

Chapter E 250

GROUNDING

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A. GENERAL

E 250.001 Scope. This chapter treats of protection of electric installations by grounding. Insulation, isolation, and guarding are suitable alternatives under certain conditions. See section E 195.16.

(1) **SYSTEMS AND CIRCUITS.** Circuits are grounded for the purpose of limiting the voltage upon the circuit which might otherwise occur through exposure to lightning or other voltages higher than that for which the circuit is designed; or to limit the maximum potential to ground due to normal voltage.

(2) **EXPOSED CONDUCTOR ENCLOSURES.** Exposed conductive materials enclosing electric conductors are grounded for the purpose of preventing a potential above ground on the enclosures.

(3) **EXPOSED EQUIPMENT ENCLOSURES.** Exposed conductive materials enclosing electric equipment, or forming a part of such equipment, are grounded for the purpose of preventing a potential above ground on the equipment.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.002 Other chapters. In other chapters, applying to particular cases of installation of conductors and equipment, there are requirements that are in addition to those of this chapter or are modifications of them:

	Chapter	Section
Appliances.....	E 422	E 422.12
Branch Circuits.....	E 210	E 210.05 E 210.06
Communications Circuits.....	E 800	
Conductors.....	E 200	
	E 310	E 310.02
Cranes and Hoists.....	E 610	
Fixtures and Lighting Equipment.....	E 410	E 410.91 E 410.92 E 410.93 E 410.94 E 410.95 E 410.96 E 400.13 E 400.14
Flexible Cords.....	E 400	E 400.13 E 400.14
Generators.....	E 445	E 445.08
Grounding Receptacles (Outlets).....	E 210	E 210.07 E 210.21 E 210.22
Hazardous Locations.....	E 500-517	
Inductive and Dielectric Heat Generating Equipment.....	E 665	
Less Than 50 V.....	E 720	
Lighting Fixtures.....	E 410	
Metal Working Machine Tools.....	E 670	
Motion Picture Studios.....	E 530	E 530.19 E 530.66
Motors and Controllers.....	E 490	
Organs.....	E 650	
Outlet, Switch and Junction Boxes, and Fittings.....	E 370	E 370.04 E 370.15
Radio and Television.....	E 810	
Receptacles and Attachment Plugs.....	E 410	E 410.55 E 410.56
Remote Control Circuits.....	E 725	E 725.21
Room Air Conditioners.....	E 422	E 422.61
Services.....	E 230	
Service Equipment.....	E 230	E 230.063
Signs and Outline Lighting.....	E 600	
Sound Recording Equipment.....	E 640	E 604.04
Swimming Pools.....	E 680	
Switchboards.....	E 384	E 384.11
Switches.....	E 380	E 380.01 E 380.12
Theaters and Assembly Halls.....	E 520	E 520.81
Trailers and Mobile Homes.....	E 391	
Transformers.....	E 450	E 450.08
X-ray Equipment.....	E 660	

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B. CIRCUIT AND SYSTEM GROUNDING

E 250.003 Two-wire direct-current systems. A two-wire direct-current system supplying interior wiring, and operating at not more than 300 volts between conductors, shall be grounded, unless such system is used for supplying industrial equipment in limited areas and the circuit is equipped with a ground detector.

Note: It is recommended that 2-wire direct-current systems operating at more than 300 volts between conductors be grounded when a neutral point can be established such that the maximum difference of potential between the neutral point and any other point on the system does not exceed 300 volts. It is recommended that 2-wire direct-current systems be not grounded when the voltage to ground of either conductor would exceed 300 volts after grounding. See section E 250.022.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.004 Three-wire direct-current systems. The neutral conductor of all 3-wire direct-current systems supplying interior wiring shall be grounded. See section E 250.022.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.005 Alternating-current systems. Secondary alternating-current systems supplying interior wiring, and interior alternating-current wiring systems, except those covered in sections E 250.006, E 250.007 and E 250.008, shall be grounded when they can be so grounded that the maximum voltage to ground does not exceed 300 volts. Where a service conductor is uninsulated in accordance with section E 230.004, the system shall be grounded.

Note 1. Higher voltage systems may be grounded.

Note 2. It is recommended that ungrounded systems supplying industrial equipment and operating at more than 150 volts and less than 600 volts be equipped with ground detectors.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.006 Furnace circuits. Electric furnace circuits need not be grounded.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.007 Electric crane circuits. Circuits for electric cranes operating over combustible fibers in Class III hazardous locations shall not be grounded. See section E 503.13.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.008 Circuits of less than 50 volts. Circuits of less than 50 volts need not be grounded, except as follows:

- (1) Where supplied by transformers from systems of more than 150 volts to ground, except as provided in subsection E 250.045 (4).
- (2) Where supplied by transformers from ungrounded systems.
- (3) Where run overhead outside buildings.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

C. LOCATION OF GROUNDING CONNECTIONS

E 250.021 Current over grounding conductors. The grounding of wiring systems, circuits, arresters, cable armor, conduit, or other metal raceways as a protective measure shall be so arranged that there will be no objectionable passage of current over the grounding conductors. The temporary currents set up under accidental conditions, while the grounding conductors are performing their intended protective func-

tions, are not to be considered as objectionable. Where an objectionable flow of current occurs over a grounding conductor, due to the use of multiple grounds, (1) one or more of such grounds shall be abandoned, or (2) their location shall be changed, or (3) the continuity of the conductor between the grounding connections shall be suitably interrupted, or (4) other means satisfactory to the administrative authority shall be taken to limit the current.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.022 Grounding connection for direct-current systems. Direct-current systems which are to be grounded shall have the grounding connection made at one or more supply stations but not at individual services nor elsewhere on interior wiring.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.023 Grounding connections for alternating-current systems. (1) Secondary alternating-current circuits which are to be grounded shall have a connection to a grounding electrode at each individual service, except as provided for in section E 250.021. The connection shall be made on the supply side of the service disconnecting means. Each secondary distribution system which is grounded shall have at least one additional connection to a grounding electrode at the transformer or elsewhere. No connection to a grounding electrode shall be made to the grounded circuit conductor on the load side of the service disconnecting means, except as provided for in section E 250.024.

(2) Where the secondary system is grounded at any point, the grounded conductor shall be run to each individual service. The grounded conductor shall terminate within the service equipment at the point where the equipment grounding conductor originates. This conductor shall be not smaller than the required grounding conductor specified in table E 250.094 (1).

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.024 Two or more buildings supplied by a single service. (1) Where more than one building is supplied by the same service, the grounded circuit conductor of the wiring system of any building utilizing one branch circuit supplied from such service may be connected to a grounding electrode at such building, and in the case of any building housing equipment required to be grounded or utilizing 2 or more branch circuits supplied from such service, and in the case of a building housing live stock, shall be so connected.

(2) When a metal raceway system is used in any such building supplied from a single service and this metal raceway or any connected non-current carrying metal part is accessible from any grounded surface, the metal raceway system and the neutral conductor shall be bonded together and connected to an approved ground electrode at the entrance to the building.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.025 Conductor to be grounded. For alternating-current interior wiring systems the conductor to be grounded shall be as follows:

- (1) Single-phase, 2-wire: the identified conductor;
- (2) Single-phase, 3-wire: the identified neutral conductor;
- (3) Multi-phase systems having one wire common to all phases: the identified common conductor;

(4) Multi-phase systems having one phase grounded: the identified conductor;

(5) Multi-phase systems in which one phase is used as in (2): the identified neutral conductor. One phase only can be grounded. See chapter E 200.

Note: The identified conductor is commonly known as "the white wire."

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.026 Isolated systems. For an interior wiring system or circuit which is required to be grounded and which is not electrically connected to an exterior secondary distribution system, the grounding connection shall be made at the transformer, generator, or other source of supply, or at the switchboard, on the supply side of the first switch controlling the system. See fine print note after section E 200.03.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

D. ENCLOSURE GROUNDING

E 250.032 Service conductor enclosures. Service raceways, service cable sheaths or armoring, when of metal, shall be grounded.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.033 Other conductor enclosures. Metal enclosures for conductors shall be grounded, except they need not be grounded in runs of less than 25 feet which are free from probable contact with ground, grounded metal, metal lath or conductive thermal insulation and which, where within reach from grounded surfaces, are guarded against contact by persons.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.034 Spacing from lightning rods. Metal enclosures of conductors shall, wherever practicable, be kept at least 6 feet away from lightning rod conductors. Where it is not practicable to secure 6 feet separation, they shall be bonded together.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E. EQUIPMENT GROUNDING

E 250.042 Fixed equipment; general. Under any of the following conditions, exposed, non-current-carrying metal parts of fixed equipment, which are liable to become energized, shall be grounded:

- (1) Where equipment is supplied by means of metal-clad wiring;
- (2) Where equipment is located in a wet location and is not isolated;
- (3) Where equipment is located within reach of a person who can make contact with any grounded surface or object;
- (4) Where equipment is located within reach of a person standing on the ground;
- (5) Where equipment is in a hazardous location; see chapters E 500-E 517 inclusive;
- (6) Where equipment is in electrical contact with metal or metal lath;
- (7) Where equipment operates with any terminal at more than 150 volts to ground, except as follows:
 - (a) Enclosures for switches or circuit-breakers where accessible to qualified persons only;

(b) Metal frames of electrically-heated devices, exempted by special permission, in which case the frames shall be permanently and effectively insulated from ground;

(c) Transformers mounted on wooden poles at a height of more than 8 feet from the ground.

Note: See subsection E 103.04 (2), in volume 1.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.043 Fixed equipment; specific. Exposed, non-current-carrying metal parts of the following kinds of equipment, regardless of voltage, shall be grounded:

- (1) Frames of motors as specified in section E 430.142;
- (2) Controller cases for motors, except lined covers of snap switches;
- (3) Electric equipment of elevators and cranes;
- (4) Electric equipment in garages, theatres and motion picture studios, except pendent lampholders on circuits of not more than 150 volts to ground;
- (5) Motion-picture projection equipment;
- (6) Electric signs and associated equipment, unless these are inaccessible to unauthorized persons and are also insulated from ground and from other conductive objects;
- (7) Generator and motor frames in an electrically operated organ, unless the generator is effectively insulated both from ground and from the motor driving it;
- (8) Switchboard frames and structures supporting switching equipment, except that frames of direct-current, single-polarity switchboards need not be grounded where effectively insulated.
- (9) Equipment supplied by class 1 and class 2 remote control and signaling circuits where part B of this chapter requires those circuits to be grounded.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.044 Non-electrical equipment. The following metal parts shall be grounded:

- (1) Frames and tracks of electrically operated cranes;
- (2) The metal frame of a non-electrically driven elevator car to which electric conductors are attached;
- (3) Hand-operated metal shifting ropes or cables of electric elevators;
- (4) Metal enclosures such as partitions, grill work, etc., around equipment carrying voltages in excess of 750 volts between conductors, unless in substations or vaults under the sole control of the supply company.

Note: Where extensive metal in or on buildings may become energized and is subject to personal contact, adequate bonding and grounding will provide additional safety.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.045 Portable equipment. Under any of the following conditions, exposed non-current carrying metal parts of portable equipment, which are liable to become energized, shall be grounded:

- (1) In hazardous locations (see chapters E 500 to E 517);
- (2) When operated at more than 150 volts to ground, except:
 - (a) Motors, where guarded;

(b) Metal frames of electrically-heated appliances exempted by section E 422.12.

(3) In residential occupancies, (a) clothes-washing, clothes-drying, and dish-washing machines, and (b) portable, hand held, motor operated tools and appliances of the following types: drills, hedge clippers, lawn mowers, wet scrubbers, sanders and saws.

1. Exception: Such tools and appliances protected by an approved system of double insulation, or its equivalent, need not be grounded. Where such an approved system is employed the equipment shall be distinctively marked.

Note: Portable tools or appliances not provided with special insulating or grounding protection are not intended to be used in damp, wet or conductive locations.

(4) In other than residential occupancies, (a) portable appliances used in damp or wet locations, or by persons standing on the ground or on metal floors or working inside of metal tanks or boilers, and (b) portable tools which are likely to be used in wet and conductive locations shall be grounded except where supplied through an insulating transformer with ungrounded secondary of not over 50 volts.

Note 1. This paragraph shall not be construed to prohibit the use of an insulating transformer with a secondary voltage greater than 50 volts, where the exposed metal parts of the appliance connected to such a transformer are grounded, and provided other conditions of this chapter are fulfilled.

Note 2. It is recommended that the frames of all portable motors which operate at more than 50 volts and less than 150 volts to ground be grounded, where this can be readily accomplished.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.046 Spacing from lightning rods. Metal frames and enclosures of electric equipment shall, wherever practicable, be kept at least 6 feet away from lightning rod conductors. Where it is not practicable to secure 6 feet separation, they shall be bonded together. See sections E 250.034 and E 250.086.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

F. METHODS OF GROUNDING

E 250.051 Effective grounding. The path to ground from circuits, equipment, or conductor enclosures shall (1) be permanent and continuous and (2) shall have ample carrying capacity to conduct safely any currents liable to be imposed on it, and (3) shall have impedance sufficiently low to limit the potential above ground and to facilitate the operation of the overcurrent devices in the circuit.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.052 Grounding a circuit conductor. The grounding conductor may be connected to the grounded circuit conductor at any convenient point on the premises on the supply side of the service disconnecting means.

Note: It is recommended that high capacity services have the grounding conductor connected to the grounded circuit conductor within the service entrance equipment enclosure.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.053 Common grounding conductor. The grounding conductor for circuits shall also be used for grounding equipment, conduit and

other metal raceways or enclosures for conductors, including service conduit or cable sheath and service equipment.

Note: See section E 250.112.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.054 Common grounding electrode. Where the alternating-current system is connected to a grounding electrode in or at a building as specified in sections E 250.023 and E 250.024, the same electrode shall be used to ground conductor enclosures and equipment in or on that building.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.055 Underground service cable. Where served from a continuous underground metal-sheathed cable system, the sheath or armor of underground service cable metallicly connected to the underground system, or underground service conduit containing a metal-sheathed cable bonded to the underground system, need not be grounded at the building and may be insulated from the interior conduit or piping.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.056 Short sections of raceway. Isolated sections of metal raceway or cable armor, where required to be grounded, shall preferably be grounded by connecting to other grounded raceway or armor, but may be grounded in accordance with section E 250.057.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.057 Fixed equipment. (1) Metal boxes, cabinets and fittings, or non-current-carrying metal parts of other fixed equipment, where metallicly connected to grounded cable armor or metal raceway, are considered to be grounded by such connection.

(2) Where not so connected they may be grounded in one of the following ways:

(a) By a grounding conductor run with circuit conductors; this conductor may be uninsulated, but where it is provided with an individual covering, the covering shall be finished to show a green color;

(b) By a separate grounding conductor installed the same as a grounding conductor for conduit and the like;

(c) By a grounding conductor in the supply cord, when cord connected as permitted in section E 400.03;

(d) By special permission, other means for grounding fixed equipment may be used.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.058 Equipment on structural metal. (1) Electric equipment, secured to and in contact with the grounded structural metal frame of a building, shall be deemed to be grounded.

(2) Metal car frames supported by metal hoisting cables attached to or running over sheaves or drums of elevator machines shall be deemed to be grounded where the machine is grounded in accordance with this code.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.059 Portable equipment. Non-current-carrying metal parts of portable equipment may be grounded in any one of the following ways:

(1) By means of the metal enclosure of the conductors feeding such equipment, provided an approved grounding type attachment plug is used, one fixed contacting member being for the purpose of grounding the metal enclosure, and provided, further, that the metal enclosure of the conductors is attached to the attachment plug and to the equipment by connectors approved for the purpose;

(a) *Exception:* The grounding contacting member of grounding type attachment plugs on the power supply cord of hand-held tools or hand-held appliances may be of the movable self-restoring type.

(2) By means of a grounding conductor run with the power supply conductors in a cable assembly or flexible cord that is properly terminated in an approved grounding-type attachment plug having a fixed grounding contacting member. The grounding conductor in a cable assembly may be uninsulated; but where an individual covering is provided for such conductors it shall be finished to show a green color.

(a) *Exception:* The grounding contacting member of grounding-type attachment plugs on the power supply cord of hand-held tools or hand-held appliances may be of the movable self-restoring type.

(3) A separate flexible wire or strap, insulated or bare, protected as well as practicable against physical damage may be used only by special permission except where a part of an approved portable equipment.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.060 Frames of electric ranges and electric clothes dryers. Frames of electric ranges and electric clothes dryers shall be grounded by any of the means provided for in sections E 250.057 and E 250.059 or where served by 120/240 volt, 3-wire branch circuits, they may be grounded by connection to the grounded circuit conductors, provided the grounded circuit conductors are not smaller than No. 10 AWG. The frames of wall-mounted ovens and counter-mounted cooking units shall be grounded and may be grounded in the same manner as electric ranges.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.061 Grounding equipment to circuit conductor. The grounded service conductor on the supply side of the service-disconnecting means may be used for grounding meter housing and service equipment. The grounded circuit conductor on the load side of the service disconnecting means shall not be used for grounding equipment, cable armor, or metal raceways except as provided in subsection E 250.057 (2) (d) and in section E 250.060.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

G. BONDING

E 250.071 Bonding at service equipment. The electrical continuity of the grounding circuit for the following equipment and enclosures shall be assured by one of the means given in section E 250.072.

(1) The service raceways or service cable armor or sheath, except as provided in subsection E 230.063 (2) and section E 250.055;

(2) All service equipment enclosures containing service entrance conductors, including meter fittings, boxes or the like, interposed in the service raceway or armor;

(3) Any conduit or armor which forms part of the grounding conductor to the service raceway.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.072 Continuity at service equipment. Electrical continuity at service equipment shall be assured by one of the following means:

(1) Bonding equipment to the grounded service conductor in a manner provided in section E 250.113;

(2) Threaded couplings and threaded bosses on enclosures with joints shall be made up wrench tight where rigid conduit is involved;

(3) Threadless couplings made up tight for rigid conduit and electrical metallic tubing;

(4) Bonding jumpers meeting the other requirements of this chapter. Bonding jumpers shall be used around concentric or eccentric knockouts which are punched or otherwise formed so as to impair the electrical connection to ground.

(5) Other devices (not locknuts and bushings) approved for the purpose.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.073 Metal armor or tape of service cable. With service cable having an uninsulated grounded service conductor in continuous electrical contact with its metallic armor or tape, the metal covering is considered to be adequately grounded.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.074 Bonding at grounding-type receptacles. Where there is likelihood that grounding continuity, especially at flush-type boxes, will not be maintained between a grounded outlet box and the grounding circuit of the receptacle through the mounting yoke, a bonding jumper shall connect the grounding terminal of the receptacle to the grounded box.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.075 Continuity at other enclosures. The electrical continuity of metallic raceway systems and cable armor that are to serve as grounding conductors shall be assured. At points where raceway or armor connects to metal enclosures, any non-conducting coating which might interrupt such continuity shall be removed unless fittings are used which are so designed that such removal is unnecessary.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.076 Voltages exceeding 250 volts. The electrical continuity of metal raceway or metal sheathed cable which contains any conductor other than service entrance conductors of more than 250 volts to ground shall be assured by one of the methods specified in subsections E 250.072 (2)-(5), or by one of the following methods:

(1) Threadless fittings, made up tight, with conduit or armored cable;

(2) Two locknuts, one inside and one outside of boxes and cabinets.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.077 Loosely-jointed metal raceways. Expansion joints and telescoping sections of raceways shall be made electrically continuous by bonding jumpers or other approved means. Metal trough raceways used in connection with sound recording and reproducing, made up in sections, shall contain a grounding conductor to which each section shall be bonded.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.078 Hazardous locations. In hazardous locations, regardless of the voltage involved, the electrical continuity of metallic raceway, boxes and the like, shall be assured by one of the methods specified in subsections E 250.072 (2)-(5).

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.079 Bonding jumpers. Bonding jumpers shall conform to the following:

(1) **MATERIAL AND SIZE.** Bonding jumpers shall be of copper or other corrosion-resistant material and shall be of sufficient size to have current-carrying capacity not less than is required in table E 250.094 (1).

(2) **ATTACHMENT.** Bonding jumpers shall be attached to cabinets and the like in a manner provided in section E 250.113; where used between grounding electrodes or around water meters and the like, they shall be attached in a manner provided for in section E 250.114.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

H. GROUNDING ELECTRODES

E 250.081 Water pipe. A metallic underground water piping system, either local or supplying a community, shall always be used as the grounding electrode where such a piping system is available. If the buried portion of the metallic piping system is less than 50 feet excluding well casings, or has a resistance to ground of more than 3 ohms, the piping system ground shall be augmented by at least 2 grounding electrodes recognized in section E 250.082 and section E 250.083 wherever the circuit or non-current carrying parts are required to be grounded.

Note: Expanding use of nonmetallic piping for water systems and insulating couplings on metallic water systems makes it more important that water piping within a building be adequately grounded without depending on connections to an outside piping system. The interior piping system should be electrically continuous. Bonding to gas, sewer, hot water piping and metallic air ducts within the premises will provide additional safety.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.082 Other available electrodes. Where a water system as described in section E 250.081 is not available, the grounding connection may be made to any of the following if the resistance to ground is less than 3 ohms or the metal is supplemented by 2 electrodes of the type recognized in section E 250.083:

(1) The metal frame of the building, if effectively grounded;

(2) Other local metallic underground systems, such as piping, tanks, and the like. Gas piping should be avoided.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.083 Made electrodes. Where electrodes described in sections E 250.081 and E 250.082 are not available, the grounding electrode shall consist of a driven pipe, driven rod, buried plate or other device approved for the purpose and conforming to the following requirements:

(1) **PLATE ELECTRODES.** Each plate electrode shall present not less than 2 square feet of surface to exterior soil. Electrodes of iron, or steel plates shall be at least $\frac{1}{4}$ inch in thickness. Electrodes of non-ferrous metal shall be at least 0.06 inch in thickness.

(2) **PIPE ELECTRODES.** Electrodes of pipe or conduit shall be not smaller than of the $\frac{3}{4}$ inch trade size and, where of iron or steel, shall have the outer surface galvanized or otherwise metal-coated for corrosion protection.

(3) **ROD ELECTRODES.** Electrodes of rods of steel or iron shall be at least $\frac{5}{8}$ inch in diameter. Approved rods of non-ferrous materials or their approved equivalent used for electrodes shall be not less than $\frac{1}{2}$ inch in diameter.

(4) **INSTALLATION.** Electrodes should, as far as practicable, be imbedded below permanent moisture level. Except where rock bottom is encountered, pipes or rods shall be driven to a depth of at least 8 feet regardless of size or number of electrodes used. Pipes or rods when less than standard commercial length shall preferably be of one piece. Such pipes or rods shall have clean metal surfaces and shall not be covered with paint, enamel or other poorly conducting materials. Where rock bottom is encountered at a depth of less than 4 feet, electrodes shall be buried in a horizontal trench, and where pipes or rods are used as the electrode they shall comply with subsections E 250.083 (2) and (3) and shall not be less than 8 feet in length. Each electrode shall be separated at least 6 feet from any other electrode, including those used for signal circuits, radio, lightning rods, or any other purpose.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.084 Resistance. If the resistance to ground of an underground piping or metallic system is more than 3 ohms, 2 made electrodes must be added to the grounding system. If a single made electrode does not have a resistance to ground of less than 25 ohms, 2 made electrodes shall be installed. The distance between made electrodes shall be at least 6 feet.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.085 Railway tracks. Rails or other grounded conductors of electric railway circuits shall not be used (1) as a ground for other than railway lightning arresters and railway equipment, conduit, armored cable, metal raceway, and the like, where other effective grounds are available; and (2) in no case shall such rails or other grounded conductors of railway circuits be used for grounding interior wiring systems other than those supplied from the railway circuit itself.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.086 Use of lightning rods. Lightning rod conductors and driven pipes, rods or other made electrodes used for grounding lightning rods, shall not be used in lieu of the made grounding electrodes

required by this chapter for grounding wiring systems and equipment. The foregoing provision shall not be taken to forbid the bonding together of the several made electrodes that are respectively provided for electric wiring systems and equipment, for communication systems, and for lightning protection. See subsection E 800.31 (2) (e).

History: Cr. Register April 1964, No. 100, eff. 5-1-64.

J. GROUNDING CONDUCTORS

E 250.091 Material. The material for the grounding conductors shall be as follows:

(1) **FOR SYSTEM OR COMMON GROUNDING CONDUCTOR.** The grounding conductor of a wiring system shall be of copper or other corrosion-resistant material. The conductor may be solid or stranded, insulated or bare. Except in cases of bus-bars, the grounding conductor shall be without joint or splice throughout its length. Where the grounding conductor is not of copper, its electrical resistance per linear foot shall not exceed that of the allowable copper conductor for such a purpose.

(2) **FOR CONDUCTOR ENCLOSURES AND EQUIPMENT ONLY.** The grounding conductor for equipment and for conduit and other metal raceways or enclosures for conductors, may be a conductor of copper or other corrosion-resistant material, stranded or solid, insulated or bare, a bus-bar or a rigid conduit, steel pipe, electrical metallic tubing or the armor of type AC metal-clad cable, except that under conditions favorable to corrosion, a suitable corrosion-resistant material shall be used. Where conduit is used as a grounding conductor, all joints and fittings shall be made wrench tight.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.092 Installation. Grounding conductors shall be installed as follows:

(1) **SYSTEM OR COMMON GROUNDING CONDUCTOR.** A grounding conductor, No. 4 or larger, may be attached to the surface on which it is carried without the use of knobs, tubes or insulators. It need not have protection unless exposed to severe physical damage. A No. 6 grounding conductor, which is free from exposure to physical damage, may be run along the surface of the building construction without metal covering or protection, where it is rigidly stapled to the construction; otherwise, it shall be in conduit, electrical metallic tubing or cable armor. Grounding conductors smaller than No. 6 shall be in conduit, electrical metallic tubing or cable armor. Metallic enclosures for grounding 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. Where rigid metallic conduit or steel pipe is used as protection for a grounding conductor, the installation shall comply with the requirement of chapter E 346; where electrical metallic tubing is used, the installation shall comply with the requirements of chapter E 348. Aluminum grounding conductors shall not be used where in direct contact with masonry or the earth or where subject to corrosive conditions. Where used outside, aluminum grounding conductors shall not be installed within 18 inches of the earth.

(2) CONDUCTOR ENCLOSURES AND EQUIPMENT ONLY. A grounding conductor for conductor enclosures and equipment only shall meet the requirements of subsection E 250.092 (1), except that where smaller than No. 6, as permitted by section E 250.095, it need not be armored or installed in a raceway where run through the hollow spaces of a wall or partition or otherwise run so as not to be subject to physical damage.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.093 Direct-current circuits. The carrying capacity of the grounding conductor for a direct-current supply system or generator shall not be less than that of the largest conductor supplied by the system, except that where the grounded circuit conductor is a neutral derived from a balancer winding or a balancer set protected in accordance with requirements of subsection E 445.04 (4), the size of the grounding conductor shall not be less than that of the neutral conductor. The grounding conductor shall in no case be smaller than No. 8 copper.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.094 Alternating-current and service equipment. (1) WIRING SYSTEM AND COMMON GROUNDING CONDUCTOR. The size of the grounding conductor for an alternating current system or for a common grounding conductor shall not be less than is given in table E 250.094 (1), except that where connected to made electrodes (as in section E 250.083) the conductor need not be larger than No. 6 copper wire or its equivalent in carrying capacity.

(2) WHERE WIRING SYSTEM IS NOT GROUNDED AT PREMISES. Where the wiring system is not grounded at the premises, the size of a grounding conductor for a service raceway, for the metal sheath or armor of a service cable, and for service equipment shall not be less than is given in table E 250.094 (2), except that where connected to made electrodes (as in section E 250.083) the conductor need not be larger than No. 6 copper or its equivalent in carrying capacity.

TABLE E 250.094 (1)
SIZES OF GROUNDING CONDUCTORS

Size of Largest Service Conductor or Equivalent for Multiple Conductors	Size of Copper Grounding Conductor AWG. No.
2 or smaller.....	8
1 or 0.....	6
00 or 000.....	4
Over 000 to 350,000 c.m.....	2
Over 350,000 c.m. to 600,000 c.m.....	0
Over 600,000 c.m. to 1,100,000 c.m.....	00
Over 1,100,000 c.m.....	000

TABLE E 250.094 (2)
SIZES OF GROUNDING CONDUCTORS

Size of Largest Service Conductor or Equivalent for Multiple Conductors	Size of Grounding Conductor		
	Copper Wire AWG. No.	Conduit or Pipe Trade Size (Inch)	Electrical Metallic Tubing Trade Size (Inch)
2 or smaller	8	1/2	1/2
1 or 0	6	1/2	1
00 or 000	4	3/4	1 1/4
Over 000 to 350,000 c.m.	2	3/4	1 1/4
Over 350,000 c.m. to 600,000 c.m.	0	1	2
Over 600,000 c.m. to 1,100,000 c.m.	00	1	2
Over 1,100,000 c.m.	000	1	2

Aluminum Service Conductor	*Aluminum Grounding Conductor
0 or smaller	6
2/0 or 3/0	4
4/0 or 250 MCM	2
Over 250 MCM to 500 MCM	0
Over 500 MCM to 900 MCM	3/0
Over 900 MCM to 1750 MCM	4/0
Over 1750 MCM	250 MCM

*See installation restrictions in subsection E 250.092(1).

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.095 Interior raceway and equipment. The size of the grounding conductor for conduit, cable sheath or armor, and other metal raceways or enclosures for conductors, and for equipment, shall not be less than given in table E 250.095 (1); except that where connected to electrodes as described in section E 250.083, the grounding conductor need not be larger than No. 6 copper or its equivalent.

TABLE E 250.095 (1)
SIZES OF GROUNDING CONDUCTORS

Rating or Setting of Automatic Overcurrent Device in Circuit Ahead of Equipment, Conduit, etc., Not Exceeding (Amperes)	Size of Grounding Conductor			
	Copper Wire No.	Aluminum* Wire No.	Conduit or Pipe (Inch)	Electrical Metallic Tubing (Inch)
20	16**	12	1/2	1/2
30	14	12	1/2	1/2
40	12	10	1/2	1/2
60	10	8	1/2	1/2
100	8	6	1/2	1/2
200	6	4	1/2	1
400	4	2	3/4	1 1/4
600	2	0	3/4	1 1/4
800	0	000	1	2
1000	00	0000	1	2
1200	000	250 MCM	1	2

*See installation restrictions in subsection E 250.092(1).

**Permissible only when part of an approved cable assembly.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.096 Portable and pendent equipment. For grounding portable or pendent equipment, the conductors of which are protected by fuses or circuit-breakers rated or set at not exceeding 20 amperes, No. 18 copper wire may be used. Conductors of Nos. 16 or 18 copper which are used for grounding portable equipment shall be part of an approved flexible cord assembly. For grounding portable or pendent equipment protected at more than 20 amperes, table E 250.095(1) shall be followed.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.097 Outline lighting. Isolated non-current-carrying metal parts of outline lighting systems may be bonded together by a No. 14 conductor protected from physical damage, where a conductor complying with section E 250.095 is used to ground the group.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.098 Common raceway. A grounding conductor may be run in the same metal raceway with other conductors of the system to which it is connected.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.099 Continuity. No automatic cutout or switch shall be placed in the grounding conductor of an interior wiring system unless the opening of the cutout or switch disconnects all sources of energy.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

K. GROUNDING CONDUCTOR CONNECTIONS

E 250.111 To raceway or cable armor. The point of connection of the grounding conductor to interior metal raceways, cable armor and the like shall be as near as practicable to the source of supply and shall be so chosen that no raceway or cable armor is grounded through a run of smaller size than is called for in section E 250.095.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.112 To electrode. The grounding connection to the electrode shall be located as follows:

(1) **TO WATER PIPES.** System or common grounding conductors shall be attached to a water piping system on the street side of the water meter or on a cold water pipe of adequate current-carrying capacity as near as practicable to the water service entrance to the building. Where the source of the water supply is from a driven well in the basement of the premises, the connection shall be made as near as practicable to the well. Where practicable, the point of attachment shall be accessible. Where the point of attachment is not on the street side of the water meter, the water piping system shall be made electrically continuous by bonding together all parts between the attachment and the street side of the water meter or the pipe entrance which contain insulating sections or are liable to become disconnected, as at meters, valves and service unions. Equipment may be grounded to a grounded cold water pipe near the equipment.

(2) **TO GAS PIPES.** The point of attachment of a grounding conductor to gas piping shall always be on the street side of the gas meter, and shall be accessible where practicable.

(3) **TO OTHER ELECTRODES.** The grounding conductor shall be attached to other electrodes permitted in sections E 250.082 and E 250.083 at a point which will assure a permanent ground. Where practicable the point of attachment shall be accessible.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.113 Attachment to circuits and equipment. The grounding conductor, bond, or bonding jumper shall be attached to circuits, conduits, cabinets, equipment, and the like, which are to be grounded, by means of suitable lugs, pressure connectors, clamps, or other approved means, except that connections which depend upon solder shall not be used.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.114 Continuity and attachment of branch circuit grounding conductors to boxes. Where more than one grounding conductor of a branch circuit enters a box, all such conductors shall be in good electrical contact with each other and the arrangement shall be such that the disconnection or removal of a receptacle, fixture, or other device fed from the box will not interfere with or interrupt the grounding continuity.

(1) **METALLIC BOXES.** A connection shall be made between the one or more grounding conductors and a metallic box by means of a grounding screw which shall be used for no other purpose, or an approved grounding device.

(2) **NONMETALLIC BOXES.** One or more grounding conductors brought into a nonmetallic outlet box shall be so arranged that a connection can be made to any fitting or device in that box which requires grounding.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.115 Attachments to electrodes. The grounding conductor shall be attached to the grounding electrode by means of (1) an approved bolted clamp of cast bronze or brass or of plain or malleable cast iron, or (2) a pipe fitting, plug, or other approved device, screwed into the pipe or into the fitting, or (3) other equally substantial approved means. The grounding conductor shall be attached to the grounding fitting by means of suitable lugs, pressure connectors, clamps, or other approved means, except that connections which depend upon solder shall not be used. Not more than one conductor shall be connected to the grounding electrode by a single clamp or fitting, unless the clamp or fitting is of a type approved for such use.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.116 Ground clamps. For the grounding conductor of a wiring system the sheet-metal-strap type of ground clamp is not considered adequate unless the strap is attached to a rigid metal base which, when installed, is seated on the water pipe, or other electrode and the strap is of such material and dimensions that it is not liable to stretch during or after installation.

Note: Ground clamps for use on copper water tubing and copper, brass, or lead pipe should preferably be of copper, and those for use on galvanized or iron pipe should preferably be of galvanized iron and so designed as to avoid physical damages to pipe. Ground clamps used with aluminum grounding conductors should be approved for the purpose.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.117 Protection of attachment. Ground clamps or other fittings, unless approved for general use without protection, shall be protected from ordinary physical damage (1) by being placed where they are not liable to be damaged or (2) by being enclosed in metal, wood, or equivalent protective covering.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.118 Clean surfaces. Where a non-conductive protective coating, such as paint or enamel, is used on the equipment, conduit, couplings or fittings, such coating shall be removed from threads and other contact surfaces in order to insure a good electrical connection.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

L. INSTRUMENT TRANSFORMERS, RELAYS, ETC.

E 250.121 Instrument transformer circuits. The secondary circuits of current and potential instrument transformers shall be grounded where the primary windings are connected to circuits of 300 volts or more to ground, and, where on switchboards, shall be grounded irrespective of voltage, except that such circuits need not be grounded where the primary windings are connected to circuits of 750 volts or less and no live parts or wiring are exposed or accessible to other than qualified persons.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.122 Instrument transformer cases. Cases or frames of instrument transformers shall be grounded where accessible to other than qualified persons, except that cases or frames of current transformers, the primaries of which are not over 150 volts to ground and which are used exclusively to supply current to meters, need not be grounded.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.123 Cases of instruments, meters and relays; operating voltage 750 or less. Instruments, meters and relays which operate with windings or working parts at 750 volts or less shall be grounded as follows:

(1) **NOT ON SWITCHBOARDS.** Instruments, meters and relays not located on switchboards, which operate with windings or working parts at 300 volts or more to ground, and accessible to other than qualified persons, shall have the cases and other exposed metal parts grounded;

(2) **ON DEAD FRONT SWITCHBOARDS.** Instruments, meters and relays (whether operated from current and potential transformers, or connected directly in the circuit) on switchboards having no live parts on the front of the panels shall have the cases grounded;

(3) **ON LIVE FRONT SWITCHBOARDS.** Instruments, meters and relays (whether operated from current and potential transformers, or connected directly in the circuit) on switchboards having exposed live parts on the front of panels shall not have their cases grounded. Mats of insulating rubber or other suitable floor insulation, shall be provided for the operator where the voltage to ground exceeds 150,

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.124 Cases of instruments, meters and relays; operating voltage over 750. Where instruments, meters and relays have current-carrying parts over 750 volts to ground, they shall be isolated by elevation or protected by suitable barriers, grounded metal or insulating covers or guards. Their cases shall not be grounded, except as follows:

(1) In electrostatic ground detectors the internal ground segments of the instrument are connected to the instrument case and grounded; the ground detector shall be isolated by elevation.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.125 Instrument grounding conductor. The grounding conductor for secondary circuits of instrument transformers and for instrument cases shall not be smaller than No. 12 where of copper; where of other metal, it shall have equal conductance. Cases of instrument transformers, instruments, meters and relays which are mounted directly on grounded metal surfaces of enclosures or grounded metal switchboard panels shall be considered to be grounded and no additional grounding conductor will be required.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

M. LIGHTNING ARRESTERS

E 250.131 On secondary services; 750 volts or less. Where a lightning arrester is installed on a secondary service, the connections to the service conductors and to the grounding conductor shall be as short as practicable. The grounding conductor may be (1) the grounded service conductor, or (2) the common grounding conductor, or (3) the service equipment grounding conductor. The bonding or grounding conductor shall be of copper not smaller than No. 14 or of equivalent corrosion-resistant material.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.

E 250.132 On primary circuits. The grounding conductor of a lightning arrester protecting a transformer which supplies a secondary distribution system may be interconnected as follows:

(1) **METALLIC INTERCONNECTION.** A metallic interconnection may be made to the secondary neutral provided that, in addition to the direct grounding connection at the arrester:

(a) The grounded conductor of the secondary has elsewhere a grounding connection to a continuous metallic underground water piping system. However, in urban water pipe areas where there are at least 4 waterpipe connections on the neutral and not less than 4 such connections in each mile of neutral, the metallic interconnection may be made to the secondary neutral with omission of the direct grounding connection at the arrester.

(b) The grounded conductor of the secondary system is part of a multi-grounded neutral system, of which the primary neutral has at least 4 ground connections in each mile of line in addition to a ground at each service.

(2) **THROUGH SPARK GAP.** Where the secondary is not grounded as in subsection E 250.132 (1), but is otherwise grounded as in sections

E 250.082 and E 250.083, such interconnection, where made, shall be through a spark gap having a 60-cycle breakdown voltage of at least twice the primary circuit voltage but not necessarily more than 10 kv, and there shall be at least one other ground on the grounded conductor of the secondary not less than 20 feet distant from the lightning arrester grounding electrode.

(3) BY SPECIAL PERMISSION. Except as above provided, interconnection of the arrester ground and the secondary neutral may be made only by special permission.

History: Cr. Register, April, 1964, No. 100, eff. 5-1-64.