

## SECTION 26 05 26 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. All sections of the project manual are directly applicable to this specification section. Should a conflict arise between specification sections or between specifications and drawings and/or code requirements, the contractor shall notify the Architect/Engineer of the conflict in writing. If direction is not provided prior to the submission of the bid, the contractor shall price the more extensive system.

#### 1.2 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. Intersystem bonding bridge grounding connector.
  - 7. Grounding and bonding busbars.
  - 8. Grounding (earthing) electrodes.
- B. Related Requirements:
  - 1. Section 27 05 28 "Pathways for Communications Systems" specifies additional requirements for grounding and bonding of communications raceways, boxes, and cable trays.
  - 2. Section 27 11 00 "Communications Equipment Room Fittings" specifies additional requirements for grounding and bonding of communications equipment.

#### 1.3 ACTION SUBMITTALS

- A. Product Data:
  - 1. For each type of product indicated.
- B. Field Quality-Control Submittals:
  - 1. Field quality-control reports.

#### 1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals.
  - 1. In addition to items specified in Section 01 78 23 "Operation and Maintenance Data," include the following:
    - a. Plans showing as-built, dimensioned locations of system described in "Field Quality Control" Article, including the following:
      - 1) Ground rods.
      - 2) Grounding busbars.
    - b. Instructions for periodic testing and inspection of grounding features at the following locations, based on NETA MTS requirements:
      - 1) Grounding busbars.
      - 2) Grounding connections for separately derived systems.
    - c. Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
    - d. Include recommended testing intervals.

#### PART 2 - PRODUCTS

##### 2.1 ACCEPTABLE MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Advanced Lightning Technology, Ltd.
  - 2. Burndy; Part of Hubbell Electrical Systems.
  - 3. Dossert; AFL Telecommunications LLC.
  - 4. ERICO International Corporation.
  - 5. Fushi Copperweld Inc.
  - 6. Harger Lightning & Grounding.
  - 7. ILSCO.
  - 8. O-Z/Gedney; a brand of Emerson Industrial Automation.
  - 9. Siemens Industry, Inc., Energy Management Division.
  - 10. Thomas & Betts Corporation; A Member of the ABB Group.

##### 2.2 GROUNDING AND BONDING CONDUCTORS

- A. Equipment Grounding Conductor:
  - 1. General Characteristics: 600 V, THHN/THWN-2, copper wire or cable, green color, in accordance with Section 26 05 19 "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.

2.3 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; see Section 27 05 26 "Grounding and Bonding for Communications Systems," for selection and installation guidelines.

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 zinc-plated 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 and KDSH - Strap-Type Pipe and Rod Grounding and Bonding Clamp:

1. General Characteristics:
  - a. Clamp Material: Aluminum.
  - b. Listed for outdoor use.

- G. 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.
- H. UL KDER - Exothermically Welded Connection:
  - 1. General Characteristics: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

## 2.4 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 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.

## 2.5 GROUNDING AND BONDING HUBS

- A. Description: Hubs with certified grounding or bonding locknut.
- 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.

D. UL KDER - Grounding and Bonding Hub:

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

2.6 GROUNDING AND BONDING CONNECTORS

A. Source Limitations: Obtain products from 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 conductor 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 or copper rated for direct burial 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 or 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 or copper alloy.

2.7 INTERSYSTEM BONDING BRIDGE GROUNDING CONNECTORS

- A. Description: Devices that provide means for connecting communications systems grounding and bonding conductors at service equipment or at disconnecting means for buildings or structures.

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 for Communications: UL CCN KDSH; including UL 467.

C. UL KDSH - One-Piece Intersystem Bonding Bridge Grounding Connector:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

- a. Galvan Industries, Inc.; Electrical Products Division, LLC.
  - b. Madison Electric Products; business of Southwire Company, LLC.

2. General Characteristics: Zinc-alloy one-piece construction; six terminating points; gangable.

D. UL KDSH - Two-Piece Intersystem Bonding Bridge Grounding Connector:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

- a. Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
  - b. Crouse-Hinds; brand of Eaton, Electrical Sector.
  - c. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

2. General Characteristics: Zinc-alloy body and polycarbonate cover; four terminating points.

## 2.8 GROUNDING AND BONDING BUSBARS

- A. Description: Miscellaneous grounding and bonding device that serves as common connection for multiple grounding and bonding conductors.
- 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.
- D. UL KDER - Rack and Cabinet Bonding Busbar:
  - 1. General Characteristics:
    - a. Bus: Rectangular bar of hard-drawn solid copper.
    - b. Horizontal Mounting Dimensions: Designed for mounting in 19 inch wide equipment racks or cabinets. Coordinate with University furnished cabinets before ordering materials.
    - c. Predrilled Hole Pattern: Accepts connectors for grounding and bonding conductor sizes 14 AWG to 2/0 AWG.
    - d. Mounting Hardware: Stainless steel or copper-plated, for attachment to rack.

## 2.9 GROUNDING (EARTHING) ELECTRODES

- A. Description: Grounding electrodes include rod electrodes, ring electrodes, metal underground water pipes, metal building frames, concrete-encased electrodes, and pipe and plate electrodes.
- 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.
- D. UL KDER - Rod Electrode:

1. General Characteristics: Copper-clad steel; 3/4 inch by 10 ft.

### PART 3 - EXECUTION

#### 3.1 EXAMINATION

- A. Examine 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.

#### 3.2 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. Underground Grounding Conductors: Install bare copper conductor, 2/0 AWG minimum.
- B. Grounding and Bonding Connectors:
  1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
  2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
  3. Connections to Structural Steel: Welded connectors.
  4. Connections between the service entrance equipment and the CGEB: Exothermically welded connectors at the external grounding bus.
  5. Connections to Telecom Ground Bus(es): Exothermically welded connectors on both ends.
  6. Connections to Water Service, Gas Service, Ground Rods, and Building Steel: Bolted connectors at the external grounding bus.
  7. Transformer(s) within the main electrical room: Bolted connectors at the external grounding bus.
- C. Grounding and Bonding Busbars: Provide in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated on Drawings.



### 3.3 SELECTION OF GROUNDING AND BONDING PRODUCTS FOR COMMUNICATIONS

- A. Comply with Section 27 05 28 "Pathways for Communications Systems" and Section 27 11 00 "Communications Equipment Room Fittings."

### 3.4 INSTALLATION OF GROUNDING AND BONDING

- A. Comply with manufacturer's published instructions.

- B. Reference Standards:

- 1. Consult Architect for resolution of conflicting requirements.

- C. Special Techniques:

- 1. Grounding and Bonding Conductors:

- a. 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. Underground Grounding Conductors:

- 1) Bury at least 30 inch below grade.
      - 2) Duct-Bank Grounding Conductor: Bury 12 inch above duct bank when indicated as part of duct-bank installation.

- 2. Grounding and Bonding Connectors: Make connections so 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 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 Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with bolted connector.
    - 3) Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.
  - h. 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. Neutral Conductors: Maintain continuity throughout the system and ground only at the service neutral.
4. Grounding and Bonding Busbars:
  - a. Install busbar horizontally, on insulated spacers 2 inch minimum from wall, 6 inch above finished floor unless otherwise indicated.
  - b. Where busbars are indicated on both sides of doorways, route bonding conductor up to top of door frame, across top of doorway, and down; connect to continuation of horizontal busbar.
  - c. Install external grounding bus on wall adjacent to the service entrance equipment. Install external grounding bus on wall adjacent to distribution equipment in rooms other than the service entrance.
  - d. Install bare copper cable (minimum 2/0 AWG) from external grounding bus to ground rod electrode and terminate with exothermic weld connection. Install bare copper cable (minimum 2/0 AWG) from GEB to external grounding bus and terminate with exothermic weld connections on both ends.
  - e. Identify each connection to the grounding busbar with an engraved nameplate.
  - f. Make exothermic-weld connections at the ground bus for the following grounding conductors:
    - 1) Service entrance equipment ground bar.
    - 2) Ground grid or ring.
    - 3) Telecommunications Bonding Conductor (TBC).
  - g. Make bolt-on connections at the ground bus for the following grounding conductors:
    - 1) Building steel.
    - 2) Water service.
    - 3) Natural gas or propane service.
    - 4) Step-down transformer within the main electrical room.
5. Electrodes:
  - a. Ground Rods: Drive rods until tops are 18 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.
    - 2) Use exothermic welds for below-grade connections.
  - b. For 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.
6. Grounding at Service:
- a. Equipment grounding conductors and grounding electrode conductors must be connected to ground bus. Install main bonding jumper between neutral and ground buses.
  - b. Bond the system neutral to service entrance equipment enclosures.
  - c. Do not run ground conductors from service transformer to service entrance equipment.
7. Grounding Separately Derived Systems:
- a. Ground each separately derived system neutral to the main building ground system unless otherwise indicated.
8. Grounding Underground Distribution System Components:
- a. Duct-Bank Grounding Conductor: Bury 12 inch above duct bank when indicated as part of duct-bank installation.
  - b. Comply with IEEE C2 grounding requirements.
  - c. Grounding Manholes and Handholes: Install driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inch will extend above finished floor. If necessary, install ground rod before manhole is placed and provide 2/0 AWG bare, tinned-copper conductor from ground rod into manhole through waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inch above to 6 inch below concrete. Seal floor opening with waterproof, nonshrink grout.
9. Equipment Grounding and Bonding:
- a. Install insulated equipment grounding conductors with feeders and branch circuits.

### 3.5 FIELD QUALITY CONTROL FOR GROUNDING AND BONDING

- A. Field tests and inspections must be witnessed by Owner.
- B. Tests and Inspections:
  1. After installing 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, and at individual ground rods. 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 Architect promptly and include recommendations to reduce ground resistance.

C. 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.

D. 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 ohms.
  - b. Manhole or Handhole Grounds: 10 ohms.

### 3.6 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