

grounding terminal or bus of the enclosure of supplied disconnecting mean(s) in accordance with (B)(1) or (B)(2).

**(1) Supply Side of Generator Overcurrent Device.** The equipment bonding jumper on the supply side of each generator overcurrent device shall be sized in accordance with 250.102(C) based on the size of the conductors supplied by the generator.

**(2) Load Side of Generator Overcurrent Device.** The equipment grounding conductor on the load side of each generator overcurrent device shall be sized in accordance with 250.102(D) based on the rating of the overcurrent device supplied.

**250.36 High-Impedance Grounded Neutral Systems.** High-impedance grounded neutral systems in which a grounding impedance, usually a resistor, limits the ground-fault current to a low value shall be permitted for 3-phase ac systems of 480 volts to 1000 volts where 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 (G).

**(A) Grounding Impedance Location.** The grounding impedance shall be installed between the grounding electrode conductor and the system neutral point. Where a neutral point is not available, the grounding impedance shall be installed between the grounding electrode conductor and the neutral point derived from a grounding transformer.

**(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. In no case shall the grounded system conductor be smaller than 8 AWG copper or 6 AWG aluminum or copper-clad aluminum.

**(C) System Grounding Connection.** The system shall not be connected to ground except through the grounding impedance.

**FPN:** The impedance is normally selected to limit the ground-fault current to a value slightly greater than or equal to the capacitive charging current of the system. This value of impedance will also limit transient overvoltages to safe values. For guidance, refer to criteria for limiting transient overvoltages in ANSI/IEEE 142-1991, *Recommended Practice for Grounding of Industrial and Commercial Power Systems*.

**(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 permitted to be installed in a separate raceway from the ungrounded conductors. It shall not be required to run this conductor with the phase conductors to the first system disconnecting means or overcurrent device.

**(E) Equipment Bonding Jumper.** The equipment bonding jumper (the connection between the equipment grounding conductors and the grounding impedance) shall be an unspliced conductor run from the first system disconnecting means or overcurrent device to the grounded side of the grounding impedance.

**(F) Grounding Electrode Conductor Location.** The grounding electrode conductor shall be connected at any point from the grounded side of the grounding impedance to the equipment grounding connection at the service equipment or first system disconnecting means.

**(G) Equipment Bonding Jumper Size.** The equipment bonding jumper shall be sized in accordance with (1) or (2) as follows:

- (1) Where the grounding electrode conductor connection is made at the grounding impedance, the equipment bonding jumper shall be sized in accordance with 250.66, based on the size of the service entrance conductors for a service or the derived phase conductors for a separately derived system.
- (2) Where the grounding electrode conductor is connected at the first system disconnecting means or overcurrent device, the equipment bonding jumper shall be sized the same as the neutral conductor in 250.36(B).

### III. Grounding Electrode System and Grounding Electrode Conductor

**250.50 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. Where none of these grounding electrodes exist, one or more of the grounding electrodes specified in 250.52(A)(4) through (A)(8) shall be installed and used.

*Exception: Concrete-encased electrodes of existing buildings or structures shall not be required to be part of the grounding electrode system where the steel reinforcing bars or rods are not accessible for use without disturbing the concrete.*

#### 250.52 Grounding Electrodes.

##### (A) Electrodes Permitted for Grounding.

**(1) Metal Underground Water Pipe.** A metal underground water pipe in direct contact with the earth for 3.0 m



(10 ft) or more (including any metal well casing bonded to the pipe) and electrically continuous (or made electrically continuous by bonding around insulating joints or insulating pipe) to the points of connection of the grounding electrode conductor and the bonding conductors. Interior metal water piping located more than 1.52 m (5 ft) from the point of entrance to the building shall not be used as a part of the grounding electrode system or as a conductor to interconnect electrodes that are part of the grounding electrode system.

*Exception: In industrial, commercial, and institutional buildings or structures where conditions of maintenance and supervision ensure that only qualified persons service the installation, interior metal water piping located more than 1.52 m (5 ft) from the point of entrance to the building shall be permitted as a part of the grounding electrode system or as a conductor to interconnect electrodes that are part of the grounding electrode system, provided that the entire length, other than short sections passing perpendicularly through walls, floors, or ceilings, of the interior metal water pipe that is being used for the conductor is exposed.*

**(2) Metal Frame of the Building or Structure.** The metal frame of the building or structure that is connected to the earth by any of the following methods:

- (1) 3.0 m (10 ft) or more of a single structural metal member in direct contact with the earth or encased in concrete that is in direct contact with the earth
- (2) Connecting the structural metal frame to the reinforcing bars of a concrete-encased electrode as provided in 250.52(A)(3) or ground ring as provided in 250.52(A)(4)
- (3) Bonding the structural metal frame to one or more of the grounding electrodes as defined in 250.52(A)(5) or (A)(7) that comply with 250.56
- (4) Other approved means of establishing a connection to earth

**(3) Concrete-Encased Electrode.** An electrode encased by at least 50 mm (2 in.) of concrete, located horizontally near the bottom or vertically, and within that portion of a concrete foundation or footing that is in direct contact with the earth, consisting of at least 6.0 m (20 ft) of one or more bare or zinc galvanized or other electrically conductive coated steel reinforcing bars or rods of not less than 13 mm (½ in.) in diameter, or consisting of at least 6.0 m (20 ft) of bare copper conductor not smaller than 4 AWG. Reinforcing bars shall be permitted to be bonded together by the usual steel tie wires or other effective means. Where multiple concrete-encased electrodes are present at a building or structure, it shall be permissible to bond only one into the grounding electrode system.

**(4) Ground Ring.** A ground ring encircling the building or structure, in direct contact with the earth, consisting of at

least 6.0 m (20 ft) of bare copper conductor not smaller than 2 AWG.

**(5) Rod and Pipe Electrodes.** Rod and pipe electrodes shall not be less than 2.44 m (8 ft) in length and shall consist of the following materials.

(a) **Grounding electrodes** of pipe or conduit shall not be smaller than metric designator 21 (trade size ¾) and, where of steel, shall have the outer surface galvanized or otherwise metal-coated for corrosion protection.

(b) **Grounding electrodes** of stainless steel and copper or zinc coated steel shall be at least 15.87 mm (⅝ in.) in diameter, unless listed and not less than 12.70 mm (½ in.) in diameter.

**(6) Other Listed Electrodes.** Other listed grounding electrodes shall be permitted.

**(7) Plate Electrodes.** Each plate electrode shall expose not less than 0.186 m<sup>2</sup> (2 ft<sup>2</sup>) of surface to exterior soil. Electrodes of iron or steel plates shall be at least 6.4 mm (¼ in.) in thickness. Electrodes of nonferrous metal shall be at least 1.5 mm (0.06 in.) in thickness.

**(8) Other Local Metal Underground Systems or Structures.** Other local metal underground systems or structures such as piping systems, underground tanks, and underground metal well casings that are not bonded to a metal water pipe.

**(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) Aluminum

FPN: See 250.104(B) for bonding requirements of gas piping.

## 250.53 Grounding Electrode System Installation.

FPN: See 547.9 and 547.10 for special grounding and bonding requirements for agricultural buildings.

**(A) Rod, Pipe, and Plate Electrodes.** Where 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.

**(B) Electrode Spacing.** Where more than one of the electrodes of the type specified in 250.52(A)(5) or (A)(7) are used, each electrode of one grounding system (including that used for air terminals) shall not be less than 1.83 m (6 ft) from any other electrode of another grounding system. Two or more grounding electrodes that are bonded together shall be considered a single grounding electrode system.

