Electrical Grounding/Bonding Requirements

Proper grounding and bonding of building electrical systems is important to protect lives and property from electrical shocks and fires. The following general requirements for grounding and bonding of the electrical service are based on the 2016 ed. of the California Electrical Code (CEC). This Job Aid provides only general information. For additional information, contact the City of Carmel-by-the-Sea Building Safety Division.

Grounding and Bonding to the Grounding Electrode System (CEC Sec. 250.50)

All grounding electrodes described below that are present at each building served shall be bonded together to form the grounding electrode system. Where none of these grounding electrodes exist, one or more of the grounding electrodes specified shall be installed and used.

Exception: Concrete-encased electrodes of existing buildings shall not be requires to be part of the grounding electrode system when the steel reinforcing bars or rods are not accessible without disturbing the concrete.

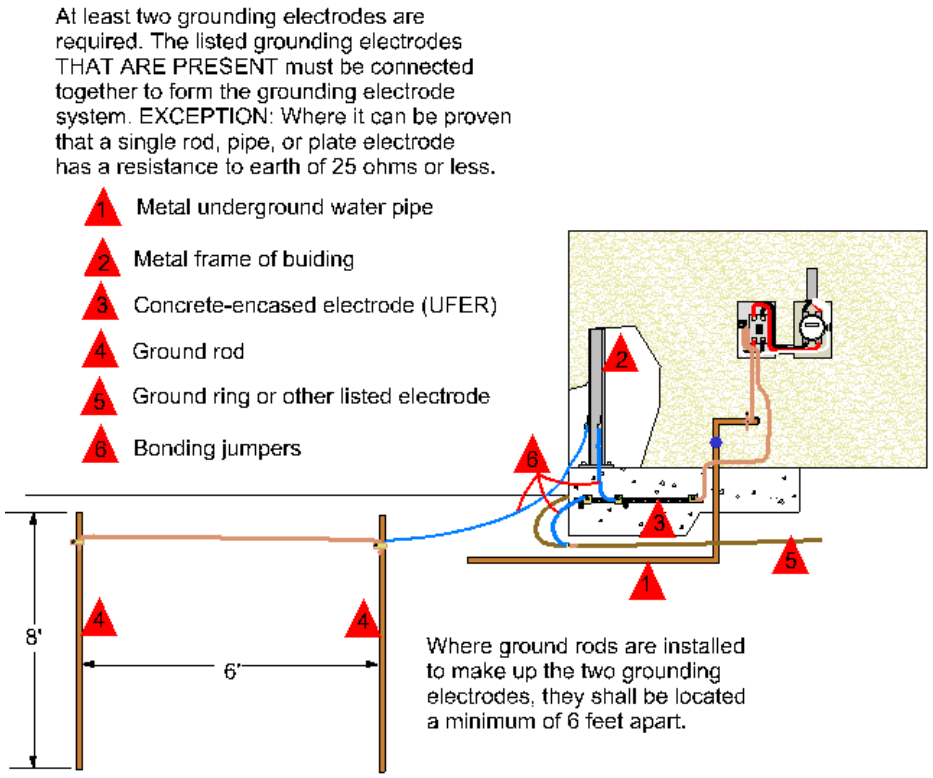

Figure 1. Grounding Electrode System - CEC Section 250.50

Grounding electrodes include:

1. **Metal underground water pipe** in direct contact with the earth for 10 ft. or more and electrically continuous (or made electrically continuous by bonding around insulating joints) to the points of connection of the grounding electrode conductor and the bonding conductor(s) or jumper(s), if installed.

2. **Metal frame of the building.** The metal frame of the building that is connected to the earth by one or more of the following methods:
    a. At least one metal structural member that is in direct contact with the earth for 10 ft. or more, with or without concrete encasement.
    b. Hold-down bolts securing the structural steel column that are connected to a concrete-encased electrode complying with the requirements for concrete-encased electrodes. The hold down bolts shall be connected to the concrete-encased electrode by welding, exothermic welding, steel tie wires, or other approved means.
3. **Concrete-encased electrode.** A concrete-encased electrode shall must consist of at least 20 ft. of either:
    a. One or more bare or zinc galvanized or other electrically conductive coated steel reinforcing bars or rods of not less than ½ inch in diameter installed in one continuous 20 ft. length or connected together by steel tie wires, exothermic welding, welding, or other effective means of creating 20 feet or greater length; or
    b. A bare copper conductor not smaller than 4 AWG

    Metallic components must be encased by at least 2" of concrete and be located horizontally within that portion of a concrete foundation or footing that is in direct contact with the earth or within vertical foundations or structural components that are in direct contact with the earth. If multiple concrete-encased electrodes are present at the building, only one need be bonded into the grounding electrode system.
4. **Ground Ring.** A ground ring encircling the building in direct contact with the earth, consisting of at least 20 ft. of bare copper conductor no smaller than 2 AWG.
5. **Rod and pipe electrodes.** Rod and pipe electrodes must be at least 8 ft. long and must consist of the following materials:
    a. Grounding electrodes of pipe or conduit no smaller than trade size ¾ and when of steel shall have the outer surface galvanized or otherwise coated for corrosion protection.
    b. Rod-type grounding electrodes of stainless steel and copper or zinc coated steel shall be at least 5/8" in diameter unless listed.

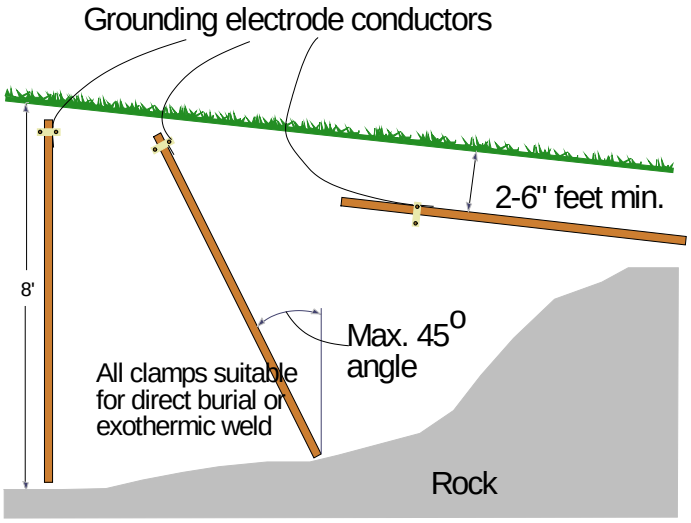

Figure 2. Rod and pipe electrode installation

6. **Other listed electrodes.** Other listed grounding electrodes shall be permitted.
7. **Plate electrodes.** Each plate electrode shall expose not less than 2 sq. ft. of surface to exterior soil. Electrodes of bare or conductively coated iron or steel plates shall be at least ¼" thick. Solid, uncoated electrodes of nonferrous metal shall be at least .06" thick.
8. **Other local metal underground systems or structures.** Other local metal underground systems or structures such as piping systems, underground tanks, and underground metal well casings that are not bonded to a metal water pipe.

The following are not permitted for use as grounding electrodes:

1. Metal underground gas piping systems
2. Aluminum

Bonding of piping systems and exposed structural metal (CEC 250.104)

1. **Metal water piping.** The metal water piping system shall be bonded as described below.
    - **a.** Meter water piping systems installed in or attached to a building 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.
    - **b.** In multiple occupancy buildings, where metal water piping system(s) installed in or attached to a building or structure for the individual occupancies by use of nonmetallic water piping, the metal water piping systems for each occupancy shall be permitted to be bonded to the equipment grounding terminal of the switchgear, switchboard, or panel board enclosure (other than service equipment) supplying that occupancy. The bonding jumper shall be sized in accordance with Table 250.122 based on the rating of the overcurrent protective device for the circuit supplying the occupancy.
    - **c.** Multiple buildings or structures supplied by a feeder(s) or branch circuit(s). The metal water piping system(s) installed in or attached to a building shall be bonded to the building disconnecting means enclosure where located at the building, to the equipment grounding conductor run with the supply conductors or one or more grounding electrodes used. The bonding jumpers shall be sized in accordance with Table 250.66 based on the size of the feeder or branch circuit conductors supplying the building. The bonding jumper is not required to be larger than the largest ungrounded feeder or branch circuit conductor supplying the building.
2. **Other metal piping.** If installed in, or attached to, a building a metal piping system , including gas piping, that is likely to become energized shall be bonded to any of the following:
    - **a.** Equipment grounding conductor for the circuit that is likely to energize the piping system
    - **b.** Service equipment enclosure
    - **c.** Grounded conductor at the service
    - **d.** Grounding electrode conductor if of sufficient size
    - **e.** One or more grounding electrodes
    - **f.** The bonding conductor(s) or jumper(s) shall be sized in accordance with 250.122 using the rating of the circuit that is likely to energize the piping system(s). The points of attachment of the bonding jumper(s) shall be accessible.
3. Structural metal. Exposed structural metal that is interconnected to form a metal building frame and is not intentionally grounded or bonded and is likely to become energized shall be bonded to the service equipment enclosure; the grounded conductor at the service; the disconnecting means for buildings supplied by a feeder or branch circuit; the grounding electrode conductor (if

sufficiently sized); or to one or more grounding electrodes used. Bonding jumpers shall be sized in accordance with T. 250.66

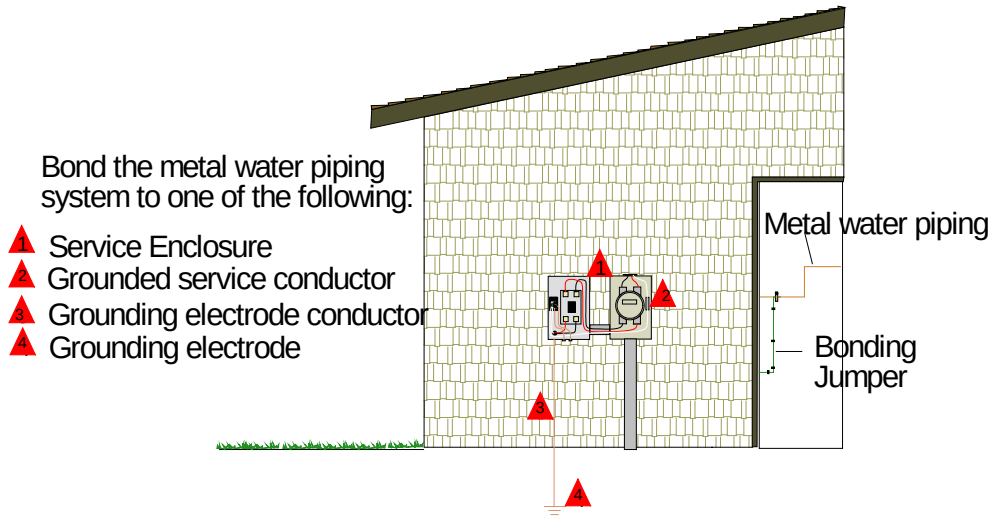

Figure 3. Bonding interior metal water pipe - CEC Sec. 250.104

4. **Separately derived systems.** Metal water piping systems and structural metal that is interconnected to form a building frame shall be bonded to separately derived systems as follows:

   a. Metal water piping systems. The grounded conductor of each separately derived system shall be bonded to the nearest point of the metal water piping system(s) in the area served by each separately derived system. This connection shall be made at the same point on the separately derived system where the grounding electrode conductor is connected. Each bonding jumper shall be sized in accordance Table 250.66 based on the largest ungrounded conductor of the separately derived system.

   Exception 1. A separate bonding jumper to the metal water piping system shall not be required where the metal water piping system is used as the grounding electrode for the separately derived system and the water piping system is in the area served.

   Exception 2. A separate water piping bonding jumper shall not be required where the metal frame of a building is used as the grounding electrode for a separately derived system and is bonded to the metal water piping in the area served by the separately derived system.

   b. Structural metal. Where exposed structural metal that is interconnected to form the building frame exists in the area served by the separately derived system, it shall be bonded to the grounded conductor of each separately derived system where the grounding electrode conductor is connected. Each bonding jumper shall be sized in accordance with Table 250.66 based on the largest ungrounded conductor of the separately derived system.

   Exception 1. A separate bonding jumper to the building structural metal shall not be required where the metal frame of a building is used as the grounding electrode for the separately derived system.

Exception 2. A separate bonding jumper to the building structural metal shall not be required where the water piping of a building is used as the grounding electrode for a separately derived system and is bonded to the building structural metal in the area served by the separately derived system.

c. Common grounding electrode conductor. Where a common grounding electrode conductor is installed for multiple separately derived systems, and exposed structural metal that is interconnected to form the building frame or interior metal piping exists in the area served by the separately derived system, the metal piping and the structural metal member shall be bonded to the common grounding electrode conductor in the same area served by the separately derived system.

Exception: A separate bonding jumper from each derived system to metal water piping and to structural metal members shall not be required where the metal water piping and the structural metal members in the area served by the separately derived system are bonded to the common grounding electrode conductor.

Size of largest ungrounded Service –entrance Conductor or Equivalent area for parallel conductors [a] (AWG/kcmil)		Size of Grounding Electrode Conductor (AWG/kcmil)	
Copper	Aluminum or Copper- Clad Aluminum	Copper	Aluminum or Copper- clad aluminum [b]
2 or smaller	1/0 or smaller	8	6
1 or 1/0	2/0 or 3/0	6	4
2/0 or 3/0	4/0 or 250	4	2
Over 3/0 – 350	Over 250 – 500	2	1/0
Over 350 – 600	Over 500 – 900	1/0	3/0
Over 600 – 1100	Over 900 – 1750	2/0	4/0
Over 1100	Over 1750	3/0	250

Table 250.66 Grounding Electrode Conductors for Alternating Current Systems

Notes – T. 250.66

1. If multiple sets of service-entrance conductors connect directly to a service drop, set of overhead service conductors, set of underground service conductors, or service lateral, the equivalent size of the largest service entrance conductor shall be determined by the largest sum of the areas of the corresponding conductors of each set.
2. Where there are no service-entrance conductors, the grounding electrode conductor size shall be determined by the equivalent size of the largest service-entrance conductor required for the load to be served.

[a] This table also applies to the derived conductors of separately derived ac systems

[b] See installation restrictions in 250.64(A)

Rating or Setting of Automatic Overcurrent Device in Circuit Ahead of Equipment, Conduit, etc. not exceeding (Amperes)	Sized (AWG or kcmil)	
	Copper	Aluminum or Copper-Clad Aluminum*
15	14	12
20	12	10
60	10	8
100	8	6
200	6	4
300	4	2
400	3	1
500	2	1/0
600	1	2/0
800	1/0	3/0
1000	2/0	4/0
1200	3/0	250
1600	4/0	350
2000	250	400
2500	350	600
3000	400	600
4000	500	750
5000	700	1200
6000	800	1200

Table 250.122 Minimum Size Equipment Grounding Conductors for Grounding Raceway and Equipment

* See installation restrictions in Art. 250.120

Note: Where necessary to comply with 250.4(A)(5) or (B)(4) the equipment grounding conductor shall