2017 NEC GROUNDING and BONDING of SYSTEMS
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What is a System?

The NEC talks about electrical systems. The system is simply the windings.

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We have two main types of systems.

- Grounded System
  - Most Common
    - Has many benefits
- Ungrounded System
  - Serves a purpose but has issues
  - Not used very much in the United States anymore
  - Has safety issues

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250.4 General Requirements for Grounding and Bonding

The following general requirements identify what grounding and bonding of electrical systems are required to accomplish

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(A) Grounded Systems

Electrical systems that are grounded shall be connected to the 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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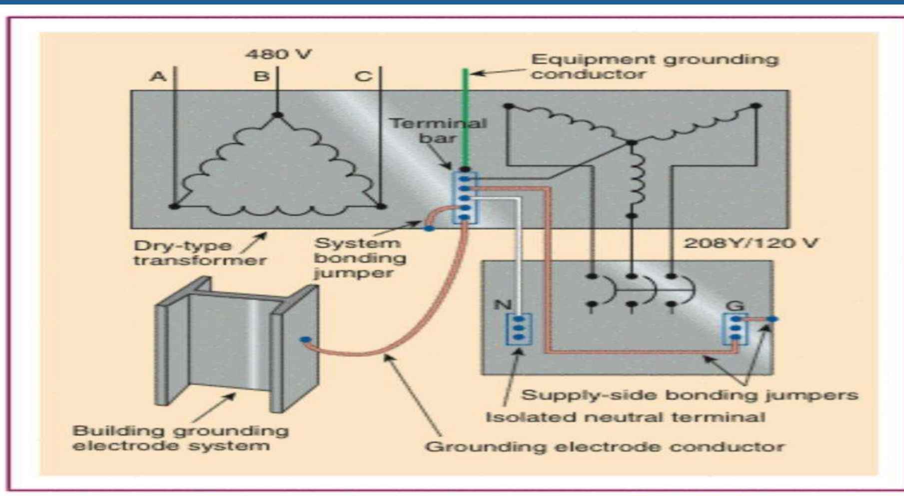

EXHIBIT 250.15 *A grounding arrangement for a separately derived system in which the grounding electrode conductor connection is made at the source of the separately derived system (transformer).*

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(2) Grounding of Electrical Equipment

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.

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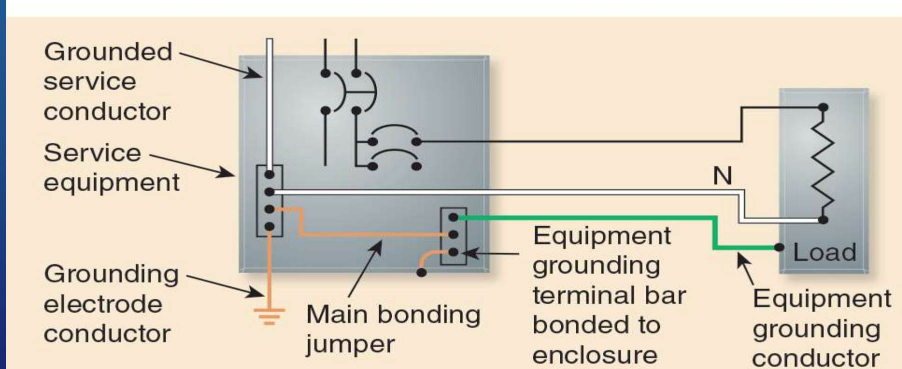

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(3) Bonding of Electrical Equipment

Normally non-current carrying conductive materials enclosing electrical conductors or equipment, or forming part of such equipment, shall be connected-together and to the electrical supply source in a manner that will establish an EFFECTIVE GROUND-FAULT CURRENT PATH.

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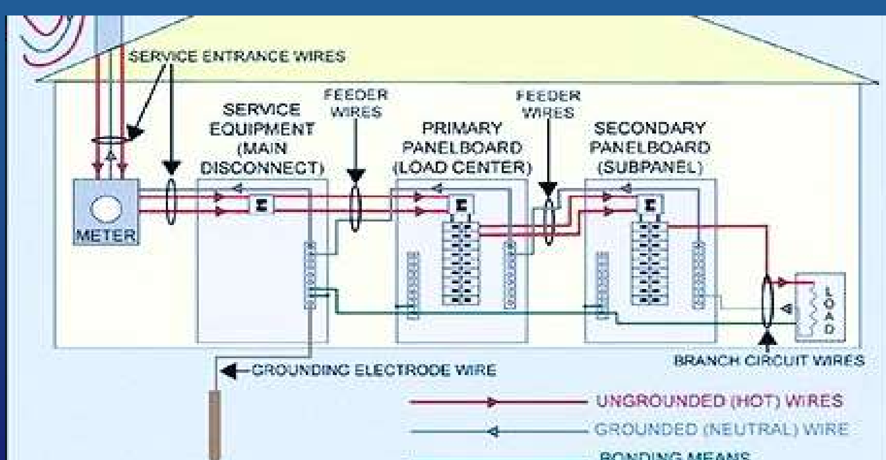

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(4) Bonding of Electrically Conductive Materials and Other Equipment

Normally non-current carrying electrically conductive materials that are likely to become energized shall be connected-together and to the electrical supply source in a manner that establishes an effective ground fault current path.

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(5) Effective Ground-Fault Current Path

Electrical equipment and wiring and other electrically conductive material likely to become energized shall be installed in 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 likely to be imposed on it from any point on the wiring system where a ground fault may occur to the electrical supply source. The earth shall not be considered as an effective ground-fault current path.

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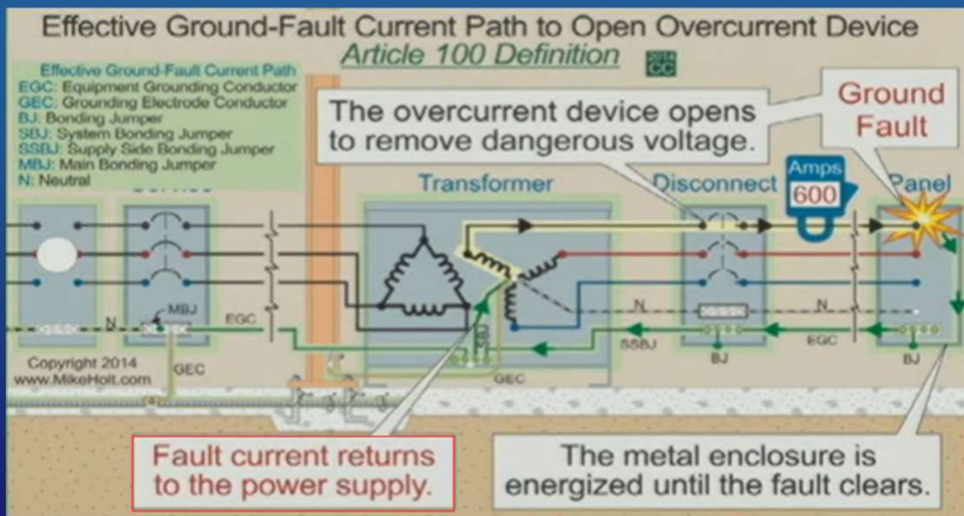

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(B) Ungrounded Systems

Non-current carrying conductive materials enclosing electrical conductors or equipment, or forming part of such equipment, shall be connected to earth in a manner that will limit the voltage imposed by lightning or unintentional contact with higher-voltage lines and limit the voltage to ground on these materials.

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(2) Bonding of Electrical Equipment

Non-current-carrying conductive materials enclosing electrical conductors or equipment, or forming part of such equipment, shall be connected-together and to the supply system grounded equipment in a manner that creates a low-impedance path for ground-fault current that is-capable-of carrying the maximum fault current likely to be imposed on it.

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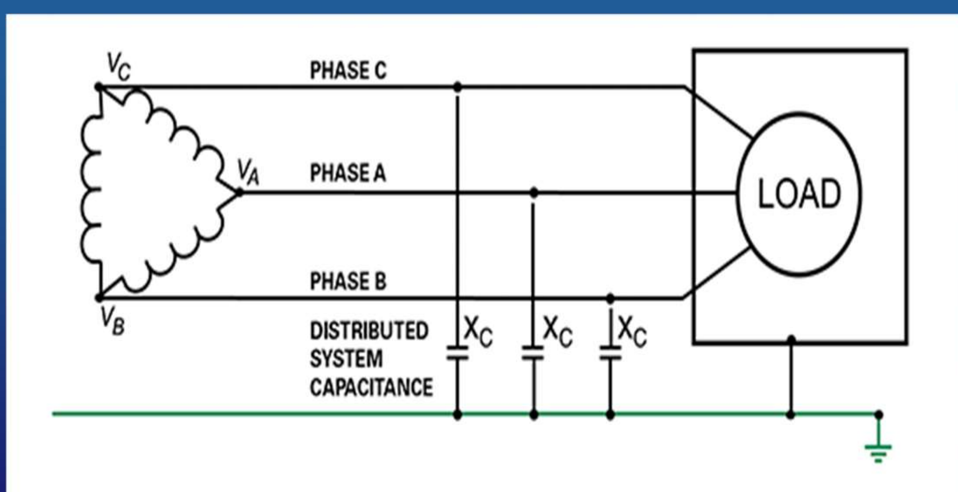

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250.8 Connection of Grounding and Bonding Equipment

Permitted Methods:

- Listed Pressure Connectors
- Terminal Bars
- Pressure connectors listed as grounding and bonding equipment
- Exothermic Welding
- Machine screws-type fasteners engaging not less than two threads
- Thread forming machine screws two threads
- Connections that are part of a listed assembly

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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 be connected by means of fittings designed so as to make such removal unnecessary.

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250.20 System Grounding

Alternating-current systems shall be grounded as provided for in 250.20(A), (B), (C), or (D). Other systems shall be permitted to be grounded.

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(A) Alternating-Current Systems of less than 50 Volts.

(1) If 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

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

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

(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.

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Grounded Conductor brought to service equipment.

Where an AC system operating at 1000 volts or less is grounded at any point, the grounded conductor shall be routed with the ungrounded conductors to each service disconnect means and shall be connected to each disconnecting means grounded conductor terminal or bus. A main bonding jumper shall connect the grounded conductor to each service disconnecting means enclosure.

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The grounded conductor shall be sized according to Table 250.102(C)(1). However, if ungrounded service conductors are installed in parallel in two or more raceways or cables, the grounded conductor shall also be in parallel and not smaller than 1/0 AWG.

Delta-Connected Services of 3-phase, 3-wire delta services shall have an ampacity not less than that of the ungrounded conductors.

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Grounding Electrode Conductor

A grounding electrode conductor shall be used to connect equipment grounding conductors, the service-equipment enclosures, and, where the system is grounded, the grounded service conductor to the grounding electrodes, required by Part III of this code.

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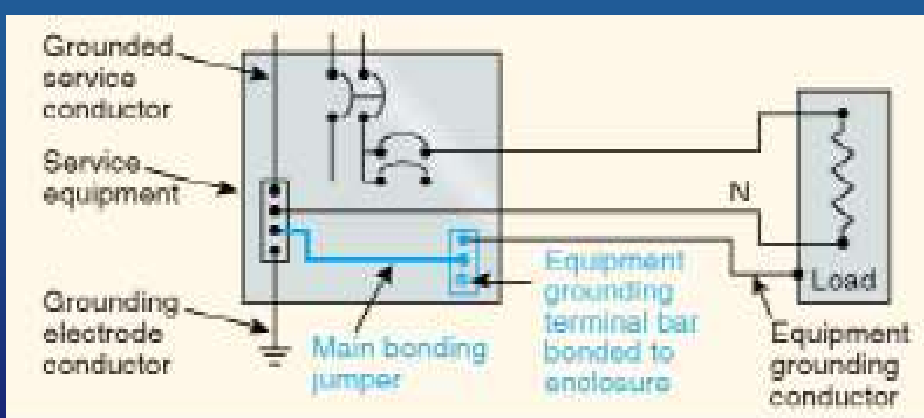

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250.28 Main bonding jumper and system bonding jumper.

For a grounded system, main bonding jumpers and system bonding jumpers shall be installed as follows.

- Made of copper or other corrosion resistant material
- Shall be a wire, bus, screw (if screw, shall be green in color)
- Shall be sized according to not smaller than Table 250.102(C)(1)
- Where a service consist of more than a single enclosure, the main bonding jumper for each enclosure shall be sized according to Table 250.102(C)(1) based on the largest ungrounded conductor for each enclosure.

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250.30(A) Grounded Systems

A separately derived ac system that is grounded shall comply with 250.30(A)(1) through (A)(8). Except as otherwise permitted in this article, a grounded conductor shall not be connected to normally non-current-carrying metal parts of equipment, be connected to equipment grounding conductors, or be reconnected to ground on the load side of the system bonding jumper.

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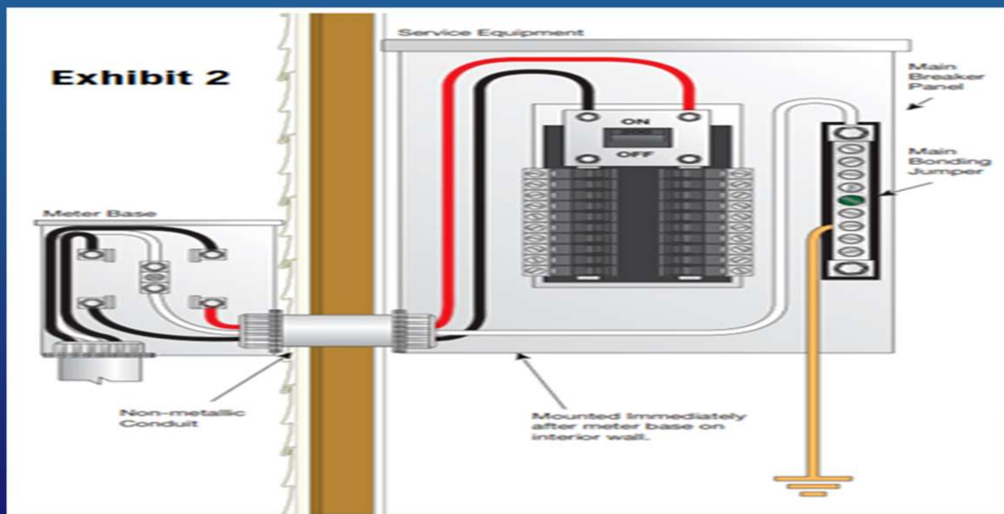

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(1) SYSTEM BONDING JUMPER

An unspliced system bonding jumper shall comply with 250.28(A) through (D). This 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, or it shall be made at the source of a separately derived system that has no disconnecting means or overcurrent devices. 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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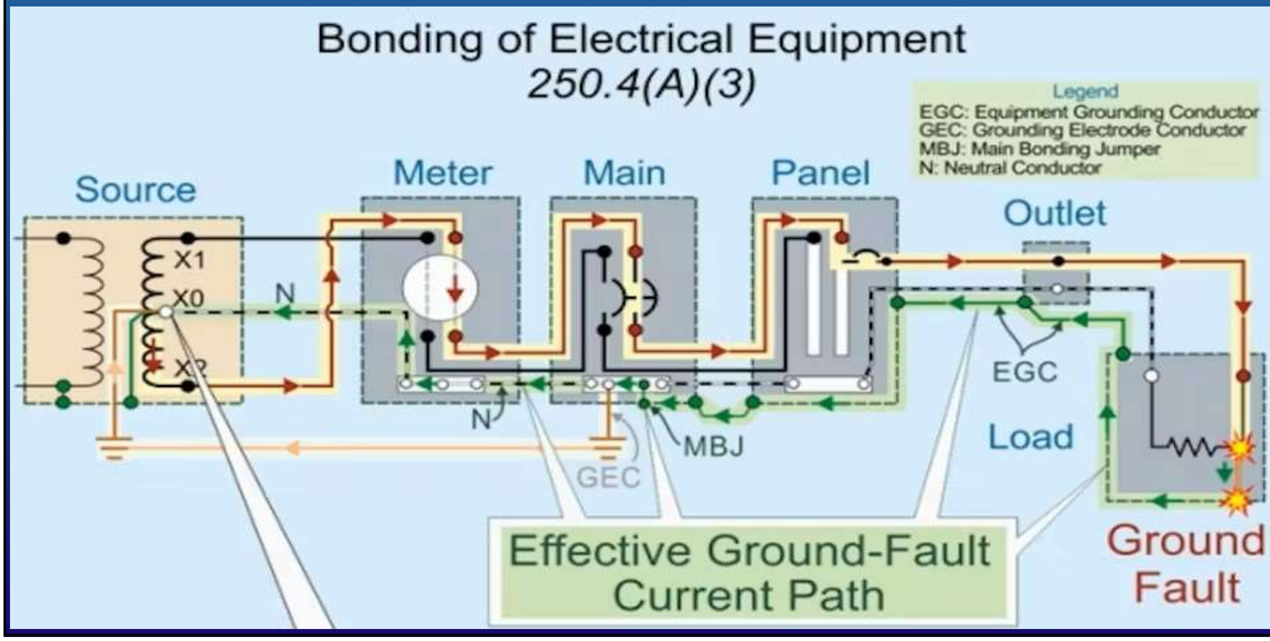

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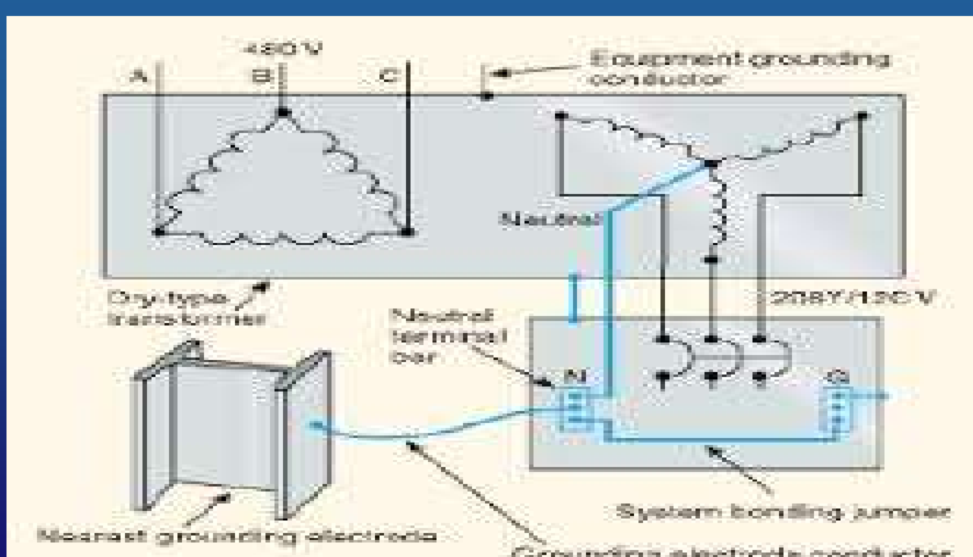

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(2) Supply-Side Bonding Jumper

If the source of a separately derived system and the first disconnecting means are-located-in separate enclosures, a supply-side bonding jumper shall be installed with the circuit conductors from the source enclosure to the first disconnecting means.

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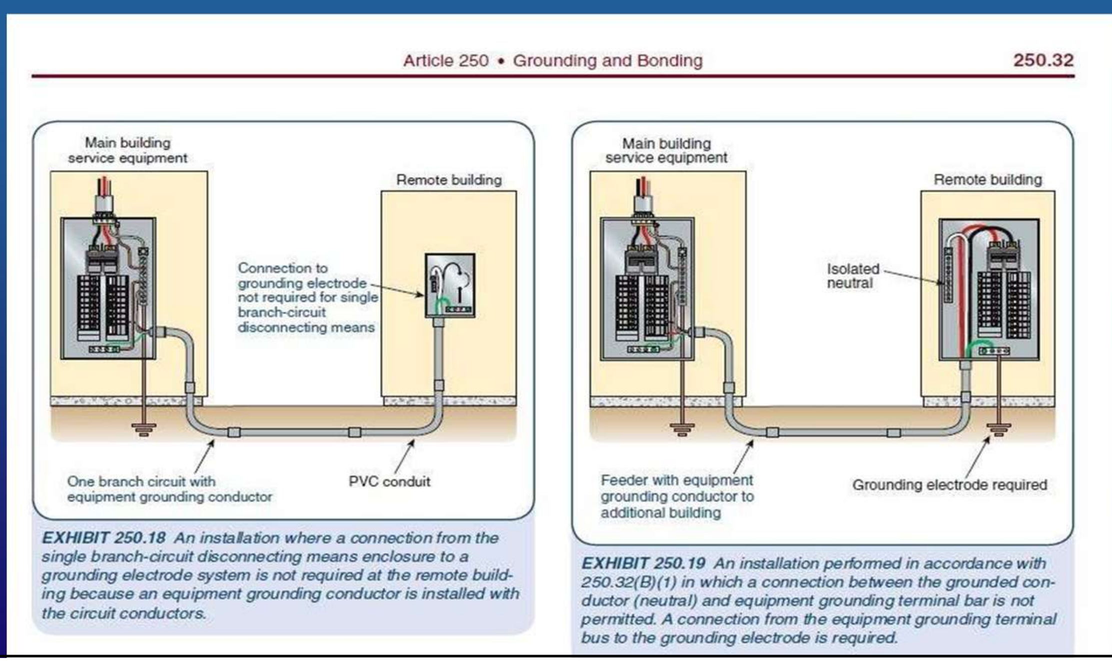

EXHIBIT 250.18 *An installation where a connection from the single branch-circuit disconnecting means enclosure to a grounding electrode system is not required at the remote building because an equipment grounding conductor is installed with the circuit conductors.*

EXHIBIT 250.19 *An installation performed in accordance with 250.32(B)(1) in which a connection between the grounded conductor (neutral) and equipment grounding terminal bar is not permitted. A connection from the equipment grounding terminal bus to the grounding electrode is required.*

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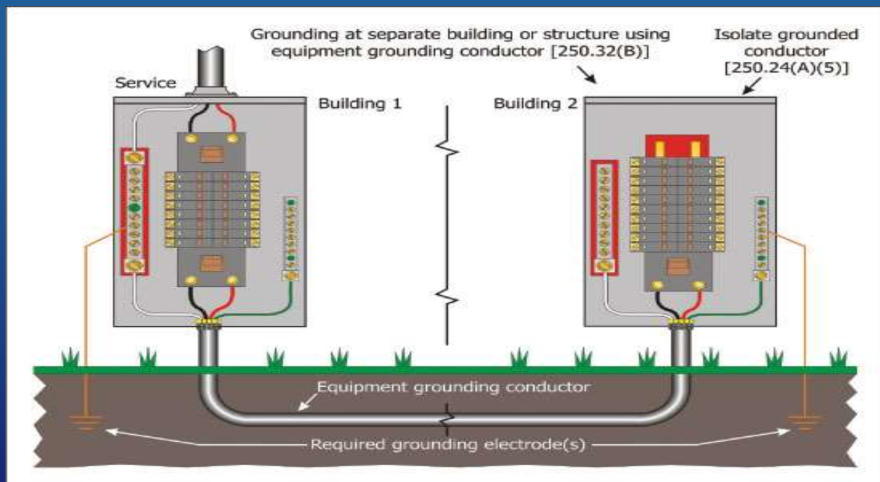

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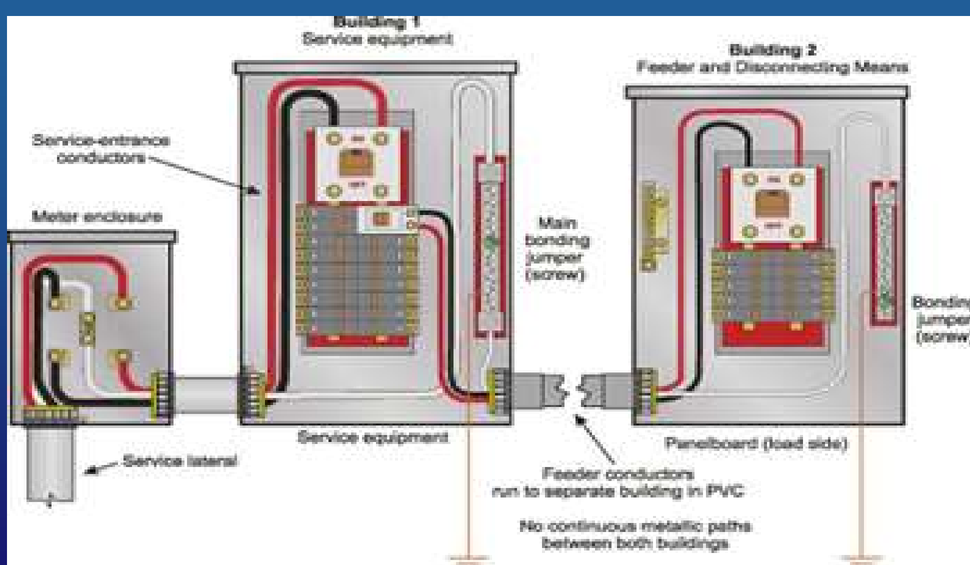

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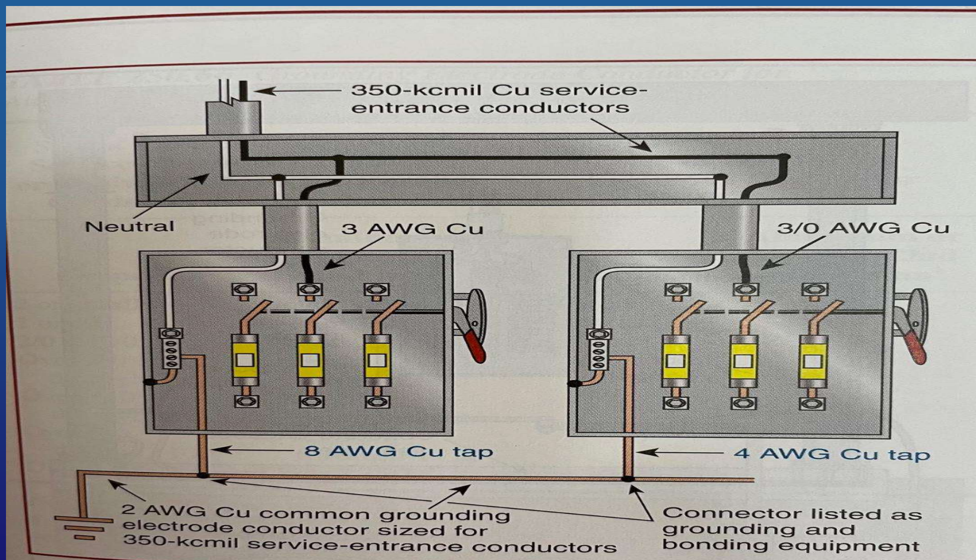

EXHIBIT 250.27 *The tap method of connecting the grounding electrode conductor to multiple service disconnecting means enclosures.*

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250.52 Grounding Electrodes

(A) Electrodes Permitted for Grounding

(1) Metal Underground Water Pipe

Must be in direct contact with the earth (10’ min) including any metal well casing bonded to the pipe and electrically continuous

(2) Metal In-ground supports (building steel)

One or more supports in DIRECT CONTACT with the EARTH VERTICALLY for 10’ or more, with or without concrete encasement. If multiple only one needs bonding.

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(3) Concrete-Encased Electrode.

A concrete encased electrode shall consist of 20' of either:

One or more bare or zinc galvanized or other electrically conductive coated steel reinforcing bars or rods of not less than ½-inch in diameter, installed in one continuous 20' length, or if multiple pieces connected-together by the usual steel tie wires, exothermic welding, welding, or other effective means to create a 20' or greater length.

Bare copper conductor not smaller than 4 AWG

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(4) Ground Ring

A ground ring encircling the building or structure, in direct contact with the earth, consisting of at least 20' of bare copper conductor not smaller than 2 AWG.

(5) Rod and Pipe Electrodes

Rod and pipe electrodes shall not be less than 8' in length and shall consist of the following:

If pipe or conduit, ¾" and if steel outer surface galvanized
If rod-type 5/8" stainless steel, copper or zinc coated

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(6) Other listed electrodes

(7) Plate electrodes

Each plate electrode shall expose no less than 2 square foot of surface to exterior soil. Electrodes of bare or electrically conductive coated iron or steel plates shall be at least ¼” in thickness. Solid, uncoated electrodes of nonferrous metal shall be at least .06 inches in thickness.

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(B) NOT PERMITTED for use as GROUNDING ELECTRODES

(1) Metal Underground gas piping systems
(2) Aluminum also not allowed within 18 inches of earth
(3) Pool structural steel

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250.53 Grounding Electrode System Installation

(A) Rod and pipe if practicable shall be installed below permanent moisture level and free from nonconductive coatings.

(2) Supplemental Electrode Required. If a single rod, pipe or plate electrode it shall be supplemented by an additional electrode.

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The supplemental electrodes shall be permitted to be bonded to one of the following:

Rod, pipe or plate electrode
Grounding electrode conductor
Grounded Service Conductor (most common)
Nonflexible Grounded Service Raceway
Any Grounded Service Enclosure

Electrodes must be 6 feet apart and the grounding electrode conductor as short as possible with minimal bends.

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Where the supplemental electrodes are rod, pipe or plate electrodes, that portion of the bonding jumper shall not be required to be larger than a 6 AWG.

Ground ring shall be a minimum of 30 inches below earth.

Ground rods shall be installed vertically 8 foot except if rock is encountered the electrodes shall be driven at an oblique angle not to exceed 45 degrees from vertical or they can be placed in a trench, 30-inches deep and 6 feet apart.

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250.58 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. Two or more grounding electrodes shall be considered a single grounding electrode system.

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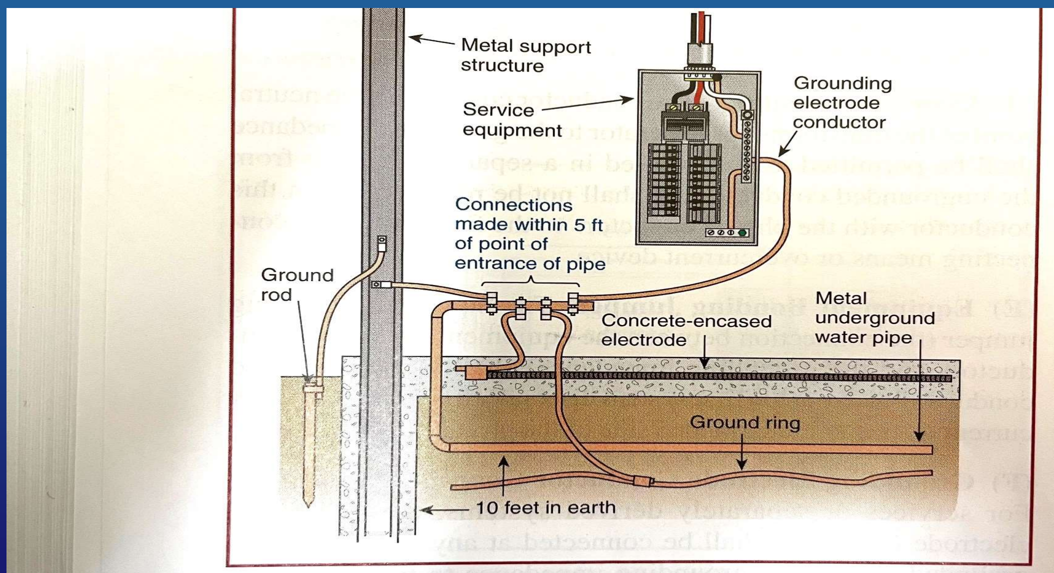

EXHIBIT 250.22 *A grounding electrode system that uses the metal frame of a building, a ground ring, a concrete-encased electrode, a metal underground water pipe, and a ground rod.*

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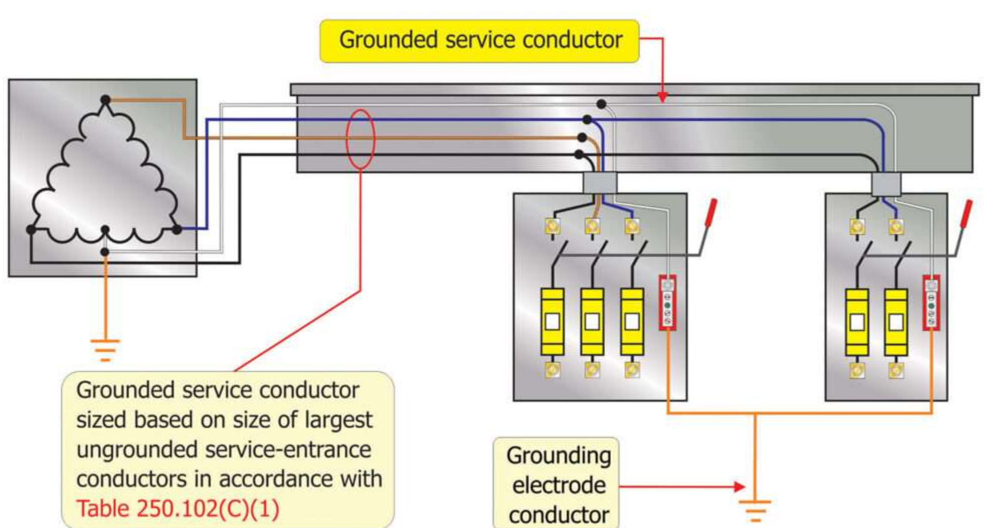
Minimum Size of Grounded Service Conductor



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A common grounding electrode conductor must remain without a splice. Taps onto it can be done with the following:

1) Exothermic welding

2) Connectors listed as grounding and bonding equipment

3) Connections to an aluminum or copper busbar not less than ¼” thick X 2-inches wide and of sufficient length to accommodate the number of terminations necessary for the installation. Busbars must be securely fastened and shall be installed in an accessible location.

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Ferrous metal raceways and 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 ground clamp or fitting. Ferrous metal raceways shall be bonded at each end of the raceway or enclosure to the grounding electrode conductor to create an electrically parallel path. Nonferrous metal raceways and enclosures shall not be required to be electrically continuous.

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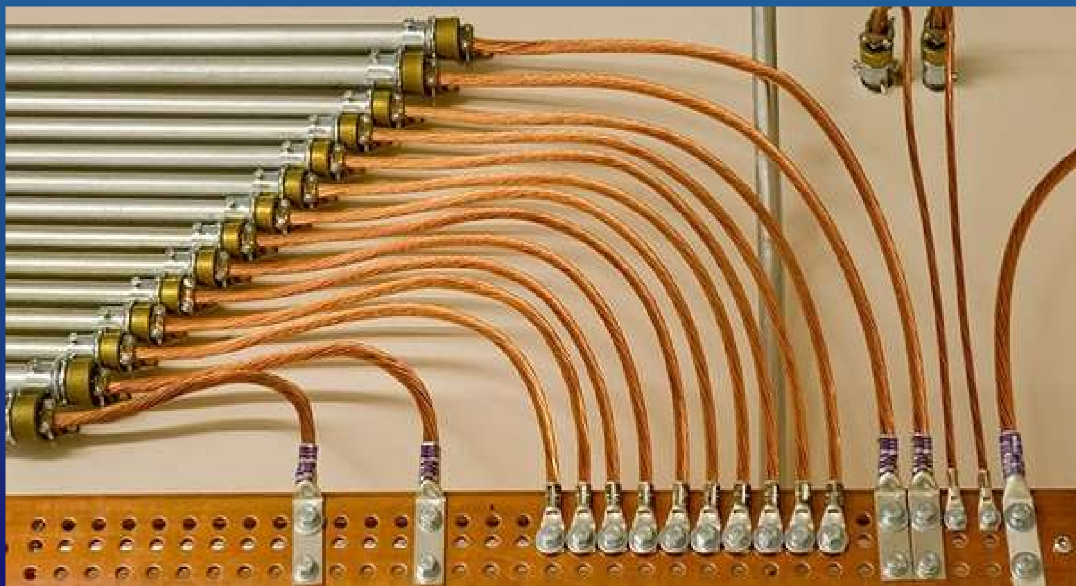

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250.66 Size of Alternating-Current Grounding Electrode Conductor

The size of the grounding electrode conductor at the service, at each building or structure where supplied by a feeder(s) or branch circuit(s), or at a separately derived system of a grounded or ungrounded AC System shall not be less than given in Table 250.66, except as permitted in 250.66 (A) through (C).

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(A) Connections to a Rod, Pipe, or Plate Electrode(s)

If the grounding electrode conductor or bonding jumper connected to a single or multiple rod, pipe, or plate electrode, or any combination thereof, if the electrode doesn't extend on to other types of electrodes that require a larger size conductor, the grounding electrode conductor shall not be required to be larger than size 6 AWG Copper or 4 AWG Aluminum. (Aluminum cannot be installed within 18-inches of earth).

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(B) Connections to Concrete-Encased Electrodes

If the grounding electrode conductor or bonding jumper connected to a single or multiple concrete-encased electrodes, as described in 250.52(A)(3), does not extend onto other types of electrodes that require a larger size of conductor, the grounding electrode conductor shall not be required to be larger than a 4 AWG Copper wire. (rebar or wire)

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(C) Connections to Ground Rings.

If the grounding electrode conductor or bonding jumper connected to a ground ring, as described in 250.52(A)(4), does not extend on to other types of electrodes that require a larger size of conductor, the grounding electrode conductor shall not be required to be larger than the conductor used for the ground ring.

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250.68(A) Accessibility

All mechanical elements used to terminate a grounding electrode conductor or bonding jumper to a grounding electrode shall be accessible.

Exception 1: An encased or buried connection to a concrete-encased electrode, driven, or buried grounding electrode shall not be required to be accessible.

Exception 2: Exothermic welding or irreversible compression connections used at terminations, together with the mechanical means used to attach such terminations to fireproofed structural steel doesn't need to be.

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(B) Effective Grounding Path

The connection of a grounding electrode conductor or bonding jumper to a grounding electrode shall be made in a manner that will ensure an effective grounding path. Bonding shall be provided around insulated joints and around any equipment likely to be disconnected for repairs or replacements. They shall be long enough to allow removal of device without loosing bonding.

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(C) Grounding Electrode Conductor Connections

(1) Interior metal water pipe within 5 feet of entrance to residence. (Only Residential). You can extend to another electrode from the water pipe as long as it's done within the 5 foot of entrance of pipe.

(2) Metal Structural Frame of a building shall be permitted to be used as a conductor to interconnect electrodes that are part of the grounding electrode system, or as a grounding electrode conductor. Hold-down bolts securing the structural steel column that are connected to a concrete encased electrode and is in the support footing or foundation shall be permitted to be used to connect to the concrete encased electrode.

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(3) A rebar type concrete-encased electrode installed in accordance with 250.52(A)(3) with an additional rebar section extended from its location within the concrete to an accessible location to an accessible location that is not subjected to corrosion shall be permitted for connection of grounding electrode conductors and bonding jumpers. The rebar extension shall not be exposed to contact with the earth without corrosion protection.

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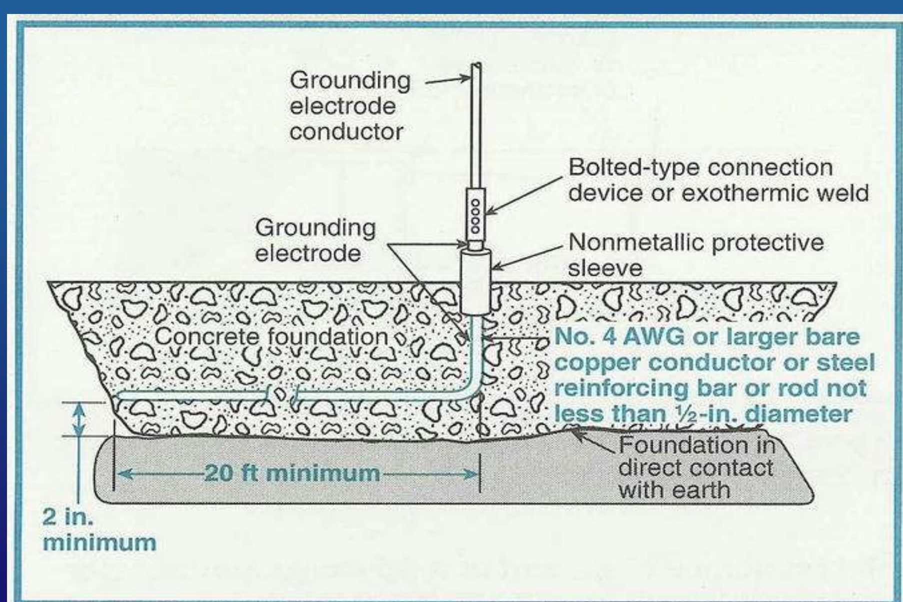

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