

Section 16060

Grounding and Bonding

PART 1: General

- 1.1 *Summary* – This Section includes methods and materials for grounding systems and equipment, plus the following special applications:
- 1.1.1 Grounding for overhead lines
 - 1.1.2 Underground distribution grounding
 - 1.1.3 Ground to grounding counterpoise
 - 1.1.4 Grounding to piping
 - 1.1.5 Grounding to rebar within slab/top of lift station
- 1.2 *Submittals* –
- 1.2.1 *Product Data* – For each type of product indicated
 - 1.2.2 *Other Informational Submittals* – Plans showing dimensioned as-built locations of grounding features specified in Part 3 "Field Quality Control" Article, including the following:
 - 1.2.2.1 Ground rods
 - 1.2.2.2 Ground counterpoise
 - 1.2.2.3 Grounding arrangements and connections for separately derived systems
 - 1.2.2.4 Grounding for sensitive electronic equipment
 - 1.2.3 *Qualification Data* – For testing agency and testing agency's field supervisor.
 - 1.2.4 *Reports* – Field quality control test reports.
 - 1.2.5 *Operation and Maintenance Data* – For grounding to include the following in operation and maintenance manuals:
 - 1.2.5.1 Instructions for periodic testing and inspection of grounding features at ground rings and grounding connections for separately derived systems based on NETA MTS and NFPA 70B.
 - 1.2.5.1.1 Tests shall be to determine if ground resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if they do not.
 - 1.2.5.1.2 Include recommended testing intervals.

1.3 *Quality Assurance* –

1.3.1 *Testing Agency Qualifications* – An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1.3.1.1 *Testing Agency's Field Supervisor* – Person currently certified by the InterNational Electrical Testing Association to supervise on-site testing specified in Part 3.

1.3.2 *Electrical Components, Devices, and Accessories* – Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.3.3 *Standards* – Comply with UL 467 for grounding and bonding materials and equipment.

PART 2: Products

2.1 *Conductors* –

2.1.1 *Insulated Conductors* – Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

2.1.2 *Bare Copper Conductors* –

2.1.2.1 Solid Conductors: ASTM B 3.

2.1.2.2 Stranded Conductors: ASTM B 8.

2.1.2.3 Tinned Conductors: ASTM B 33.

2.1.2.4 Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.

2.1.2.5 Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.

2.1.2.6 Bonding Jumper: Copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

2.1.3 *Bare Grounding Conductor and Conductor Protector for Wood Poles* –

2.1.3.1 Material: No. 4 AWG minimum, soft-drawn copper.

2.1.3.2 Conductor Protector - Half-round PVC or wood molding. If wood, use pressure-treated fir or cypress or cedar.

2.2 *Connectors* –

2.2.1 *Material* – Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.

2.2.2 *Bolted Connectors for Conductors and Pipes* – Copper or copper alloy, bolted pressure-type, with at least two bolts.

2.2.2.1 Pipe Connectors: Clamp type, sized for pipe.

2.2.3 *Welded Connectors* – Exothermic-welding kits of types recommended by kit Manufacturer for materials being joined and installation conditions.

2.3 *Grounding Electrodes* –

2.3.1 Ground Rods: Copper-clad; 3/4 inch in diameter by 10 feet in diameter.

PART 3: Execution

3.1 *Applications* –

3.1.1 *Conductors* – Install solid conductor for overhead would poles, and stranded conductors for all other conductors, unless otherwise indicated.

3.1.2 *Underground Grounding Conductors* – Install bare copper conductor, No. 2/0 AWG minimum. Bury at least 24 inches below grade.

3.1.3 *Conductor Terminations And Connections* –

3.1.3.1 Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.

3.1.3.2 Underground Connections: Welded connectors, except as otherwise indicated.

3.1.3.3 Connections to Structural Steel: Welded connectors.

3.2 *Grounding Overhead Lines* –

3.2.1 Comply with IEEE C2 grounding requirements.

3.2.2 Install 2 parallel ground rods if resistance to ground by a single, ground-rod electrode exceeds 25 ohms.

3.2.3 Drive ground rods until tops are 12 inches below finished grade in undisturbed earth.

3.2.4 Install welded connectors for underground connections and connections to rods.

3.3 *Grounding Underground Distribution System Components* –

3.3.1 Comply with IEEE C2 grounding requirements.

3.3.2 Retain and edit paragraph below to exceed NFPA 70 requirements. If concrete pad is for equipment to be supplied by utility company, revise to comply with utility company's grounding standards or delete and detail on Drawings.

- 3.3.2.1 Pad-Mounted Transformers: Concrete pad for equipment to be supplied by utility company; grounding shall comply with utility company's grounding standards

3.4 *Equipment Grounding –*

- 3.4.1 *Conductors* – Install insulated equipment grounding conductors with all feeders and branch circuits.
- 3.4.2 *Metal Poles Supporting Outdoor Lighting Fixtures* – Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

3.5 *Installation –*

- 3.5.1 *Grounding Conductors* – Route along shortest and straightest paths possible, unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

- 3.5.2 *Ground Rods* – Drive rods until tops are 2 inches below final grade, unless otherwise indicated.

- 3.5.2.1 Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing rod or damaging rod coating.

- 3.5.2.2 For grounding electrode counterpoise system, install three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.

- 3.5.3 *Bonding Straps and Jumpers* – Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.

- 3.5.3.1 Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.

- 3.5.3.2 Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.

3.5.4 *Grounding And Bonding For Piping –*

- 3.5.4.1 Install insulated copper grounding conductors, in conduit, from service equipment to main metal water service into lift station. Connect grounding conductors to main metal water service pipes, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.

- 3.5.4.2 Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

- 3.5.5 *Grounding for Top of Lift Station* – Install a driven ground rod at base at distances not more than 60 feet apart, as measured around perimeter. Provide a minimum of 1 for each separated slab.
- 3.5.6 *Grounding for Slabs – Ufer Ground (Concrete-Encased Grounding Electrode)*: Fabricate according to NFPA 70, using a minimum of 20 feet of bare copper conductor not smaller than No. 4 AWG.

3.5.6.1 If concrete foundation is less than 20 feet long, coil excess conductor within base of foundation.

3.5.6.2 Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building grounding grid or to grounding electrode external to concrete.

3.6 *Field Quality Control* –

3.6.1 *Testing Agency* – Contractor shall perform the following field tests and inspections and prepare test reports:

3.6.2 *Tests and Inspections* – Perform the following tests and inspections and prepare test reports:

3.6.2.1 After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.

3.6.2.2 Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal and at individual ground rods. Make tests at ground rods before any conductors are connected.

3.6.2.2.1 Measure ground resistance not less than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.

3.6.2.2.2 Perform tests by fall-of-potential method according to IEEE 81.

3.6.2.3 Prepare dimensioned drawings locating each test well, ground rod and ground rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

3.6.3 *Resistance* – Report measured ground resistances that exceed the following values:

3.6.3.1 *Control Panel*: 3 ohm(s).

3.6.3.2 *Pad-Mounted Equipment*: 5 ohms.

3.6.4 *Excessive Ground Resistance* – If resistance to ground exceeds specified values, notify Engineer promptly and include recommendations to reduce ground resistance