

Chapter 5

Grounding, Bonding, and Neutrals

Grounding • Bonding • Grounded Conductors • Metal Bonding Jumper • Grounding Electrode Conductor • Grounding Electrodes • Equipment Grounding Conductors • Bonding Jumper (Conductors) • System Bonding Jumper • System Grounding Electrode Conductor • Grounding Electrode Conductor • Grounding Electrode Conductor for Single-Phase (1ø) and Three-Phase (3ø) Systems • Ungrounded Systems

1

Plans and Spec's

- ▶ What we will be covering will be the Codebook on Grounding and Bonding.
- ▶ If you project has specific items that are in the spec's then **that is what you will need to install if greater than what the code requires.**

2

Grounding/Bonding

- ▶ We use these terms in multiple locations and uses.
- ▶ We say we grounded a motor, did we?

3

Definitions

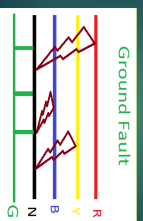
Ground – The Earth



4

Ground fault

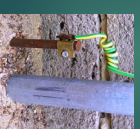
- ▶ An unintentional, electrically conductive connection between an ungrounded conductor of an electrical circuit and the normally non-current carrying conductors, metallic enclosures, metallic raceways, metallic equipment, or earth.



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Grounded (Grounding)

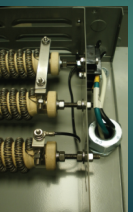
- ▶ Connected (connecting) to ground or to a conductive body that extends the ground connections.



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Grounded, Solidly

- ▶ Connected to ground without inserting any resistor or impedance device.
- ▶ A system with a impedance in it is called an HRCg system.



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Grounded Conductor

- ▶ A system or circuit conductor that is intentionally grounded. White or Gray in Color.



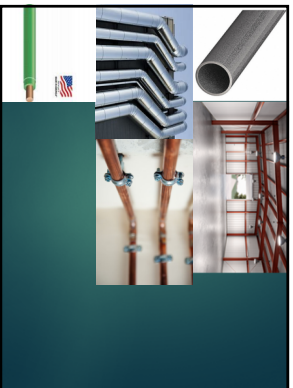
8

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, equipment, or the earth to the electrical supply source.

This is any conductive path from the ground fault back to the power source.

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EFFECTIVE GROUND FAULT CURRENT PATH.

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 on high-impedance grounded systems.



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Grounding Conductor (Equipment)

- ▶ A conductive path 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.



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Grounding Electrode

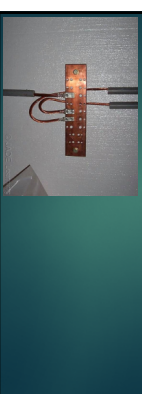
- ▶ A conductive object through which a direct connection to earth is established.



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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.



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Bonded (Bonding)

- ▶ Connection to establish electrical continuity and conductivity.



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BONDED (BONDING) Conductor

- ▶ A reliable conductor to ensure the required electrical conductivity between metal parts required to be electrical connected.



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BONDING JUMPER, EQUIPMENT

- ▶ A reliable conductor to ensure the required electrical conductivity between metal parts required to be electrically connected.



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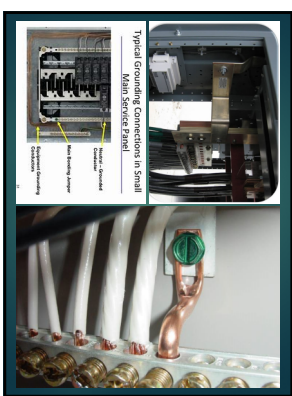


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MAIN BONDING JUMPER

▶ The connection between the grounded circuit conductor and the equipment grounding conductor at the service.

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BONDING JUMPER SUPPLY SIDE

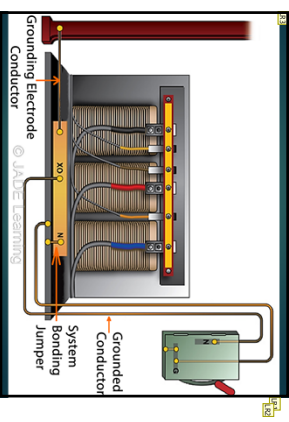
A conductor installed on the supply side of a service or within a service equipment enclosure(s), or for a separately derived system, that ensures the required electrical conductivity between metal parts required to be electrically connected.

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SYSTEM BONDING JUMPER

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

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250.4 General Requirements for Grounding and Bonding

(A) (1) Electrical System Grounding
Electrical systems that are grounded shall be connected to earth in a manner that will limit the voltage imposed by lightning, line surges, or unintentional contact with higher-voltage lines and that will stabilize the voltage to earth during normal operation.

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Slide 24

LR1 Supply Side Bonding Jumper

Lowell Reith, 2/23/2020

LR2 Supply Side Bonding Jumper

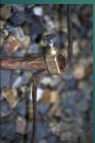
Lowell Reith, 2/23/2020

LR3 Lowell Reith, 2/23/2020

250.4 General Requirements for Grounding and Bonding

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

- Establish a low-impedance path and wiring and other electrically conducting material likely to become energized shall be related to a manner that creates a low-impedance circuit facilitating the operation of the overcurrent device or ground detector for high-impedance grounded systems. It shall be capable of safely carrying the maximum ground-fault current without causing the system to become an ungrounded system while ground-fault current is being carried by the electrical system. The earth shall not be considered as an effective ground-fault current path.



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This is NOT an Effective Ground-Fault Current Path



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Objectionable Current

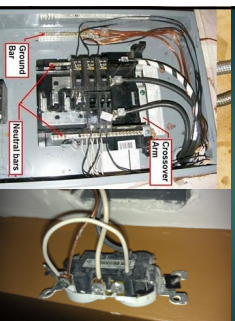
- Article 250.6 – Objectionable Currents
- Objectionable currents happen:
 - Wrong neutral is connected to panel
 - 277 neutral to 120 panel
- Equipment grounding conductor connected to grounded conductor
- Feeder panels with Main bonding jumper installed.

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Objectionable Current

- Article 250.6 – Objectionable Currents
- How to stop Objectionable Currents
- Disconnect all but one of the grounding connections
- Change locations of grounding connections
- Interrupt the continuity of the conductor or conductive path causing the objectionable currents.

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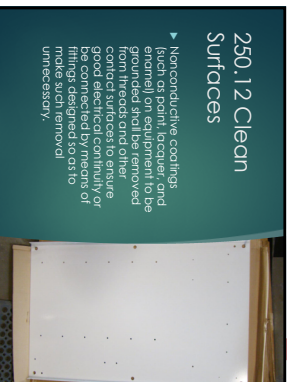
250.8 Connections for Grounding and Bonding

- Connections for grounding and bonding shall be made by one of the following means:
 - (1) Listed pressure connectors
 - (2) Terminal bars
 - (3) Pressure connectors listed as grounding & bonding equipment
 - (4) Exothermic welding process
 - (5) Machine screw-type fasteners that engage not less than 1/2 inch of threaded length
 - (6) Machine screw-type fasteners that engage not less than 1/2 inch of threaded length
 - (7) The fasteners are secured with a nut and washer
 - (8) The fasteners are secured with a nut and washer and the fasteners are not less than two threads in the enclosure
 - (9) Connections that are part of a listed assembly
 - (10) Other listed means

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250.12 Clean Surfaces

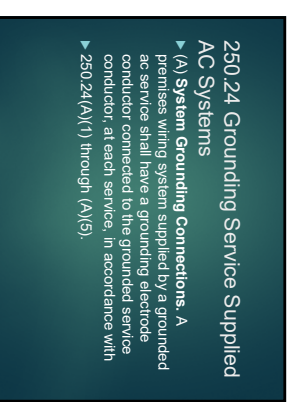
- Nonconductive coatings (such as paint, lacquer, and enamel) on equipment to be grounded shall be removed from threads and other contact surfaces to ensure good electrical continuity or the equipment shall be made electrically continuous by means of make such removal unnecessary.



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250.24 Grounding Service Supplied AC Systems

- (A) System Grounding Connections. A premises wiring system supplied by a grounded ac service shall have a grounding electrode conductor connected to the grounded service conductor, at each service, in accordance with 250.24(A)(1) through (A)(5).



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250.24 Grounding Service Supplied AC Systems

- ▶ (A) (1) **General.** The grounding electrode conductor connection shall be made at any accessible point from the load end of the service drop or service lateral to and including the terminal or bus to which the grounded service conductor is connected at the service disconnecting means.

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250.24 Grounding Service Supplied AC Systems

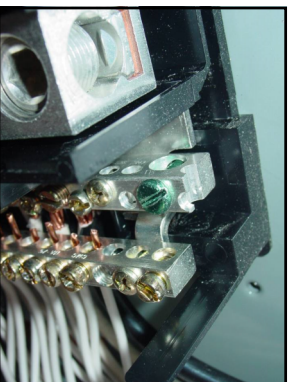
- ▶ (A) (2) **Outdoor Transformer.** Where the transformer supplying the service is located outside the building, at least one additional grounding connection shall be made from the grounded service conductor to a grounding electrode, either at the transformer or elsewhere outside the building.

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250.24 Grounding Service Supplied AC Systems

- ▶ (A) (5) **Load-Side Grounding Connections.** A grounded conductor shall not be connected to normally non-current carrying metal parts of equipment, to equipment grounding conductor(s), or be reconnected to ground on the load side of the service disconnecting means except as otherwise permitted in this article.
- ▶ Bonding in Feeder panels

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250.24 Grounding Service Supplied AC Systems

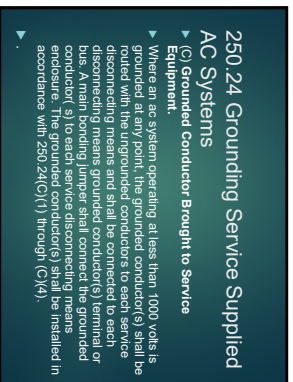
- ▶ (B) **Main Bonding Jumper.** For a grounded system, an unspliced main bonding jumper shall be used to connect the equipment grounding conductor(s) and the service-disconnect enclosure to the grounded conductor within the enclosure for each service disconnect in accordance with 250.28.

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250.24 Grounding Service Supplied AC Systems

- ▶ (C) **Grounded Conductor Brought to Service Equipment.**
- ▶ Where an ac system operating at less than 1000 volts is grounded at any point, the grounded conductor(s) shall be routed with the ungrounded conductors to each service disconnecting means and shall be connected to each bus. A main bonding jumper shall connect the grounded conductor(s) to each service disconnecting means enclosure. The grounded conductor(s) shall be installed in accordance with 250.24(C)(1) through (C)(4).

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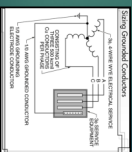
Sizing Grounded Conductor

- ▶ (C) (1) **Sizing for a Single Raceway.** The grounded conductor shall not be smaller than the required grounded conductor for the ungrounded conductors. The grounded conductor shall be sized in accordance with 250.102(C)(1) and shall be installed in the same raceway as the ungrounded conductors. In addition, for sets of ungrounded service-entrance conductors larger than 1100 kcmil copper or 1750 kcmil aluminum, the grounded conductor shall not be smaller than 12 1/2 percent of the circular mil area of the largest set of service-entrance ungrounded conductor(s).

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Sizing Grounded Conductor

- (c) (1) **Starting for a Single Raceway.** The grounded conductor shall be sized so that it is not smaller than the required grounding electrode conductor specified in Table 250.102(C).
- (1) Note that the required 50 kCMIL grounded conductor is based on the 125% multiplier for ungrounded service-entrance conductors. In addition, for service-entrance conductors, the grounded conductor shall not be smaller than 12/2 AWG.



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Sizing Grounded Conductor

What size is required for the grounded conductor for a service that is rated at 400 amps using 600 KCMIL copper conductors?

250.24 C 1, 250.102(C)(1) Table

Answer #1/0 AWG

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Sizing Grounded Conductor

What size grounded conductor is required for a service that has 1500 KCMIL used to feed the service?

250.24 C 1, 250.102(C)(1) Note 1, Table 8 Chapter 9
Circular Mils $\times 12.5\%$

Answer
 $1,500,000 \times 12.5\% = 187,500 \text{ CM} =$
#4/0 AWG

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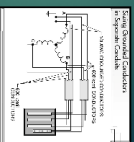
Sizing Grounded Conductor

- (c) (2) **Parallel Conductors in Two or More Raceways.** If the ungrounded service-entrance conductors are installed in parallel in two or more raceways, the grounded conductor shall also be installed in parallel. The size of the grounded conductor in each raceway shall be based on the total circular mil area of the parallel ungrounded conductors in the raceway, as indicated in 250.24(C)(1), but not smaller than 1/0 AWG.

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- When conductors are installed in separate conduits, the grounded conductor shall be sized based on the service-entrance conductors in each raceway.

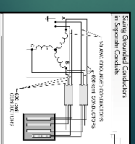
- The minimum size of the grounded conductor in parallel is #1/0 AWG as per 250.24 C 2



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- What size grounded conductor is required for a 800 amp service using 2-sets of 600 KCMIL conductors?
- 250.24 C 2, 250.102 (C)(1)

► Answer #1/0 AWG



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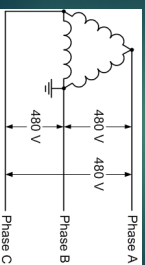
Sizing Grounded Conductor

- What size grounded conductors are required for a 400 amp service with 2 sets of 250 KCMIL conductors per phase?
- 250.24 C 2, 250.102 (C)(1)
- Answer #1/0 AWG

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250.24 Grounding Service Supplied AC Systems

- [C] (3) **Delta-Connected Service.** The grounded conductor of a 3-phase, 3-wire delta service shall have an ampacity not less than that of the ungrounded conductors.



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250.24 Grounding Service Supplied AC Systems

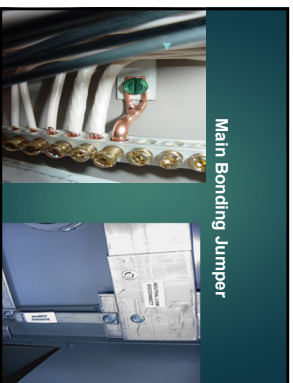
- [C] (4) **High Impedance.** The grounded conductor on a high impedance grounded neutral system shall be grounded in accordance with 250.36



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250.28 Main Bonding Jumper

- ▶ The main bonding jumper provides the fault current path from the equipment grounding conductor to the grounded conductor.
- ▶ The grounded conductor takes it back to the transformer and allows the OCPD to open.

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250.28 Main Bonding Jumper

250.28 A
Can be a Wire, Screw, Bus, or similar suitable conductor

▶ 250.28 A.2
If it is a screw it has to have a Green finish that is visible after installation.

250.28 D.1 Sizing if it is a Wire
Not less than 100 KCMIL (Al), or 12.5% of conductor(s) per phase if over 1100 KCMIL in Al.

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250.28 Main Bonding Jumper

▶ What size main bonding jumper of the wire type is required for a 225 amp service using 250 KCMIL copper conductors?

250.28 D.1, 280, 102 (C)(1)

#2 AWG

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250.30 Separately Derived Systems

Page 57 in Book.

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250.30 Separately Derived Systems

(A) Grounded Systems

▶ (1) System Bonding Jumper. An unspliced system bonding jumper shall comply with 250.28(A) through (C). The connection shall be made at any single point on the separately derived system from the source to the first system disconnecting means or overcurrent device. (continued)

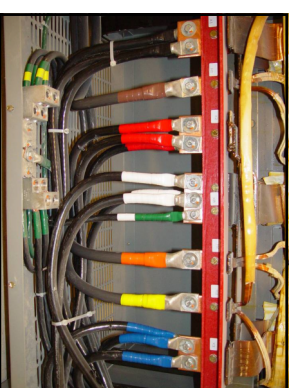
61

250.30 Separately Derived Systems

System Bonding Jumper.

or it shall be made at the source of a separately derived system that has no disconnecting means or overcurrent devices, in accordance with 250.30(A)(1)(a) or (b). The system bonding jumper shall remain within the enclosure where it originates. If the source is located outside the building or structure supplied, a system bonding jumper shall be installed at the grounding electrode connection in compliance with 250.30(C).

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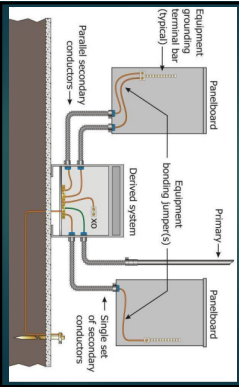


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250.30 Separately Derived Systems

- (2) Supply-Side Bonding Jumper. The supply-side bonding jumper shall be permitted to be of nonflexible metal raceway type or of the wire or bus type as follows:
- (a) A supply-side bonding jumper of the wire type shall comply with 250.142(C), based on the size of the derived ungrounded conductors.
- (b) 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).

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250.30 Separately Derived Systems

- (3) Grounded Conductor. If a grounded conductor is installed and the system bonding jumper connection is not located at the source, 250.30(A)(3)(e) through (A)(3)(d) shall apply.

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250.30 Separately Derived Systems

- (3) Grounded Conductor.
- (i) Sizing for a Single Raceway. The grounded conductor shall not be smaller than the required grounding electrode conductor specified in Table 250.102 (C) (1) but shall not be required to be larger than the largest derived ungrounded conductor(s). In addition, Note 1, for sets of derived ungrounded conductors larger than 1100 kcmil copper or 750 kcmil aluminum, the grounded conductor shall not be smaller than 12 1/2 percent of the circular mil area of the largest set of derived ungrounded conductors.

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250.30 Separately Derived Systems

- (3) Grounded Conductor.
- (ii) Parallel Conductors in Two or More Raceways. If the ungrounded conductors are installed in parallel in two or more raceways, the grounded conductor shall also be installed in parallel. The size of the grounded conductor in each raceway shall be based on the total circular mil area of the parallel derived ungrounded conductors in the raceway as indicated in 250.30(A)(3)(e), but not smaller than 1/6 AWG.

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250.30 Separately Derived Systems

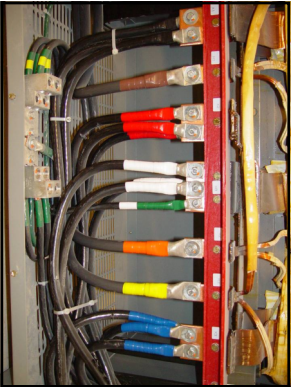
- (4) Grounding Electrode. The building's structure grounding electrode shall be used as the grounding electrode for the separately derived system.
- (c) If outdoors, the grounding electrode shall be accordance with 250.30

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250.30 Separately Derived Systems

- (4) Grounding Electrode Conductor, Single Separately Derived System. A conductor for a single separately derived system shall be sized in accordance with 250.66 for the derived ungrounded conductors.
- It shall be used to connect the grounded conductor of the derived system to the grounding electrode as specified in 250.30(A)(4). This connection shall be made at the same point on the separately derived system where the system bonding jumper is connected.

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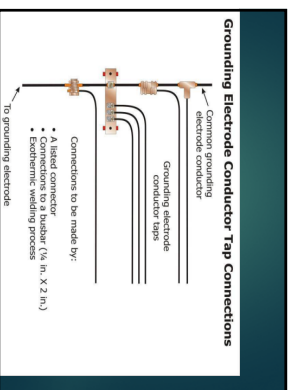


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250.30 Separately Derived Systems

- (6) Grounding Electrode Conductor, Multiple Separately Derived Systems. A common grounding electrode conductor for multiple separately derived systems shall be permitted. If installed, the common grounding electrode conductor shall be used to connect the grounded conductor of the separately derived systems to the grounding electrode as specified in 250.30(A)(4). (Continue)

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250.30 Separately Derived Systems

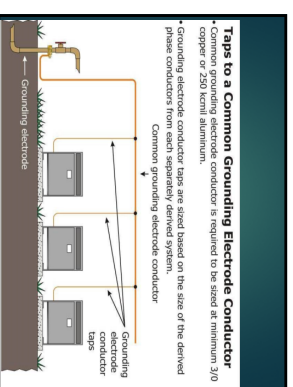
(B) Grounding Electrode Conductor, Multiple Separately Derived Systems

(a) Common Grounding Electrode Conductor. The common grounding electrode conductor shall be permitted to be one of the following:

(1) A conductor of the wire type not smaller than 3/0 AWG copper or 250 kcmil aluminum.

(2) A conductor of the building or structure that complies with 250.52(A)(2), or is connected to the grounding electrode system by a conductor that shall not be smaller than 3/0 AWG copper or 250 kcmil aluminum, 250.68 (C)(2).

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250.32 Building or Structures Supplied by a Feeder or Branch Circuits

(A) Grounding Electrodes

Each building or structure supplied by feeders or branch circuits shall have a grounding electrode or grounding electrode system installed in accordance with Part III of Article 250.

When no existing grounding electrode, the grounding electrodes required in 250.52 shall be installed.

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250.32 Building or Structures Supplied by a Feeder or Branch Circuits

(B) Grounded Systems

(1) Supplied by a Feeder or Branch Circuit. An equipment grounding conductor, as described in 250.118, shall be run with the supply conductors in the raceway or cable, and shall be connected to the equipment grounding conductor of the feeder or branch circuit at the point of entrance to the building or structure. The equipment grounding conductor shall be grounded or bonded to the equipment grounding conductor that shall be connected to the equipment grounding conductor or to the grounding electrode(s). See Exception.

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250.35 Permanently Installed Generators

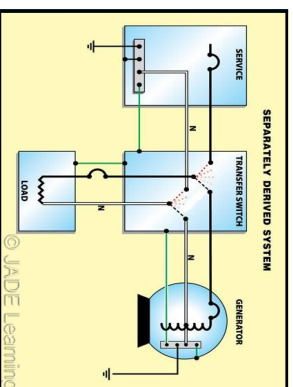
(A) Separately Derived Systems

Must follow 250.30 requirements.

Must have the neutral switched as well as phases.

Note: Bonding jumper in generator must be installed from case to neutral.

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250.35 Permanently Installed Generators

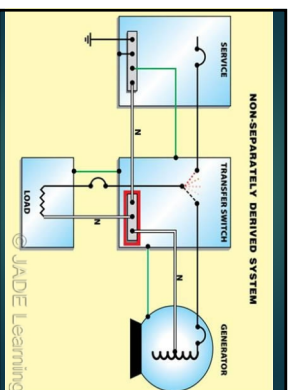
(B) Non-Separately Derived Systems

Must remove Bonding Jumper in generator.

Must install Supply side Bonding Jumper from Generator to disconnecting means or transfer switch.

Must size the Supply Side Bonding Jumper from 250.102 (C).

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250.36 High Impedance Grounds

High-Impedance Grounded Neutral Systems.

High-impedance grounded neutral systems in which a grounding impedance, usually a reactor, limits the ground fault current to a low value shall be permitted for 3-phase systems and 2-phase, 3-wire systems having line-to-line voltages not in excess of 1000 volts if all the following conditions are met:

- (1) The conditions of maintenance and supervision ensure that only qualified persons service the installation.
- (2) Ground detectors are installed on the system.
- (3) Line-to-neutral loads are not served.

High-impedance grounded neutral systems shall comply with the provisions of 250.36(A) through (C).

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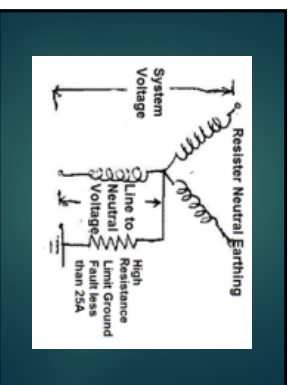
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250.36 High Impedance Grounds

(B) Grounded System Conductor. The grounded system conductor from the neutral point of the transformer or generator to its connection point to the grounding impedance shall be fully insulated.

The grounded system conductor shall have an ampacity of not less than the maximum current rating of the grounding impedance but in no case shall the grounded system conductor be smaller than 8 AWG copper or 4 AWG aluminum or copper-clad aluminum.

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250.36 High Impedance Grounds

(C) System Grounding Connection.

The system shall not be connected to ground except through the grounding impedance.

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250.36 High Impedance Grounds

D) Neutral Point to Grounding Impedance Conductor Routing.

The conductor connecting the neutral point of the transformer or generator to the grounding impedance shall be fully insulated in respect to the grounded conductors. It shall not be required to run this conductor with the phase conductors to the first system disconnecting means or overcurrent device.

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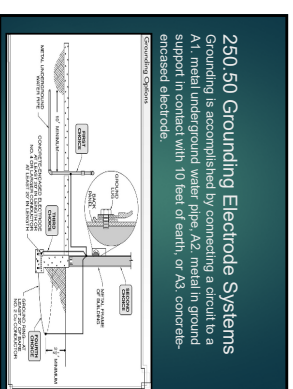
250.50 Grounding Electrode Systems

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Grounding Electrode System. All grounding electrodes as described in 250.52(A)(1) through (A)(7) that are present at each building or structure served shall be bonded together to form the grounding electrode system.

(Continue)

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250.50 Grounding Electrode Systems

Grounding Electrode System

Where more 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.

Exception: Concrete-encased electrodes of existing buildings or structures are required to be part of the grounding electrode system only if the building has or will have a metal roof and the bars or rods are not accessible for use without disturbing the concrete.

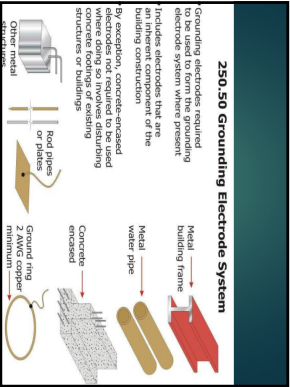
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250.52 Grounding Electrode Types

Grounding Electrodes That are Permitted to be Used

- A4 Ground Ring #2 copper or larger and at least 20' AS Rod or Pipe #1 in contact with earth.
- A5 Other Labeled Electrodes
- A7 Plate Electrode 2 sq ft in contact with earth
- A8 Other local metal underground systems (Well Casing, Metal Tanks)

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250.52 Grounding Electrodes

(B) Not Permitted for Use as Grounding Electrodes. The following systems and materials shall not be used as grounding electrodes.

- (1) Metal underground gas piping systems
- (2) Plenum
- (3) Reinforcing steel on a swimming pool.

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250.53 Grounding Electrode System Installation

(A) Rod, Pipe, and Plate Electrodes. Rod, pipe, and plate electrodes shall meet the requirements of 250.53(A)(1) through (A)(3).

(1) Below Permanent Moisture Level. If practicable, rod, pipe, and plate electrodes shall be embedded below permanent moisture level. Rod, pipe, and plate electrodes shall be free from nonconductive coatings such as paint or enamel



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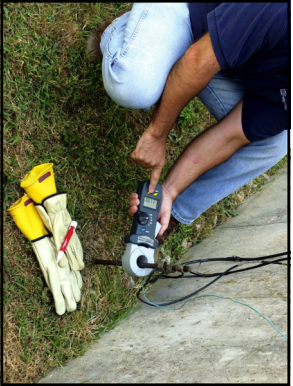
250.53 Grounding Electrode System Installation

(A)(2) Supplemental Electrode Required. A single rod, pipe, or plate electrode shall be supplemented by an additional electrode of a type specified in 250.52(A)(1) through (A)(8) if the supplemental electrode shall be permitted to be bonded to one of the following:

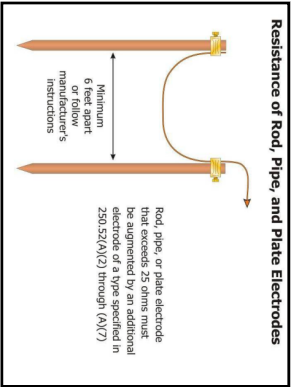
- (1) Rod, pipe, or plate electrode
 - (2) Grounding electrode conductor
 - (3) Grounded service-entrance conductor
 - (4) Nonflexible grounded service raceway
 - (5) Any grounded service entrance
 - (6) Any grounded metal raceway
- Supplemental electrode has a resistance to earth of 25 ohms or less. The supplemental electrode shall not be required.



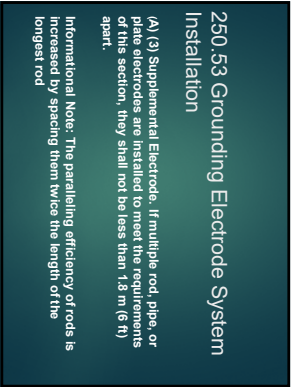
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98



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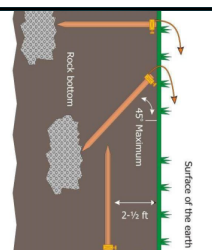
250.53 Grounding Electrode System

Installation

(A)(4) Rod and Pipe Electrodes. The electrode shall be installed such that at least 2.44 m (8 ft) of length is in contact with the soil. It shall be driven to a depth of not less than 2.44 m (8 ft) except that, where rock bottom is encountered, the electrode shall be installed to a depth of not less than 1.83 m (6 ft) below the vertical or, where rock bottom is encountered at an angle up to 45 degrees, the electrode shall be permitted to be buried in a trench that is at least 750 mm (30 in.) deep. The upper end of the electrode shall be flush with or below ground level unless the electrode is installed in a trench, in which case the upper end attachment is protected against physical damage as specified in 250.10.

100

Installation of Rod or Pipe Electrodes



250.53 Grounding Electrode System Installation

101

250.53 Grounding Electrode System Installation

M(1) Metal Underground Water Pipe. The electrode shall be installed in the water pipe, not less than 1.83 m (6 ft) below the surface of the earth, and shall comply with the requirements of 250.53(C)(1) and (D)(2).

N(1) Cast-In-Place Concrete. The bonding connection to the grounding path or the electrode shall be made on water meters or filtering devices and similar equipment.



102

250.53 Grounding Electrode System Installation

- (D) Metal Underground Water Pipe. The electrode shall be installed in the water pipe, not less than 1.83 m (6 ft) below the surface of the earth, and shall comply with the requirements of 250.53(C)(1) and (D)(2).
- (E) Supplemental Electrode Bonding Connection Size. Where the supplemental electrode is a rod, pipe, or plate electrode, that portion of the bonding jumper that is the sole connection to the supplemental grounding electrode shall not be required to be larger than 6 AWG copper wire or 4 AWG aluminum wire.
- (F) Ground Ring. The ground ring shall be buried at a depth below the earth's surface of not less than 750 mm (30 in.).
- (G) Grounding Electrode Material. The electrode shall be made of one of the following:
 - (1) Galvanized steel
 - (2) Grounded service-entrance conductor
 - (3) Nonflexible grounded service raceway
 - (4) Any grounded service enclosure
 - (5) As provided by 250.32(B)

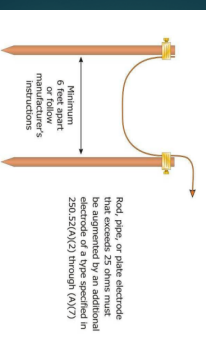
103

250.53 Grounding Electrode System Installation

(E) Supplemental Electrode Bonding Connection Size. Where the supplemental electrode is a rod, pipe, or plate electrode, that portion of the bonding jumper that is the sole connection to the supplemental grounding electrode shall not be required to be larger than 6 AWG copper wire or 4 AWG aluminum wire.

104

Resistance of Rod, Pipe, and Plate Electrodes



105

250.53 Grounding Electrode System Installation

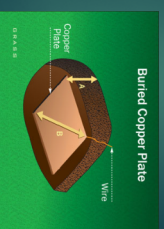
(F) Ground Ring. The ground ring shall be buried at a depth below the earth's surface of not less than 750 mm (30 in.).



106

250.53 Grounding Electrode System Installation

(H) Plate Electrode. Plate electrodes shall be installed not less than 750 mm (30 in.) below the surface of the earth.

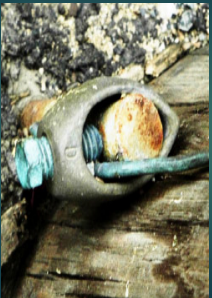


107

250.54 Auxiliary Grounding Electrodes

Grounding Electrodes. One or more grounding electrodes shall be permitted to be connected to the equipment grounding conductors specified in 250.118 and shall not be required to comply with the electrode bonding requirements of 250.53(A)(2) or the resistance requirements of 250.53(A)(2) Exception, but the earth shall not be used as an effective ground-fault current path as specified in 250.4(A)(9) and 250.4(B)(4).

108



109

250.58 Common Electrodes

Common Grounding Electrode. Where an ac system is connected to a grounding electrode in or at a building or structure, the same electrode shall be used to ground conductor enclosures and equipment in or on that building or structure. Where separate services, feeders, or branch circuits supply a building and are required to be grounded to a separate grounding electrode(s), the same grounding electrode(s) shall be used.

Two or more grounding electrodes that are bonded together shall be considered as a single grounding electrode system in this sense.

110



111

250.64 Grounding Electrode Conductor Installation

(A) Aluminum or Copper-Clad Aluminum Conductors or copper conductors can be used. . . . Bare aluminum or copper-clad aluminum grounding electrode conductors shall not be used where in direct contact with masonry or the earth or where subject to corrosion. Aluminum or copper-clad aluminum grounding electrode conductors shall not be terminated within 450 mm (18 in.) of the earth.

112

250.64 Grounding Electrode Conductor Installation

(B) Securing and Protection Against Physical Damage. Where exposed, a grounding electrode conductor or its enclosure shall be securely fastened to the surface on which it is carried. Grounding electrode conductors shall be permitted to be installed on or through framing members.

113

250.64 Grounding Electrode Conductor Installation

(B) Securing and Protection Against Physical Damage. Where exposed, a grounding electrode conductor or its enclosure shall be securely fastened to the surface on which it is carried. Grounding electrode conductors shall be permitted to be installed on or through framing members

114

250.64 Grounding Electrode Conductor Installation

C) Continuous. Except as provided in 250.30(A)(9) and (A)(9), 250.30(B)(1), and 250.68(C), grounding electrode conductor(s) shall be installed in one continuous length without a splice or joint. If necessary, splices or joints shall be made as permitted in (1) through (4):

- (1) Splicing of the wire-type grounding electrode conductor shall be permitted only by irreversible compression type connectors listed as grounding and bonding equipment or by the exothermic welding process.
- (2) Connections 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) The sheet, welded, brazed, soldered or bolted-flange connections of metal water piping.

115

250.64 Grounding Electrode Conductor Installation

(D) Service with Multiple Disconnecting Means Enclosures. If a service consists of more than a single enclosure as permitted in 230.71(A), grounding electrode connections shall be made in accordance with 250.64(D)(1), (D)(2), or (D)(3).

116

250.64 Grounding Electrode Conductor Installation

(1) Common Grounding Electrode Conductor and Taps. A common grounding electrode conductor and grounding electrode conductor taps shall be installed. The common grounding electrode conductor shall be installed in one continuous length without a splice or joint. The common grounding electrode conductor shall be installed in one continuous length without a splice or joint. The common grounding electrode conductor shall be installed in one continuous length without a splice or joint. The common grounding electrode conductor shall be installed in one continuous length without a splice or joint.

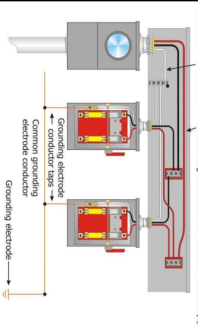
117

250.64 Grounding Electrode Conductor Installation

- Can be done with:
- (1) Exothermic welding
 - (2) Connections made by brazing
 - (3) Connections to an aluminum or copper busbar and not less than 6 mm x 50 mm (1/4 in. x 2 in.). The busbar shall be securely fastened and shall be installed in an accessible location. Connections shall be made by a listed connector or by the exothermic welding process. Aluminum conductors are used only in installations that comply with 250.64(A).

118

Taps to Common Grounding Electrode Conductor



119

250.64 Grounding Electrode Conductor Installation

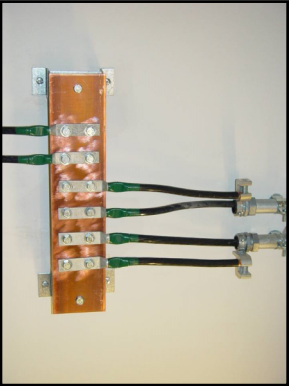
- (E) Enclosures for Grounding Electrode Conductors
- (1) Ferrous metal enclosures for grounding electrode conductors shall be electrically continuous from the point of attachment to cabinets or equipment to the grounding electrode and shall be securely fastened to the nonferrous metal enclosures shall not be required to be electrically continuous. Ferrous metal enclosures that are not physically continuous from cabinets or equipment to the grounding electrode shall be made electrically continuous by bonding each end of the raceway or enclosure to the grounding electrode conductor.
- (Continued)

121

250.64 Grounding Electrode Conductor Installation

- (E) Enclosures for Grounding Electrode Conductors
- Bonding methods in compliance with 250.92(B) for installations at service equipment locations and with 250.92(B)(2) through (B)(4) for other than service equipment locations shall apply. A cable and cable assembly for grounding electrode conductors shall be installed in a raceway or other suitable enclosure and shall be electrically continuous from the grounding electrode conductor raceway or cable armor shall be the same grounding electrode conductor raceway or cable armor shall be the same raceway is used as protection for a grounding electrode conductor, the installation shall comply with the requirements of the applicable raceway article.

122



123

250.66 Grounding Electrode Conductor

- 250.66. Steel based on the phase conductors brought to the service based on the largest is a 350 AWG
- A. Connection to Rod, Pipe, and Plate Electrode
 - B. Connection to Concrete Encased Electrode
 - C. Connection to Ground Ring
- Not larger than what is used for the ring. #2 minimum. Add parallel phase conductor 90A together to get phase size.

124

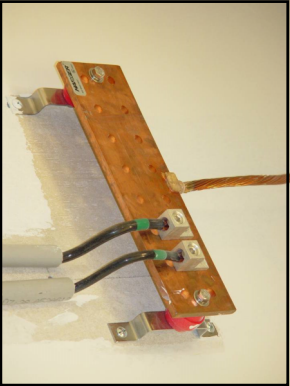


125

250.68 Grounding Electrode Conductor and Bonding Jumper Connection to Grounding Electrodes.

- (C) Metallic Water Pipe and Its Ground Support Metal. Grounding electrode shall be connected to the water pipe within 1.52 m (5 ft) from the point of entrance to the building shall not be permitted to be used as a grounding electrode system.
- (1) Interior metal water piping located not more than 1.52 m (5 ft) from the point of entrance to the building shall not be permitted to be used as a grounding electrode system, connect electrodes that are part of the grounding electrode system.

126



120

250.68 Grounding Electrode Conductor and Bonding Jumper Connection to Grounding Electrodes.

- (2) The structural frame of a building that is directly connected to a grounding electrode, as specified in 250.52(A)(2) or 250.56(C)(2)(a), (b), or (c), shall be connected to the grounding electrode by a bonding jumper. The electrodes that are part of the grounding electrode system, or as a grounding electrode conductor:
- a. By connecting the structural metal frame to the reinforcing bars of a concrete-encased electrode, as provided in 250.52(A)(3), or
 - b. By bonding the structural metal frame to one or more of the grounding electrodes, as specified in 250.52(A)(9) or (A)(10), that comply with (2) c. By other approved means of establishing a connection to earth.

127

250.92 Service Bonding

(A) Bonding of Equipment for Examples. The normally non-current-carrying metal parts of equipment included in 250.52(A)(1) and (A)(2) shall be bonded together.

- (1) All raceways, cable trays, cabinets, framework, auxiliary gutters, or service cable armor or sheath that enclose, contain, or support service conductors, except as permitted in 250.90
- (2) All enclosures containing service conductors, including meter fittings, boxes, or the like, interposed in the service raceway or armor

128

250.92 Service Bonding

(B) Method of Bonding at the Service. Bonding jumpers meeting the requirements of this article shall be used around impaired connections, such as reducing washers or oversized, concentric, or eccentric knockouts. Standard locknuts or bushings shall not be the only means for the bonding required by this section but shall be permitted to be installed to make a mechanical connection of the raceways(f).

129

250.92 Service Bonding

- (B) Electrical continuity at service equipment, service raceways, and service conductor enclosures shall be ensured by one of the following:**
- (1) Bonding jumpers, as required in 250.92(A), shall be installed in a raceway provided in 250.8
 - (2) Connections utilizing threaded couplings or threaded hubs on enclosures if made up wrench-tight
 - (3) Threadless couplings and connectors if made up tight for metal raceways and metal-clad cables
 - (4) Other listed devices, such as bonding-type locknuts, bushings, or bushings with bonding jumpers

130



131

250.94 Bonding Other Systems

An intersystem bonding termination for connecting intersystem bonding conductors required for other systems shall be provided external to enclosures at the service equipment or metering equipment enclosure and at the disconnecting means for any additional buildings or structures. The intersystem bonding termination shall comply with the following:

132



250.94 Bonding Other Systems

- (1) Be accessible for connection and inspection.
- (2) Connect at least one end directly for connection of metal raceways, cable trays, or metal raceways with less than three intersystem bonding conductors.
- (3) Not interfere with opening the enclosure for a service, building or structure disconnecting means, or metering equipment.
- (4) At the service equipment, be securely mounted and electrically bonded to an exposed nonferrous metallic service raceway or enclosure, or to an exposed nonferrous metallic service raceway or enclosure, or to the grounding electrode conductor with a minimum 6 AWG copper conductor

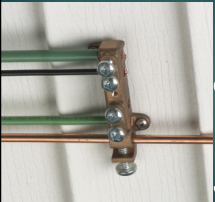
133

250.94 Bonding Other Systems

- (5) At the disconnecting means for a building or structure, be securely mounted and electrically connected to the metallic enclosure for the building or structure disconnecting means, or be mounted at the disconnecting means and be connected to the metallic enclosure or to the grounding electrode conductor with a minimum 6 AWG copper conductor.
- (6) The terminals shall be listed as grounding and bonding equipment.

134

250.94 Bonding Other Systems



135

250.97 Over 250 Volts

For circuits of over 250 volts to ground, the electrical continuity of metal raceways and cables with metal sheaths that contain any conductor other than service conductors shall be ensured by one or more of the methods specified for services in 250.92(B), except for (B)(1).

136

250.97 Over 250 Volts


Exception: Where oversized, concentric, or eccentric knockouts or eccentric knockouts is listed to provide a reliable bonding connection, the following methods shall be permitted:

- (1) Threadless couplings and connectors for cables with metal sheaths
- (2) Two locknuts, on rigid metal conduit or intermediate metal conduit, one inside and one outside of boxes and cabinets
- (3) Fittings with shoulders that seat firmly against the box or cabinet connectors, and cable connectors, with one locknut on the inside of boxes and cabinets
- (4) Listed fittings

137

250.97 Over 250 Volts

Bonding for Circuits Over 250 Volts



- 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 cabinet connectors for EMT, flexible metal conduit, and cable connectors with one locknut inside

Also permitted:

- Threaded couplings and bosses
- Two locknuts, one inside and one outside
- Bonding jumper and wedges
- Listed approved devices

138

250.100 Hazardous 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 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 shall be used whether or not equipment surrounding conductors, the wire type, are installed.**

139

250.100 Hazardous Locations

Other codes that deal with this are

- 501.30 Class I
- 502.30 Class II
- 503.30 Class 3

One main thing is that Flex or any types cannot be a path for grounding or bonding and must have Bonding jumpers installed.

140



141

250.102 Bonding Conductors and Jumpers

(c) Size — Supply-Side Bonding Jumper.

(1) Size for Supply Conductors in a Single Raceway or Cable. The supply-side bonding jumper shall not be smaller than the sizes shown in Table 250.102(C)(1) for grounding electrode conductors. Where the ungrounded supply conductors are larger than 1100 kcmil copper or 1750 kcmil aluminum, the supply-side bonding jumper shall have an area not less than 121/2 percent of the area of the largest set of ungrounded supply conductors.

142

250.102 Bonding Conductors and Jumpers

(c) Size — Supply-Side Bonding Jumper.

(2) Size for Parallel Conductor Installations. Where the ungrounded supply conductors are paralleled in two or more raceways or cables, and an individual supply-side bonding jumper is used for bonding these raceways or cables, the size of the supply-side bonding jumper for each raceway or cable shall be determined in accordance with the size of the ungrounded supply conductors in each raceway or cable. A single supply-side bonding jumper installed for bonding two or more raceways or cables shall be sized in accordance with 250.102(C)(1).

143

250.102 Bonding Conductors and Jumpers

Size of Equipment Bonding Jumper on Line Side of Service

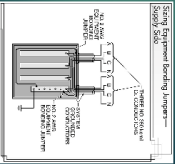


Where installed individually, equipment grounding conductors shall be installed in each raceway or cable. Where installed in each raceway or cable, the size of the ungrounded service-entrance conductors not shown

144

250.102 Bonding Conductors and Jumpers

When service conductors are installed in two separate conduits, the equipment bonding jumper is sized for the service conductors in each raceway.



145

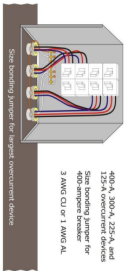
250.102 Bonding Conductors and Jumpers

(D) Size — Equipment Bonding Jumper on Load Side of an Overcurrent Device. The equipment bonding jumper on the load side of an overcurrent device(s) shall be sized in accordance with 250.122. A single common continuous equipment bonding jumper shall be permitted to connect two or more raceways or cables if the bonding jumper is sized in accordance with 250.122 for the largest overcurrent device supplying circuits therein.

146

250.102 Bonding Conductors and Jumpers

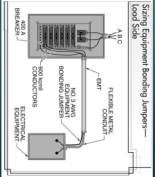
Bonding Multiple Raceways



147

250.102 Bonding Conductors and Jumpers

The size of the equipment bonding jumpers on the load side is determined by the OCPD size or rating from Table 250.122.



148

250.102 Bonding Conductors and Jumpers

(E) Installation. Bonding jumpers or conductors and equipment bonding jumpers shall be permitted to be installed inside or outside of a raceway or enclosure. (1) Inside a Raceway or an Enclosure. If installed inside a raceway, equipment bonding jumpers and bonding jumpers of conductors shall comply with the requirements of 250.119 and 250.148. (2) Outside a Raceway or an Enclosure. If installed on the outside, the length of the bonding jumper or conductor or equipment bonding jumper shall not exceed 1.8 m (6 ft) and shall be routed with the raceway or enclosure.

149

250.104 Bonding of Piping Systems or Structural Steel

(A) Metal Water Piping. The metal water piping system shall be bonded as required in (A)(1), (A)(2), or (A)(3) of this section. The bonding jumper(s) shall be installed in accordance with 250.64(A), (B), and (E). The points of attachment of the bonding jumper(s) shall be accessible.

150



151

250.104 Bonding of Piping Systems or Structural Steel

(B) Other Metal Piping. If installed in or attached to a building or structure, metal piping, if (1) containing gas piping that is likely to be subjected to the hazard of gas leakage, or (2) installed in an enclosure, the grounded conductor at the service, the grounding electrode conductor, if of sufficient size; or to one or more grounding electrodes used. The bonding conductor(s) or jumper(s) shall be sized in accordance with 250.122, using the rating of the circuit that is likely to be subjected to the hazard of gas leakage. The bonding conductor for the piping shall be likely to accept the bonding jumper(s) shall be permitted to serve as the bonding means. The points of attachment of the bonding jumper(s) shall be accessible.

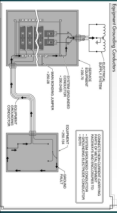
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153

250.119 Identification of EGC

An equipment grounding conductor is an electrical conductor that provides a low-impedance path between electrical equipment and enclosures and the system-grounded conductor and grounding electrode conductor.



163

250.122 Equipment Grounding Conductor

The Size of Equipment Grounding Conductors is based on OCPD size.



164

Table 250.122 (in part)

Minimum Size of Equipment Grounding Conductors for Grounding Raceway and Equipment

Rating or Setting of Automatic Overcurrent Device in Circuit Ahead of Equipment, or Rating of Equipment, Not Exceeding (Amperes)	Size (AWG or kcmil)	
	Copper	Aluminum or Copper-Clad
15	14	12
20	12	10
30	10	8
40	8	6
60	6	4
100	4	2
200	3	1
400		

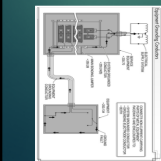
Notes: Where the rating or setting of the OCPD is 250, 400, or 600 A, the equipment grounding conductors shall be sized in accordance with Table 250.122(A). Where the rating or setting of the OCPD is 75, 100, 150, 200, 300, or 400 A, the equipment grounding conductors shall be sized in accordance with Table 250.122(B).

165

250.122 Equipment Grounding Conductor

250.122 B Increase in Size.

If ungrounded conductors are increased due to voltage drop the EGC must also be increased in size.



166

250.122 Equipment Grounding Conductor

Example: 200-ampere feeder normally requires a 3/0 copper kcmil. For excessive voltage drop the feeder size needed is 250 cm of 3/0 copper is 167,800 per Table 8, Chapter 9, cm for 250 is 250,000.

$250,000 / 67,800 = 1.49$

250.122 give a #6 as the EGC, cm of #6 is 26,240 (cir. mil. of 6 AWG) x 1.49 = 39,098 Per Table 8 Chapter 9, the next larger size required would be a 4 AWG copper conductor

167

250.122 Equipment Grounding Conductor

(c) Multiple Circuits. Where a single equipment grounding conductor is run with multiple circuits in the same raceway, cable, or cable tray, it shall be sized for the largest overcurrent device protecting conductors in the raceway, cable, or cable tray. Equipment grounding conductors installed in cable trays shall meet the minimum requirements of 392.10(B)(1)(c).

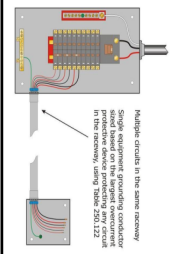
168

250.122 Equipment Grounding Conductor

Multiple Circuits in the Same Raceway

Where multiple circuits are run in the same raceway, cable, or cable tray, the equipment grounding conductor shall be sized in accordance with (D)(1) or (D)(2).

(1) General. The equipment grounding conductor size shall not be smaller than determined by 250.122(A) based on the rating of the branch-circuit short-circuit and ground fault protective device.



169

250.122 Equipment Grounding Conductor

(D) Motor Circuits. Equipment grounding conductors for motor circuits shall be sized in accordance with (D)(1) or (D)(2).

(1) General. The equipment grounding conductor size shall not be smaller than determined by 250.122(A) based on the rating of the branch-circuit short-circuit and ground fault protective device.

170

250.122 Equipment Grounding Conductor

(D) Motor Circuits. Equipment grounding conductors for motor circuits shall be sized in accordance with (D)(1) or (D)(2).

(1) General. The equipment grounding conductor size shall not be smaller than determined by 250.122(A) based on the rating of the branch-circuit short-circuit and ground fault protective device.

171

250.122 Equipment Grounding Conductor

- (D) **Motor Circuits.** Equipment grounding conductors for motor circuits shall be sized in accordance with (D)(1) or (D)(2).
- (2) **General.** Instantaneous and Motor Short-Circuit Protectors. If one of the two type of protection devices listed above, the equipment grounding conductors shall be sized based on a Dual Element Fuse x the FLC of the motor. Rounded up to a standard size as found in 240.6.

172

250.134 Equipment Fasten in place.

- (1) Connected to one of the items listed in 250.118 (2) – (14) to be used as an EGC.
- (2). Connected to a wire type grounding conductor in the same raceway or cable.

173

250.136 Equipment Secured to a Grounded metal Support.

Equipment secured to and in electrical contact with a metal rack or structure that provides support for the equipment shall be considered connected to the EGC if the support method is connected to the EGC.



174

250.138 Cord and plug connected Equipment

Non-current-carrying metal parts of cord-and-plug-connected equipment, if grounded, shall be connected to an equipment grounding conductor by one of the methods in 250.138(A) or (B).

(A) By Means of an Equipment Grounding Conductor.

By means of an equipment grounding conductor run with the power supply conductors in a cable assembly or flexible cord properly terminated in a grounding-type attachment plug with one fixed grounding contact.

175

250.138 Cord and plug connected Equipment

Non-current-carrying metal parts of cord-and-plug-connected equipment, if grounded, shall be connected to an equipment grounding conductor by one of the methods in 250.138(A) or (B).

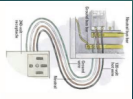
(B) By Means of a Separate Flexible Wire or Strap.

By means of a separate flexible wire or strap, insulated or bare, connected to an equipment grounding conductor, and protector as well as practicable against physical damage, where part of equipment.

176

250.140 Ranges and Dryers

Frames of electric ranges, wall-mounted ovens, counter-mounted cooking units, clothes dryers, and outlet or junction boxes that are part of the circuit for these appliances shall be connected to the equipment grounding conductor in the manner specified by 250.134 or 250.138



177

250.140 Ranges and Dryers

Exception: For existing branch-circuit installations only where an equipment grounding conductor is not present in the outlet or junction box, the flames of electric ranges, wall-mounted ovens, counter-mounted cooking units, clothes dryers, and outlet or junction boxes that are part of the circuit for these appliances shall be permitted to be connected to the grounded circuit conductor if all the following conditions are met:

178

250.140 Ranges and Dryers

- (1) The supply circuit is 120/240-volt, single-phase, 3-wire, or 208Y/120-volt derived from a 3-phase, 4-wire, wye connected system.
- (2) The grounded conductor is not smaller than 10 AWG copper or 8 AWG aluminum.
- (3) The grounded conductor is insulated, or the grounded conductor is uninsulated and part of a Type SE service entrance cable and the branch circuit originates at the service equipment.
- (4) Grounding contacts of receptacles furnished as part of the equipment are bonded to the equipment.

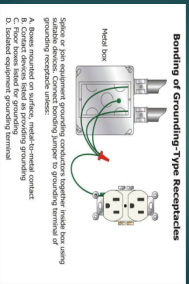
179

250.146 Connecting Receptacles Grounding terminals to box

An equipment bonding jumper shall be used to connect the grounding terminal of a grounding-type receptacle to a grounded box unless grounded as in 250.146(A) through (D). The equipment bonding jumper shall be sized in accordance with Table 250.122 based on the rating of the overcurrent device protecting the circuit conductors.

180

250.146 Connecting Receptacles
Grounding terminals to box



181

250.146 Connecting Receptacles
Grounding terminals to box

(A) **Surface-Mounted Box.** Where the box is mounted on the surface, direct metal-to-metal contact between the device yoke and the box or a contact yoke or device shall comply with 250.146(B). It shall be permitted to connect the grounding conductor to the box or the contact yoke or device. The conductor shall be removed from receptacles that do not have a contact yoke or device that complies with 250.146(B) to ensure direct metal-to-metal contact. This provision shall not apply to cover-mounted receptacles unless the box and cover combination are listed as providing satisfactory ground continuity between the box and the receptacle.

182



183

250.146 Connecting Receptacles
Grounding terminals to box

Surface-Mounted Box. Where the box is mounted on the surface, direct metal-to-metal contact between the device yoke and the box or a contact yoke or device shall comply with 250.146(B). It shall be permitted to connect the grounding conductor to the box or the contact yoke or device. The conductor shall be removed from receptacles that do not have a contact yoke or device that complies with 250.146(B) to ensure direct metal-to-metal contact. This provision shall not apply to cover-mounted receptacles unless the box and cover combination are listed as providing satisfactory ground continuity between the box and the receptacle.

184



185

250.148 Continuity and attachment
of Equipment Grounding Conductor
to Boxes.

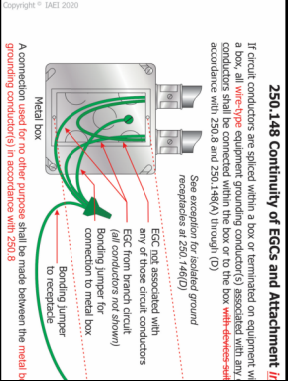
Where circuit conductors are spliced within a box or terminated on equipment within or supported by a box, any equipment grounding conductor(s) associated with those circuit conductors shall be connected within the box or to the box with devices suitable for the use in accordance with 250.148(A) through (E).

186

250.148 Continuity and attachment
of Equipment Grounding Conductor
to Boxes.

(B) **Grounding Continuity.** The arrangement of grounding connections shall be such that the disconnection or the removal of a receptacle, luminaire, or other device and from the box does not interfere with or interrupt the grounding continuity.

187

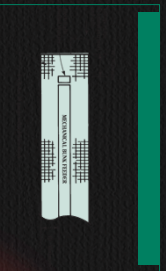


188

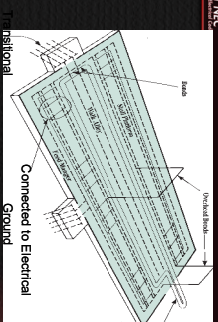
250.148 Continuity and attachment
of Equipment Grounding Conductor
to Boxes.

(C) **Metal Boxes.** A connection shall be made between the one or more equipment grounding conductors and a metal box by means of a grounding screw that shall be used for no other purpose, equipment listed for grounding, or a listed grounding device.

189



199



200

Health Care Facilities 517.13

(A) 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.

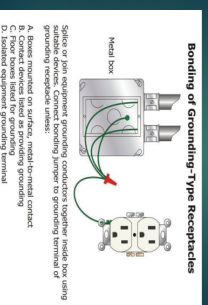
201

Health Care Facilities 517.13

- (B) Insulated Equipment Grounding Conductor.
- General. The following shall be directly connected to an insulated copper equipment grounding conductor that is installed with the branch circuit conductors in the wiring methods as provided in 517.13(A).
 - The grounding terminals of all receptacles.
 - Metal boxes and enclosures containing receptacles.
 - All non-current-carrying conductive surfaces of fixed electrical equipment likely to become energized that are subject to personal contact, operating at over 100 volts.

203

Health Care Facilities Bonding of Grounding-Type Receptacles



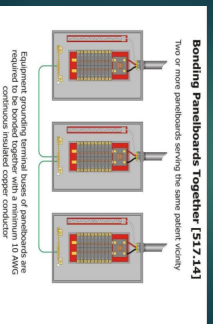
204

Health Care Facilities

517.14 Panelboard Bonding. The equipment-grounding terminal buses of the normal and essential branch-circuit panelboards serving the same individual patient care vicinity shall be connected together with an insulated continuous copper conductor not smaller than 10 AWG. Where the equipment-grounding terminal bus of the emergency care vicinity are served from separate transfer switches on the emergency 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 shall be permitted to be broken in order to accommodate the equipment-grounding terminal bus in each panelboard.

205

Health Care Facilities



206

Swimming Pools



207

Swimming Pools 680.6

- ▶ Electrical equipment shall be bonded as found in 250 Part V. Things that need to be connected is:
 - ▶ 1. Trough Wall Lights
 - ▶ 2. All electrical equipment within 5 feet of the inside wall of pool.
 - ▶ 3. All recirculating equipment.
 - ▶ 4. Junction Boxes
 - ▶ 5. Transformers and power supplies
 - ▶ 6. GFCI
 - ▶ 7. Panelboards that are not part of the service equipment.

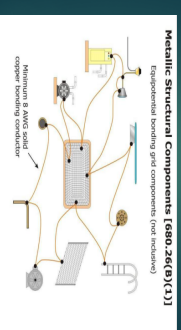
208

680.26 (B)(1) Equipotential Bonding

(B) **Bonded Parts.** The 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 or with rigid metal conduit of brass or other identified corrosion-resistant metal. Connections to bonded parts shall be made in accordance with 250.8. At 8 AWG or larger solid copper bonding conductor provided to reduce voltage gradients in the pool area shall not be required to be extended or attached to remote panelboards, service equipment, or electrodes.

209

680.26 (B)(1) Equipotential Bonding



210

680.43 (D) Spa's and Hot tubs

- (D) **Bonding.** The following parts shall be bonded together:
- (1) All metal fittings within or attached to the spa or hot tub structure
 - (2) Metal parts of electrical equipment associated with the spa or hot tub water circulating system, including pump motors, unless part of a listed self-contained spa or hot tub
 - (3) All Metal raceway and metal piping that are within 1.5 m (5 ft) of the inside walls of the spa or hot tub and that are not separated from the spa or hot tub by a permanent barrier.

211



212

680.43 (D) Spa's and Hot tubs

- (D) **Bonding.** The following parts shall be bonded together:
- (3) Metal raceway and metal piping that are within 1.5 m (5 ft) of the inside walls of the spa or hot tub and that are not separated from the spa or hot tub by a permanent barrier
 - (4) All metal surfaces that are within 1.5 m (5 ft) of the inside walls of the spa or hot tub and that are not separated from the spa or hot tub by a permanent Barrier
 - (5) Electrical devices and controls that are not associated with the spas or hot tubs and that are located less than 1.5 m (5 ft) from such units; otherwise, they shall be bonded to the spa or hot tub system

213

680.43 Spa's and Hot tubs

- (E) **Methods of Bonding.** All metal parts associated with the spa or hot tub shall be bonded by any of the following methods:
- (1) The interconnection of threaded metal piping and fittings
 - (2) Metal-to-metal mounting on a common frame or base
 - (3) The provisions of a solid copper bonding jumper, insulated, covered, or bare, not smaller than 8 AWG

214

680.43 Spa's and Hot tubs

- (F) **Equipment connected to the equipment grounding conductor.**
1. All electrical equipment located within 5 feet of the inside edge of the spa
 2. All electrical equipment associated with the circulating system of the spa.

215

680.54 Grounding and Bonding Fountains

- (A) **Grounding**
1. Other than listed low voltage luminaires, all electrical equipment within 5 feet
 2. All electrical recirculating equipment.
 3. Panelboards not part of the service equipment.

216

**680.54 Grounding and Bonding
Fountains**

- (B) Bonding
- 1. All metal piping system used on the foundation.
 - 2. All metal fittings attached to the fountain.
 - 3. Metal parts of the recirculating system.
 - 4. Metal raceway within 5 feet of fountain.
 - 5. All metal surfaces within 5 feet of fountain.
 - 6. Electrical devices and controls not part of the fountain within 3 feet.

217

680.74 Bonding

- ▶ (A) General
 - ▶ 1. All metal fittings attached to the fountain.
 - ▶ 2. Metal parts of the recirculating system.
 - ▶ 3. Metal raceway or metal cables within 5 feet of fountain.
 - ▶ 4. All metal surfaces within 5 feet of fountain.
 - ▶ 5. Electrical devices and controls not part of the fountain within 5 feet.

218

**680.74 Bonding
Hydro massage Bathtubs**

(B) All metal piping systems and all grounded metal parts in contact with the circulating water shall be bonded together using a solid copper bonding jumper, insulated, covered, or bare, not smaller than 8 AWG. The bonding jumper shall be connected to the terminal on the circulating pump motor that is bonded to the equipment grounding conductor. The bonding jumper shall be connected to a double insulated circulating pump motor. The 8 AWG or larger solid copper bonding jumper shall be required for equipotential bonding in the area of the hydromassage bathtub and shall not be required to be extended or attached to any remote panelboard, service equipment, or other equipment. The bonding jumper shall be secured to the equipment, or long enough to terminate on a replacement double-insulated pump motor and shall be terminated to the equipment grounding conductor of the branch circuit of the motor when a double-insulated circulating pump motor is used.

219

**680.74 Bonding
Hydro massage Bathtubs**



220

Chapter 8 - 800.100

General Requirements for Communication Circuits. – 800.100

(A) (1) Conductors can be insulated, covered or bare.

(2) Conductors shall be copper or other corrosion resistant materials.

3. Minimum size of #14, Bonding conductor not smaller than #6

4. Length Short as practical not over 20 feet long.

5. Run in a straight line.

6. Protection from physical damage.

221

Chapter 8

General Requirements for Communication Circuits. – 800.100

Radio and Television Equipment – 810.21, 810.58

Community Antenna TV & Radio Distribution – 820-100

Network Powered Broadband Communication Systems 830-100

Premises Powered Broadband system 840-100

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