

SECTION 16060

GROUNDING AND BONDING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section

1.2 SUMMARY

- A. This Section includes methods and materials for grounding systems and equipment, plus the following special applications:
 - 1. Underground distribution grounding
 - 2. Common ground bonding with lightning protection system

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated in accordance with Section 01340
- B. Other Informational Submittals: Plans showing dimensioned as-built locations of grounding features specified in Part 3 "Field Quality Control" Article, including the following
 - 1. Ground rods
 - 2. Ground rings
 - 3. Grounding arrangements and connections for separately derived systems
 - 4. Grounding for sensitive electronic equipment

1.4 QUALITY ASSURANCE

- A. 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
- B. Comply with UL 467 for grounding and bonding materials and equipment

PART 2 - PRODUCTS

2.1 CONDUCTORS

- A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction

B. Bare Copper Conductors

1. Solid conductors: ASTM B3
2. Stranded conductors: ASTM B8
3. Tinned conductors: ASTM B33
4. Bonding cable: 28 kcmil, 14 strands of No. 17 AWG conductor, ¼ inch in diameter
5. Bonding jumper: Copper tape, braided conductors, terminated with copper ferrules; 1⁵/₈-inches wide and 1/16 inch thick

C. Grounding Bus: Rectangular bars of annealed copper, ¼ by 2 inches in cross section, unless otherwise indicated; with insulators

2.2 CONNECTORS

A. 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

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

1. Pipe Connectors: Clamp type, sized for pipe

C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions

2.3 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel; ¾ inch in diameter by 10 feet

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger, unless otherwise indicated

B. Underground Grounding Conductors: Install bare copper conductor, No. 2/0 AWG minimum

1. Bury at least 24 inches below grade
2. Duct-bank grounding conductor: Bury 12 inches above duct bank when indicated as part of duct-bank installation

C. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow

- D. Grounding Bus: Install in electrical and telephone equipment rooms, in rooms housing service equipment, and elsewhere as indicated
 - 1. Install bus on insulated spacers 1 inch, minimum, from wall 6 inches above finished floor, unless otherwise indicated
 - 2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, down to specified height above floor, and connect to horizontal bus
- E. Conductor Terminations and Connections
 - 1. Pipe and equipment grounding conductor terminations: Bolted connectors
 - 2. Underground connections: Welded connectors

3.2 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

- A. Comply with IEEE C2 grounding requirements
- B. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall
- C. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields as recommended by manufacturer of splicing and termination kits
- D. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches from the foundation

3.3 EQUIPMENT GROUNDING

- A. Install insulated equipment grounding conductors with all feeders and branch circuits
- B. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping
- C. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-

tracing cable. Bond conductor to heater units, piping, connected equipment, and components

- D. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated
- E. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated
- F. Signal and Communication Equipment: For telephone, alarm, voice and data, and other communication equipment, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location
 - 1. Service and central equipment locations and wiring closets: Terminate grounding conductor on a ¼ by 2 by 12-inch grounding bus
 - 2. Terminal cabinets: Terminate grounding conductor on cabinet grounding terminal
- G. 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

3.4 INSTALLATION

- A. 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
- B. Common Ground Bonding with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit
- C. Ground Rods: Drive rods until tops are 2 inches below finished floor or final grade, unless otherwise indicated
 - 1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating, if any

- D. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit
 - 1. Bonding to structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts
 - 2. Bonding to equipment mounted on vibration isolation hangers and supports: Install so vibration is not transmitted to rigidly mounted equipment
 - 3. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp
- E. Grounding and Bonding for Piping
 - 1. Metal water service pipe and meters and other process piping: Not allowed
 - 2. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve
- F. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned bonding jumper to bond across flexible duct connections to achieve continuity
- G. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet apart
- H. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each steel column or indicated item, extending around the perimeter of building or structure
 - 1. Install copper conductor not less than No. 4/0 AWG for ground ring and for taps to building steel
 - 2. Bury ground ring not less than 24 inches from building foundation
- I. 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
 - 1. If concrete foundation is less than 20-feet long, coil excess conductor within base of foundation
 - 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

3.5 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections and prepare test reports
 - 1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements
 - 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

- a. 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
 - b. Perform tests by fall-of-potential method according to IEEE 81
3. Prepare dimensioned drawings locating each 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
- B. Report measured ground resistances that exceed the following values
1. Power and lighting equipment or system with capacity 500 kVA and less: 10 ohms
 2. Power and lighting equipment or system with capacity 500 to 1000 kVA: 5 ohms
 3. Power and lighting equipment or system with capacity more than 1000 kVA: 3 ohms
 4. Power distribution units or panelboards serving electronic equipment: 3 ohm(s)
 5. Substations and pad-mounted equipment: 5 ohms
 6. Manhole grounds: 10 ohms
- C. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Engineer promptly and include recommendations to reduce ground resistance

END OF SECTION