# CHAPTER 35
# ELECTRICAL DEFINITIONS

## SECTION E3501
## GENERAL

**E3501.1 Scope.** This chapter contains definitions that shall apply only to the electrical requirements of Chapters 34 through 43. Unless otherwise expressly stated, the following terms shall, for the purpose of this code, have the meanings indicated in this chapter. Words used in the present tense include the future; the singular number includes the plural and the plural the singular. Where terms are not defined in this section and are defined in Section R202 of this code, such terms shall have the meanings ascribed to them in that section. Where terms are not defined in these sections, they shall have their ordinarily accepted meanings or such as the context implies.

**ACCESSIBLE.** (As applied to equipment.) Admitting close approach; not guarded by locked doors, elevation or other effective means.

**ACCESSIBLE.** (As applied to wiring methods.) Capable of being removed or exposed without damaging the building structure or finish, or not permanently closed in by the structure or finish of the building.

**ACCESSIBLE, READILY.** Capable of being reached quickly for operation, renewal or inspections, without requiring those to whom ready access is requisite to climb over or remove obstacles or to resort to portable ladders, etc.

**AMPACITY.** The current in amperes that a conductor can carry continuously under the conditions of use without exceeding its temperature rating.

**APPLIANCE.** Utilization equipment, normally built in standardized sizes or types, that is installed or connected as a unit to perform one or more functions such as clothes washing, air conditioning, food mixing, deep frying, etc.

**APPROVED**. Acceptable to the authority having jurisdiction.

**ARC-FAULT CIRCUIT INTERRUPTER.** A device intended to provide protection from the effects of arc-faults by recognizing characteristics unique to arcing and by functioning to de-energize the circuit when an arc-fault is detected.

**ATTACHMENT PLUG (PLUG CAP) (PLUG).** A device that, by insertion into a receptacle, establishes connection between the conductors of the attached flexible cord and the conductors connected permanently to the receptacle.

**AUTOMATIC.** Self-acting, operating by its own mechanism when actuated by some impersonal influence, as, for example, a change in current, pressure, temperature or mechanical configuration.

**BATHROOM.** An area, including a basin, with one or more of the following: a toilet, a tub or a shower.

**BONDED (BONDING).** Connected to establish electrical continuity and conductivity.

**BONDING JUMPER.** A reliable conductor to ensure the required electrical conductivity between metal parts required to be electrically connected.

**BONDING JUMPER (EQUIPMENT).** The connection between two or more portions of the equipment grounding conductor.

**BONDING JUMPER, MAIN.** The connection between the grounded circuit conductor and the equipment grounding conductor at the service.

**BRANCH CIRCUIT.** The circuit conductors between the final overcurrent device protecting the circuit and the outlet(s).

**BRANCH CIRCUIT, APPLIANCE.** A branch circuit that supplies energy to one or more outlets to which appliances are to be connected, and that has no permanently connected luminaires that are not a part of an appliance.

**BRANCH CIRCUIT, GENERAL PURPOSE.** A branch circuit that supplies two or more receptacle outlets or outlets for lighting and appliances.

**BRANCH CIRCUIT, INDIVIDUAL.** A branch circuit that supplies only one utilization equipment.

**BRANCH CIRCUIT, MULTIWIRE.** A branch circuit consisting of two or more ungrounded conductors having voltage difference between them, and a grounded conductor having equal voltage difference between it and each ungrounded conductor of the circuit, and that is connected to the neutral or grounded conductor of the system.

**CABINET.** An enclosure designed either for surface or flush mounting and provided with a frame, mat or trim in which a swinging door or doors are or may be hung.

**CIRCUIT BREAKER.** A device designed to open and close a circuit by nonautomatic means and to open the circuit automatically on a predetermined overcurrent without damage to itself when properly applied within its rating.

**CLOTHES CLOSET.** A nonhabitable room or space intended primarily for storage of garments and apparel.

**CONCEALED.** Rendered inaccessible by the structure or finish of the building. Wires in concealed raceways are considered to be concealed, even though they become accessible upon withdrawing them [see "Accessible (As applied to wiring methods)"].

**CONDUCTOR**

**Bare.** A conductor having no covering or electrical insulation whatsoever.

**Covered.** A conductor encased within material of composition or thickness that is not recognized by this code as electrical insulation.

**Insulated.** A conductor encased within material of composition and thickness that is recognized by this code as electrical insulation.

**CONDUIT BODY.** A separate portion of a conduit or tubing system that provides access through a removable cover(s) to the interior of the system at a junction of two or more sections of the system or at a terminal point of the system. Boxes such as FS and FD or larger cast or sheet metal boxes are not classified as conduit bodies.

**CONNECTOR, PRESSURE (SOLDERLESS).** A device that establishes a connection between two or more conductors or between one or more conductors and a terminal by means of mechanical pressure and without the use of solder.

**CONTINUOUS LOAD.** A load where the maximum current is expected to continue for 3 hours or more.

**COOKING UNIT, COUNTER-MOUNTED.** A cooking appliance designed for mounting in or on a counter and consisting of one or more heating elements, internal wiring and built-in or separately mountable controls.

**COPPER-CLAD ALUMINUM CONDUCTORS.** Conductors drawn from a copper-clad aluminum rod with the copper metallurgically bonded to an aluminum core. The copper forms a minimum of 10 percent of the cross-sectional area of a solid conductor or each strand of a stranded conductor.

**CUTOUT BOX.** An enclosure designed for surface mounting and having swinging doors or covers secured directly to and telescoping with the walls of the box proper (see "Cabinet").

**DEAD FRONT.** Without live parts exposed to a person on the operating side of the equipment.

**DEMAND FACTOR.** The ratio of the maximum demand of a system, or part of a system, to the total connected load of a system or the part of the system under consideration.

**DEVICE.** A unit of an electrical system that carries or controls electrical energy as it principal function.

**DISCONNECTING MEANS.** A device, or group of devices, or other means by which the conductors of a circuit can be disconnected from their source of supply.

**DWELLING**

**Dwelling unit.** A single unit, providing complete and independent living facilities for one or more persons, including permanent provisions for living, sleeping, cooking and sanitation.

**One-family dwelling.** A building consisting solely of one dwelling unit.

**Two-family dwelling.** A building consisting solely of two dwelling units.

**ENCLOSED.** Surrounded by a case, housing, fence or walls that will prevent persons from accidentally contacting energized parts.

**ENCLOSURE.** The case or housing of apparatus, or the fence or walls surrounding an installation, to prevent personnel from accidentally contacting energized parts or to protect the equipment from physical damage.

**ENERGIZED.** Electrically connected to, or is, a source of voltage.

**EQUIPMENT.** A general term including material, fittings, devices, appliances, luminaires, apparatus, machinery and the like used as a part of, or in connection with, an electrical installation.

**EXPOSED.** (As applied to live parts.) Capable of being inadvertently touched or approached nearer than a safe distance by a person. It is applied to parts not suitably guarded, isolated or insulated.

**EXPOSED.** (As applied to wiring methods.) On or attached to the surface or behind panels designed to allow access.

**EXTERNALLY OPERABLE.** Capable of being operated without exposing the operator to contact with live parts.

**FEEDER.** All circuit conductors between the service equipment, or the source of a separately derived system, or other power supply source and the final branch-circuit overcurrent device.

**FITTING.** An accessory such as a locknut, bushing or other part of a wiring system that is intended primarily to perform a mechanical rather than an electrical function.

**GROUND.** The earth.

**GROUNDED (GROUNDING).** Connected (connecting) to ground or to a conductive body that extends the ground connection.

**GROUNDED, EFFECTIVELY.** Intentionally connected to earth through a ground connection or connections of sufficiently low impedance and having sufficient current-carrying capacity to prevent the buildup of voltages that may result in undue hazards to connected equipment or to persons.

**GROUNDED CONDUCTOR.** A system or circuit conductor that is intentionally grounded.

**GROUNDING CONDUCTOR.** A conductor used to connect equipment or the grounded circuit of a wiring system to a grounding electrode or electrodes.

**GROUNDING CONDUCTOR, EQUIPMENT (EGC).** The conductive path installed to connect normally noncurrent-carrying metal parts of equipment together and, to the system grounded conductor, the grounding electrode conductor or both.

**GROUNDING ELECTRODE.** A conducting object through which a direct connection to earth is established.

**GROUNDING ELECTRODE CONDUCTOR.** A conductor used to connect the system grounded conductor or the equipment to a grounding electrode or to a point on the grounding electrode system.

**GROUND-FAULT CIRCUIT-INTERRUPTER.** A device intended for the protection of personnel that functions to de-energize a circuit or portion thereof within an established period of time when a current to ground exceeds the value for a Class A device.

**GUARDED.** Covered, shielded, fenced, enclosed or otherwise protected by means of suitable covers, casings, barriers, rails, screens, mats or platforms to remove the likelihood of approach or contact by persons or objects to a point of danger.

**IDENTIFIED.** (As applied to equipment.) Recognizable as suitable for the specific purpose, function, use, environment, application, etc., where described in a particular code requirement.

**INTERRUPTING RATING.** The highest current at rated voltage that a device is intended to interrupt under standard test conditions.

**INTERSYSTEM BONDING TERMINATION.** A device that provides a means for connecting communications system(s) grounding conductor(s) and bonding conductor(s) at the service equipment or at the disconnecting means for buildings or structures supplied by a feeder or branch.

**ISOLATED.** (As applied to location.) Not readily accessible to persons unless special means for access are used.

**KITCHEN.** An area with a sink and permanent facilities for food preparation and cooking.

**LABELED.** Equipment or materials to which has been attached a label, symbol or other identifying mark of an organization acceptable to the authority having jurisdiction and concerned with product evaluation that maintains periodic inspection of production of labeled equipment or materials and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

**LIGHTING OUTLET.** An outlet intended for the direct connection of a lampholder or luminaire.

**LISTED.** Equipment, materials or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states either that the equipment, material or services meets identified standards or has been tested and found suitable for a specified purpose.

**LIVE PARTS.** Energized conductive components.

**LOCATION, DAMP.** Location protected from weather and not subject to saturation with water or other liquids but subject to moderate degrees of moisture. Examples of such locations include partially protected locations under canopies, marquees, roofed open porches and like locations, and interior locations subject to moderate degrees of moisture, such as some basements, some barns and some cold-storage warehouses.

**LOCATION, DRY.** A location not normally subject to dampness or wetness. A location classified as dry may be temporarily subject to dampness or wetness, as in the case of a building under construction.

**LOCATION, WET.** Installations underground or in concrete slabs or masonry in direct contact with the earth and locations subject to saturation with water or other liquids, such as vehicle-washing areas, and locations exposed to weather.

**LUMINAIRE.** A complete lighting unit consisting of a light source such as a lamp or lamps together with the parts designed to position the light source and connect it to the power supply. A luminaire can include parts to protect the light source or the ballast or to distribute the light. A lampholder itself is not a luminaire.

**MULTIOUTLET ASSEMBLY.** A type of surface, or flush, or freestanding raceway; designed to hold conductors and receptacles, assembled in the field or at the factory.

**NEUTRAL CONDUCTOR.** The conductor connected to the neutral point of a system that is intended to carry current under normal conditions.

**NEUTRAL POINT.** The common point on a wye-connection in a polyphase system or midpoint on a single-phase, 3-wire system, or midpoint of a single-phase portion of a 3-phase delta system, or a midpoint of a 3-wire, direct-current system.

**OUTLET.** A point on the wiring system at which current is taken to supply utilization equipment.

**OVERCURRENT.** Any current in excess of the rated current of equipment or the ampacity of a conductor. Such current might result from overload, short circuit or ground fault.

**OVERLOAD.** Operation of equipment in excess of normal, full-load rating, or of a conductor in excess of rated ampacity that, when it persists for a sufficient length of time, would cause damage or dangerous overheating. A fault, such as a short circuit or ground fault, is not an overload.

**PANELBOARD.** A single panel or group of panel units designed for assembly in the form of a single panel, including buses and automatic overcurrent devices, and equipped with or without switches for the control of light, heat or power circuits, designed to be placed in a cabinet or cutout box placed in or against a wall, partition or other support and accessible only from the front.

**PLENUM.** A compartment or chamber to which one or more air ducts are connected and that forms part of the air distribution system.

**POWER OUTLET.** An enclosed assembly that may include receptacles, circuit breakers, fuseholders, fused switches, buses and watt-hour meter mounting means, intended to supply and control power to mobile homes, recreational vehicles or boats, or to serve as a means for distributing power required to operate mobile or temporarily installed equipment.

**PREMISES WIRING (SYSTEM).** Interior and exterior wiring, including power, lighting, control and signal circuit wiring together with all of their associated hardware, fittings and wiring devices, both permanently and temporarily installed. This includes wiring from the service point or power source to the outlets and wiring from and including the power source to the outlets where there is no service point. Such wiring does not include wiring internal to appliances, luminaires, motors, controllers, and similar equipment.

**QUALIFIED PERSON.** One who has the skills and knowledge related to the construction and operation of the electrical equipment and installations and has received safety training to recognize and avoid the hazards involved.

**RACEWAY.** An enclosed channel of metal or nonmetallic materials designed expressly for holding wires, cables, or busbars, with additional functions as permitted in this code. Raceways include, but are not limited to, rigid metal conduit,

rigid nonmetallic conduit, intermediate metal conduit, liquid-tight flexible conduit, flexible metallic tubing, flexible metal conduit, electrical nonmetallic tubing, electrical metallic tubing, underfloor raceways, cellular concrete floor raceways, cellular metal floor raceways, surface raceways, wireways and busways.

**RAINPROOF.** Constructed, protected or treated so as to prevent rain from interfering with the successful operation of the apparatus under specified test conditions.

**RAIN TIGHT.** Constructed or protected so that exposure to a beating rain will not result in the entrance of water under specified test conditions.

**RECEPTACLE.** A receptacle is a contact device installed at the outlet for the connection of an attachment plug. A single receptacle is a single contact device with no other contact device on the same yoke. A multiple receptacle is two or more contact devices on the same yoke.

**RECEPTACLE OUTLET.** An outlet where one or more receptacles are installed.

**SERVICE.** The conductors and equipment for delivering energy from the serving utility to the wiring system of the premises served.

**SERVICE CABLE.** Service conductors made up in the form of a cable.

**SERVICE CONDUCTORS.** The conductors from the service point to the service disconnecting means.

**SERVICE DROP.** The overhead service conductors from the last pole or other aerial support to and including the splices, if any, connecting to the service-entrance conductors at the building or other structure.

**SERVICE-ENTRANCE CONDUCTORS, OVERHEAD SYSTEM.** The service conductors between the terminals of the service equipment and a point usually outside the building, clear of building walls, where joined by tap or splice to the service drop.

**SERVICE-ENTRANCE CONDUCTORS, UNDERGROUND SYSTEM.** The service conductors between the terminals of the service equipment and the point of connection to the service lateral.

**SERVICE EQUIPMENT.** The necessary equipment, usually consisting of a circuit breaker(s) or switch(es) and fuse(s), and their accessories, connected to the load end of the service conductors to a building or other structure, or an otherwise designated area, and intended to constitute the main control and cutoff of the supply.

**SERVICE LATERAL.** The underground service conductors between the street main, including any risers at a pole or other structure or from transformers, and the first point of connection to the service-entrance conductors in a terminal box or meter or other enclosure, inside or outside the building wall. Where there is no terminal box, meter or other enclosure with adequate space, the point of connection shall be considered to be the point of entrance of the service conductors into the building.

**SERVICE POINT.** Service point is the point of connection between the facilities of the serving utility and the premises wiring.

**STRUCTURE.** That which is built or constructed.

**SWITCHES**

**General-use switch.** A switch intended for use in general distribution and branch circuits. It is rated in amperes and is capable of interrupting its rated current at its rated voltage.

**General-use snap switch.** A form of general-use switch constructed so that it can be installed in device boxes or on box covers or otherwise used in conjunction with wiring systems recognized by this code.

**Isolating switch.** A switch intended for isolating an electric circuit from the source of power. It has no interrupting rating and is intended to be operated only after the circuit has been opened by some other means.

**Motor-circuit switch.** A switch, rated in horsepower that is capable of interrupting the maximum operating overload current of a motor of the same horsepower rating as the switch at the rated voltage.

**UNGROUNDED.** Not connected to ground or to a conductive body that extends the ground connection.

**UTILIZATION EQUIPMENT.** Equipment that utilizes electric energy for electronic, electromechanical, chemical, heating, lighting or similar purposes.

**VENTILATED.** Provided with a means to permit circulation of air sufficient to remove an excess of heat, fumes or vapors.

**VOLTAGE (OF A CIRCUIT).** The greatest root-mean-square (rms) (effective) difference of potential between any two conductors of the circuit concerned.

**VOLTAGE, NOMINAL.** A nominal value assigned to a circuit or system for the purpose of conveniently designating its voltage class (e.g., 120/240). The actual voltage at which a circuit operates can vary from the nominal within a range that permits satisfactory operation of equipment.

**VOLTAGE TO GROUND.** For grounded circuits, the voltage between the given conductor and that point or conductor of the circuit that is grounded. For ungrounded circuits, the greatest voltage between the given conductor and any other conductor of the circuit.

**WATERTIGHT.** Constructed so that moisture will not enter the enclosure under specified test conditions.

**WEATHERPROOF.** Constructed or protected so that exposure to the weather will not interfere with successful operation.

# CHAPTER 36
# SERVICES

## SECTION E3601
## GENERAL SERVICES

**E3601.1 Scope.** This chapter covers service conductors and equipment for the control and protection of services and their installation requirements.

**E3601.2 Number of services.** One- and two-family dwellings shall be supplied by only one service.

**E3601.3 One building or other structure not to be supplied through another.** Service conductors supplying a building or other structure shall not pass through the interior of another building or other structure.

**E3601.4 Other conductors in raceway or cable.** Conductors other than service conductors shall not be installed in the same service raceway or service cable.

**Exceptions:**

1. Grounding conductors and bonding jumpers.
2. Load management control conductors having overcurrent protection.

**E3601.5 Raceway seal.** Where a service raceway enters from an underground distribution system, it shall be sealed in accordance with Section E3803.6.

**E3601.6 Service disconnect required.** Means shall be provided to disconnect all conductors in a building or other structure from the service entrance conductors.

**E3601.6.1 Marking of service equipment and disconnects.** Service disconnects shall be permanently marked as a service disconnect. Service equipment shall be listed for the purpose. Individual meter socket enclosures shall not be considered service equipment.

**E3601.6.2 Service disconnect location.** The service disconnecting means shall be installed at a readily accessible location either outside of a building or inside nearest the point of entrance of the service conductors. Service disconnecting means shall not be installed in bathrooms. Each occupant shall have access to the disconnect serving the dwelling unit in which they reside.

**E3601.7 Maximum number of disconnects.** The service disconnecting means shall consist of not more than six switches or six circuit breakers mounted in a single enclosure or in a group of separate enclosures.

**E3601.8 Energizing service equipment.** The building official shall give permission to energize the electrical service equipment of a one- or two-family dwelling unit when all of the following requirements have been approved:

1. The service wiring and equipment, including the meter socket enclosure, shall be installed and the service wiring terminated.
2. The grounding electrode system shall be installed and terminated.
3. At least one receptacle outlet on a ground fault protected circuit shall be installed and the circuit wiring terminated.
4. Service equipment covers shall be installed.
5. The building roof covering shall be installed.
6. Temporary electrical service equipment shall be suitable for wet locations unless the interior is dry and protected from the weather.

## SECTION E3602
## SERVICE SIZE AND RATING

**E3602.1 Ampacity of ungrounded conductors.** Ungrounded service conductors shall have an ampacity of not less than the load served. For one-family dwellings, the ampacity of the ungrounded conductors shall be not less than 100 amperes, 3 wire. For all other installations, the ampacity of the ungrounded conductors shall be not less than 60 amperes.

**E3602.2 Service load.** The minimum load for ungrounded service conductors and service devices that serve 100 percent of the dwelling unit load shall be computed in accordance with Table E3602.2. Ungrounded service conductors and service devices that serve less than 100 percent of the dwelling unit load shall be computed as required for feeders in accordance with Chapter 37.

**TABLE E3602.2**
**MINIMUM SERVICE LOAD CALCULATION**

| LOADS AND PROCEDURE |
|---|
| 3 volt-amperes per square foot of floor area for general lighting and general use receptacle outlets. |
| **Plus** |
| 1,500 volt-amperes multiplied by total number of 20-ampere-rated small appliance and laundry circuits. |
| **Plus** |
| The nameplate volt-ampere rating of all fastened-in-place, permanently connected or dedicated circuit-supplied appliances such as ranges, ovens, cooking units, clothes dryers not connected to the laundry branch circuit and water heaters. |
| **Apply the following demand factors to the above subtotal:** |
| The minimum subtotal for the loads above shall be 100 percent of the first 10,000 volt-amperes of the sum of the above loads plus 40 percent of any portion of the sum that is in excess of 10,000 volt-amperes. |
| **Plus the largest of the following:** |
| One-hundred percent of the nameplate rating(s) of the air-conditioning and cooling equipment. |
| One hundred percent of the nameplate rating(s) of the heat pump where a heat pump is used without any supplemental electric heating. |
| One-hundred percent of the nameplate rating of the electric thermal storage and other heating systems where the usual load is expected to be continuous at the full nameplate value. Systems qualifying under this selection shall not be figured under any other category in this table. |
| One-hundred percent of nameplate rating of the heat pump compressor and sixty-five percent of the supplemental electric heating load for central electric space-heating systems. If the heat pump compressor is prevented from operating at the same time as the supplementary heat, the compressor load does not need to be added to the supplementary heat load for the total central electric space-heating load. |
| Sixty-five percent of nameplate rating(s) of electric space-heating units if less than four separately controlled units. |
| Forty percent of nameplate rating(s) of electric space-heating units of four or more separately controlled units. |
| **The minimum total load in amperes shall be the volt-ampere sum calculated above divided by 240 volts.** |

**E3602.2.1 Services under 100 amperes.** Services that are not required to be 100 amperes shall be sized in accordance with Chapter 37.

**E3602.3 Rating of service disconnect.** The combined rating of all individual service disconnects serving a single dwelling unit shall not be less than the load determined from Table E3602.2 and shall not be less than as specified in Section E3602.1.

**E3602.4 Voltage rating.** Systems shall be three-wire, 120/240-volt, single-phase with a grounded neutral.

## SECTION E3603
## SERVICE, FEEDER AND GROUNDING ELECTRODE CONDUCTOR SIZING

**E3603.1 Grounded and ungrounded service conductor size.** Conductors used as ungrounded service entrance conductors, service lateral conductors, and feeder conductors that serve as the main power feeder to a dwelling unit shall be those listed in Table E3603.1. The main power feeder shall be the feeder(s) between the main disconnect and the panelboard that supplies, either by branch circuits or by feeders, or both, all loads that are part of or are associated with the dwelling unit. The feeder conductors to a dwelling unit shall not be required to have an allowable ampacity greater than that of the service-entrance conductors that supply them. Ungrounded service conductors shall have a minimum size in accordance with Table E3603.1. The grounded conductor ampacity shall be not less than the maximum unbalance of the load and its size shall be not smaller than the required minimum grounding electrode conductor size specified in Table E3603.1.

**E3603.2 Ungrounded service conductors for accessory buildings and structures.** Ungrounded conductors for other than dwelling units shall have an ampacity of not less than 60 amperes and shall be sized as required for feeders in Chapter 37.

**Exceptions:**

1. For limited loads of a single branch circuit, the service conductors shall have an ampacity of not less than 15 amperes.
2. For loads consisting of not more than two two-wire branch circuits, the service conductors shall have an ampacity of not less than 30 amperes.

**E3603.3 Overload protection.** Each ungrounded service conductor shall have overload protection.

**E3603.3.1 Ungrounded conductor.** Overload protection shall be provided by an overcurrent device installed in series with each ungrounded service conductor. The overcurrent device shall have a rating or setting not higher than the allowable service or feeder rating specified in Table E3603.1. A set of fuses shall be considered all the fuses required to protect all of the ungrounded conductors of a circuit. Single pole circuit breakers, grouped in accordance with Section E3601.7, shall be considered as one protective device.

**Exception:** Two to six circuit breakers or sets of fuses shall be permitted as the overcurrent device to provide the overload protection. The sum of the ratings of the circuit breakers or fuses shall be permitted to exceed the ampacity of the service conductors, provided that the calculated load does not exceed the ampacity of the service conductors.

**E3603.3.2 Not in grounded conductor.** Overcurrent devices shall not be connected in series with a grounded service conductor except where a circuit breaker is used that simultaneously opens all conductors of the circuit.

**E3603.3.3 Location.** The service overcurrent device shall be an integral part of the service disconnecting means or shall be located immediately adjacent thereto.

**TABLE E3603.1**
**SERVICE CONDUCTOR AND GROUNDING ELECTRODE CONDUCTOR SIZING**

| CONDUCTOR TYPES AND SIZES—THHN, THHW, THW, THWN, USE, RHH, RHW, XHHW, RHW-2, THW-2, THWN-2, XHHW-2, SE, USE-2 (Parallel sets of 1/0 and larger conductors are permitted in either a single raceway or in separate raceways) | | SERVICE OR FEEDER RATING (AMPERES) | MINIMUM GROUNDING ELECTRODE CONDUCTOR SIZE[a] | |
|---|---|---|---|---|
| Copper (AWG) | Aluminum and copper–clad aluminum (AWG) | Maximum load (amps) | Copper (AWG) | Aluminum (AWG) |
| 4 | 2 | 100 | 8[b] | 6[c] |
| 3 | 1 | 110 | 8[b] | 6[c] |
| 2 | 1/0 | 125 | 8[b] | 6[c] |
| 1 | 2/0 | 150 | 6[c] | 4 |
| 1/0 | 3/0 | 175 | 6[c] | 4 |
| 2/0 | 4/0 or two sets of 1/0 | 200 | 4[d] | 2[d] |
| 3/0 | 250 kcmil or two sets of 2/0 | 225 | 4[d] | 2[d] |
| 4/0 or two sets of 1/0 | 300 kcmil or two sets of 3/0 | 250 | 2[d] | 1/0[d] |
| 250 kcmil or two sets of 2/0 | 350 kcmil or two sets of 4/0 | 300 | 2[d] | 1/0[d] |
| 350 kcmil or two sets of 3/0 | 500 kcmil or two sets of 250 kcmil | 350 | 2[d] | 1/0[d] |
| 400 kcmil or two sets of 4/0 | 600 kcmil or two sets of 300 kcmil | 400 | 1/0[d] | 3/0[d] |

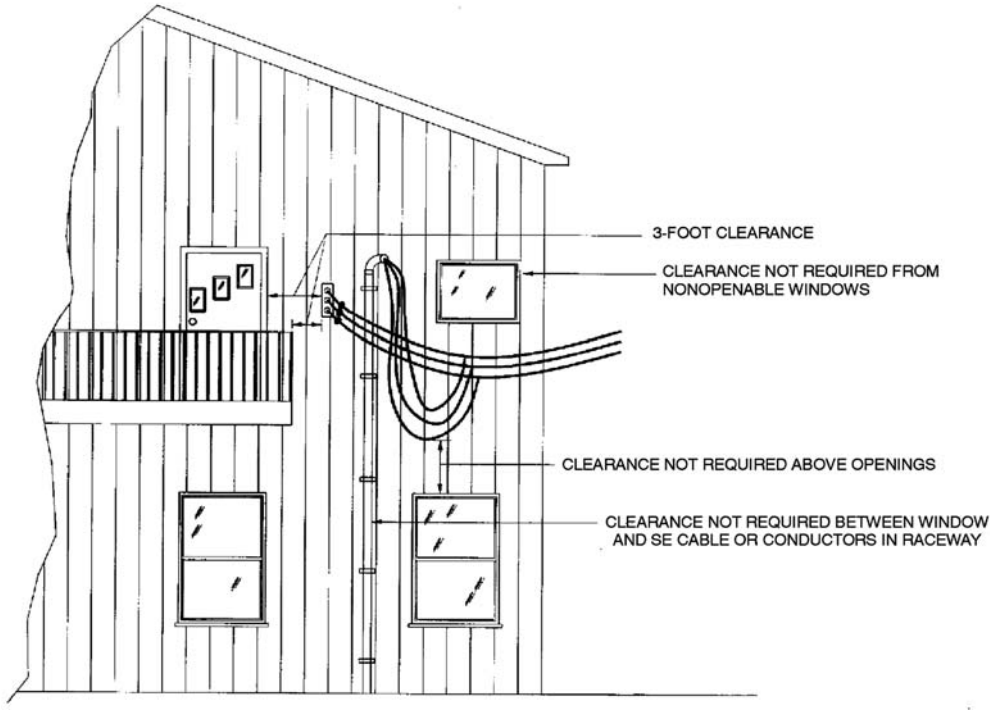
For SI: 1 inch = 25.4 mm.

a. Where protected by a ferrous metal raceway, grounding electrode conductors shall be electrically bonded to the ferrous metal raceway at both ends.

b. An 8 AWG grounding electrode conductor shall be protected with metal conduit, nonmetallic conduit, electrical metallic tubing or cable armor

c. Where not protected, 6 AWG grounding electrode conductor shall closely follow a structural surface for physical protection. The supports shall be spaced not more than 24 inches on center and shall be within 12 inches of any enclosure or termination.

d. Where the sole grounding electrode system is a ground rod or pipe as covered in Section E3608.2, the grounding electrode conductor shall not be required to be larger than 6 AWG copper or 4 AWG aluminum. Where the sole grounding electrode system is the footing steel as covered in Section E3608.1.2, the grounding electrode conductor shall not be required to be larger than 4 AWG copper conductor.




For SI: 1 foot = 304.8 mm.

**FIGURE E3604.1**
**CLEARANCES FROM BUILDING OPENINGS**

**E3603.4 Grounding electrode conductor size.** The grounding electrode conductors shall be sized based on the size of the service entrance conductors as required in Table E3603.1.

**E3603.5 Temperature limitations.** Except where the equipment is marked otherwise, conductor ampacities used in determining equipment termination provisions shall be based on Table E3603.1.

## SECTION E3604
## OVERHEAD SERVICE-DROP AND SERVICE CONDUCTOR INSTALLATION

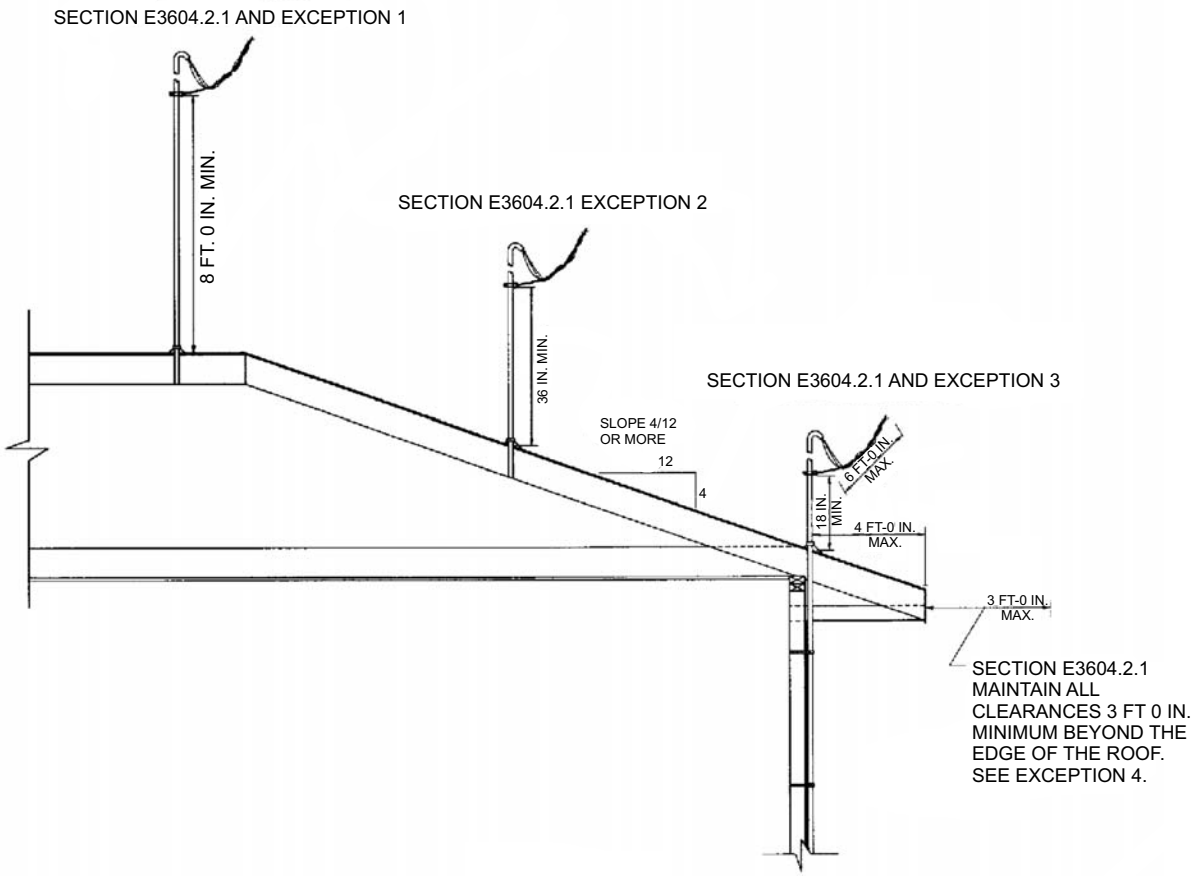
**E3604.1 Clearances on buildings.** Open conductors and multiconductor cables without an overall outer jacket shall have a clearance of not less than 3 feet (914 mm) from the sides of doors, porches, decks, stairs, ladders, fire escapes and balconies, and from the sides and bottom of windows that open. See Figure E3604.1.

**E3604.2 Vertical clearances.** Service-drop conductors shall not have ready access and shall comply with Sections E3604.2.1 and E3604.2.2.

**E3604.2.1 Above roofs.** Conductors shall have a vertical clearance of not less than 8 feet (2438 mm) above the roof surface. The vertical clearance above the roof level shall be maintained for a distance of not less than 3 feet (914 mm) in all directions from the edge of the roof. See Figure E3604.2.1.

**Exceptions:**

1. Conductors above a roof surface subject to pedestrian traffic shall have a vertical clearance from the roof surface in accordance with Section E3604.2.2.
2. Where the roof has a slope of 4 inches (102 mm) in 12 inches (305 mm), or greater, the minimum clearance shall be 3 feet (914 mm).
3. The minimum clearance above only the overhanging portion of the roof shall not be less than 18 inches (457 mm) where not more than 6 feet (1829 mm) of conductor length passes over 4 feet (1219 mm) or less of roof surface measured horizontally and such conductors are terminated at a through-the-roof raceway or approved support.
4. The requirement for maintaining the vertical clearance for a distance of 3 feet (914 mm) from the edge of the roof shall not apply to the final conductor span where the service drop is attached to the side of a building.




For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

**FIGURE E3604.2.1**
**CLEARANCES FROM ROOFS**

**E3604.2.2 Vertical clearance from grade.** Service-drop conductors shall have the following minimum clearances from final grade:

1. For service-drop cables supported on and cabled together with a grounded bare messenger wire, the minimum vertical clearance shall be 10 feet (3048 mm) at the electric service entrance to buildings, at the lowest point of the drip loop of the building electric entrance, and above areas or sidewalks accessed by pedestrians only. Such clearance shall be measured from final grade or other accessible surfaces.
2. Twelve feet (3658 mm)—over residential property and driveways.
3. Eighteen feet (5486 mm)—over public streets, alleys, roads or parking areas subject to truck traffic.

**E3604.3 Point of attachment.** The point of attachment of the service-drop conductors to a building or other structure shall provide the minimum clearances as specified in Sections E3604.1 through E3604.2.2. In no case shall the point of attachment be less than 10 feet (3048 mm) above finished grade.

**E3604.4 Means of attachment.** Multiconductor cables used for service drops shall be attached to buildings or other structures by fittings approved for the purpose.

**E3604.5 Service masts as supports.** Where a service mast is used for the support of service-drop conductors, it shall be of adequate strength or be supported by braces or guys to withstand the strain imposed by the service drop. Where raceway-type service masts are used, all equipment shall be approved. Only power service drop conductors shall be permitted to be attached to a service mast.

**E3604.6 Supports over buildings.** Service-drop conductors passing over a roof shall be securely supported. Where practicable, such supports shall be independent of the building.

## SECTION E3605
## SERVICE-ENTRANCE CONDUCTORS

**E3605.1 Insulation of service-entrance conductors.** Service-entrance conductors entering or on the exterior of buildings or other structures shall be insulated in accordance with Section E3406.5.

**Exceptions:**

1. A copper grounded conductor shall not be required to be insulated where it is:
   1.1. In a raceway or part of a service cable assembly,
   1.2. Directly buried in soil of suitable condition, or
   1.3. Part of a cable assembly listed for direct burial without regard to soil conditions.
2. An aluminum or copper-clad aluminum grounded conductor shall not be required to be insulated where part of a cable or where identified for direct burial or utilization in underground raceways.

**E3605.2 Wiring methods for services.** Service-entrance wiring methods shall be installed in accordance with the applicable requirements in Chapter 38.

**E3605.3 Spliced conductors.** Service-entrance conductors shall be permitted to be spliced or tapped. Splices shall be made in enclosures or, if directly buried, with listed underground splice kits. Conductor splices shall be made in accordance with Chapters 34, 37, 38 and 39.

**E3605.4 Protection against physical damage.** Underground service-entrance conductors shall be protected against physical damage in accordance with Chapter 38.

**E3605.5 Protection of service cables against damage.** Above-ground service-entrance cables, where subject to physical damage, shall be protected by one or more of the following: rigid metal conduit, intermediate metal conduit, Schedule 80 PVC conduit, electrical metallic tubing or other approved means.

**E3605.6 Locations exposed to direct sunlight.** Insulated conductors and cables used where exposed to direct rays of the sun shall comply with one of the following:

1. The conductors and cables shall be listed, or listed and marked, as being sunlight resistant.
2. The conductors and cables are covered with insulating material, such as tape or sleeving, that is listed, or listed and marked, as being sunlight resistant.

**E3605.7 Mounting supports.** Service cables shall be supported by straps or other approved means within 12 inches (305 mm) of every service head, gooseneck or connection to a raceway or enclosure and at intervals not exceeding 30 inches (762 mm).

**E3605.8 Raceways to drain.** Where exposed to the weather, raceways enclosing service-entrance conductors shall be suitable for use in wet locations and arranged to drain. Where embedded in masonry, raceways shall be arranged to drain.

**E3605.9 Overhead service locations.** Connections at service heads shall be in accordance with Sections E3605.9.1 through E3605.9.7.

**E3605.9.1 Rain-tight service head.** Service raceways shall be equipped with a rain-tight service head at the point of connection to service-drop conductors. The service head shall comply with the requirements for fittings in Section E3905.12.

**E3605.9.2 Service cable, service head or gooseneck.** Service cable shall be equipped with a rain-tight service head or shall be formed into a gooseneck in an approved manner. The service head shall comply with the requirements for fittings in Section E3905.12.

**E3605.9.3 Service head location.** Service heads, and goosenecks in service-entrance cables, shall be located above the point of attachment of the service-drop conductors to the building or other structure.

**Exception:** Where it is impracticable to locate the service head or gooseneck above the point of attachment, the service head or gooseneck location shall be not more than 24 inches (610 mm) from the point of attachment.

**E3605.9.4 Separately bushed openings.** Service heads shall have conductors of different potential brought out through separately bushed openings.

**E3605.9.5 Drip loops.** Drip loops shall be formed on individual conductors. To prevent the entrance of moisture, service-entrance conductors shall be connected to the service-drop conductors either below the level of the service head or below the level of the termination of the service-entrance cable sheath.

**E3605.9.6 Conductor arrangement.** Service-drop conductors and service-entrance conductors shall be arranged so that water will not enter service raceways or equipment.

**E3605.9.7 Secured.** Service cables shall be held securely in place.

## SECTION E3606
## SERVICE EQUIPMENT—GENERAL

**E3606.1 Service equipment enclosures.** Energized parts of service equipment shall be enclosed.

**E3606.2 Working space.** In no case shall the working space in the vicinity of service equipment be less than that specified in Chapter 34.

**E3606.3 Available short-circuit current.** Service equipment shall be suitable for the maximum fault current available at its supply terminals, but not less than 10,000 amperes.

**E3606.4 Marking.** Service equipment shall be marked to identify it as being suitable for use as service equipment. Individual meter socket enclosures shall not be considered service equipment.

## SECTION E3607
## SYSTEM GROUNDING

**E3607.1 System service ground.** The premises wiring system shall be grounded at the service with a grounding electrode conductor connected to a grounding electrode system as required by this code. Grounding electrode conductors shall be sized in accordance with Table E3603.1.

**E3607.2 Location of grounding electrode conductor connection.** The grounding electrode conductor shall be connected to the grounded service conductor 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. A grounding connection shall not be made to any grounded circuit conductor on the load side of the service disconnecting means, except as provided in Section E3607.3.2.

**E3607.3 Buildings or structures supplied by feeder(s) or branch circuit(s).** Buildings or structures supplied by feeder(s) or branch circuit(s) shall have a grounding electrode or grounding electrode system installed in accordance with Section E3608. The grounding electrode conductor(s) shall be connected in a manner specified in Section E3607.3.1 or, for existing premises wiring systems only, Section E3607.3.2. Where there is no existing grounding electrode, the grounding electrode(s) required in Section E3608 shall be installed.

**Exception:** A grounding electrode shall not be required where only one branch circuit, including a multiwire branch circuit, supplies the building or structure and the branch circuit includes an equipment grounding conductor for grounding the noncurrent-carrying parts of all equipment. For the purposes of this section, a multiwire branch circuit shall be considered as a single branch circuit.

**E3607.3.1 Equipment grounding conductor.** An equipment grounding conductor as described in Section E3908 shall be run with the supply conductors and connected to the building or structure disconnecting means and to the grounding electrode(s). The equipment grounding conductor shall be used for grounding or bonding of equipment, structures or frames required to be grounded or bonded. The equipment grounding conductor shall be sized in accordance with Section E3908.12. Any installed grounded conductor shall not be connected to the equipment grounding conductor or to the grounding electrode(s).

**E3607.3.2 Grounded conductor, existing premises.** This section shall apply only to existing premises wiring systems. Where an equipment grounding conductor is not run with the supply conductors to the building or structure, there are no continuous metallic paths bonded to the grounding system in both buildings or structures involved, and ground-fault protection of equipment has not been installed on the supply side of the feeder(s), the grounded conductor run with the supply to the buildings or structure shall be connected to the building or structure disconnecting means and to the grounding electrode(s) and shall be used for grounding or bonding of equipment, structures, or frames required to be grounded or bonded. Where used for grounding in accordance with this provision, the grounded conductor shall be not smaller than the larger of:

1. That required by Section E3704.3.
2. That required by Section E3908.12.

**E3607.4 Grounding electrode conductor.** A grounding electrode conductor shall be used to connect the equipment grounding conductors, the service equipment enclosures, and the grounded service conductor to the grounding electrode(s). This conductor shall be sized in accordance with Table E3603.1.

**E3607.5 Main bonding jumper.** An unspliced main bonding jumper shall be used to connect the equipment grounding conductor(s) and the service-disconnect enclosure to the grounded conductor of the system within the enclosure for each service disconnect.

**E3607.6 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 connected to a grounding electrode(s), the same grounding electrode(s) shall be used. Two or

more grounding electrodes that are effectively bonded together shall be considered as a single grounding electrode system.

## SECTION E3608
## GROUNDING ELECTRODE SYSTEM

**E3608.1 Grounding electrode system.** All electrodes specified in Sections E3608.1.1, E3608.1.2, E3608.1.3, E3608.1.4 E3608.1.5 and E3608.1.6 that are present at each building or structure served shall be bonded together to form the grounding electrode system. Where none of these electrodes are present, one or more of the electrodes specified in Sections E3608.1.3, E3608.1.4, E3608.1.5 and E3608.1.6 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.

**E3608.1.1 Metal underground water pipe.** A metal underground water pipe that is in direct contact with the earth for 10 feet (3048 mm) or more, including any well casing effectively bonded to the pipe and that is 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, shall be considered as a grounding electrode (see Section E3608.1). Interior metal water piping located more than 5 feet (1524 mm) from the entrance to the building shall not be used as part of the grounding electrode system or as a conductor to interconnect electrodes that are part of the grounding electrode system.

**E3608.1.1.1 Installation.** Continuity of the grounding path or the bonding connection to interior piping shall not rely on water meters, filtering devices and similar equipment. A metal underground water pipe shall be supplemented by an additional electrode of a type specified in Sections E3608.1.2 through E3608.1.6. The supplemental electrode shall be bonded to the grounding electrode conductor, the grounded service entrance conductor, a nonflexible grounded service raceway or any grounded service enclosure. Where the supplemental electrode is a rod, pipe or plate electrode in accordance with Section E3608.1.4 or E3608.1.5, it shall comply with Section E3608.4.

Where the supplemental electrode is a rod, pipe or plate electrode in accordance with Section E3608.1.4 or E3608.1.5, 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 or 4 AWG aluminum wire.

**E3608.1.2 Concrete-encased electrode.** An electrode encased by at least 2 inches (51 mm) 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 20 feet (6096 mm) of one or more bare or zinc-galvanized or other electrically conductive coated steel reinforcing bars or rods of not less than $^1/_2$ inch (12.7 mm) diameter, or consisting of at least 20 feet (6096 mm) of bare copper conductor not smaller than 4 AWG shall be considered as a grounding electrode. 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, only one shall be required to be bonded into the grounding electrode system.

**E3608.1.3 Ground rings.** A ground ring encircling the building or structure, in direct contact with the earth at a depth below the earth's surface of not less than 30 inches (762 mm), consisting of at least 20 feet (6096 mm) of bare copper conductor not smaller than 2 AWG shall be considered as a grounding electrode.

**E3608.1.4 Rod and pipe electrodes.** Rod and pipe electrodes not less than 8 feet (2438 mm) in length and consisting of the following materials shall be considered as a grounding electrode:

1. Grounding electrodes of pipe or conduit shall not be smaller than trade size $^3/_4$ (metric designator 21) and, where of iron or steel, shall have the outer surface galvanized or otherwise metal-coated for corrosion protection.
2. Grounding electrodes of rods of stainless steel and copper or zinc-coated steel shall be at least $^5/_8$ inch (15.9 mm) in diameter. Stainless steel rods less than $^5/_8$ inch (15.9 mm) in diameter, nonferrous rods or their equivalent shall be listed and shall be not less than $^1/_2$ inch (12.7 mm) in diameter.

**E3608.1.4.1 Installation.** The rod and pipe electrodes shall be installed such that at least 8 feet (2438 mm) of length is in contact with the soil. They shall be driven to a depth of not less than 8 feet (2438 mm) except that, where rock bottom is encountered, electrodes shall be driven at an oblique angle not to exceed 45 degrees from the vertical or shall be buried in a trench that is at least 30 inches (762 mm) deep. The upper end of the electrodes shall be flush with or below ground level except where the aboveground end and the grounding electrode conductor attachment are protected against physical damage.

**E3608.1.5 Plate electrodes.** A plate electrode that exposes not less than 2 square feet (0.186 $m^2$) of surface to exterior soil shall be considered as a grounding electrode. Electrodes of iron or steel plates shall be at least $^1/_4$ inch (6.4 mm) in thickness. Electrodes of nonferrous metal shall be at least 0.06 inch (1.5 mm) in thickness. Plate electrodes shall be installed not less than 30 inches (762 mm) below the surface of the earth.

**E3608.1.6 Other electrodes.** In addition to the grounding electrodes specified in Sections E3608.1.1 through E3608.1.5, other listed grounding electrodes shall be permitted.

**E3608.2 Bonding jumper.** The bonding jumper(s) used to connect the grounding electrodes together to form the grounding electrode system shall be installed in accordance with Sections E3610.2, and E3610.3, shall be sized in accordance with

Section E3603.4, and shall be connected in the manner specified in Section E3611.1.

**E3608.3 Rod, pipe and plate electrode requirements.** Where practicable, rod, pipe and plate electrodes shall be embedded below permanent moisture level. Such electrodes shall be free from nonconductive coatings such as paint or enamel. Where more than one such electrode is used, each electrode of one grounding system shall be not less than 6 feet (1829 mm) from any other electrode of another grounding system. Two or more grounding electrodes that are effectively bonded together shall be considered as a single grounding electrode system. That portion of a bonding jumper that is the sole connection to a rod, pipe or plate electrode shall not be required to be larger than 6 AWG copper or 4 AWG aluminum wire.

**E3608.4 Resistance of rod, pipe and plate electrodes.** A single electrode consisting of a rod, pipe or plate that does not have a resistance to ground of 25 ohms or less shall be augmented by one additional electrode of any of the types specified in Sections E3608.1.2 through E3608.1.6. Where multiple listed electrodes or rod, pipe or plate electrodes are installed to meet the requirements of this section, they shall be not less than 6 feet (1829 mm) apart.

**E3608.5 Aluminum electrodes.** Aluminum electrodes shall not be permitted.

**E3608.6 Metal underground gas piping system.** A metal underground gas piping system shall not be used as a grounding electrode.

## SECTION E3609
## BONDING

**E3609.1 General.** Bonding shall be provided where necessary to ensure electrical continuity and the capacity to conduct safely any fault current likely to be imposed.

**E3609.2 Bonding of services.** The noncurrent-carrying metal parts of the following equipment shall be effectively bonded together:

1. The service raceways or service cable armor.
2. All service enclosures containing service conductors, including meter fittings, and boxes, interposed in the service raceway or armor.

**E3609.3 Bonding for other systems.** An intersystem bonding termination for connecting intersystem bonding and grounding conductors required for other systems shall be provided external to enclosures at the service equipment and at the disconnecting means for any additional buildings or structures. The intersystem bonding termination shall be accessible for connection and inspection. The intersystem bonding termination shall have the capacity for connection of not less than three intersystem bonding conductors. The intersystem bonding termination device shall not interfere with the opening of a service or metering equipment enclosure. The intersystem bonding termination shall be one of the following:

1. A set of terminals securely mounted to the meter enclosure and electrically connected to the meter enclosure. The terminals shall be listed as grounding and bonding equipment.
2. A bonding bar near the service equipment enclosure, meter enclosure, or raceway for service conductors. The bonding bar shall be connected with a minimum 6 AWG copper conductor to an equipment grounding conductor(s) in the service equipment enclosure, to a meter enclosure, or to an exposed nonflexible metallic raceway.
3. A bonding bar near the grounding electrode conductor. The bonding bar shall be connected to the grounding electrode conductor with a minimum 6 AWG copper conductor.

**E3609.4 Method of bonding at the service.** Electrical continuity at service equipment, service raceways and service conductor enclosures shall be ensured by one or more of the methods specified in Sections E3609.4.1 through E3609.4.4.

Bonding jumpers meeting the other requirements of this code shall be used around concentric or eccentric knockouts that are punched or otherwise formed so as to impair the electrical connection to ground. Standard locknuts or bushings shall not be the sole means for the bonding required by this section.

**E3609.4.1 Grounded service conductor.** Equipment shall be bonded to the grounded service conductor in a manner provided in this code.

**E3609.4.2 Threaded connections.** Equipment shall be bonded by connections using threaded couplings or threaded bosses on enclosures. Such connections shall be made wrench tight.

**E3609.4.3 Threadless couplings and connectors.** Equipment shall be bonded by threadless couplings and connectors for metal raceways and metal-clad cables. Such couplings and connectors shall be made wrench tight. Standard locknuts or bushings shall not be used for the bonding required by this section.

**E3609.4.4 Other devices.** Equipment shall be bonded by other listed devices, such as bonding-type locknuts, bushings and bushings with bonding jumpers.

**E3609.5 Sizing bonding jumper on supply side of service and main bonding jumper.** The bonding jumper shall not be smaller than the sizes shown in Table E3603.1 for grounding electrode conductors. Where the service-entrance conductors are paralleled in two or more raceways or cables, the equipment bonding jumper, where routed with the raceways or cables, shall be run in parallel. The size of the bonding jumper for each raceway or cable shall be based on the size of the service-entrance conductors in each raceway or cable.

**E3609.6 Metal water piping bonding.** The metal water piping system shall be bonded to the service equipment enclosure, the grounded conductor at the service, the grounding electrode conductor where of sufficient size, or to the one or more grounding electrodes used. The bonding jumper shall be sized in accordance with Table E3603.1. The points of attachment of the bonding jumper(s) shall be accessible.

**E3609.7 Bonding other metal piping.** Where installed in or attached to a building or structure, metal piping systems, including gas piping, capable of becoming energized shall be bonded to the service equipment enclosure, the grounded con-

ductor at the service, the grounding electrode conductor where of sufficient size, or to the one or more grounding electrodes used. The bonding jumper shall be sized in accordance with Table E3908.12 using the rating of the circuit capable of energizing the piping. The equipment grounding conductor for the circuit that is capable of energizing the piping shall be permitted to serve as the bonding means. The points of attachment of the bonding jumper(s) shall be accessible.

## SECTION E3610
## GROUNDING ELECTRODE CONDUCTORS

**E3610.1 Continuous.** The grounding electrode conductor shall be unspliced and shall run to any convenient grounding electrode available in the grounding electrode system where the other electrode(s), if any, are connected by bonding jumpers in accordance with Section E3608.2, or to one or more grounding electrode(s) individually. The grounding electrode conductor shall be sized for the largest grounding electrode conductor required among all of the electrodes connected to it.

**Exception:** Splicing of the grounding electrode conductor by irreversible compression-type connectors listed as grounding and bonding equipment or by the exothermic welding process shall not be prohibited.

**E3610.2 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. A 4 AWG or larger conductor shall be protected where exposed to physical damage. A 6 AWG grounding conductor that is free from exposure to physical damage shall be permitted to be run along the surface of the building construction without metal covering or protection where it is securely fastened to the construction; otherwise, it shall be in rigid metal conduit, intermediate metal conduit, rigid nonmetallic conduit, electrical metallic tubing or cable armor. Grounding electrode conductors smaller than 6 AWG shall be in rigid metal conduit, intermediate metal conduit, rigid nonmetallic conduit, electrical metallic tubing or cable armor.

Bare aluminum or copper-clad 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 or copper-clad aluminum grounding conductors shall not be installed within 18 inches (457 mm) of the earth.

**E3610.3 Enclosures for grounding electrode conductors.** 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 ground clamp or fitting. Nonferrous metal enclosures shall not be required to be electrically continuous. Ferrous metal enclosures that are not physically continuous from cabinet or equipment to the grounding electrode shall be made electrically continuous by bonding each end to the grounding conductor. The bonding jumper for a grounding electrode conductor raceway shall be the same size or larger than the required enclosed grounding electrode conductor.

Where a raceway is used as protection for a grounding conductor, the installation shall comply with the requirements of Chapter 38.

## SECTION E3611
## GROUNDING ELECTRODE CONDUCTOR CONNECTION TO THE GROUNDING ELECTRODES

**E3611.1 Methods of grounding conductor connection to electrodes.** The grounding or bonding conductor shall be connected to the grounding electrode by exothermic welding, listed lugs, listed pressure connectors, listed clamps or other listed means. Connections depending on solder shall not be used. Ground clamps shall be listed for the materials of the grounding electrode and the grounding electrode conductor and, where used on pipe, rod or other buried electrodes, shall also be listed for direct soil burial or concrete encasement. Not more than one conductor shall be connected to the grounding electrode by a single clamp or fitting unless the clamp or fitting is listed for multiple conductors. One of the methods indicated in the following items shall be used:

1. A pipe fitting, pipe plug or other approved device screwed into a pipe or pipe fitting.
2. A listed bolted clamp of cast bronze or brass, or plain or malleable iron.
3. For indoor telecommunications purposes only, a listed sheet metal strap-type ground clamp having a rigid metal base that seats on the electrode and having a strap of such material and dimensions that it is not likely to stretch during or after installation.
4. Other equally substantial approved means.

**E3611.2 Accessibility.** All mechanical elements used to terminate a grounding electrode conductor or bonding jumper to the grounding electrodes that are not buried or concrete encased shall be accessible.

**E3611.3 Effective grounding path.** The connection of the grounding electrode conductor or bonding jumper shall be made in a manner that will ensure a permanent and effective grounding path. Where necessary to ensure effective grounding for a metal piping system used as a grounding electrode, effective bonding shall be provided around insulated joints and sections and around any equipment that is likely to be disconnected for repairs or replacement. Bonding jumpers shall be of sufficient length to permit removal of such equipment while retaining the integrity of the grounding path.

**E3611.4 Protection of ground clamps and fittings.** Ground clamps or other fittings shall be approved for applications without protection or shall be protected from physical damage by installing them where they are not likely to be damaged or by enclosing them in metal, wood or equivalent protective coverings.

**E3611.5 Clean surfaces.** Nonconductive coatings (such as paint, enamel and lacquer) on equipment to be grounded shall be removed from threads and other contact surfaces to ensure good electrical continuity or shall be connected by fittings that make such removal unnecessary.