Biography

Dave Molnar
Victaulic University Training Leader



Education

- Associates Degree – Mechanical Drafting and Design
  - Lincoln Technical Institute

Current Job Description

- Victaulic University course facilitator, specializing in:
  - Virtual Design & Construction
- Facilitating the following Victaulic University Continuing Education courses:
  - Victaulic Tools For Revit – Increasing Modeling Efficiency

Experience Relevant To Course Topic

- VDC/Special Projects Manager for Victaulic and
  - Managed a team of BIM project coordinators in the development and coordination of Fire Protection and Mechanical piping systems in accordance with design documents for prefabrication and construction shop drawing submissions
- Experience training on Revit and BIM best practices for Fire Protection and Mechanical contractors and engineers
- Over 25 years of experience in the construction design and drafting industry
  - Project management and senior BIM project coordinator positions with consulting engineering firms and mechanical contractors before joining Victaulic
- Member of NFPA and a certified designer under NFPA 13: Installation of Sprinkler Systems

VU-QRG-9110-E-ENG-GLB 15165 REV A 04/2020
© 2020 VICTAULIC COMPANY. ALL RIGHTS RESERVED.

Victaulic® University Continuing Education Course Instructor Biography



Colin Phelps
Manager of Sales & Customer Training

Education

- Associate of Applied Science – Welding Technology
  - Northampton Community College, Bethlehem, PA
- Bachelor of Science – Organizational Leadership
  - Pennsylvania State University, University City, PA
- Master of Education – Adult Education
  - Rutgers University, New Brunswick, NJ
  - Expected Date of Graduation: September of 2021

Current Job Description

- With a team of training professionals manage educating our customers and the industries we serve about Victaulic
- Manage a year-long new Sales hire onboarding training program
- Facilitating the following Victaulic University Continuing Education courses:
  - Basic Principles Of Grooved Mechanical Joints
  - Gasket Technology
  - Victaulic Certification Program
  - Victaulic Grooving And Installation Fundamentals
  - Victaulic Grooving And Installation Fundamentals For Copper Connections
  - Victaulic Grooving And Installation Fundamentals For Hydraulic Elevator Piping
  - Victaulic System Solution For HDPE Pipe Joining Certification

Experience Relevant To Course Topic

- Over 20 years of experience in welding industry
- Over 10 years of experience in education and training
- Over six years of experience in educating Victaulic employees and customers

VU-QRG-9110-E-ENG-GLB 15165 REV A 04/2020

© 2020 VICTAULIC COMPANY. ALL RIGHTS RESERVED.

Victaulic® University Continuing Education Course Instructor Biography

Michael Stamets
Victaulic University Technical Trainer



Education

- Associate Of Arts – Business Administration (Completion of 81 credits)
  - Northampton Community College, Bethlehem, PA
- Seven years of Professional Fire Service Experience & Certifications
  - NFPA Fire Instructor II
  - NFPA Fire Inspector II
  - NFPA Fire Officer III

Current Job Description

- Victaulic University course facilitator, specializing in:
  - Pipe joining and flow control solutions
  - Grooved mechanical joints engineering design principles
  - Fire protection valves and sprinklers
  - Flexible sprinkler systems
- Facilitating the following Victaulic University Continuing Education courses:
  - Basic Principles Of Grooved Mechanical Joints
  - Dry Sprinklers For Commercial And Residential Fire Protection
  - Flexible Sprinkler Hose Systems
  - Introduction To Victaulic Vortex™ Hybrid Fire Extinguishing Systems
  - Victaulic Fire Protection Workshop
  - Victaulic FireLock NXT™ Deluge System Check Valves
  - Victaulic FireLock NXT™ Dry System Check Valves
  - Victaulic FireLock NXT™ Preaction System Check Valves
  - Victaulic FireLock™ Products: Fire Protection Valves
  - Victaulic FireLock™ Valves For Wet Pipe Systems
  - Victaulic Grooving And Installation Fundamentals
  - Victaulic Small Diameter Fire Protection Solutions
  - Victaulic System Solution For HDPE Pipe Joining Certification
  - Victaulic Vortex™ Hybrid Fire Extinguishing Systems Integrator Training Courses

Experience Relevant To Course Topic

- Over five years of experience in the fire protection industry
  - Including the inspection, maintenance and installation of pre-engineered fire suppression systems
- Two years of experience in Application Engineering – Fire Protection
  - Providing technical expertise to Victaulic customers
  - Working closely with Product Development and Quality Assurance for design and manufacturing of fire protection products
- NFPA Member (2019 – Present)

VU-QRG-9110-E-ENG-GLB 15165 REV A 04/2020
© 2020 VICTAULIC COMPANY. ALL RIGHTS RESERVED.



1

VICTAULIC®
VICFLEX™
SPRINKLERS

VU-PPT-8136-E-ENG-US 18386 Rev A 08/2022

2

IACET Accredited Provider: Victaulic® University Continuing Education has been awarded Accredited Provider status by the International Association for Continuing Education and Training (IACET), 21670 Ridgetop Circle, Suite 170, Sterling, VA 20166 — (703) 763-0705 — info@iacet.org. In obtaining this approval, *Victaulic* University Continuing Education has demonstrated that it complies with the ANSI / IACET Standard, which is recognized internationally as a standard of good practice. As a result of their Accredited Provider accreditation status, *Victaulic* University Continuing Education is authorized to offer IACET CEUs for its programs that qualify under the ANSI / IACET Standard.

International Code Council (ICC) Preferred Provider: *Victaulic* University continuing Education is a member of the ICC Preferred Provider Network. The Preferred Provider Program recognizes and promotes ICC-approved educational offerings by a variety of Providers, as they relate to codes, standards, and guidelines, as well as building construction materials, products, and methods.

Course 31279

VU-PPT-8136-E-ENG-US 18386 Rev A 08/2022

3

LEARNING OBJECTIVES:

- Identify the components of VicFlex™ sprinklers
- Understand the use of *VicFlex* sprinklers
- Know how to identify and inspect *VicFlex* sprinklers
- Compare the hydraulic performance of a *VicFlex* standard coverage sprinkler with hard pipe and flexible sprinkler hose systems
- Understand how proper exposed barrel length is achieved with a *VicFlex* dry sprinkler

LESSONS:

- VicFlex™ Sprinklers: Combined Technology
- *VicFlex* Flexible Dry Sprinkler
- *VicFlex* Standard Coverage Sprinkler

Victaulic UNIVERSITY | CONTINUING EDUCATION

VU-PPT-8136-E-ENG-US 18386 Rev A 08/2022

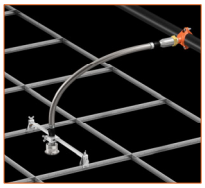
4

Victaulic® VicFlex™ Sprinklers
Combined Technology

5

Combining Technology

- Fully-assembled, Listed & Approved K5.6 Sprinkler
- Eliminates The Need For An Armover
- The Flexible Hose Component Is Part Of The Sprinkler
- System Design: No Equivalent Length Calculations Req'd



Dry Sprinkler (VS1)



Standard Coverage Sprinkler (VS2)

6

Victaulic® VicFlex™ Sprinklers
Flexible Dry Sprinkler
Style VS1

7

VicFlex™ Dry Sprinkler

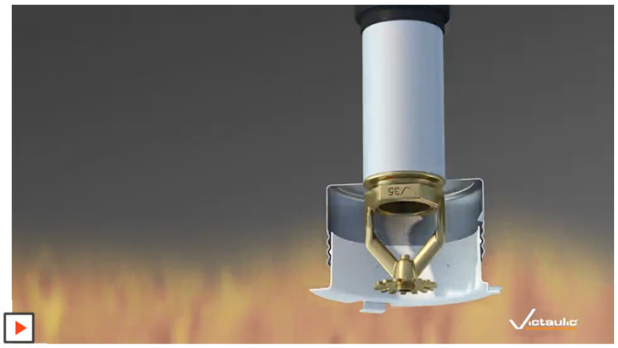




Flexible Dry Sprinkler
A cULus Listed and FM Approved dry sprinkler, used to prevent water from entering the sprinkler and eliminate freeze-ups in outdoor or unheated areas.
See NFPA 13, 2022 edition ***3.3.215.4.4* Dry Sprinkler***

8

How It Works



9

Sprinkler Characteristics

Style
- Pendent
- Concealed Pendent
- Horizontal Sidewall

Response
- Quick Response
- Standard Response

K Factor
- 5.6 | 8.1 S.I.
- For system design purposes, no equivalent length calculations are required

Sprinkler Length
- 38" | 965 mm
- 50" | 1270 mm
- 58" | 1475 mm
- Order and stock standard lengths without custom measurement

Maximum Working Pressure
- 175 psi | 1200 kPa

Factory Hydrostatic Test
- 100% @ 500 psi | 3450 kPa

Minimum Operating Pressure
- 7 psi | 48 kPa

Branchline Connection
- To branch line (inlet) via:
  - 1" NPT | 25mm BSPT
  - 1" IGS

Minimum Bend Radius:
- UL: 2" | 51 mm
- FM: 7" | 178 mm

Maximum Number of 90° Bends:
- UL: 4
- FM:
  - 2 bends for 38"
  - 3 bends for 50"
  - 4 bends for 58"

Hazard Classifications
- Light and Ordinary Hazard

10

Listing & Approval

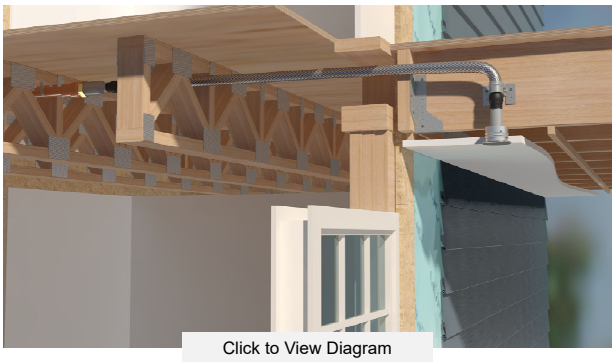


Maximum Allowable Number of Bends

Sprinkler Length inches mm	Maximum Allowable Number of 90° Bends at 2"/51mm Bend Radius for UL Listing	Maximum Allowable Number of 90° Bends at 7"/178mm Bend Radius for FM Approval
38 965	4	2
50 1270	4	3
58 1475	4	4

11

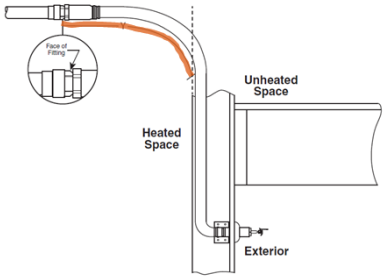
Exposed Barrel Lengths



Click to View Diagram

12

Exposed Barrel Lengths



NFPA 13: Standard for the Installation of Sprinkler Systems, 2022 Edition

13

Determining Exposed Barrel Length

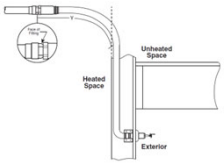


Table 15.3.1(a) Exposed Barrel Lengths for Dry Sprinklers (U.S. Customary Units)

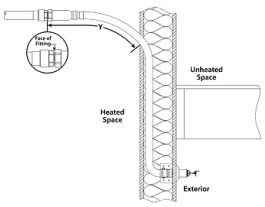
Ambient Temperature Exposed to Discharge End of Sprinkler (°F)	Minimum Exposed Barrel Length when Exposed to 40°F (in.)	Minimum Exposed Barrel Length when Exposed to 50°F (in.)	Minimum Exposed Barrel Length when Exposed to 60°F (in.)
40	0	0	0
30	0	0	0
20	4	0	0
10	8	1	0
0	12	3	0
−10	14	4	1
−20	14	6	3
−30	16	8	4
−40	18	8	4
−50	20	10	6
−60	20	10	6

NFPA 13: Standard for the Installation of Sprinkler Systems, 2022 Edition

14

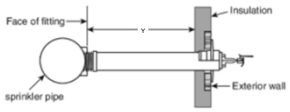
Eliminating Soffits

Flexible Dry Sprinkler



Flexible dry sidewall sprinkler through wall

Hard Pipe

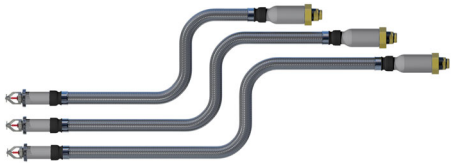


Dry sidewall sprinkler through wall

15

Stocking Spares

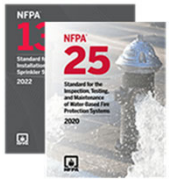
- Stock And Replace Whole Assemblies
  - Standard Sizes 38”, 50” and 58”
  - Access Replacements In A Timely Manner
  - Restore Service Faster



16

Inspection

- The *Vicflex* Dry Sprinkler Should Be Installed, Inspected, Tested, And Maintained In The Same Manner As Other Dry Sprinklers: According To NFPA 13 And NFPA 25.



17

1. Identification



For more, see Victaulic Publication 10.91.

18

2. Maximum Allowable Bends

Maximum Allowable Number of Bends

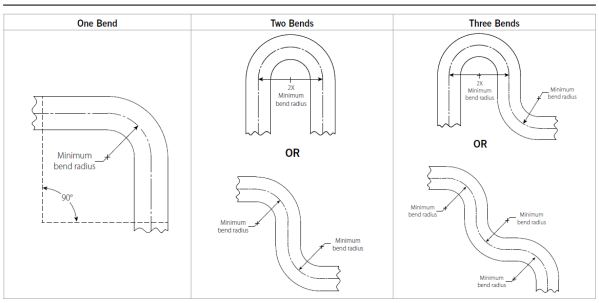
Sprinkler Length inches mm	Maximum Allowable Number of 90° Bends at 2"/51mm Bend Radius for UL Listing	Maximum Allowable Number of 90° Bends at 7"/178mm Bend Radius for FM Approval
38 965	4	2
50 1270	4	3
58 1475	4	4

Correcting Mistakes: Mistakes in bend radius or allowable bends can often be corrected by rerouting the flexible sprinkler in a different path.

For more, see Victaulic Publication 10.91.

19

Bend Radius Guide

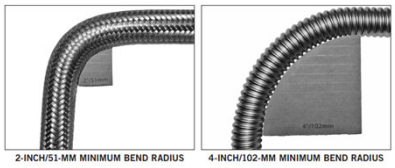


For out-of-plane (three-dimensional) bends, care must be taken to avoid imparting torque on the hose.

20

3. Minimum Bend Radius

- Smallest Allowed Radius The Flexible Sprinkler Is Allowed To Be Bent

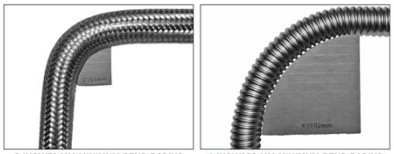


2-INCH/51-MM MINIMUM BEND RADIUS 4-INCH/102-MM MINIMUM BEND RADIUS

Visual Comparison:
2” Bend Radius vs 4” Bend Radius

21

3. Minimum Bend Radius



2-INCH/51-MM MINIMUM BEND RADIUS 4-INCH/102-MM MINIMUM BEND RADIUS

Maximum Allowable Number of Bends

Sprinkler Length inches mm	Maximum Allowable Number of 90° Bends at 2"/51mm Bend Radius for UL Listing	Maximum Allowable Number of 90° Bends at 7"/178mm Bend Radius for FM Approval
38 965	4	2
50 1270	4	3
58 1475	4	4

For more, see Victaulic Publication 10.91.

22

4. Exposed Barrel Length*

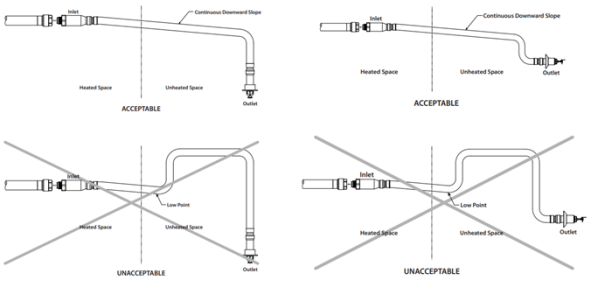
- Verify That The Exposed Minimum Barrel Length In The Heated Space Is Measured And Maintained In Accordance With The Table
- Refer To NFPA 13, 2022 Edition: **15.3 Dry Sprinklers**.

The flexible portion of the sprinkler is part of the sprinkler barrel and can be used to achieve the minimum exposed barrel length.

*When used in cold /unheated spaces. For more, see Victaulic Publication 10.91.

23

5. Continuous Downward Slope



For more, see Victaulic Publication 10.91.

24

Victaulic® VicFlex™ Sprinklers

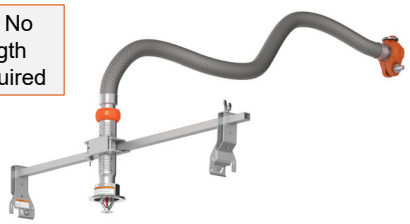
Standard Coverage Sprinkler
Style VS2

25

VicFlex™ Standard Coverage Sprinkler

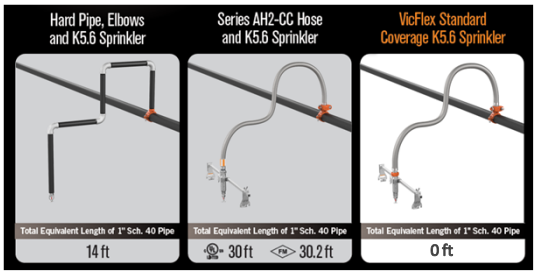
- Fully-assembled, UL Listed K5.6 Sprinkler
- Eliminates The Need For An Armover
- The Flexible Component Is Part Of The Sprinkler

System Design: No Equivalent Length Calculations Required



26

The Need for Flexible Sprinklers



Challenge: When the system is already calculated, switching from hard pipe to flexible hose meant recalculating the system to factor in equivalent lengths at each sprinkler connection.
Solution: No Equivalent Lengths Needed

27

Sprinkler Characteristics

Style
- Recessed Pendent
- Concealed Pendent

Response
- Quick Response
- Standard Response

K Factor
- 5.6 (US) | 80 (Metric)
- For system design purposes, no equivalent length calculations are required

Sprinkler Length
- 56" | 1422 mm
- 68" | 1727 mm
- Order and stock standard lengths without custom measurement

Maximum Working Pressure
- 175 psi | 1200 kPa

Factory Hydrostatic Test
- 100% @ 500 psi | 3447 kPa

Branchline Connection
- To branch line (inlet) via:
  - 1" NPT | 25mm BSPT
  - 1" IGS

Minimum Bend Radius:
- UL: 2" | 51 mm

Maximum Number of 90° Bends:
- UL: 4

Hazard Classifications
- Light and Ordinary Hazard

28

UL Listing


Concealed Pendent

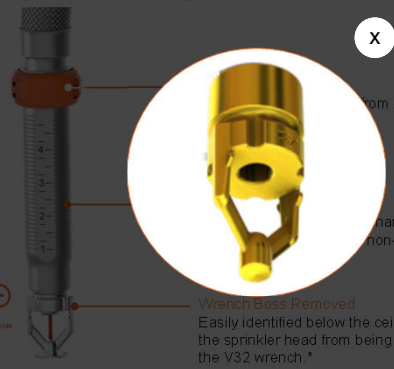

Recessed Pendent

APPROVALS/LISTINGS				
SIN	V3201	V3202	V3203	V3204
Nominal K Factor Imperial	5.6	5.6	5.6	5.6
Metric K-Factor (lpm/(bar)½)	80	80	80	80
Orientation	Pendent	Pendent	Pendent	Pendent
Escutcheon	Recessed	Recessed	Concealed	Concealed
	Approved Temperature Ratings F°/C°			
cULus	155°F/68°C 200°F/93°C	155°F/68°C 200°F/93°C	155°F/68°C 200°F/93°C	155°F/68°C 200°F/93°C

MAXIMUM ALLOWABLE NUMBER OF BENDS	
Nominal Sprinkler Length inches mm	Maximum Allowable Number of 90° Bends at 2"/51mm Bend Radius for UL Listing
56.0 1422	4
68.0 1727	4

29

Tamper Safeguards



30

Stocking Spares

- Spare Sprinklers Per NFPA 13
  - Access Replacements In A Timely Manner
- Replacement Head Kits Available
  - Head Is A Maintainable Component

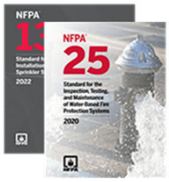


  - Do Not Need To Replace The Entire Assembly
  - Tamper Safeguards Make This Possible

31

Inspection

- The *Vicflex* Dry Sprinkler Should Be Installed, Inspected, Tested, And Maintained In The Same Manner As Other Dry Sprinklers: According To NFPA 13 And NFPA 25.



32

3696

1. Identification



For more, see Victaulic Publication 10.93.

33

2. Maximum Allowable Bends

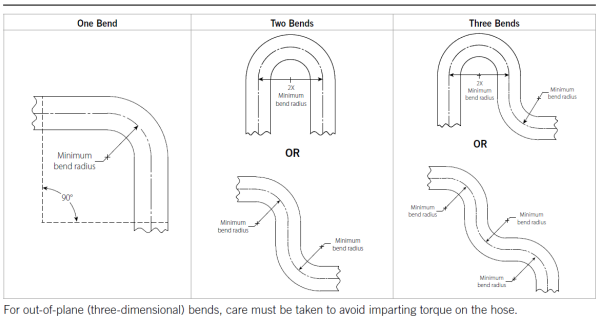
MAXIMUM ALLOWABLE NUMBER OF BENDS	
Nominal Sprinkler Length inches mm	Maximum Allowable Number of 90° Bends at 2"/51mm Bend Radius for UL Listing
56.0 1422	4
68.0 1727	4

Correcting Mistakes: Mistakes in bend radius or allowable bends can often be corrected by rerouting the flexible sprinkler in a different path.

For more, see Victaulic Publication 10.93.

34

Bend Radius Guide

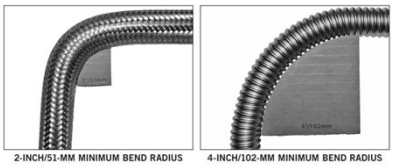


For out-of-plane (three-dimensional) bends, care must be taken to avoid imparting torque on the hose.

35

3. Minimum Bend Radius

- Smallest Allowed Radius The Flexible Sprinkler Is Allowed To Be Bent



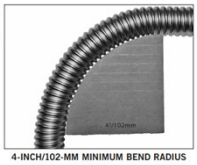
Visual Comparison:
2" Bend Radius vs 4" Bend Radius

36

3. Minimum Bend Radius



2-INCH/51-MM MINIMUM BEND RADIUS



4-INCH/102-MM MINIMUM BEND RADIUS

MAXIMUM ALLOWABLE NUMBER OF BENDS	
Nominal Sprinkler Length inches mm	Maximum Allowable Number of 90° Bends at 2"/51mm Bend Radius for UL Listing
56.0 1422	4
68.0 1727	4

For more, see Victaulic Publication 10.93.

37

Victaulic® VicFlex™ Sprinklers

Review Session / Q&A

38

Learn More

- Victaulic Website: **victaulic.com**
  - Product Submittals
  - Product / System Videos
  - Installation Manuals
  - Technical And Design Data
  - White Papers
  - Case Studies
- Approving Industry Organizations

39

LEARNING OBJECTIVES:

- Identify the components of VicFlex™ sprinklers
- Understand the use of *VicFlex* sprinklers
- Know how to identify and inspect *VicFlex* sprinklers
- Compare the hydraulic performance of a *VicFlex* standard coverage sprinkler with hard pipe and flexible sprinkler hose systems
- Understand how proper exposed barrel length is achieved with a *VicFlex* dry sprinkler

LESSONS:

- VicFlex™ Sprinklers: Combined Technology
- *VicFlex* Flexible Dry Sprinkler
- *VicFlex* Standard Coverage Sprinkler

Victaulic UNIVERSITY | CONTINUING EDUCATION

40

Victaulic® VicFlex™ Sprinklers

Assessment & Course Close

41

Instructions

- Complete Final Assessment And Provide To Facilitator
- Complete Course Evaluation And Provide To Facilitator
- Verify You Have Signed The Attendance Book

42

Victaulic® VicFlex™ Sprinklers

Thank You!

43



44

Victaulic | CONTINUING EDUCATION since 1919

Victaulic History



45

Victaulic | CONTINUING EDUCATION since 1919

Grooved Mechanical Piping Products



- 100,000+ Products & Patented Technologies
- ½" - 144" | DN15 – DN3600 Diameter Solutions

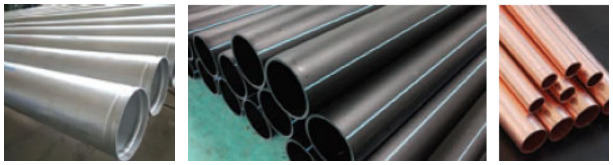
46

Victaulic | CONTINUING EDUCATION since 1919

Diverse Material Solutions

- Metals
- Plastics
- Coatings / Li
- Epoxy





47

Victaulic | CONTINUING EDUCATION since 1919

Diversity In Market Solutions



48

3700

Design Document

Purpose

- The purpose of this document is to identify course structure, learning outcomes, and facilitation and assessment methods

Details

- Course Name: Victaulic VicFlex Sprinklers
- Learning Solution: Instructor-Led Classroom
- Revision Dates:
  - Rev A: 08/2022

Lesson Name	Time Allotted (Minutes)	Learning Objective	Tasks	Required Materials	Learning Method / Style	Assessment Method And Performance Criteria	Comments
• Welcome	5	• Provide the learner with an introduction to staff, and an overview of guidelines, expectations and course structure	• Define expectations and course structure	• Attendance Book • PowerPoint Presentation File • Learner Guide	• Lecture / Presentation – Auditory – Visual	• N/A	
• Introduction		• Provide the learner with an overview of lessons, materials, and objectives	• Describe program details and purpose	• PowerPoint Presentation File • Learner Guides	• Lecture / Presentation – Auditory – Visual	• N/A	
• Lesson 1: VicFlex Sprinklers – Combined Technology	10	• Understand the use of VicFlex sprinklers	• Define what a flexible sprinkler is • Explain the benefits of the VicFlex sprinkler	• PowerPoint Presentation File • Learner Guide	• Lecture / presentation – Auditory – Visual	• Q&A during lesson • Assessment at the end of the course – Passing score is 80%	

Continued on next page

Details, continued

Lesson Name	Time Allotted (Minutes)	Learning Objective	Tasks	Required Materials	Learning Method / Style	Assessment Method And Performance Criteria	Comments
• Lesson 2: VicFlex Dry Sprinkler Style VS1	15	• Identify the components of VicFlex™ Dry Sprinkler Style VS1 • Know how to identify and inspect VicFlex Style VS1 sprinklers • Understand how proper exposed barrel length is achieved with a VicFlex Style VS1 sprinkler	• Identify the applicable listings & approvals • Review the types of applications • Explain how it works • Review the sprinkler characteristics • Determine the proper exposed barrel length	• PowerPoint Presentation File • Learner guide	• Lecture / presentation – Auditory – Visual	• Q&A during lesson • Assessment at the end of the course – Passing score is 80%	

Continued on next page

Details, continued

Lesson Name	Time Allotted (Minutes)	Learning Objective	Tasks	Required Materials	Learning Method / Style	Assessment Method And Performance Criteria	Comments
• Lesson 3: VicFlex Standard Coverage Sprinkler Style VS2	15	• Identify the components of VicFlex™ Dry Sprinkler Style VS2 • Know how to identify and inspect VicFlex Style VS2 sprinklers • Understand how proper exposed barrel length is achieved with a VicFlex Style VS2 sprinkler	• Identify the applicable listings & approvals • Review the types of applications • Explain how it works • Review the sprinkler characteristics • Determine the proper exposed barrel length	• PowerPoint Presentation File • Learner guide	• Lecture / presentation – Auditory – Visual	• Q&A during lesson • Assessment at the end of the course – Passing score is 80%	

Continued on next page

Details, continued

Lesson Name	Time Allotted (Minutes)	Learning Objective	Tasks	Required Materials	Learning Method / Style	Assessment Method And Performance Criteria	Comments
• Review Session / Q&A	5	• Provide learner with a knowledge of additional resources • Answer all learner questions • Ask learners questions to check for comprehension of new skills and knowledge	• Discuss new knowledge and skills	• All materials listed above	• Discussion / review material and skills	• N/A	
• Assessment	15	• Measure comprehension of new knowledge and skills	• Demonstrate new knowledge and skills	• Assessment – Hardcopy • Pen	• Application of new knowledge and skills – Knowledge – Comprehension – Analysis • Evaluation	• Assessment at the end of the course • Passing score is 80%	

Continued on next page

Lesson Name	Time Allotted (Minutes)	Learning Objective	Tasks	Required Materials	Learning Method / Style	Assessment Method And Performance Criteria	Comments
• Course Close	5	• Review resources • Review assessment • Verify – All learner questions have been answered – All registration information completed and collected – All course evaluations completed and collected	• Present feedback on the learner's comprehension of new knowledge and skills • Communicate resource information • Present feedback on learning experience	• Learner guide – Course evaluation is the last page • Additional course materials as needed	• Discussion	• Q&A as needed	• The assessment is reviewed after all learners have provided their completed assessment to the facilitator • The facilitator is responsible for: – Collecting the completed assessments, course evaluations, and attendance book – Returning the above materials to the Training Administrator in the specified timeline