**SECTION 26 05 26**

**GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS**

**BASED ON DFD MASTER ELECTRICAL SPEC DATED 03/01/23**

This section has been written to cover most (but not all) situations that you will encounter. Depending on the requirements of your specific project, you may have to add material, delete items, or modify what is currently written. The Division of Facilities Development expects changes and comments from you.

**PART 1 - GENERAL**

**SCOPE**

The work under this section includes grounding electrodes and conductors, equipment grounding conductors, and bonding for Electrical and Communications systems. Included are the following topics:

PART 1 - GENERAL

 Scope

 Related Work

 References

 Performance Requirements

 Submittals

 Project Record Documents

 Regulatory Requirements

PART 2 - PRODUCTS

 Rod Electrode

 Concrete-Encased Grounding Electrode

 Mechanical Connectors

 Compression Connectors

 Exothermic Connections

 Conductors

 Bus/Busbar

PART 3 - EXECUTION

 Examination

 General

 Medium Voltage System Grounding

 Less Than 600 Volt System Grounding

 Communication System Grounding

 Field Quality Control

 Identification and Labeling

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 Warranty

All hardware, cables and related termination and support hardware shall be furnished, installed, wired, tested, labeled, and documented by the Contractor, as detailed in this and related sections.

RELATED WORK

Applicable provisions of Division 1 govern work under this Section.

Section 26 08 00 - Commissioning of Electrical.

Section 01 91 01 or 01 91 02 – Commissioning Process

**REFERENCES**

ANSI/IEEE 81 (Latest edition) - Guide to Measuring Earth Resistivity, Ground Impedance and Earth Surface Potentials of a Grounding System

ANSI/IEEE 142 (Latest edition) - Recommended Practice for Grounding of Industrial and Commercial Power Systems

UL 467 Electrical Grounding and Bonding Equipment

IEEE 837 - IEEE Standard for Qualifying Permanent Connections Used in Substation Grounding

TIA-607-C - Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications

**PERFORMANCE REQUIREMENTS**

Grounding System Resistance:

• Equipment Rated 500 KVA and Less: 10 ohms maximum at building service entrance.

• Equipment Rated 500 to 1000 KVA: 5 ohms maximum at building service entrance.

• Equipment Rated more than 1000 KVA: 3 ohms building service entrance.

• Communications Ground Busbars: 5 ohms maximum.

Use suitable test instrument to measure resistance to ground of system.  Perform testing in accordance with test instrument manufacturer's recommendations.  Perform fall-of-potential test in accordance with ANSI/ IEEE 81 on main grounding electrode system.

**Testing of grounding system resistance is to be witnessed by the DFD Electrical Inspector or Construction Representative.**

**Provide test report of grounding system overall resistance and resistance of each electrode in final O&M manuals and noted on record documents**.

**SUBMITTALS**

Product Data: Provide data for grounding electrodes and connections.

Provide samples of ground labels.

Test Reports: Indicate overall resistance to ground and resistance of each electrode.

Manufacturer's Instructions: Include instructions for preparation, installation and examination of exothermic connectors.

**PROJECT RECORD DOCUMENTS**

Record locations of all electrical and telecommunications grounding electrodes, busbars and grounding conductors as installed including recorded ground resistance test results.

**REGULATORY REQUIREMENTS**

Conform to requirements of NFPA 70.

Furnish products listed and classified by Underwriters Laboratories, Inc. or testing firm acceptable to authority having jurisdiction as suitable for purpose specified and shown.

**PART 2 - PRODUCTS**

**ROD ELECTRODE**

Material: Copper‑clad steel.

Diameter: 3/4 inch (19 mm) minimum.

Length: 10 feet (3.5 m) minimum. Rod shall be driven at least 9' 6" deep.

**CONCRETE-ENCASED GROUNDING ELECTRODE FOR BUILDINGS**

Fabricate per NFPA 70, Article 250.52 (A)(3)(2) using 20 feet (6m) of bare copper wire not smaller than bare seven-strand #4 AWG. Metallic components shall be encased by at least 2 in. of concrete and shall be located horizontally with in that portion of a concrete foundation or footing that is in direct contact with earth or within vertical foundations or structural components or members that are in direct contact with the earth.

**CONCRETE-ENCASED GROUNDING ELECTRODE FOR POLE BASES**

Fabricate per NFPA 70, Article 250.52 (A)(3)(2) using 20 feet (6m) of bare copper wire not smaller than bare seven-strand #4 AWG. If concrete foundation is less than 20 feet (6m) long, coil excess conductor within the base of the foundation. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts.

**MECHANICAL CONNECTORS**

The mechanical connector bodies shall be manufactured from high strength, high conductivity cast copper alloy material. Bolts, nuts, washers and lock washers shall be made of Silicon Bronze and supplied as a part of the connector body and shall be two hole, two bolt type.

Split bolt connector types are NOT allowed. Exception: the use of split bolts is acceptable for grounding of wire-basket type cable tray, and for cable shields/straps of medium voltage cable.

The connectors shall meet or exceed UL 467 and be clearly marked with the catalog number, conductor size and manufacturer.

**COMPRESSION CONNECTORS**

The compression connectors shall be manufactured from pure wrought copper. The conductivity of this material shall be no less than 99% by IACS standards.

Each connector shall be factory filled with an oxide-inhibiting compound.

The connectors shall meet or exceed the performance requirements of IEEE 837, latest revision.

The connectors shall be clearly marked with the manufacturer, catalog number, conductor size and the required compression tool settings.

The installation of the connectors shall be made with a compression tool and die system, as recommended by the manufacturer of the connectors, and shall be irreversible.

Pre-crimping of the ground rod is required for all irreversible compression connections to a ground rod.

Terminal lug for communication system grounding shall be compression type and conform to the following:

Material: Tin Plated Copper (aluminum not permitted).

Wire Size: to match conductor

Number of Stud Holes: 2

Stud Hole Size: 3/8”

Bolt Hole Spacing: per TIA-607-C

Tongue Angle: Straight

**EXOTHERMIC CONNECTIONS**

As manufactured by Erico Cadweld, Harger Ultraweld or similar.

**CONDUCTORS**

Material: Stranded copper (aluminum not permitted).

Grounding Electrode Conductor: Bare seven-strand conductors. Size as shown on drawings, specifications or as required by NFPA 70, whichever is larger.

***The consultant shall show foundation grounding system on drawings for new buildings.***

Foundation Electrodes: As shown on drawings.

Primary Manhole, Main Switchgear room and Vault Bonding: No. 4/0 minimum.

Feeder and Branch Circuit Equipment Ground: Size as shown on drawings, specifications or as required by NFPA 70, whichever is larger. Differentiate between the normal ground and the isolated ground when both are used at the same facility.

Branch Circuit Equipment Ground shall be proportionately increased in size when routed with phase conductors increased in size.

Conductors for Telecommunications shall be as follows:

Telecommunications Bonding Conductor (TMGB to Service Ground): No. 3/0 minimum or as shown on drawings.

Telecommunications Bonding Backbone (TBB; TMGB to TGB): No. 3/0 minimum or as shown on drawings.

Telecommunications Grounding Equalizer (GE): No. 3/0 minimum or as shown on drawings.

Bonding Conductors shall be insulated with a Green Jacket or jacket marked with Green Tape or labeled per NEC Guidelines.

***The consultant shall provide a main building ground bus/busbar for new electrical services. Busbar shall be centrally located in new main electrical room to provide single ground point for all facility grounds. Each remote electrical room with step down transformers shall be provided with ground Busbar. In addition, a main telecommunications ground Busbar shall be provided, tied to main electrical ground Busbar. Each secondary telecom room shall also be provided with ground Busbar. Utilize DFD grounding detail. Indicate ground Busbar locations on drawings.***

**BUS/BUSBAR**

Material: Copper (aluminum not permitted).

Size:

All Power systems: 1/4" X 2", length as needed (24” minimum).

Telecommunications Main Ground Busbar (TMGB): 1/4" x 4" x 20" long (minimum).

Telecommunications Grounding Busbar (TGB): 1/4" x 2" x 12" long (minimum).

Busbars:

Be pre-drilled to accommodate two-hole lugs.

3/8” stud hole size; hole spacing per TIA-607-C.

Incorporate insulators and stand-off brackets that electrically isolate busbar from mounting surface.

Provide main ground busbar located adjacent to main electrical service equipment to terminate all ground conductors. Refer to DFD grounding detail 26 05 26-1.

**PART 3 - EXECUTION**

**EXAMINATION**

Verify that final backfill and compaction has been completed before driving rod electrodes.

**GENERAL**

Install Products in accordance with manufacturer's instructions.

Mechanical connections shall be accessible for inspection and checking. No insulation shall be installed over mechanical ground connections.

Ground connection surfaces shall be cleaned and all connections shall be made so that it is impossible to move them. Attach grounds permanently before permanent building service is energized.

All grounding conductor connections to Busbars shall be via two hole lugs.

Terminate each grounding conductor on its own terminal lug. Sharing a single lug by multiple conductors is not allowed.

All grounding electrode conductors and individual grounding conductors shall be installed in SCH 80 PVC conduit, in exposed locations.

Each grounding electrode conductor shall be labeled at each terminated end as to system served and location of second termination.

**MEDIUM VOLTAGE SYSTEM GROUNDING**

Provide and install a ¼” x 2” ground bus 18" above finished floor with insulated standoffs 36” on center, completely around the perimeter of the room (vault) containing the medium voltage switchgear and unit substation. Route bus over door. All connections to bus shall be bolted with Belleville washers and tool applied compression spade lugs (2 hole) or exothermic.

***Consultant shall provide a detail of the ground bus installation within Electrical Room including ground rod locations and bus connections to equipment and ground rods.***

***For new construction sites, specify six (6) ground rods around room perimeter. For existing buildings with an existing concrete floor in the electrical room, specify exterior ground rods in triangular configuration. Delete the option not being used.***

[Provide a minimum of six (6) ground rods equally spaced around the perimeter of the high voltage switchgear room or as indicated by the drawings, whichever is greater.] [Provide three (3) ground rods arranged in a triangle configuration on the exterior of the building.] Connect ground rods to perimeter ground bus with 4/0 copper conductor. Connection from ground rod to conductor shall be irreversible compression or exothermic. Pre-crimping of the ground rod is required for all irreversible compression connections. Connection from ground bus to conductor shall be bolted with Belleville washers and tool applied compression spade lugs (2 hole) or exothermic.

Provide separate 4/0 copper conductor from perimeter ground bus to:

XO terminal of each transformer.

Each high voltage switch ground bus.

Secondary service equipment ground bus.

Transformer high voltage grounded terminal (if applicable).

Provide full size 600V copper THHN/THWN or XHHW-2 grounding conductor in each conduit, raceway or enclosure which contains high voltage conductors. Terminate at ground bus of equipment containing high voltage terminations. Connect to ground rod and grounding conductor in each manhole.

Bond each enclosure containing high voltage parts (switches, fuses, transformers, pull boxes, etc.) to room ground bus with 4/0 copper conductor.

Bond all conduits containing high voltage conductors or secondary service conductors to penetrated enclosures using grounding bushing and #4 copper conductor. Attach to penetrated enclosures using grounding bushing and #4 copper conductor. Attach to penetrated enclosure using compression lug on stud or bolt and Belleville washers.

Provide #10 stranded wire from each high voltage termination shield drain wire to ground bus within enclosure. Connect to nearest grounded conductor if ground bus is not within 24". Route shield drains away from energized parts. Make connections with "Sta-Kon" type terminals or tool applied tap connectors. Use of split bolts is acceptable when braided drain wires are used.

Bond all conduits carrying individual grounding or grounding electrode conductors with grounding bushing and separate #4 copper grounding conductor to ground bus.

Provide ground rod in each section of each secondary switchboard. Connect ground rod to ground bus with 4/0 copper conductor and irreversible compression connectors or exothermic.

**LESS THAN 600 VOLT ELECTRICAL SYSTEM GROUNDING**

***The consultant shall provide a grounding detail (grounding riser diagram) and supplementary grounding requirements for both power and telecommunication systems on the drawings.***

***Coordinate Telecommunications Grounding system design with Division 27 consultant. Confirm location of TMGB, TGB(s), conductors, etc. and that Telecommunications Bonding Backbone is not shown as connected thru TGBs.***

Supplementary Grounding Electrode: [Use driven ground rod on exterior of building.] [Use effectively grounded metal frame of the building.]

Provide code sized copper grounding electrode conductor from electrical room ground bus to secondary switchboard ground bus, each separately derived system neutral, secondary service system neutral to street side of water meter, building steel, ground rod, and any concrete encased electrodes. Provide bonding jumper around water meter. Provide physical protection as required.

Equipment Grounding Conductor: Provide separate, insulated equipment grounding conductor within each raceway. Terminate each end on suitable lug, bus, enclosure or bushing. Provide a ground wire from each device to the respective enclosure.

Bond together system neutrals, service equipment enclosures, exposed non-current carrying metal parts of electrical equipment, metal raceway systems, grounding conductor in raceways and cables, receptacle ground connectors, and plumbing systems.

Install ground grid under access floors. Construct grid of #4 AWG bare copper wire installed on 72 inch centers both ways. Bond each access floor support pedestal to grid.

Bond together each metallic raceway, pipe, duct and other metal object entering space under access floors. Bond to under floor ground grid. Use #4 AWG bare copper conductor.

**COMMUNICATION SYSTEM GROUNDING**

***The consultant shall take note of the following paragraphs (to end of article) and incorporate these requirements into the drawings.***

***Coordinate preparation of the Telecommunications Grounding Schematic with Division 27 consultant. Confirm location of TMGB, TGB(s), conductors, etc. and that Telecommunications Bonding Backbone is not shown as connected thru TGBs.***

Grounding and Bonding System for Communications shall be an isolated grounding system with a single ground point. That ground point is to be the common grounding electrode system at the building electrical service entrance (main ground bar located in electrical room).

The system shall be compliant with ANSI J-STD-607-B with the exception that the ground cable shall not be bonded to building steel except at the electrical service entrance.

Provide Grounding Busbar for Telecommunications at each Telecommunications Room, the Main Equipment Room and at the electrical service entrance per project drawings. Coordinate Busbar location(s) and conductor routing per drawings with Division 27 contractor.

Provide Telecommunications Bonding Conductor from Telecommunications Main Grounding Busbar (TMGB) at the Communications Entrance Facility to building common grounding electrode system. Attach grounding conductor to building steel as allowed only at the main electrical service entrance. Provide physical protection as required.

Provide Telecommunications Bonding Backbone (TBB) conductor from the TMGB to Telecommunications Grounding Busbar (TGB) at each Telecommunication Room, Telecommunications Equipment Room and Telecommunications Enclosure.

TBB shall be continuous and not connected through Telecommunications Grounding Busbars (TGBs).

Bond TGBs to TBB via tap off of TBB. Gauge of conductor to be same at TBB.

Leave 10 feet slack in conductor from TBB to TGB at TGB location(s).

Do not bond TBB or TGB to building steel at TGB location(s).

Provide Grounding Equalizer(s) (GE) per project drawings. Connect GE conductor directly to TGBs being interconnected.

**FIELD QUALITY CONTROL**

Inspect grounding and bonding system conductors and connections for tightness and proper installation.

Testing of grounding system resistance is to be witnessed by the DFD Electrical Inspector or Construction Representative. Provide test report of grounding system resistance in final O&M manuals and noted on record drawings.

Provide resistance test at each electrical and telecommunications Busbar to ground.

**IDENTIFICATION AND LABELING**

Label Grounds at point of termination.

Label for Bus Bars and Ground Bars shall be engraved laminate or Pre-printed (manufactured) plastic and include the following:

IF THIS CONNECTOR OR CABLE IS LOOSE OR MUST BE REMOVED, PLEASE CALL THE BUILDING

MANAGER.

Provide additional labeling of each individual terminated ground conductor at bus bar identifying installed source per NEC 250.52 A 1-7.

Label for TBB connection at TMGB and TGB(s) shall be engraved laminate or Pre-printed (manufactured) plastic and include the following:

IF THIS CONNECTOR OR CABLE IS LOOSE OR MUST BE REMOVED, PLEASE CALL THE BUILDING

TELECOMMUNICATIONS MANAGER.

**CONSTRUCTION VERIFICATION**

Contractor is responsible for utilizing the construction verification checklists supplied under specification Section 26 08 00 in accordance with the procedures defined for construction verification in Section 01 91 01 or 01 91 02.

Record locations of all electrical and telecommunications grounding electrodes, busbars and grounding conductors as installed including recorded ground resistance test results.

**WARRANTY**

See Division 1, General Conditions, and General Requirements.

END OF SECTION