Chapter 35

SERVICES

SECTION E3501
GENERAL SERVICES

E3501.1 Scope. This chapter covers service conductors and equipment for the control and protection of services and their installation requirements.

E3501.2 Number of services. A dwelling unit shall be supplied by only one service.

E3501.3 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.

E3501.4 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.

E3501.5 Raceway seal. Where a service raceway enters from an underground distribution system, it shall be sealed in accordance with Section E3703.7.

E3501.6 Service disconnect required. A means shall be provided to disconnect all conductors in a building or other structure from the service entrance conductors.

E3501.6.1 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.

E3501.6.2 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.

E3501.7 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.

SECTION E3502
SERVICE SIZE AND RATING

E3502.1 Rating of ungrounded conductors. Ungrounded service conductors shall have an ampacity of not less than the load served. For one-family dwellings, the rating of the ungrounded conductors shall be not less than 100 amperes, 3 wire. For all other installations, the rating of the ungrounded conductors shall be not less than 60 amperes.

E3502.2 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 E3502.2. 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 36.

TABLE E3502.2
MINIMUM SERVICE LOAD CALCULATION

LOADS AND PROCEDURE
3 volt-amperes per square foot of floor area for general lighting and convenience receptacle outlets.
Plus
1,500 volt-amperes × 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 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:
Nameplate rating(s) of air-conditioning and cooling equipment including heat pump compressors.
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.
Sixty-five percent of nameplate rating of central electric space-heating equipment, including integral supplemental heating for heat pump systems.
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.

E3502.2.1 Services under 100 amperes. Services that are not required to be 100 amperes shall be sized in accordance with Chapter 36.

E3502.3 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 3502.2 and shall not be less than as specified in Section 3502.1.

Chapter 35 through 42 are not adopted in the city of Seattle. See the Seattle Electrical Code for electrical regulations.

E3502.4 Voltage rating. Systems shall be three-wire, 120/240-volt, single-phase with a grounded neutral.

SECTION E3503
SERVICE, FEEDER AND GROUNDING ELECTRODE CONDUCTOR SIZING

E3503.1 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 E3503.1. Ungrounded service conductors shall have a minimum size in accordance with Table E3503.1. The grounded conductor size shall not be less than the maximum unbalance of the load and shall not be smaller than the required minimum grounding electrode conductor size specified in Table E3503.1.

E3503.2 Ungrounded service conductors for accessory buildings and structures. Ungrounded conductors for other than dwelling units shall have a minimum rating of 60 amperes and shall be sized as required for feeders in Chapter 36.

Exceptions:

1. For loads consisting of not more than two two-wire branch circuits, the minimum size shall be No. 8 copper or No. 6 aluminum or copper-clad aluminum.
2. For loads limited by demand or by the source of supply, the minimum size shall be No. 8 copper or No. 6 aluminum or copper-clad aluminum.
3. For limited loads of a single branch circuit, the minimum size shall be No. 12 copper or No. 10 aluminum or copper-clad aluminum, but in no case smaller than the branch-circuit conductors.

E3503.3 Overload protection. Each ungrounded service conductor shall have overload protection.

E3503.3.1 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 ampacity specified in Table E3503.1. 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 E3501.7, 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.

TABLE E3503.1
SERVICE CONDUCTOR AND GROUNDING ELECTRODE CONDUCTOR SIZING

CONDUCTOR TYPES AND SIZES—THHW, THW, THWN, USE, XHHW (Parallel sets of 1/0 and larger conductors are permitted in either a single raceway or in separate raceways)		ALLOWABLE AMPACITY	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 metal raceway, grounding electrode conductors shall be electrically bonded to the metal raceway at both ends.

b. No. 8 grounding electrode conductors shall be protected with metal conduit or nonmetallic conduit.

c. Where not protected, No. 6 grounding electrode conductors 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 E3508.2, the grounding electrode conductor shall not be required to be larger than No. 6 copper or No. 4 aluminum. Where the sole grounding electrode system is the footing steel as covered in Section E3508.1.2, the grounding electrode conductor shall not be required to be larger than No. 4 copper conductor.

Chapter 33 through 42 are not adopted in the City of Seattle. See the Seattle Electrical Code for electrical regulations.

E3503.3.2 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.

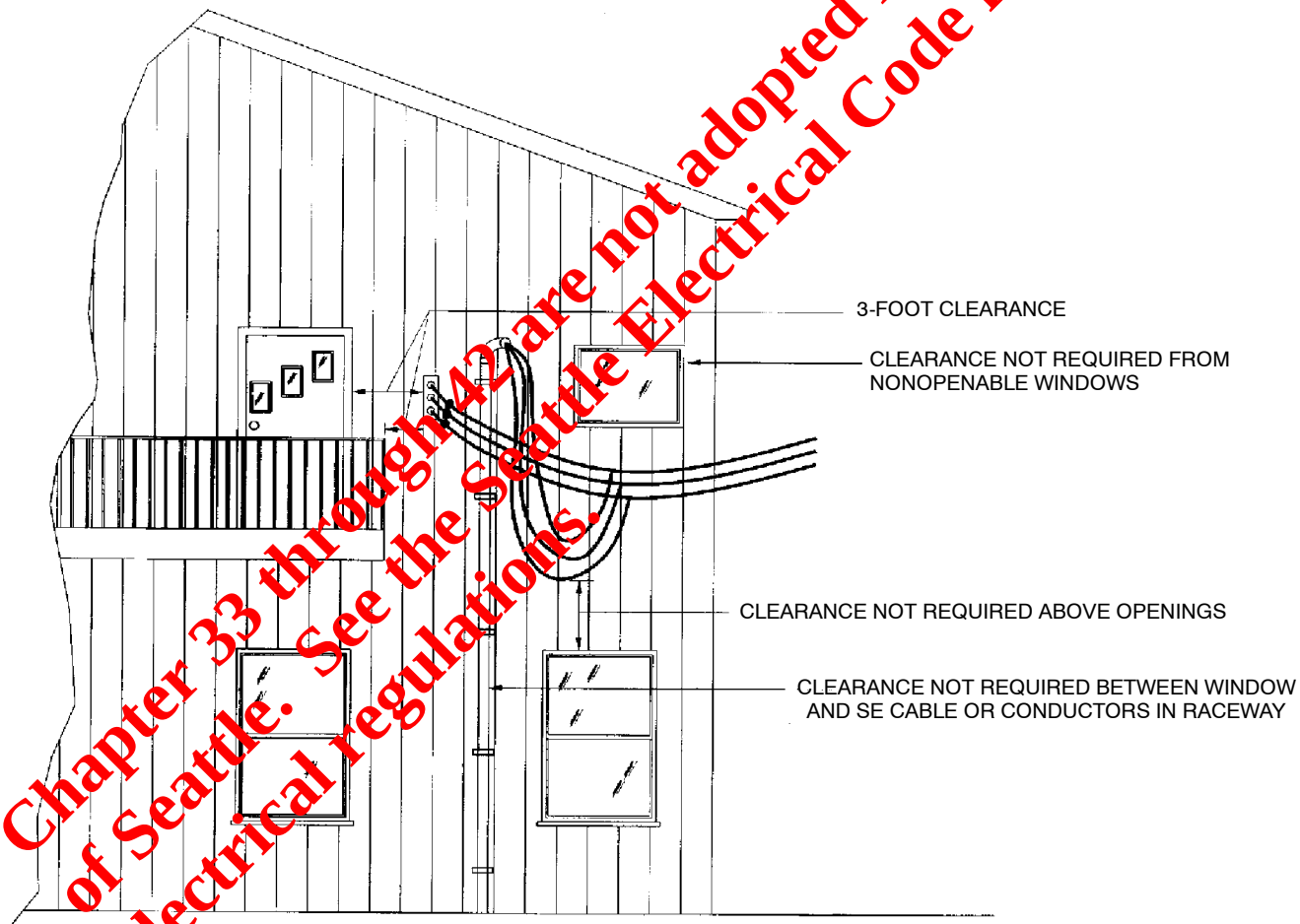
E3503.3.3 Location. The service overcurrent device shall be an integral part of the service disconnecting means or shall be located immediately adjacent thereto.

E3503.4 Grounding electrode conductor size. The grounding electrode conductors shall be sized based on the size of the service entrance conductors as required in Table E3503.1.

SECTION E3504
OVERHEAD SERVICE-DROP AND SERVICE CONDUCTOR INSTALLATION

E3504.1 Clearance from building openings. 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 E3504.1.

Chapter 33 through 42 are not adopted in the City of Seattle. See the Seattle Electrical Code for electrical regulations.



For SI: 1 foot = 304.8 mm.

FIGURE E3504.1
CLEARANCES FROM BUILDING OPENINGS

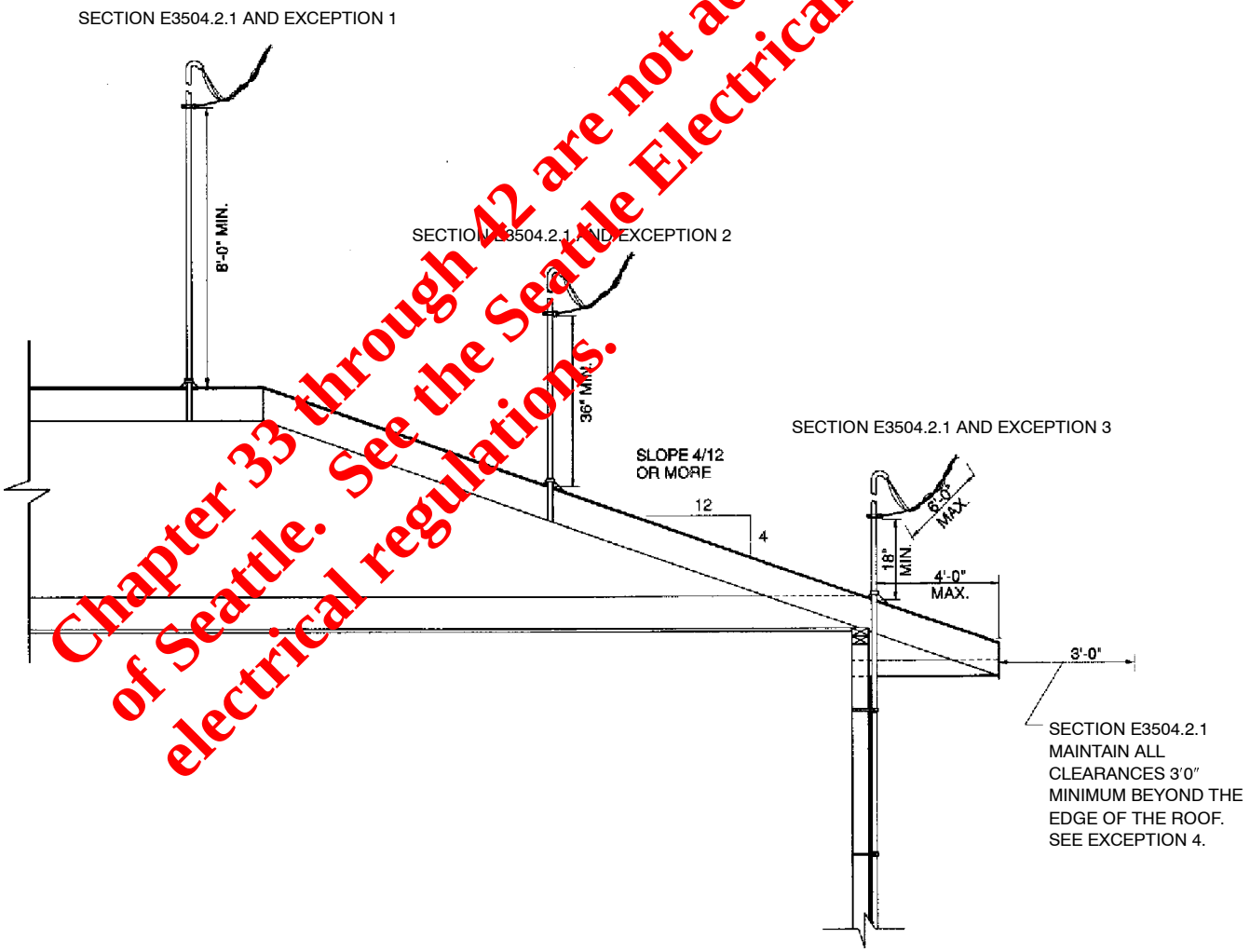
E3504.2 Vertical clearances. The vertical clearances of all service-drop conductors shall be based on a conductor temperature of 60°F (15°C), with no wind and with final unloaded sag in the wire, conductor or cable. Service-drop conductors shall not have ready access and shall comply with Sections E3504.2.1 and E3504.2.2.

E3504.2.1 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 E3504.2.1.

Exceptions:

1. Conductors above a roof surface subject to pedestrian traffic shall have a vertical clearance from the roof surface in accordance with Section E3504.2.2.
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.

Chapter 33 through 42 are not adopted in the City of Seattle. See the Seattle Electrical Code for electrical regulations.



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

FIGURE E3504.2.1
CLEARANCES FROM ROOFS

E3504.2.2 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.

E3504.3 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 E3504.1 through E3504.2.2. In no case shall the point of attachment be less than 10 feet (3048 mm) above finished grade.

E3504.4 Means of attachment. Multiconductor cables used for service drops shall be attached to buildings or other structures by fittings approved for the purpose.

E3504.5 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.

E3504.6 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 E3505
SERVICE-ENTRANCE CONDUCTORS

E3505.1 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 E3300.5.

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.

E3505.2 Wiring methods for services. Service-entrance wiring methods shall be installed in accordance with the applicable requirements in Chapter 37.

E3505.3 Spliced conductors. Service-entrance conductors shall permitted to be spliced or tapped by clamped or bolted connections. Splices shall be made in enclosures or, if directly buried, with listed underground splice kits. Conductor splices shall be made in accordance with Chapters 33, 36, 37 and 38.

E3505.4 Protection against physical damage. Underground service-entrance conductors shall be protected against physical damage in accordance with Chapter 37.

E3505.5 Protection of service cables against damage. Above-ground service-entrance cables, where subject to physical damage, such as where installed in exposed areas near sidewalks, walkways and driveways or where subject to contact with awnings, shutters or similar objects, shall be protected by one or more of the following: rigid metal conduit, intermediate metal conduit, rigid nonmetallic conduit suitable for the location, electrical metallic tubing or other approved means.

E3505.6 Direct sunlight exposure. Where exposed to direct rays of the sun, insulated conductors and cables shall be of a type listed for sunlight resistance or listed and marked "sunlight resistant."

E3505.7 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).

E3505.8 Raceways to drain. Where exposed to the weather, raceways enclosing service-entrance conductors shall be raintight and arranged to drain. Where embedded in masonry, raceways shall be arranged to drain.

E3505.9 Overhead service locations. Connections at service heads shall be in accordance with Sections E3505.9.1 through E3505.9.7.

E3505.9.1 Rain-tight service head. Service raceways shall be equipped with a rain-tight service head at the point of connection to service-drop conductors.

E3505.9.2 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.

E3505.9.3 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 above the point of attachment, the service head location shall not be more than 24 inches (610 mm) from the point of attachment.

E3505.9.4 Separately bushed openings. Service heads shall have conductors of different potential brought out through separately bushed openings.

Chapter 33 through 42 are not adopted in the City of Seattle. See the Seattle Electrical Code for electrical regulations.

E3505.9.5 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.

E3505.9.6 Conductor arrangement. Service-drop conductors and service-entrance conductors shall be arranged so that water will not enter service raceways or equipment.

E3505.9.7 Secured. Service cables shall be held securely in place.

SECTION E3506
SERVICE EQUIPMENT—GENERAL

E3506.1 Service equipment enclosures. Energized parts of service equipment shall be enclosed.

E3506.2 Working space. In no case shall the working space in the vicinity of service equipment be less than that specified in Chapter 33.

E3506.3 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.

E3506.4 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 E3507
SYSTEM GROUNDING

E3507.1 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 E3507.1.

E3507.2 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 E3507.3.

E3507.3 Two or more buildings or structures supplied from a common service. Where two or more buildings or structures are supplied from a common service, the grounding electrode(s) required in Section E3508 at each building or structure shall be connected in a manner specified in Section E3507.3.1 or E3507.3.2. Where there is no existing grounding electrode, the grounding electrode(s) required in Section E3508 shall be installed.

Exception: A grounding electrode at separate buildings or structures shall not be required where only one 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.

E3507.3.1 Equipment grounding conductor. An equipment grounding conductor as described in Section 3808 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. Any installed grounded conductor shall not be connected to the equipment grounding conductor or to the grounding electrode(s).

E3507.3.2 Grounded conductor. Where an equipment grounding conductor is not run with the supply conductors to the building or structure, and 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 common ac service, the grounded circuit conductor run with the supply conductors to the building 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.

E3507.4 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).

E3507.5 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.

E3507.6 Common grounding electrode. The service grounding electrode in or at a building shall be used to ground conductor enclosures and equipment in or on that building. Two or more grounding electrodes that are effectively bonded together shall be considered as a single grounding electrode system.

SECTION E3508
GROUNDING ELECTRODE SYSTEM

E3508.1 Grounding electrode system. Where available on the premises at each building or structure served, electrodes specified in Sections E3508.1.1, E3508.1.2 and E3508.1.3, and any made electrodes specified in Section E3508.2, shall be bonded together to form the grounding electrode system. Interior metal water piping located more than 5 feet (1524 mm) from the point of entrance to the building shall not be used as part of the grounding electrode system or as a conductor to interconnect the electrodes that are part of the grounding electrode system. The bonding jumper shall be sized and installed in accordance with Section E3509. The unspliced

Chapter 33 through 42 are not adopted in the City of Seattle. See the Seattle Electrical Code for electrical regulations.

grounding electrode conductor shall run to any convenient grounding electrode available in the grounding electrode system. Such conductor shall be sized based on the largest grounding electrode conductor required for any of the available electrodes.

E3508.1.1 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 insulated pipe to the points of connection of the grounding electrode conductor and the bonding conductors, shall be considered as a grounding electrode. Interior metal water pipe located more than 5 feet (1524 mm) from the entrance to the building shall not be used as a part of the grounding electrode system or as a conductor to interconnect electrodes that are part of the grounding electrode system. Continuity of the grounding path or the bonding connection to interior piping shall not rely on water meters or filtering devices and similar equipment. A metal underground water pipe shall be supplemented by an additional electrode of a type specified in this section or in Section E3508.2. The supplemental electrode shall be bonded to the grounding electrode conductor, the grounded service-entrance conductor, the grounded service raceway or any grounded service enclosure.

Where the supplemental electrode is a made electrode in accordance with Section E3508.2, that portion of the bonding jumper that is the sole connection to the supplemental grounding electrode shall not be required to be larger than No. 6 copper wire or No. 4 aluminum wire.

E3508.1.2 Concrete-encased electrode. An electrode encased by at least 2 inches (51 mm) of concrete, located within and near the bottom 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 No. 4 shall be considered as a grounding electrode. Reinforcing bars shall be permitted to be bonded together by the usual tie wires or other effective means.

E3508.1.3 Ground rings. A ground ring encircling the building or structure, in direct contact with the earth consisting of at least 20 feet (6096 mm) of bare copper conductor not smaller than No. 2 shall be considered as a grounding electrode.

E3508.2 Made and other electrodes. Where none of the electrodes specified in Section E3508.1 is available, one or more of the electrodes specified in Section E3508.2.1 shall be used. Where practicable, made electrodes shall be embedded below permanent moisture level. Made electrodes shall be free from nonconductive coatings such as paint or enamel. Where more than one 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.

E3508.2.1 Rod and pipe electrodes. Rod and pipe electrodes shall be not less than 8 feet (2438 mm) in length and shall consist of the following materials:

1. Electrodes of pipe or conduit shall not be smaller than $^3/_4$-inch trade size (metric designator 21) and, where of iron or steel, shall have the outer surface galvanized or otherwise metal-coated for corrosion protection.
2. Electrodes of rods of iron or 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.

E3508.2.2 Installation. The electrode shall be installed such that at least 8 feet (2438 mm) of length is in contact with the soil. It shall be driven to a depth of not less than 8 feet (2438 mm) except that, where rock bottom is encountered, the electrode 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 2.5 feet (762 mm) deep. The upper end of the electrode shall be flush with or below ground level unless the aboveground end and the grounding electrode conductor attachment are protected against physical damage.

E3508.2.3 Aluminum electrodes. Aluminum electrodes shall not be permitted.

E3508.3 Resistance of made electrodes. A single electrode consisting of a rod or pipe 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 E3508.1 or E3508.2. Where multiple rod or pipe electrodes are installed to meet the requirements of this section, they shall be not less than 6 feet (1829 mm) apart.

E3508.4 Metal underground gas piping system. A metal underground gas piping system shall not be used as a grounding electrode.

SECTION E3509
BONDING

E3509.1 General. Bonding shall be provided where necessary to ensure electrical continuity and the capacity to conduct safely any fault current likely to be imposed.

E3509.2 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.
3. Any metallic raceways or armor enclosing a grounding electrode conductor. Bonding shall apply at each end and to all intervening raceways, boxes and enclosures

Chapter 22 through 42 are not adopted in the City of Seattle. See the Seattle Electrical Code for electrical regulations.

between the service equipment and the grounding electrode.

E3509.3 Bonding to other systems. An accessible means external to enclosures for connecting intersystem bonding and grounding conductors shall be provided at the service by at least one of the following means:

1. Exposed nonflexible metallic service raceways.
2. Exposed grounding electrode conductor.
3. Approved means for the external connection of a copper or other corrosion-resistant bonding or grounding conductor to the service raceway or equipment.

For the purposes of providing an accessible means for intersystem bonding, the disconnecting means at a separate building or structure as permitted in Section E3507.3 shall be considered the service equipment.

E3509.4 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 E3509.4.1 through E3509.4.4.

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.

E3509.4.1 Grounded service conductor. Equipment shall be bonded to the grounded service conductor in a manner provided in this code.

E3509.4.2 Threaded connections. Equipment shall be bonded by connections using threaded couplings or threaded bosses on enclosures. Such connections shall be made wrench tight.

E3509.4.3 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.

E3509.4.4 Other devices. Equipment shall be bonded by approved devices, such as bonding-type locknuts and bushings.

E3509.5 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 E3503.1 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. The bonding jumper for a grounding electrode conductor raceway shall be the same size or larger than the required enclosed grounding electrode conductor.

E3509.6 Metal water piping bonding. The interior 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 E3503.1. The points of attachment of the bonding jumper(s) shall be accessible.

E3509.7 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 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 E3818.12 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.

Chapter 33 through 42 are not adopted in the City of Seattle. See the Seattle Electrical Code for electrical regulations.

SECTION E3510
GROUNDING ELECTRODE CONDUCTORS

E3510.1 Installation. A grounding electrode conductor or its enclosure shall be securely fastened to the surface on which it is carried. A No. 4 or larger conductor shall be protected where exposed to severe physical damage. A No. 6 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 and 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 conductors smaller than No. 6 shall be in rigid metal conduit, intermediate metal conduit, rigid nonmetallic conduit, electrical metallic tubing or cable armor.

Insulated or 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.

E3510.2 Enclosures for grounding electrode conductors. 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. 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. Where a raceway is used as protection for a grounding conductor, the installation shall comply with the requirements of Chapter 37.

SECTION E3511
GROUNDING ELECTRODE CONDUCTOR CONNECTION TO THE GROUNDING ELECTRODES

E3511.1 Methods of grounding conductor connection to electrodes. The grounding conductor shall be connected to the grounding electrode by 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.

E3511.2 Accessibility. The connection of the grounding electrode conductor or bonding jumper to the grounding electrodes that are not buried or concrete encased shall be accessible.

E3511.3 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 conductors shall be of sufficient length to permit removal of such equipment while retaining the integrity of the bond.

E3511.4 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.

E3511.5 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.

Chapter 35 through 42 are not adopted in the City of Seattle. See the Seattle Electrical Code for electrical regulations.

Chapter 33 through 42 are not adopted in the City of Seattle. See the Seattle Electrical Code for electrical regulations.