

SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Grounding and bonding conductors.
2. Grounding and bonding clamps.
3. Grounding and bonding bushings.
4. Grounding and bonding hubs.
5. Grounding and bonding connectors.
6. Grounding and bonding busbars.
7. Grounding (earthing) electrodes.

B. Related Requirements:

1. Section 270528 "Pathways for Communications Systems" specifies additional requirements for grounding and bonding of communications raceways, boxes, and cable trays.

1.02 BUY AMERICAN REQUIREMENTS

A. Provide certificates to show that all products meet the following requirements.

1. American Iron and Steel (AIS)
2. Build America, Buy America Act

B. See Supplementary Conditions for details.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Field quality-control reports.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data:

1. Include the following:
 - a. Plans showing locations of grounding features described in "Field Quality Control for Grounding and Bonding of Electrical Power" Article, including the following:
 - 1) Grounding electrodes.

- 2) Grounding arrangements and connections for separately derived systems.

PRODUCTS

2.01 GROUNDING AND BONDING CONDUCTORS

A. Equipment Grounding Conductor:

1. General Characteristics: 600 V, THWN-2 or XHHW-2, copper wire or cable, green color, in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. ASTM - Bare Copper Grounding and Bonding Conductor:

1. Referenced Standards: Complying with one or more of the following:
 - a. Soft or Annealed Copper Wire: ASTM B3.
 - b. Concentric-Lay Stranded Copper Conductor: ASTM B8.
 - c. Tin-Coated Soft or Annealed Copper Wire: ASTM B33.
 - d. 19-Wire Combination Unilay-Stranded Copper Conductor: ASTM B787/B787M.

2.02 GROUNDING AND BONDING CLAMPS

A. Description: Clamps suitable for attachment of grounding and bonding conductors to grounding electrodes, pipes, tubing, and rebar. Grounding and bonding clamps specified in this article are also suitable for use with communications applications.

B. Source Limitations: Obtain products from single manufacturer.

C. Performance Criteria:

1. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
2. Listing Criteria:
 - a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
 - b. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.

D. UL KDER and KDSH - Hex-Fitting-Type Pipe and Rod Grounding and Bonding Clamp :

1. General Characteristics:
 - a. Two pieces with stainless steel bolts.
 - b. Clamp Material: Silicon bronze.

- c. Listed for outdoor use.
- E. UL KDER and KDSH - U-Bolt-Type Pipe and Rod Grounding and Bonding Clamp:
 - 1. General Characteristics:
 - a. Clamp Material: Brass.
 - b. Listed for outdoor use.
- F. UL KDER - Beam Grounding and Bonding Clamp :
 - 1. General Characteristics: Mechanical-type, terminal, ground wire access from four directions; with dual, tin-plated or silicon bronze bolts.

2.03 GROUNDING AND BONDING BUSHINGS

- A. Description: Bonding bushings connect conduit fittings, tubing fittings, threaded metal conduit, and unthreaded metal conduit to metal boxes and equipment enclosures and have one or more bonding screws intended to provide electrical continuity between bushing and enclosure. Grounding bushings have provision for connection of bonding or grounding conductor and may or may not also have bonding screws.
- B. Source Limitations: Obtain products from a single manufacturer.
- C. Performance Criteria:
 - 1. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - 2. Listing Criteria:
 - a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
- D. UL KDER - Bonding Bushing :
 - 1. General Characteristics: Threaded bushing with insulated throat.
- E. UL KDER - Grounding Bushing :
 - 1. General Characteristics: Threaded bushing with insulated throat and mechanical-type wire terminal.

2.04 GROUNDING AND BONDING HUBS

- A. Description: Hubs with certified grounding or bonding locknut.
- B. Source Limitations: Obtain products from a single manufacturer.

C. Performance Criteria:

1. Regulatory Requirements:

- a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.

2. Listing Criteria:

- a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.

D. UL KDER - Grounding and Bonding Hub :

1. General Characteristics: Insulated, gasketed, watertight hub with mechanical-type wire terminal.

2.05 GROUNDING AND BONDING CONNECTORS

A. Source Limitations: Obtain products from a single manufacturer.

B. Performance Criteria:

1. Regulatory Requirements:

- a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.

2. Listing Criteria:

- a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
- b. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.

C. UL KDER - Pressure-Type Grounding and Bonding Busbar Cable Connector:

1. General Characteristics: Copper or copper alloy, for compression bonding of one or more conductors directly to copper busbar. Listed for direct burial.

D. UL KDER - Lay-In Lug Mechanical-Type Grounding and Bonding Busbar Terminal

1. General Characteristics: Mechanical type, aluminum terminal with set screw.

E. UL KDER - Crimped Lug Pressure-Type Grounding and Bonding Busbar Terminal:

1. General Characteristics: Cast silicon bronze, solderless compression-type wire terminals; with long barrel and two holes spaced on 5/8 or 1 inch centers for two-bolt connection to busbar.

F. UL KDER - Split-Bolt Service-Post Pressure-Type Grounding and Bonding Busbar Terminal :

1. General Characteristics: Bolts that surround cable and bond to cable under compression when nut is tightened after assembly is screwed into busbar opening.
 - G. UL KDER - Crimped Pressure-Type Grounding and Bonding Cable Connector:
 1. General Characteristics: Crimp-and-compress connectors that bond to conductor when connector is compressed around conductor.
 - a. Copper alloy, C and H shaped.
 - H. UL KDER - Split-Bolt Pressure-Type Grounding and Bonding Cable Connector:
 1. General Characteristics: Bolts that surround cable and bond to cable under compression when nut is tightened.
 - a. Copper alloy.
- 2.06 GROUNDING (EARTHING) ELECTRODES
- A. Source Limitations: Obtain products from a single manufacturer.
 - B. Performance Criteria:
 1. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 2. Listing Criteria:
 - a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
 - C. UL KDER - Rod Electrode :
 1. General Characteristics: Copper-clad; 5/8 inch by 8 ft.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine the facility's grounding electrode system and equipment grounding for compliance with requirements for maximum ground-resistance level and other conditions affecting performance of grounding and bonding of electrical system.
- B. Inspect test results of grounding system measured at point of electrical service equipment connection.

- C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
- D. Proceed with connection of electrical service equipment only after unsatisfactory conditions have been corrected.

3.02 SELECTION OF GROUNDING AND BONDING PRODUCTS

A. Grounding and Bonding Conductors:

- 1. Provide solid conductor for 8 AWG and smaller, and stranded conductors for 6 AWG and larger unless otherwise indicated.
- 2. Custom-Length Insulated Equipment Bonding Jumpers: 6 AWG, 19-strand, Type THHN.
- 3. Bonding Cable: 28 kcmil, 14 strands of 17 AWG conductor, 1/4 inch in diameter.
- 4. Bonding Conductor: 4 AWG or 6 AWG, stranded conductor.
- 5. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inch wide and 1/16 inch thick.
- 6. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inch wide and 1/16 inch thick.
- 7. Underground Grounding Conductors: Install bare tinned-copper conductor, 2/0 AWG minimum.

B. Grounding and Bonding Connectors:

- 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
- 2. Underground Connections: Crimped pressure connectors.
- 3. Connections to Structural Steel: Welded connectors.

- C. Grounding and Bonding Busbars: Provide in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated on Drawings.

3.03 SELECTION OF GROUNDING AND BONDING PRODUCTS FOR COMMUNICATIONS

- A. Comply with Section 270528 "Pathways for Communications Systems".

3.04 INSTALLATION OF GROUNDING AND BONDING

- A. Comply with manufacturer's published instructions.
- B. Reference Standards:

C. Special Techniques:

1. Grounding and Bonding Conductors:

- a. Route along the 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. Underground Grounding Conductors:

- 1) Bury at least 30 inch below grade.

2. Grounding and Bonding Connectors: Make connections so the possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact are galvanically compatible.

- a. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
- b. Make connections with clean, bare metal at points of contact.
- c. Make aluminum-to-steel connections with stainless steel separators and mechanical clamps.
- d. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
- e. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.
- f. 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 adjacent parts.
 - 2) Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
 - 3) Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use bolted clamp.

g. Grounding and Bonding for Piping:

- 1) Metal Water Service Pipe: Install 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; use bolted clamp connector or bolt lug-type connector to pipe flange by using one of lug bolts of flange. Where 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.
 - 2) Water Meter and Sensor Device Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with bolted connector.
- h. 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.

- i. Grounding for Steel Building Structure: Install driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 ft apart.

3. Electrodes:

- a. Ground Rods: Drive rods until tops are 2 inch 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.
 - 2) Use exothermic welds for below-grade connections.
- b. For the grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least same distance from other grounding electrodes, and connect to service grounding electrode conductor.
- c. Concrete-Encased Electrode (Ufer Ground):
 - 1) Fabricate in accordance with NFPA 70; use minimum of 20 ft of bare copper conductor not smaller than 4 AWG.
 - a) If concrete foundation is less than 20 ft long, coil excess conductor within base of foundation.
 - b) Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building's grounding grid or to grounding electrode external to concrete.
 - 2) Fabricate in accordance with NFPA 70; using electrically conductive coated steel reinforcing bars or rods, at least 20 ft long. If reinforcing is in multiple pieces, connect together by usual steel tie wires or exothermic welding to create required length.

4. Grounding at Service:

- a. Equipment grounding conductors and grounding electrode conductors must be connected to ground busbar. Install main bonding jumper between neutral and ground buses.

5. Equipment Grounding and Bonding:

- a. Install insulated equipment grounding conductors with 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 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. Poles Supporting Outdoor Lighting Fixtures: Bond insulated equipment grounding conductor to equipment grounding terminal inside pole base.
 - e. Metallic Fences: Comply with requirements of IEEE C2.
 - 1) Grounding Conductor: Bare, tinned copper, not less than 8 AWG .
 - 2) Gates: Must be bonded to the grounding conductor with flexible bonding jumper.
 - 3) Barbed Wire: Strands must be bonded to the grounding conductor.
6. Fence Grounding:
- a. Grounding Method: At each grounding location, drive grounding rod vertically until top is 6 inch below finished grade. Connect rod to fence with 6 AWG conductor. Connect conductor to each fence component at grounding location.
 - b. Fences within 100 ft of Buildings, Structures, Walkways, and Roadways: Ground fence at maximum intervals of 750 ft.
 - 1) Gates and Other Fence Openings: Ground fence on each side of opening.
 - a) Bond metal gates to gate posts by connecting bonding jumpers between gate post and gate frame.
 - b) Bond across openings, with and without gates, except at openings indicated as intentional fence discontinuities. Use 2 AWG wire and bury it at least 18 inch below finished grade.

3.05 FIELD QUALITY CONTROL FOR GROUNDING AND BONDING

- A. Acceptance Testing Preparation:
- B. Field tests and inspections must be witnessed by Engineer .
- C. Tests and Inspections:
 - 1. After installing the grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
 - 2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with calibrated torque wrench in accordance with manufacturer's published instructions.
 - 3. Test completed grounding system at each location where maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells, and at the group of ground rods and Ufer ground. Make tests at ground rods before conductors are connected.
 - a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by 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 in accordance with IEEE Std 81.
 - c. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Engineer promptly and include recommendations to reduce ground resistance.
4. 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 record of tests and observations. Include 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. Nonconforming Work:
1. Grounding system will be considered defective if it does not pass tests and inspections.
 2. Remove and replace defective components and retest.
- E. Collect, assemble, and submit test and inspection reports.
1. Report measured ground resistances that exceed the following values:
 - a. Power and Lighting Equipment or System with Capacity of 500 kVA and Less:
10 Ω .

3.06 PROTECTION

- A. After installation, protect grounding and bonding cables and equipment from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION