SECTION 26 05 26 - GROUNDING AND BONDING

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes grounding of electrical systems and equipment. Grounding requirements specified in this Section may be supplemented by special requirements of systems described in other Sections.

1.02 SUBMITTALS

A. Product Data: For the following:
   1. Ground rods.
   2. Chemical rods.
   3. Exothermal weld molds, cartridges, materials and accessories.
   4. Mechanical connectors

B. Qualification Data: For firms and persons specified in "Quality Assurance" Article.

C. Field Test Reports: Submit written test reports to include the following:
   1. Test procedures used.
   2. Test results that comply with requirements.
   3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

1.03 QUALITY ASSURANCE

A. Testing Agency Qualifications: In accordance with 26 05 53.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in the California Electric Code (CEC) and NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
   1. Comply with UL 467.
   2. Comply with the CEC and NFPA 70 for systems rated less than 600V; for medium-voltage underground construction, also comply with IEEE C2 and IEEE 80 and 81.
PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with requirements, provide products by one of the following:

1. Grounding Conductors, Cables, Connectors, and Rods:
   a. Boggs, Inc.
   b. Chance/Hubbell.
   c. Copperweld Corp.
   d. Dossert Corp.
   e. Erico Inc.; Electrical Products Group.
   f. Framatome Connectors/Burndy Electrical.
   g. Hastings Fiber Glass Products, Inc.
   h. Ideal Industries, Inc.
   i. ILSCO.
   k. Korns: C. C. Korns Co.; Division of Robroy Industries.
   l. Lyncole XIT Grounding.
   m. O-Z/Gedney Co.; a business of the EGS Electrical Group.
   n. Raco, Inc.; Division of Hubbell.
   p. Superior Grounding Systems, Inc.
   q. Thomas & Betts, Electrical.

2.02 GROUNDING CONDUCTORS

A. Insulated building wire type THHN/THWN for grounds routed in conduit with feeders. Size as noted on plans. Insulation to be green in color, unless otherwise noted, or taped ends as allowed by the Code.


C. Equipment Grounding Conductors: Insulated with green-colored insulation.
D. Isolated Ground Conductors: Insulated with green-colored insulation with yellow stripe. On feeders with isolated ground, use colored tape, alternating bands of green and yellow tape to provide a minimum of three bands of green and two bands of yellow.

E. Grounding Electrode Conductors: Soft drawn Bare, stranded copper, unless otherwise indicated.

F. Bare Copper Conductors: Comply with the following:

G. Copper Bonding Conductors as follows:
   2. Bonding Jumper: Bare copper tape, braided bare copper conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
   3. Tinned Bonding Jumper: Tinned-copper tape, braided copper conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

H. Grounding Bus: Bare, annealed copper bars of rectangular cross section, minimum of 1/8 inch thick by 1 inch wide, with insulators.

2.03 CONNECTOR PRODUCTS
A. Comply with IEEE 837 and UL 467; listed for use for specific types, sizes, and combinations of conductors and connected items.

B. Bolted Connectors: Bolted-pressure-type connectors, or compression type.

C. Welded Connectors: Exothermic-welded type, in kit form, and selected per manufacturer’s written instructions.

2.04 GROUNDING ELECTRODES
A. Ground Rods: Copper-clad steel.

B. Ground Rods: Sectional type; copper-clad steel. 1. Size: ¾” diameter by 120 inches in length.
C. Chemical Electrodes: Copper tube, straight or L-shaped, filled with nonhazardous chemical salts, terminated with a 4/0 bare conductor. Provide backfill material recommended by manufacturer.

PART 3 - EXECUTION

3.01 APPLICATION

A. Use only copper conductors for both insulated and bare grounding conductors in direct contact with earth, concrete, masonry, crushed stone, and similar materials.

B. In raceways, use insulated equipment grounding conductors.

C. Exothermic-Welded Connections: Use for connections to structural steel and for underground connections, except those at test wells.

D. Equipment Grounding Conductor Terminations: Use bolted pressure clamps.

E. Ground Rod Clamps at Test Wells: Use bolted pressure clamps with at least two bolts.

F. Grounding Bus: Install in electrical and telephone equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
   1. Use insulated spacer; space 1 inch from wall and support from wall 6 inches above finished floor, unless otherwise indicated.
   2. Locate ground buses to limit grounding conductor lengths not exceeding 15 feet.
   3. All ground buses shall be interconnected with the ground system and bonded together.

G. Underground Grounding Conductors: Use copper conductor, No. 4/0 AWG minimum. Bury at least 24 inches below grade. Duct bank ground conductors shall be encased in the duct bank as shown on the duct bank section cuts on the drawings.

3.02 EQUIPMENT GROUNDING CONDUCTORS

A. Comply with NFPA 70, Article 250, for types, sizes, and quantities of equipment grounding conductors, unless specific types, larger sizes, or more conductors than required by NFPA 70 are indicated.

B. Install equipment grounding conductors in the raceways with feeders conductors and branch circuits.

C. Install insulated equipment grounding conductor with circuit conductors for the following items:
1. Where required by CEC.
2. Lighting circuits.
3. Receptacle circuits.
5. Three-phase motor and appliance branch circuits.
6. Flexible raceway runs.
7. Armored and metal-clad cable runs.

D. Busway Supply Circuits: Install insulated equipment grounding conductor from the grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bus bar terminal on busway.

E. Computer Outlet Circuits: Install insulated equipment grounding conductor in branch-circuit runs from computer-area power panels or power-distribution units.

F. Isolated Grounding Receptacle Circuits: Install an insulated isolated ground conductor in addition to an equipment grounding conductor between the panel and isolated grounding receptacle. Terminate isolated grounding conductor at isolated grounding terminal of the receptacle and isolated ground bus terminal of panelboard. Equipment grounding conductor shall bond the receptacle enclosure to the equipment grounding system.

G. Nonmetallic Raceways: Install an equipment grounding conductor in nonmetallic raceways unless they are designated for telephone or data cables.

H. Air-Duct Equipment Circuits: Install an equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners and heaters. Bond conductor to each unit and to air duct.

I. Water Heater, Heat-Tracing, and Anti-frost Heating Cables: Install a separate equipment grounding conductor to each electric water heater, heat-tracing, and anti-frost heating cable. Bond conductor to heater units, piping, connected equipment, and components.

J. Signal and Communication Systems: For telephone, alarm, voice and data, and other communication systems, provide No. 2 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.

2. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

K. Metal Poles Supporting Outdoor Lighting Fixtures: Provide a grounding electrode in addition to installing a separate equipment grounding conductor with supply branch-circuit conductors.

3.03 MEDIUM-VOLTAGE COUNTERPOISE GROUNDING SYSTEM

A. Provide an electrical grounding counterpoise grounding system for the medium-voltage distribution system which includes substations, duct banks, manholes, SF6 switches and building service transformers. The counterpoise grounding system shall consist of multiple grounding electrodes of driven ground rods, ground ring and concrete-encased electrodes bonded together. Provide a bare grounding conductor extending around the perimeter of the substation building, manhole, transformer, or SF6 switch to form a ground ring. Bond foundation rebar to No. 4/0 AWG bare copper installed in foundation concrete as a concrete-encased electrode. Electrically bond each grounding electrode together. Bond the steel framework of the building, manhole, transformer or SF6 switch to the counterpoise. Connect the counterpoise to the ground bus of each switchboard. Use copper conductor not less than No. 4/0 AWG for counterpoise and for taps. Bury ground ring not less than 18 inches below grade and 24 inches from building or equivalent foundation.

3.04 INSTALLATION

A. Ground Rods: Install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes.

1. Drive ground rods until tops are 6 inches below finished floor or final grade, unless otherwise indicated.

2. Interconnect ground rods with grounding electrode conductors. Use exothermic welds, except at test wells and as otherwise indicated. Make connections without exposing steel or damaging copper coating.

B. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

C. Bonding Straps and Jumpers: Install so vibration by equipment mounted on vibration isolation hangers and supports is not transmitted to rigidly mounted equipment. Use exothermic-welded connectors for outdoor locations, unless a disconnect-type
connection is required; then, use a bolted clamp. Bond straps directly to the basic structure taking care not to penetrate any adjacent parts. Install straps only in locations accessible for maintenance.

D. Metal Water Service Pipe: Provide insulated copper grounding conductors, in conduit, from building’s main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes by grounding clamp connectors. Where a dielectric main water fitting is installed, connect grounding conductor to street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.

E. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with grounding clamp connectors.

1. Bond interior metal piping systems and metal air ducts to equipment grounding conductors of associated pumps, fans, blowers, electric heaters, and air cleaners. Use braided-type bonding straps.

F. Bond each aboveground portion of gas piping system upstream from equipment shutoff valve.

G. Install one test well for each tie-in between grounding electrode systems. A test well or test location with bolted connections shall be provided for each concrete encased electrode, ground loop and other grounding electrodes. Set top of well flush with finished grade or floor.

H. Ufer Ground (Concrete-Encased Grounding Electrode): Fabricate according to NFPA 70, Paragraph 250-50(c), using a minimum of 40 feet of bare copper conductor not smaller than No. 4/0 AWG. If concrete foundation is less than 40 feet long, loop conductor within the base of the foundation. 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 a grounding electrode test well external to concrete.

3.05 CONNECTIONS

A. General: Make connections so galvanic action or electrolysis possibility is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.

1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer to order of galvanic series.
2. Make connections with clean, bare metal at points of contact.
3. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

B. Exothermic-Welded Connections: Comply with manufacturer’s written instructions. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable.

C. Equipment Grounding Conductor Terminations: For No. 8 AWG and larger, use pressure-type grounding lugs. No. 10 AWG and smaller grounding conductors may be terminated with winged pressure-type connectors.

D. Feeder Conduit Terminations: At metallic enclosures, terminate each metallic conduit containing feeder conductors with a grounding bushing. Connect grounding bushings with a bare grounding conductor to grounding bus or terminal in housing.

E. Bond electrically noncontinuous conduits at entrances and exits with grounding bushings and bare grounding conductors, unless otherwise indicated.

F. Connections at Test Wells: Use compression-type connectors on conductors and make bolted- and clamped-type connections between conductors and ground rods.

G. Tighten screws and bolts for grounding and bonding connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

H. Compression-Type Connections: Use hydraulic compression tools to provide correct circumferential pressure for compression connectors. Use tools and dies recommended by connector manufacturer. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed on grounding conductor.

I. Moisture Protection: If insulated grounding conductors are connected to ground rods or grounding buses, insulate entire area of connection and seal against moisture penetration of insulation and cable.

3.06 UNDERGROUND DISTRIBUTION SYSTEM GROUNDING

A. Duct Banks: Each feeder and branch circuit conduit in a duct bank shall contain equipment grounding conductor(s). In addition, a 4/0 grounding conductor shall be encased in the concrete duct bank and run the full length of the duct bank.

B. Manholes and Hand-holes: Install a driven ground rod close to wall and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before
manhole is placed. Where ground rod must be outside the manhole provide a No. 4/0 AWG bare, copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, non-shrink grout.

C. Connections to Manhole Components: Connect 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. 2 AWG minimum, stranded, soft-drawn copper conductor. Train conductors level or plumb around corners and secure 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 perimeter of pad. Bond rods and ground ring to grounding system. Bond pad-mounted equipment and noncurrent-carrying metal items to ground system. Connect all cable shields to grounding system. Use tinned-copper conductor not less than No. 2 AWG for taps to equipment ground pad and other metal parts. Bury ground ring not less than 18 inches below grade and 6 inches from the foundation.

3.07 FIELD QUALITY CONTROL

A. Testing: Engage a qualified testing agency to perform the following field quality-control testing in accordance with Section 26 05 53:

1. Testing: Perform the following field quality-control testing:
   a. After installing grounding system but before permanent electrical circuitry has been energized, test for compliance with requirements.
   b. Inspect completed grounding system at each ground well and test location for proper connections. Test completed grounding system where a maximum ground-resistance level is specified. Measure ground resistance not less than two full days after the last trace of precipitation, and without the 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. Perform tests, by the fall-of-potential method according to IEEE 81.
   c. Provide drawings locating each ground rod, 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.

d. Perform tests as specified in Section 26 05 53.

e. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify the University’s Representative promptly and include recommendations to reduce ground resistance.

2. Submit a report of testing results as specified in Section 26 05 53.