

MFSI

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Standard ground plate for residential concrete footing applications.
PGP1029

Certified ground plate by Intertek.
Conforms to UL STD 467
Cert. to CSA STD(s) C22-2 #41
100% Canadian Build
Canadian Patent Pending
US Patent Pending

INSTALLATION INSTRUCTIONS FOR PGP1029

1. Ground plate to be installed on undisturbed soil at the bottom of foundation wall concrete footing.
2. 5/8" stub-up to protrude from footing within 3"-4" from inside foundation wall to facilitate the placement of concrete forms. (See Photo)
3. Ground plate preferred located is underneath residential main distribution panel.
4. Grounding connector can be one of many approved for dry locations when installed in the above-described manner. (Acorn type is the preferred style).
5. #2/0 AWG copper is the largest allowed ground wire to be connected to the PGP1029 plate (1000 Amp Service) #6 AWG required for residential service of 200 Amp or less.
6. Footing reinforcing rebar to be tied to 5/8 round bar to further enhance the dispersal of any fault current. (optional)



Advantages to using the PGP1029 ground plate.

Overall substantial reduced labor cost.

1. No hole to dig.
2. Shorter ground wire required.
3. Ground connection is accessible in compliance with C22.1-18 Section 10-118 (2).
Where practicable, the connection to a grounding electrode shall be accessible.
4. No external PVC protection pipe and fitting required (one less building penetration)
5. Avoid re-inspection fees that can result from faulty external ground plate installations.



22-01

DANDY GROUNDING PLATES - SERIES DGP

Model #DGP

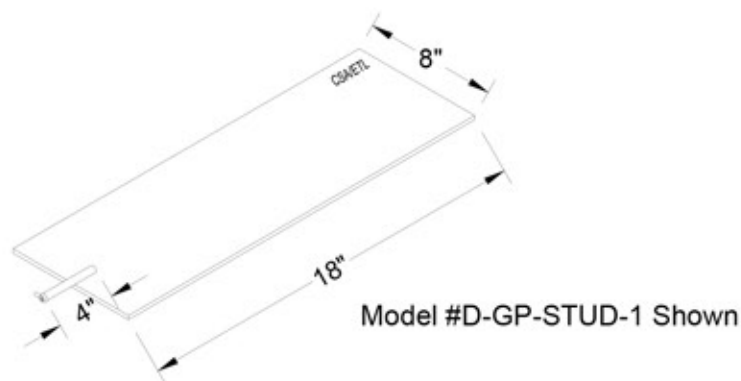
- Certified ground electrode plate
- Meets and exceeds C.E.C. Part 1 10-102 Grounding Electrodes and CSA Standard Rule 6.10.4 and certified as such
- Stud design is acceptable where authority having jurisdiction allows ground wire connection not to be visible
- Hook design allows for ground wire to be visible by way of the rod being above finished grade with this plate the electrode being in direct contact to virgin soil directly below footing and/or encased in 2" concrete

OPTIONS

- Corrosive resistant bronze oval cable clamp #8-3/0 (when terminal is not visible)

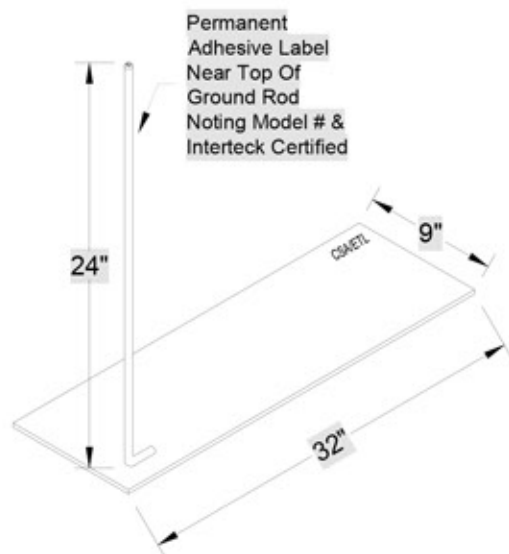
NOTES

- Oversized 32" x 9" unit is suggested when plate surface contact is only in contact on 1 side of plate (as in bottom of footing)
- Unique hook design is specific to obtaining a visible, corrosion resistant, code compliant and certified secure cable connection to a buried electric system metal plate. Grounding electrode compatible to direct earth burial and concrete encasement or combination of both for metal electrode electric system grounding. ** PATENT PENDING**
- Cable clamp by others to authority having jurisdiction
- Intertek certified to C.S.A. C22.2 #41-13

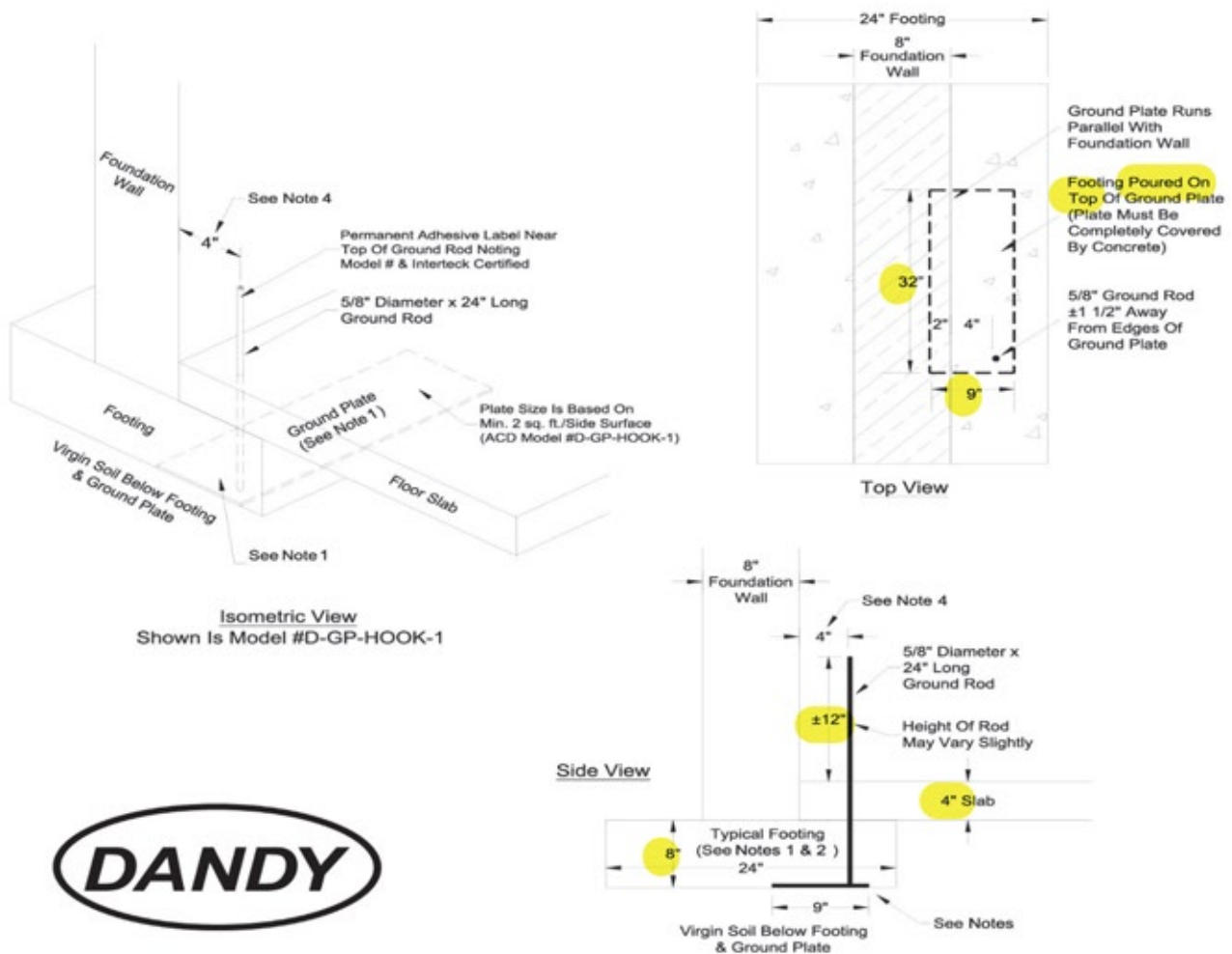


Model #	Ground Plate Dimensions	Ground Rod Length	Size
D-GP-STUD-1	18" x 8" x 1/4"	4"	Standard
D-GP-HOOK-1	32" x 9" x 1/4"	24"	Oversized

- Standard size is applicable to location where ground plate is per C.E.C. 10-102 where both sides of plate are in contact with soil
- Oversized unit is uniquely applicable to locations where under side only of ground plate is in contact with virgin soil and when top is encased with concrete



ISSUES WITH ENCASED GROUNDING PLATE ELECTRODE. SUPPLY-INSTALL-INSPECTION



QUOTE : Plate electrodes must (CEC10-700) (CSA 1.24 SEC 10-102)

-have an exterior surface area of at least 0.2 m² (as required by CSA C22.2 No. 41) in contact with the soil and be buried at a depth not less than 600 mm below finished grade level; or

-be encased within the bottom 50 mm of a concrete foundation footing that is in direct contact with the earth, having an exterior surface area to the concrete [NOT SOIL] of at least 0.4 m² (as required by CSA C22.2 No. 41), and buried at a depth not less than 600 mm below finished grade

ELECTRODE ENCASED WITHIN FOOTING – CONCRETE ABSORBS MOISTURE - LOWERING RESISTANCE

RESISTANCE SURFACE AREA MIN 0.4 SQM (4.3 SQFT) = 4.30556 SQFT-NOT 4 SQFT–UNDERSIZED BY 43.2 SQIN

BURIED 600 MM BELOW FLOOR –NOT UNDER FOOTING AND SLAB AT 12 IN, AS ABOVE – ROD UNDERSIZED

CSA C22.2 No 41.22 Sec 6.10.4.2 C & 6.1.3– MUST SUPPLY CONNECTOR USED IN TEST-DANDY DOES NOT

Intersystem bonding termination – a device that provides a means for connecting bonding conductor(s) for communications systems to the grounding electrode system.

Plate electrode – a metal plate, having a defined surface area, with a means for attachment to the system-grounding conductor.

Protective-type clamp – a ground clamp designed so that the grounding conductor and its connection will be effectively protected against mechanical damage.

Separable wire connector – a wire connector that is removable from the bushing with which it is used.

Strap-type clamp – a clamp constructed of perforated or expanded flexible metal suitable for assembly on pipe.

4 General requirements

4.1 The values given in SI (metric) units shall be normative, except for AWG/kcmil conductor sizes and other trade sizes. Any other values given shall be for information only.

4.2 For products intended for use in Canada, general requirements are given in CAN/CSA-C22.2 No. 0 and grounding and bonding requirements are given in C22.2 No. 0.4.

5 Components

A component shall comply with the ANCE, CSA Group or UL standards as appropriate for the country where the product is to be used.

6 Construction

6.1 General

6.1.1 A grounding or bonding device shall be constructed of metals or metal alloys that provide sufficient strength and rigidity to permit installation and use in the intended manner without either:

- a) adversely affecting the function of the device; or
- b) damaging the grounding or bonding conductor, the grounding electrode, or equipment to which the device is attached.

6.1.2 A grounding or bonding device marked for direct burial shall be provided with all screws necessary for assembly or connection of the device, and all components shall be constructed of:

- a) copper or a copper alloy containing not less than 80 % copper;
- b) stainless steel; or
- c) materials other than aluminum and aluminum alloys, if investigated and found to be acceptable for the application.

Note: Among the factors to be taken into consideration when judging the acceptability of such materials are the

- a) change of resistance across the bonding-grounding joint; and
- b) amount and degree of corrosion.

6.1.3 Connectors provided as part of a grounding or bonding device shall comply with the construction requirements of

- a) NMX-J-543-ANCE, CSA C22.2 No. 65 or UL 486A-486B; or
- b) NMX-J-548-ANCE, CSA C22.2 No. 188 or UL 486C and may be made of iron or steel with a steel terminal screw.

6.1.4 Means for the attachment of a grounding or bonding conductor shall be so designed that the conductor is securely and reliably held without depending on solder.

6.1.5 For connectors not covered in Clause 6.1.3, and where the conductor is attached by means of a single screw, the size of the screw shall not be smaller than as specified in Table 1.

6.1.6 A wire-binding screw shall be provided with upturned lugs or the equivalent capable of holding a wire under the head of the screw.

6.1.7 A cast iron part, other than malleable iron, shall be not less than 3.2 mm (1/8 in) thick. A malleable iron part, a nonferrous cast-metal part, and a die-cast or extruded part shall be not less than 2.4 mm (3/32 in) thick, except that a die-cast part may be not less than 1.6 mm (1/16 in) thick if it is ribbed or otherwise reinforced and not marked for direct burial.

6.1.8 A fitting, such as a hub, a bushing, or a locknut to be used for grounding and intended to provide a rain-tight or liquid-tight connection between threaded metal conduit and a sheet metal enclosure shall comply with the requirements in this Standard and with the requirements for such a fitting in NMX-J-017-ANCE, CSA C22.2 No. 18.3, or UL 514B. See Clause 10.4.

6.1.9 A device intended for the connection of metal conduit, electrical metallic tubing, or flexible armor shall be provided with an end stop or the equivalent, and if intended for the connection of metal conduit, it shall be provided with not less than three full threads in the metal.

6.2 Protective-type ground clamps

6.2.1 A clamp intended to be threaded onto or otherwise rigidly attached to any form of metal raceway or flexible armor enclosing a grounding conductor shall be of the protective type. The clamp shall be such that the grounding conductor and its connection will be effectively protected against mechanical damage, except that a grounding conductor connection having inherent protection against mechanical damage, because of its size, shape, and the like, is not required to be otherwise protected.

6.2.2 A ground clamp in which the grounding conductor and its connection to the clamp is recessed between protective side walls shall be acceptable, provided that such protective walls are not formed by removable parts that are not essential for the assembly of the device.

6.2.3 A protective-type clamp shall provide an electrical and mechanical connection between the grounding electrode and a grounding conductor protected by armor or metal raceway. The mechanical connection shall be rigid if the clamp is designed for use with metal conduit.

6.2.4 A protective-type clamp of the strap type shall have a rigid metal base to be seated on the grounding electrode, and if the clamp is designed for use with metal conduit, it shall be provided with not less than the applicable number of straps specified in Table 2, depending upon the trade size of metal conduit with which it is intended to be used.

6.3 Strap-type clamps

6.3.1 A strap-type clamp shall not be less than 12.7 mm (1/2 in) wide and 0.64 mm (0.025 in) thick.

6.3.2 A communications strap-type clamp shall not be less than 12.7 mm (1/2 in) in width and not be less than 0.64 mm (0.025 in) in thickness. Strap-type clamps intended for outdoor use shall satisfy the temperature conditioning test described in Clause [9.9](#).

6.3.3 Communication ground clamps may be in the form of straps of copper or other suitable metal.

6.3.4 Communication ground straps shall be fitted either with brass or galvanized steel screws.

6.4 Protection against corrosion

6.4.1 A grounding or bonding device shall be protected by a zinc coating at least 0.025 mm (0.001 in) thick, except as follows:

- a) if the metal is inherently resistant to corrosion such as nonferrous or stainless steel;
- b) a device that is used in conjunction with an electrical metallic raceway or metallic cable system and complies with the corrosion protection requirements for fittings in CSA C22.2 No.18.3 or UL 514B;
- c) the thickness of the coating shall be at least 0.013 mm (0.0005 in) if the device provides for a direct pressure connection between the grounding or bonding conductor and the surface of an outlet box; or
- d) the thickness of the coating shall be at least 0.0038 mm (0.00015 in) if the device is intended for use completely inside an outlet box.

Also see Clause [6.4.6](#).

6.4.2 In regards to Clause [6.4.1](#), corrosion protection on small parts of the grounding and bonding device, such as screws, is not specified. Evidence of corrosion protection shall be verified by visual inspection.

6.4.3 Unless a grounding or bonding device is made of a material specified in Clause [6.1.2](#), a plating or a coating provided on the device shall not be of a material or color that would tend to indicate that the device is of a material other than that of which it is actually made.

6.4.4 Except as specified in Clause [6.4.3](#), colored chromate shall be permitted.

6.4.5 Die-cast zinc or another metal shall be one or more of the following:

- a) a grade or alloy known to be resistant to atmospheric corrosion;
- b) subjected to appropriate tests; or
- c) additionally protected against corrosion.

6.4.6 In accordance with Clause [6.4.1](#), a device constructed of ferrous metal shall be protected against corrosion by one of the following means or by other metallic coatings that have been found to give equivalent protection, as described in Clause [6.4.7](#):

a) hot-dipped, mill-galvanized sheet steel conforming with the coating designation G90 in Table I of ASTM A 653/A 653M, with not less than 40 % of the zinc on any side, based on the minimum single-spot-test requirement in ASTM A 653/A 653M. The weight of zinc coating may be determined by any acceptable method; however, in case of question, the weight of coating shall be established in accordance with ASTM A 90/A 90M; and

b) a zinc coating, other than that provided on hot-dipped mill-galvanized sheet steel, uniformly applied to a thickness of not less than 0.025 mm (0.001 in) on each surface. The thickness of the coating shall be established by the thickness of protective coating test described in Clause 9.6.

6.4.7 With reference to Clause 6.4.6, other finishes, including special metallic finishes, may be used when comparative tests with galvanized sheet steel having no annealing, wiping, or other surface treatment that conform to Clause 6.4.6, Item (a), indicate they provide equivalent protection.

Note: Among the factors that are taken into consideration when judging the acceptability of such coating systems are exposure to salt spray, moist carbon dioxide-sulphur dioxide-air mixtures, moist hydrogen sulphide-air mixtures, ultraviolet light, and water.

6.5 Ground clamps

6.5.1 Clamps and electrode connections shall be any one of the following:

a) rigid bolted clamps of cast, formed, or extruded metal;

b) plug-type grounding fittings (pipe fittings, plugs, or other approved forms for threading into pipes or pipe fittings); or

c) exothermically welded connections.

6.5.2 A clamp for use in damp or dry locations shall be made of copper alloy, malleable iron, aluminum, or die-cast zinc.

6.5.3 In Canada, a clamp used for a wet location shall be of copper, bronze, or brass, and the bolts shall be of similar material or of stainless steel.

In Mexico and the United States, a clamp used for a wet location shall be of copper, bronze, brass, zinc alloys, or aluminum, and the bolts shall be of similar material or of stainless steel.

6.6 Bushings

6.6.1 Bushings shall meet the requirements of CSA C22.2 No. 18.3, UL 514B, or NMX-J-017-ANCE. For an insulated metal bushing, all surfaces of the throat that can be contacted by a conductor shall be lined with the insulating material.

6.6.2 Bonding bushings shall be provided with a means (usually one or more set screws) for reliably bonding the bushing (and the conduit or fittings on which it is attached) to the metal equipment enclosure or box. A means for connecting a grounding or bonding conductor shall not be provided.

Note: If there is need for a grounding or bonding conductor, a grounding bushing should be used.

6.6.3 A bonding screw intended to bond a bushing to an enclosure shall be adjustable to extend not less than 3.2 mm (1/8 in) beyond the surface of the bushing, except that if two or more such screws or the equivalent are evenly spaced around the bushing, this adjustment may be less than 3.2 mm (1/8 in), but not less than 1.6 mm (1/16 in). When adjusted in any position, a bonding screw shall engage not less than two threads in the bushing.

6.6.4 Grounding bushings shall have provision for the connection of the minimum size bonding or grounding conductor in accordance with [Table 3](#) or have provisions for mounting a separable wire connector accepting the minimum size conductor in accordance with [Table 3](#). A grounding bushing shall also have means (usually one or more set screws) for reliably bonding the bushing to the metal equipment enclosure or box in the same manner that is accomplished by a bonding bushing, see Clauses [6.6.2](#) and [6.6.3](#).

Note: Grounding bushings may be used with or without a bonding or grounding conductor as determined by the bonding or grounding function that is intended to be accomplished.

6.6.5 With reference to the requirement in Clause [6.6.4](#), an integral wire connector is considered to be nonremovable from the grounding bushing. A separable wire connector may be either factory assembled to the grounding bushing or be separately available from the manufacturer.

6.7 Fittings

A grounding fitting or bonding fitting shall meet the requirements of Clauses [6.2](#), [6.4](#), [6.5](#), and [6.6](#), as applicable.

6.8 Water-meter shunts

A water-meter shunt shall consist of two clamps connected by means of a 4 AWG (21.2 mm²) or larger solid copper wire. The clamps shall comply with the requirements for clamps given in this Standard.

6.9 Armored grounding wire

6.9.1 General

Armored grounding wire shall consist of a single corrosion-resistant copper, aluminum, or copper-clad aluminum conductor, within a flexible, helically formed steel armor similar in general design to that employed in armored cable.

6.9.2 Conductor

The conductor shall be sized in accordance with [Table 4](#) and shall comply with the short-time current requirement in Clause [9.5](#). The conductor is not required to be tinned.

6.9.3 Armor

6.9.3.1 Splices made in the steel strip forming the armor shall not increase the thickness or diameter of the armor or lessen its mechanical strength.

6.9.3.2 The strip used in the armor shall not be less than 0.64 mm (0.025 in) thick.

6.9.3.3 In an armored grounding wire employing an uninsulated (bare) conductor, the weight of single-strip steel armor shall not be less than specified in [Table 4](#).

6.9.3.4 The steel armor of an armored grounding wire shall comply with the requirements for zinc coating, be able to support a tension of 667 N (150 lbf), and have the flexibility applicable to armored cable.

Note: The steel armor of an armored grounding wire conforming to CSA C22.2 No. 51 or UL 4 is considered to be in compliance with Clauses [6.9.3.1](#) to [6.9.3.4](#).

6.10 Grounding electrodes

6.10.1 General

Grounding electrodes shall be one of the types described in Clauses [6.10.2](#) to [6.10.4](#).

6.10.2 Rod electrodes

6.10.2.1 In Canada and Mexico, a rod electrode shall not be less than 3 m (10 ft) long.

In the United States, a rod electrode shall be not less than 2.44 m (8 ft) long.

6.10.2.2 In Mexico, a solid rod electrode of iron or steel shall have a diameter not less than 16 mm (5/8 in).

In Canada, a solid rod electrode of iron or steel shall have a diameter not less than 15.8 mm (5/8 in).

In the United States, a solid rod electrode of iron or steel shall have a diameter not less than 15.87 mm (5/8 in).

6.10.2.3 In Mexico, an uncoated solid rod electrode of stainless steel, copper, or suitable nonferrous metal shall have a diameter of not less than 14.8 mm (0.583 in).

In Canada and the United States, a solid rod electrode of stainless steel, copper, or suitable nonferrous metal shall have a diameter not less than 12.7 mm (1/2 in).

6.10.2.4 A coated solid rod electrode of iron or steel shall have a zinc, stainless steel, copper, or suitable nonferrous metal coating and shall have a diameter of not less than 12.7 mm (1/2 in).

6.10.2.5 The stainless steel coating shall not be less than 0.38 mm (0.015 in) thick at any point.

6.10.2.6 The copper coating shall not be less than 0.25 mm (0.010 in) thick at any point and shall comply with the adherence requirement in Clause [7.7.1](#) and the bending requirement in Clause [7.7.2](#).

6.10.2.7 A zinc coating shall not be less than 0.099 mm (0.0039 in) thick at any point and shall comply with the adherence requirements in Clause [7.7.1](#) and the bending requirements in Clause [7.7.2](#).

6.10.2.8 The stainless steel coating or a stainless steel rod shall be formed of an austenitic stainless steel of the 18 % chromium, 8 % nickel type.

6.10.3 Chemically charged rod electrodes

6.10.3.1 A hollow-tube, chemically-charged-rod electrode shall

- a) be constructed of copper or an equivalent material resistant to the corrosive effects of moist soil;
- b) have an internal diameter not less than 49.3 mm (1.94 in) and a wall thickness not less than 1.93 mm (0.076 in);
- c) comply with the minimum length in Clause [6.10.2.1](#); and
- d) be accompanied by adequate installation and maintenance instructions.

6.10.3.2 The chemical charge within the rod electrode shall be a substance that does not cause the electrode to corrode at a faster rate than an electrode constructed of trade size 3/4 (21) ferrous metal conduit.

6.10.3.3 A chemical charge of 60 % sodium chloride and 40 % calcium chloride having a total weight of less than 5 kg (11 lb) may be used without further evaluation.

6.10.4 Plate electrodes

6.10.4.1 A plate electrode shall

- a) be not less than 6.4 mm (1/4 in) in thickness if of iron or steel, or 1.5 mm (0.06 in) if of nonferrous metal, other than aluminum;
- b) have a total surface area of not less than 0.186 m² (2 ft²);
- c) if provided with a means of connection to the system grounding conductor, have connections that comply with the requirements of Clauses 6.1.3, 7.1, and 7.5; and
- d) shall be marked in accordance with Clause 10.10.

6.10.4.2 In Canada, a plate electrode for concrete encasement shall

- a) be not less than 6 mm (0.24 in) in thickness if of iron or steel or 1.5 mm (0.06 in) if of nonferrous metal, other than aluminum;
- b) have a total surface area of not less than 0.4 m² (4.3 ft²);
- c) have a means of connection to the system-grounding conductor that shall be accessible. Solderless connections used for attachment to the system grounding conductor shall comply with the requirements of Clauses 6.1.3, 7.1, and 7.5; and
- d) comply with the requirements of Clauses 6.4 and 10.11.

In the United States, the requirements of Clause 6.10.4.1 apply to all plate electrodes.

6.11 Ground mesh

6.11.1 Ground mesh shall consist of 8 AWG minimum copper or copper alloy wire, stainless steel wire, or other material found to meet the requirement of this Standard.

6.11.2 The wire shall be fashioned into a grid. The grid pattern shall not have any dimension less than 102 mm (4 in) or greater than 610 mm (24 in). The intersections of the wires of the grid shall be welded or brazed.

6.12 Miscellaneous devices

Grounding or bonding devices not specifically covered in the preceding requirements, such as bonding locknuts, gaskets, grounding wedge lugs, signal reference grids, exothermic welding connection systems (see Annex D), twist-on connecting devices, and adapters, shall be judged under the intent of these requirements. Special attention shall be given to the reliability of the bonding afforded, the protection of iron and steel parts against corrosion, and the provision of means for the connection of suitable grounding or bonding conductors where the use of such conductors is involved. Unusual features and those not contemplated by these requirements shall be investigated to determine if they are suitable for the purpose.

10.4 A fitting with the environmental ratings specified in Clause [6.1.8](#) shall be marked in accordance with CSA C22.2 No. 18.3, NMX-J-017-ANCE, or UL 514B.

10.5 In a series or complete line of products that consists of devices assembled from interchangeable parts, each part shall have a marking that, taken together with the markings on all of the other parts assembled as intended to form a complete device, results in a distinctive catalog number, type designation, or the like that identifies the assembled device.

Note: As an example of compliance of devices with the requirement in Clause [10.5](#), threaded parts for the connection of metal conduit might be designated and marked A for trade size 1/2 (16), B for trade size 3/4 (21), C for trade size 1 (27), D for trade size 1-1/4 (35), and the like. Clamp parts for water-pipe or rod electrodes might be designated and marked 2 for trade size 1/2 (16), 3 for trade size 3/4 (21), 4 for trade size 1 (27), 5 for trade size 1-1/4 (35), and the like. Then the complete assemblies constituting the series would be designated and identifiable as A-2, B-3, B-4, C-3, C-4, D-5, and the like.

10.6 The temperature rating of an insulating bushing shall be marked or color-coded in accordance with CSA C22.2 No. 18.3, NMX-J-017-ANCE, or UL 514B.

10.7 The marking of a ground rod shall be located within 305 mm (12 in) of the top of the rod and shall include the following:

- a) the manufacturer's name, trade name, or both, or any other distinctive marking whereby the organization responsible for the product can readily be identified;
- b) a distinctive catalog number or an equivalent identification; and
- c) the length of the rod.

Note: UPC labels do not meet the intent of readily identifying the organization responsible for the product.

10.8 The following information shall be plainly marked on a tag that is to be tied to every shipping length of finished armored grounding wire. If the wire is wound on a reel or coiled in a carton, the tag may be glued, tied, stapled, or otherwise attached to the reel or carton, or the information may be printed or stencilled on the reel or carton. Other information may be included if it is not confusing or misleading. The marking shall be as follows:

- a) the words "armored grounding wire";
- b) the manufacturer's name, trade name, or both, or any other distinctive marking whereby the organization responsible for the product can readily be identified; and
- c) the wire size of the grounding conductor.

Note: UPC labels do not meet the intent of readily identifying the organization responsible for the product.

10.9 An armored grounding conductor shall have a distinctive marking throughout its entire length by which it may be readily identified as the product of a particular factory. The marking shall consist of a letter or symbol legibly indented or embossed in the armor at intervals of not more than 305 mm (12 in).

10.10 A plate electrode conforming to Clause [6.10.4.1](#) shall be marked with the manufacturer's name, trade name, or both, or any other distinctive marking whereby the organization responsible for the product can readily be identified.

Note: UPC labels do not meet the intent of readily identifying the organization responsible for the product.

10.11 A plate electrode for concrete encasement conforming to Clause [6.10.4.2](#) shall be marked within 50 mm (2 in) of the top of the means for attachment of the system-grounding conductor with the information in Clause [10.10](#).

- Δ **System bonding jumper** — a connection between the point of an electrical system to be solidly grounded and the non-current-carrying conductive parts of that electrical system.

Ungrounded system — an electrical system in which no point of the system is intentionally grounded.

Grounding

Grounding — General

10-100 Current over grounding conductors (see Appendix B)

There shall be no objectionable passage of current over a grounding conductor.

10-102 Grounding electrodes (see Appendix B)

- 1) Grounding electrodes shall consist of
 - a) manufactured grounding electrodes;
 - b) field-assembled grounding electrodes; or
 - c) in-situ grounding electrodes forming part of existing infrastructure.
- 2) Manufactured grounding electrodes shall
 - a) in the case of a rod grounding electrode, consist of two rod electrodes
 - i) spaced not less than 3 m apart;
 - ii) interconnected with a grounding conductor sized as prescribed for grounding conductors; and
 - iii) driven to the full length of the rod;
 - b) in the case of a chemically charged rod electrode, be installed to the full length of the rod; or
 - c) in the case of a plate electrode, be
 - i) in direct contact with exterior soil at not less than 600 mm below grade level; or
 - ii) encased within the bottom 50 mm of a concrete foundation footing in direct contact with the earth at not less than 600 mm below finished grade.
- 3) A field-assembled grounding electrode shall consist of
 - a) a bare copper conductor not less than 6 m in length, sized in accordance with Table 43 and encased within the bottom 50 mm of a concrete foundation footing in direct contact with the earth at not less than 600 mm below finished grade; or
 - b) a bare copper conductor not less than 6 m in length, sized in accordance with Table 43 and directly buried in earth at least 600 mm below finished grade.
- 4) For the purposes of Rule 2-024, an in-situ grounding electrode shall not be considered electrical equipment and shall provide, at 600 mm or more below finished grade, a surface area exposure to earth equivalent to that of a similar manufactured grounding electrode.
- 5) Where a local condition such as rock or permafrost prevents a grounding electrode from being installed at the required burial depth, a lesser acceptable depth shall be permitted.

10-104 Spacing and interconnection of grounding electrodes (see Appendix B)

Where there are multiple grounding electrodes at a building, they shall be

- a) separated by at least 2 m from each other;
- b) interconnected with a conductor
 - i) made of material prescribed for grounding conductors;
 - ii) sized as prescribed for grounding conductors; and
 - iii) protected from mechanical damage as required for grounding conductors; and
- c) in the case of lightning protection systems, interconnected in accordance with Item b) at or below ground level.

10-106 Railway track as grounding electrodes (see Appendix B)

Railway track shall be permitted to be used as a grounding electrode only for railway lightning arresters and for the railway circuit itself.

10-108 Lightning protection system down conductors and grounding electrodes (see Appendices B and G)

- 1) Down conductors shall not be used for grounding electrical systems or electrical equipment.

- 2) The grounding electrode for a lightning protection system shall be dedicated for use solely by the lightning protection system.

10-110 Continuity of grounding conductors

No automatic cut-out or switch shall be installed in the grounding conductor unless the opening of the cut-out or switch disconnects all sources of energy.

10-112 Material for grounding conductors (see Appendix B)

- 1) The grounding conductor shall be
 - a) of copper, aluminum, or other acceptable material; and
 - b) permitted to be insulated or bare.
- 2) Grounding conductors shall be resistant to any corrosive condition existing at the installation or shall be protected against corrosion.

10-114 Grounding conductor size (see Appendix B)

- 1) Except as permitted by Subrule 2), the grounding conductor shall be sized not smaller than
 - a) No. 6 AWG if of copper; or
 - b) No. 4 AWG if of aluminum.
- 2) The grounding conductor shall be permitted to be sized smaller than prescribed in Subrule 1), provided that it is not smaller than the current-carrying conductor(s) of the system being grounded.

10-116 Installation of grounding conductors (see Appendix B)

- 1) The grounding conductor shall be electrically continuous throughout its length.
- 2) Where necessary, devices to control the effects of stray earth current shall be permitted to be connected in series with the grounding conductor.
- 3) A grounding conductor shall be protected from damage
 - a) mechanically; or
 - b) by location.
- 4) Raceways or sleeves constructed of magnetic materials used to enclose grounding conductors shall be connected to the grounding conductor at both ends.
- 5) A grounding conductor installed in the same raceway with service conductors shall be insulated, except that an uninsulated grounding conductor shall be permitted where the length of the raceway
 - a) does not exceed 15 m between pull points; and
 - b) does not contain more than the equivalent of two 90° bends between pull points.

10-118 Grounding conductor connection to grounding electrodes (see Appendix B)

- 1) The grounding conductor shall be connected to the grounding electrode at a point that will assure a permanent ground by means of
 - a) a bolted clamp;
 - b) copper welding by a fusion welding process;
 - c) brazing;
 - d) silver solder; or
 - e) other equally substantial means.
- 2) Where practicable, the connection to a grounding electrode shall be accessible.

Solidly grounded systems

10-200 DC systems required to be solidly grounded

DC systems shall be solidly grounded unless they meet the requirements for

- a) ungrounded systems; or
- b) impedance grounded systems.

10-202 Conductor of a dc system to be grounded (see Appendix B)

The conductor of a dc system to be grounded shall be

- a) one conductor of a 2-wire system; or
- b) the common conductor of a 3-wire system.



Understanding Our Electrical World: 8 Items that Form the Grounding Electrode System

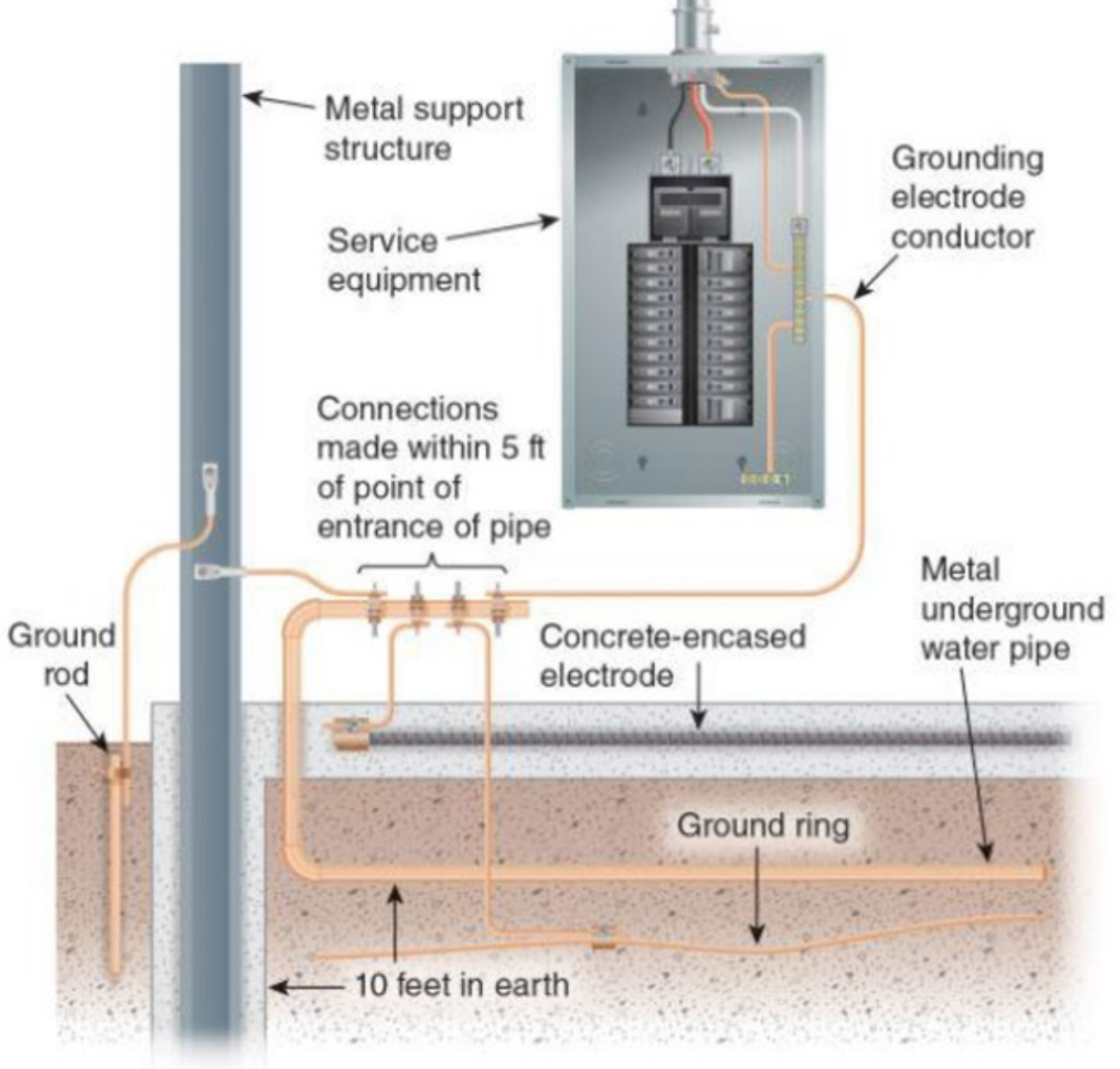
21-May-2021

NFPA 70®, *National Electrical Code®* (NEC®) has many areas of interest that keep the technical staff at NFPA on their toes. One of the areas that always seems to get a lot of questions through NFPA's Technical Questions Service, available to members and AHJs, has to do with the electrical system grounding. Questions range from how to size the various grounding conductors and bonding jumpers to what can be used to connect the system to earth. Before we jump into figuring out how big the wire needs to be for the grounding electrode conductor, it is critical that we understand exactly how we will be connecting our electrical system to the ground and why.

First, we need to understand a few terms that are used within the NEC when it comes to grounding and bonding so that we can fully understand the intent of what is required. When we hear the term “grounded electrical system,” what does that even mean? Well, since the NEC defines “ground” as the earth and “grounded” as being connected to ground, or a conductive object that extends the ground connection, to have a grounded system means that you have an electrical system that is connected to the earth. Other terms that we must familiarize ourselves with is grounding electrode and the grounding electrode system. Basically, a grounding electrode is a conductive object that establishes a direct connection to the earth or ground. The important part is that a grounding electrode has direct contact with ground. There are lots of conductive objects within a structure, however, not all of them establish a direct connection to ground. This is where the grounding electrode system begins to take shape.

The NEC contains a list of items that are permitted to be used as grounding electrodes and requires that if any are present, they must be used to form the grounding electrode system. There are 8 items that are listed in 250.52 as allowable grounding electrodes, here is the list:

1. Metal Underground Water Pipe
2. Concrete-encased Electrode
3. Metal In-ground Support Structure
4. Ground Ring
5. Rod and Pipe Electrodes
6. Plate Electrodes
7. Other Listed Electrodes
8. Other local underground metal systems or structures



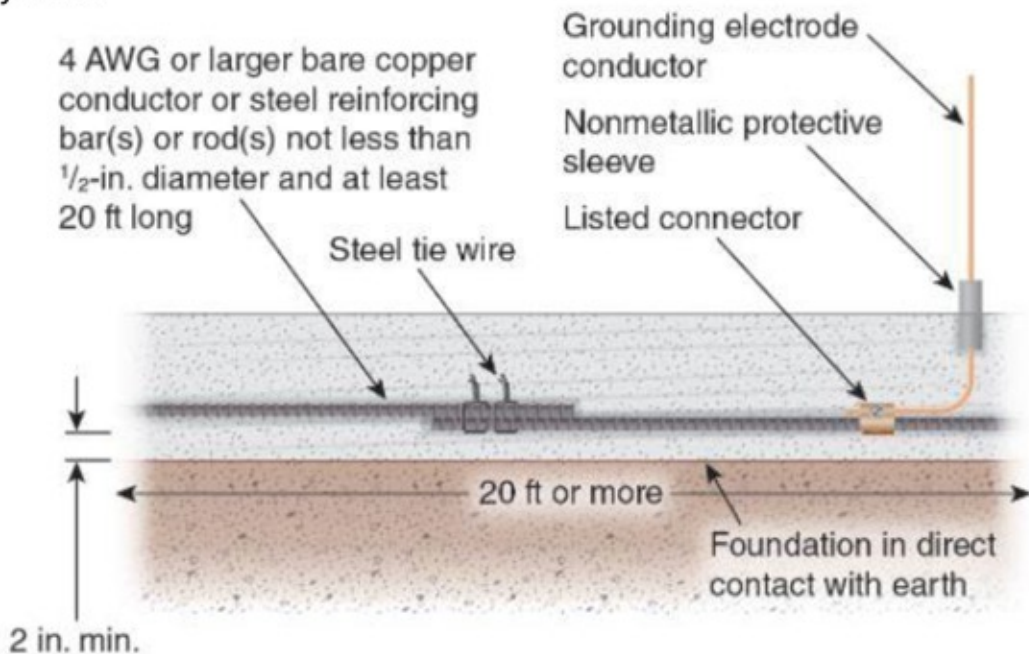
Any of these electrodes that are present in the building or structure, must be bonded together to form the grounding electrode system. There are some qualifying conditions for each item on the list that we will address shortly, but it is important to note that the first three on the list are components of the building itself and the rest are what is sometime referred to as "made electrodes." In other words, a building will either have the first three or it will not, but 4-8 are items that the installer will put into the ground to establish the grounding electrode system. Let's take a look at each of the specific items on the list:

1. Metal Underground Water Pipe

The metal underground water pipe electrode is often called the “water bond” by many in the field. For a metal underground water pipe to qualify as an electrode, we need to have at least 10 feet in direct contact with Earth. This also needs to be electrically continuous or made electrically continuous to the point of attachment for the grounding electrode conductor or bonding jumper.

2. Metal In-Ground Support Structure

The metal in-ground support structure electrode is often referred to as “building steel” but it is important to note that not all steel frames of a building will qualify as this type of electrode. To qualify as a grounding electrode, there needs to be direct contact with the ground or concrete-encasement that has direct contact with the ground. Steel building frames are often bolted down to bolts that are embedded into the concrete foundation and have no physical contact with the Earth itself. For the metal frame of a building to qualify as an electrode, there must be a minimum of 10 feet vertically in contact with the ground, with or without concrete-encasement. If there are numerous metal pilings that meet this qualification, only one needs to be connected to the grounding electrode system. However, there would be nothing to prevent the use of multiple metal in-ground electrodes as part of the building grounding electrode system.



3. **Concrete-Encased Electrode**

The concrete-encased electrode is an electrode that uses a building's concrete structural components to establish a connection with the Earth. Often referred to as the Ufer ground, this method is very effective in making the connection to Earth. There are two different methods for establishing this electrode. This electrode can be either a minimum of a #4 AWG bare copper conductor or it can be unencapsulated reinforcing steel rods with a minimum diameter of ½ inch. Either method must be a minimum of 20 feet in length and encased within a minimum of 2 inches of concrete that is in direct contact with the Earth. When this electrode consists of reinforcing steel, it is allowed to join multiple shorter sections of rods together through the usual methods but the final assembled length must meet or exceed 20 feet. Again, in buildings with multiple electrodes available, it is permitted to simply use a single electrode in the overall system

4. **Ground Ring Electrode**

A ground ring electrode is a grounding electrode that completely encircles the building or structure. This consists of a bare copper conductor that is a minimum of a #2 AWG conductor and must be a minimum of 20 feet in length. This type of electrode must be installed and is not a part of the building or structure like the first three electrodes.

5. **Rod or Pipe Electrodes**

Rod and pipe electrodes are another type of electrode that can be installed to build a more robust grounding electrode system or when the building or structure does not contain a component that qualifies as an electrode, such as when the water supply to a home is in PVC and the footings are not in direct contact with Earth. These electrodes must be a minimum of 8 feet long and in contact with the Earth and a minimum of trade size ¾ inch when consisting of pipe or conduit and 5/8 when a rod type electrode. Smaller diameter ground rods can be used when they are listed as grounding electrodes. If corrosive materials, such as steel are used, they must be galvanized or have other measures taken for corrosion protection.

6. Plate Electrodes

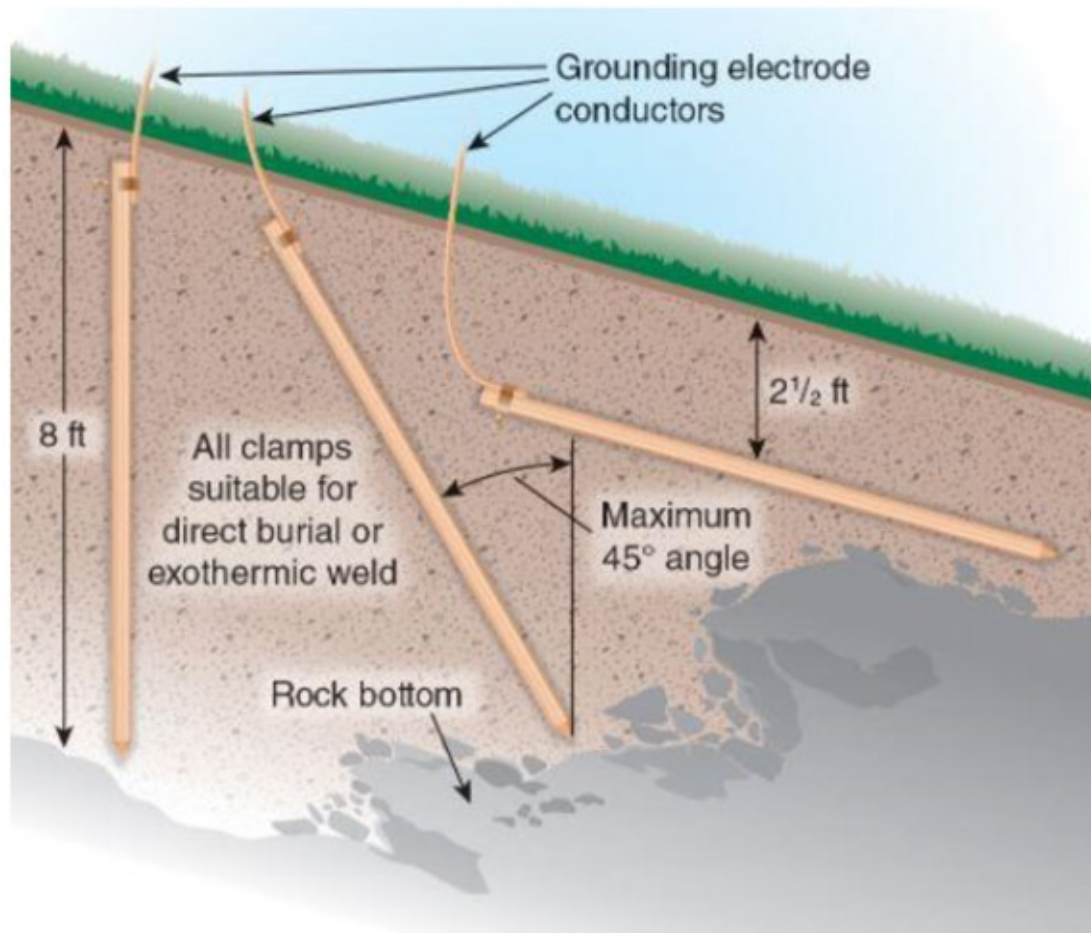
A grounding connection can also be established through the use of a conductive plate. The plate must expose a minimum of 2 square feet of surface area to contact with Earth. This could mean that a grounding plate can measure 12 inches by 12 inches since there are 2 sides to the plate in contact with the Earth. For plates made from uncoated iron or steel, the minimum thickness of the plate is $\frac{1}{4}$ inch to account for corrosion of the plate over time. Non-ferrous metal plates are permitted to have a thickness of just 1.5 millimeters.

7. Other Electrodes

Other electrodes are permitted to be used and 250.52 lists two categories that fall under the term "other". If an electrode of a type not previously mentioned is listed by a nationally recognized testing laboratory as being a grounding electrode, the AHJ can permit the use of such an electrode. There are also other local underground metal structures and systems that are permitted to be used such as piping systems, metal well casings not bonded to a metal water line, and underground tanks. However, keep in mind that there are certain systems not permitted to be used as grounding electrodes, such as metal underground gas lines and the equipotential bonding grid required for in-ground pools. The AHJ must make the determination if such an object meets the requirements for a grounding electrode.

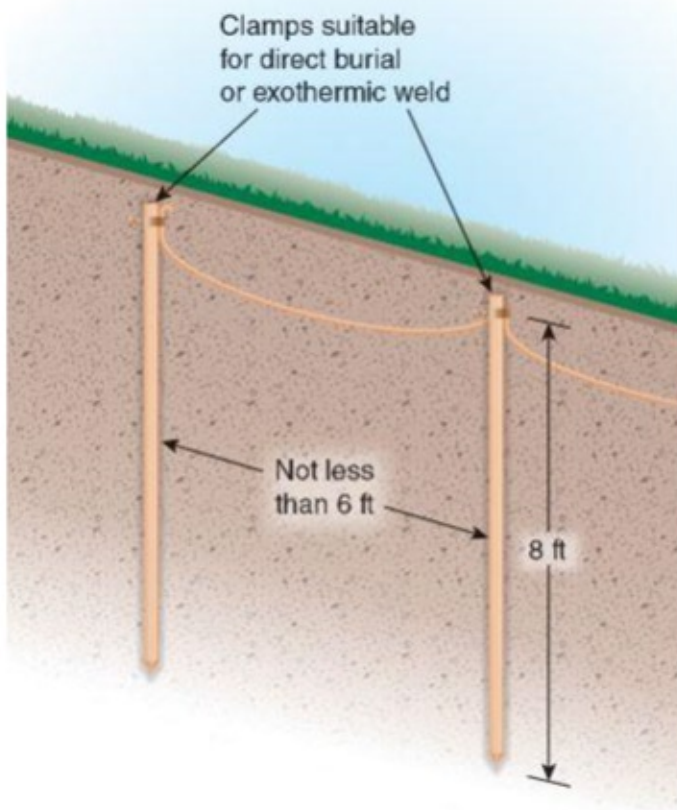
We must also talk about how these electrodes will be installed in order to form the grounding electrode system. Like stated earlier, metal underground water pipe, metal in-ground support structure, and concrete-encased electrodes are typically either a part of the building and therefore required to be used or they are not present and one of the other installed or "made" electrodes must be used. There is one exception to the general rule that if an electrode exists it must be used and that is for existing buildings. It is not the intent of the NEC to require that the concrete footing be disturbed to expose the reinforcing steel within and connect to it. The exception allows an installer the ability to not use an existing concrete-encased electrode if it would require disturbing the concrete.

Rod, pipe, plate, and metal underground water pipe electrodes all require the use of a supplemental grounding electrode. It is important to understand what can be used as a supplemental electrode as well. For instance, a ground rod can be used to supplement a metal underground water pipe however, a metal underground water pipe is not permitted to supplement a ground rod. Yet, 250.53(A) still requires rod, pipe, and plate electrodes to have a supplemental grounding electrode. This means that we are often installing a second ground rod or plate to supplement the ground rod which was installed to supplement the metal underground water pipe. This is because the metal underground water pipe has the potential to be changed out by the water utility for PVC and the homeowner is not often aware of the fact that this would place them only with a single ground rod afterwards. However, metal in-ground support structures, concrete-encased electrodes, and ground rings are all not required to be supplemented and therefore might be a viable option instead.



We also have the requirements for physically installing each electrode. In addition to needing to be in contact with the ground, there are specific requirements such as burial depth that we must follow. Rod and pipe electrodes must have a minimum of 8 feet in contact with the Earth and be installed vertically, unless bedrock is encountered at less than an 8 foot depth. In this case the electrode can be installed at an angle or horizontal if need be. In the event that a rod must be laid flat, it must be buried at a depth of 30 inches. This is a common burial depth for most "made" electrodes. Plate and ground ring electrodes must also be installed at a minimum depth of 30 inches.

Lastly, there is the connections of the grounding electrode conductors and bonding jumpers to consider as well. Just like with most every connection in the electrical world, we need any mechanical connections to remain accessible after installation. With a few exceptions for those listed for concrete-encasement or direct burial. Keep in mind that since these accessible locations are no longer in contact with the Earth, there are sections in the NEC granting permission to use items like the first 5 feet of interior metal water pipe, building steel, or exposed reinforcing steel to extend the connection to the electrode as well.



Understanding exactly how our electrical systems connect to ground helps us better achieve the goal set forth in 250.4 of grounding a system in a manner that limits the voltage imposed by lightning, line surges, or unintentional contact with higher-voltage lines and that will stabilize the voltage to earth during normal operation. Which in turn will ultimately help achieve the purpose statement of the NEC itself and that is the practical safeguarding of persons and property from the hazards that arise from the use of electricity. Being able to properly apply these concepts leads us all down a path towards protecting the world from the dangers present when electricity enters our world. At NFPA we can't do it alone and we need your help to accomplish our mission of saving lives! Remember, it's a big world, let's protect it together!

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What is an ufer ground? The National Electrical Code (NEC) addresses it as a concrete-encased grounding electrode.

At a recent seminar, one of the attendees asked, "What is a 'Ufer' ground?" This is a common question. A "[Ufer ground](#)" is slang for what the *National Electrical Code (NEC)* addresses as a concrete-encased grounding electrode. The term "Ufer" does not appear in the *Code*, but many in the industry use it. Ufer is the name of the engineer who created it as a solution to significant grounding problems discovered by the U.S. military.

What is an Ufer ground?

The *NEC* defines the term "[grounding electrode](#)" as "a conducting object through which a direct connection to earth is established." The 2005 *NEC* first defined the term, and the definition has been subsequently revised to describe how electrodes function and to apply to conductive objects or materials that qualify as grounding electrodes. An important feature of this definition is that the electrode is in direct contact with the earth, making a connection. It is important to remember that, without a connection to the earth, there is no grounding. Let's take a closer look at what constitutes a concrete-encased electrode (Ufer), when it is required, and the installation techniques.^[P]_{SEP}]

What are the *NEC* requirements for ufer ground?

Section 250.52(A)(3) clearly specifies what constitutes a concrete-encased electrode. The concrete-encased electrode can be bare, zinc-galvanized, or other steel reinforcing bars or rods of not less than ½ inch in diameter coated in electrically conductive material. It can be installed in one continuous 20-foot length, or, if in multiple pieces, it can be connected by the usual steel tie wires, exothermic welding, welding or other effective means to create a 20-foot or greater length. A concrete-encased electrode can also be constructed using 20 feet or more of bare copper conductor not smaller than 4 AWG. Note that the 20 feet of conductive rods or bare wire used in creating a concrete-encased electrode only establishes the connection to the concrete. The combination of the concrete and the conductive component serve as the grounding electrode as clarified in the definition of the term.^[P]_{SEP}]

Editor's Note: read more about [Ufer ground code requirements in the 2023 NEC](#) and other grounding and bonding techniques

Ufer ground rods as part of the mandatory grounding electrode system^[P]_{SEP}]

Section 250.50 mandates the use of all grounding electrodes to form the grounding electrode system. This includes all concrete-encased electrodes present at the building or structure. An exception to Section 250.50 relaxes this mandatory requirement for existing buildings and structures in which connecting the concrete-encased electrode could damage the structural integrity of the building or otherwise disturb the existing construction. (Because the installation of the footings and foundation is one of the first elements of a construction project and, in most cases, has been completed by the time the electric service is installed, this rule necessitates an awareness and coordinated effort from designers and the construction trades to ensure the concrete-encased electrode is incorporated into the grounding electrode system during the placement of rebar and concrete footings.) If a concrete-encased electrode is not present at the building or structure, it is not required that a 4 AWG copper wire be used to form one, but it is an option.

Understanding Ufer ground: Concrete-encased electrode performance and longevity

The concrete-encased electrode has proven that it offers optimal performance and longevity. The footing or foundation of any building will typically be there as long as the building is. Because all of the rebar in the bottom perimeter of the building footing is usually tied together with tie wires, the electrode acts similar to a ground ring, only it has much more surface area in the concrete connection to the earth. The footing is present around the bottom of the building perimeter, which means there is significant ground (earth) contact from concrete-encased electrodes. Concrete retains moisture and is continuously absorbing moisture through the bottom of the footing. This ensures an effective connection between the footing and the earth. The footing of a building is also typically the largest grounding electrode in each structure.

Brief history of ufer grounding system installation and requirements

Herbert G. Ufer was a vice president and engineer at Underwriters Laboratories who assisted the U.S. military with ground-resistance problems at installations in Arizona. Ufer's findings in the 1940s proved the effectiveness of concrete-encased grounding electrodes. The military required low-resistance (5 ohms or less) ground connections for lightning protection systems installed at its ammunition and pyrotechnic storage sites at the Navajo Ordnance Depot in Flagstaff and Davis-Monthan Air Force Base in Tucson. Ufer developed the initial design for a concrete-encased grounding electrode that consisted of ½-inch, 20-foot-long reinforcing bars placed within and near the bottom of 2-foot-deep concrete footings for the ammunition storage buildings. Test readings over a 20-year period revealed steady resistance values of 2 to 5 ohms, which satisfied the specifications of the U.S. government at that time. This work eventually resulted in what we know today as the concrete-encased electrode in the *NEC*. More details about Ufer's research are provided in his October 1964 IEEE paper CP-978, "Investigation and Testing of Footing-Type Grounding Electrodes for Electrical Installations."

About The Author



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JOHNSTON, who retired as NECA's executive director of codes and standards in 2023, is a former member and chair of *NEC* CMP-5 and immediate past chair of the *NEC* Correlating Committee. Johnston continues to serve on the NFPA Standards Council and the UL Electrical Council.