26 05 26 Grounding: SIGNIFICANT (OR TOTAL) DELETION OF EXISTING TEXT

Delete the following current section in its entirety.

~~**.01 General**~~

~~A. Contact Engineering Services for a copy of the basic PSU grounding connections detail.~~
~~B. Provide a common bare copper main ground bus, wall mounted adjacent to the service entrance equipment. Bus should be minimum 1/4 inch by 2 inch by 24 inches long, 2-hole lugs, mounted on insulators. Confirm final bus sizing with Engineering Services.~~
~~C. Exothermically weld the connection between the service entrance equipment and the ground bus at the ground bus only. Identify each connection to the ground bus with an engraved nameplate. Run bare copper cable (minimum 1/0) from bus to ground rod bed. Make bolt-on connections at ground bus as follows:~~
~~1. Water service~~
~~2. Ground rods (minimum 3-rod bed, spaced at least rod length apart, buried at least 12 inches below grade)~~
~~3. Building steel~~
~~4. Telecom ground bus(es)~~
~~5. Lightning protection system (when provided)~~
~~6. Step-down transformer(s) within the main electrical room (when provided)~~
~~D. Any connections made below grade shall be exothermically welded.~~
~~E. Ground resistance in reference to physical earth connection shall be below levels as follows:~~
~~1. Systems below 500kVA – 10 ohms~~
~~2. Systems between 500 and 1000kVA – 5 ohms~~
~~3. Systems above 1000kVA – 3 ohms~~
~~4. Systems serving Data Center Equipment - 3 ohms~~
~~5. Point to point grounding resistance between main grounding bus and all major electrical equipment frames – 0.5 ohms~~
~~F. All conduits carrying conductors shall have a ground wire.~~
~~G. Provide separate 4/0 ground wire from ground bus to telecom room. Refer to~~ 27 05 00 Communications ~~for required size.~~
~~H. Do not run ground conductors from service transformer to service entrance equipment.~~
~~I. Isolated ground systems must be approved by Engineering Service.~~
~~J. Ground connections to the ground bus bar shall utilize a long barrel two lug connection. Single lug short barrel connections are NOT acceptable.~~
~~K. Grounding conductors shall be installed in PVC conduit. RMC is an acceptable alternative. However, if RMC is used grounding hubs shall be installed on each end of the conduit and connected to the grounding conductor.~~
~~L. Typical CADD details are listed below for the Design Professionals reference:~~

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Replace with following text.

.01 General

A. Isolated ground systems must be approved by Engineering Service.

B. Typical CADD details are listed below for the Design Professionals reference:

Document	Version Date	Description
Detail # 260526-D01 Grounding Details (AutoCAD) Grounding Details (PDF)	June 2016	Typical University Grounding Details for the Professionals' use. The details provided are a baseline and it is the responsibility of the professional to design and develop complete details that are acceptable.

.02 Guide Specifications

A. Design Professional shall carefully review and edit the guideline specifications below, adapting them as needed to achieve application-specific, fully developed specifications for each project.

B. These shall be edited using the process described in the instructions contained at the beginning of the document. Proposed modifications shall be reviewed with OPP Engineering Services.

C. Finalized version shall be included in the project contract documents. Use of other specifications is not acceptable.

Document	Version Date	Description
260526 - Grounding and	June 2016	University's guide specification for grounding

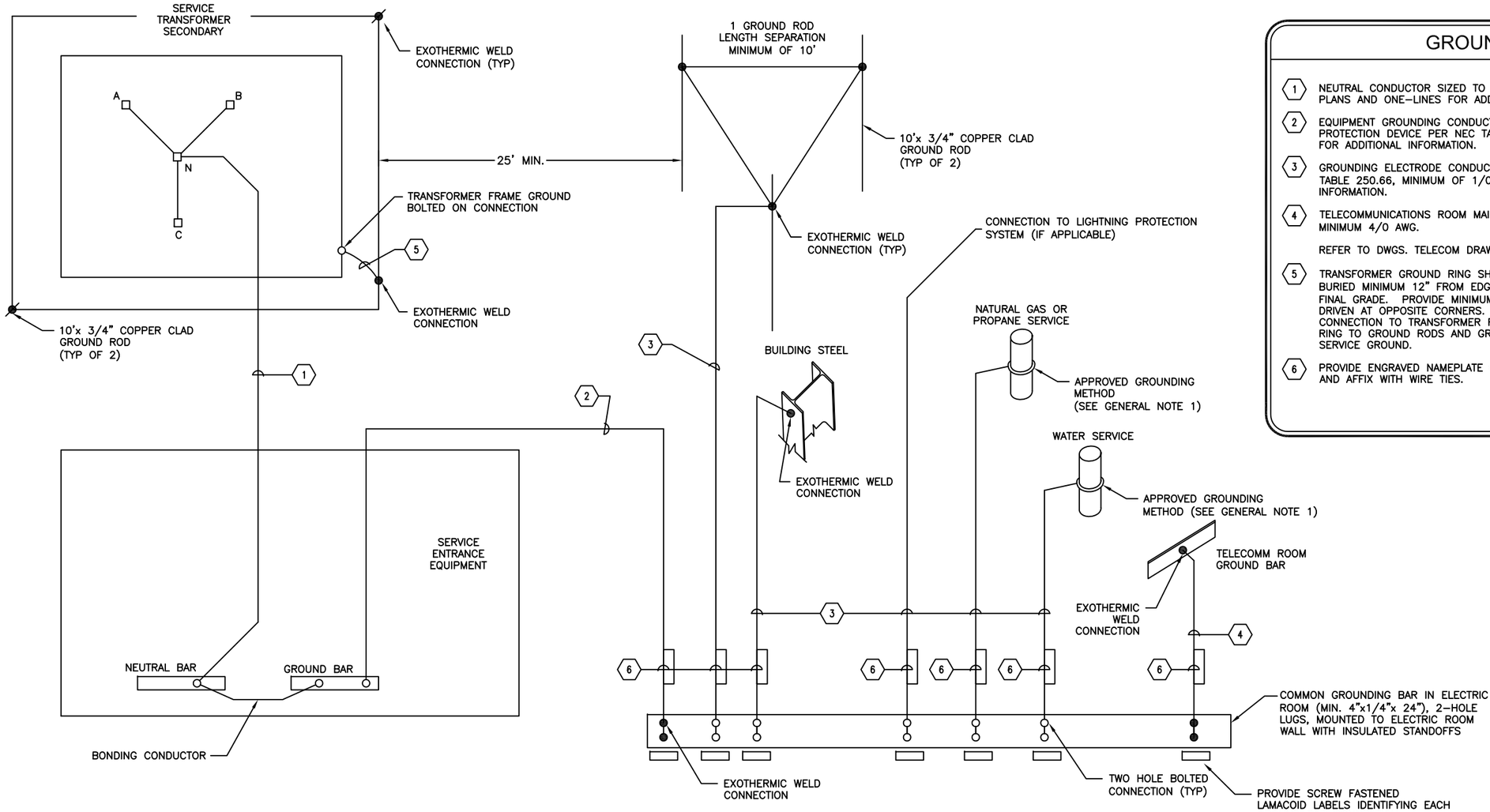
Document	Version Date	Description
Bonding for Electrical Systems.docx		and bonding of electrical systems; to be used by the design professional.

END of revision

Update Commentary:

Section was updated primarily for the following reasons:

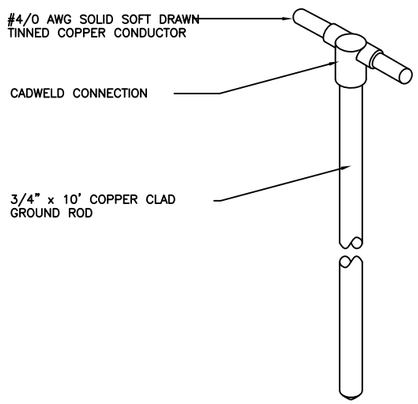
1) *Deleted old section and replaced with new section, which includes a new guide specification section and updated grounding details.*



GROUNDING KEY NOTES

1. NEUTRAL CONDUCTOR SIZED TO MATCH PHASE CONDUCTORS MINIMUM. REFER TO FLOOR PLANS AND ONE-LINES FOR ADDITIONAL INFORMATION.
2. EQUIPMENT GROUNDING CONDUCTOR SIZED BASED ON SWITCHGEAR MAIN OVERCURRENT PROTECTION DEVICE PER NEC TABLE 250-122. REFER TO FLOOR PLANS FOR ADDITIONAL INFORMATION.
3. GROUNDING ELECTRODE CONDUCTOR SIZED BASED ON PHASE CONDUCTORS PER NEC TABLE 250.66, MINIMUM OF 1/0 AWG. REFER TO FLOOR PLANS FOR ADDITIONAL INFORMATION.
4. TELECOMMUNICATIONS ROOM MAIN GROUND BUSBAR GROUNDING CONDUCTOR SHALL BE MINIMUM 4/0 AWG.

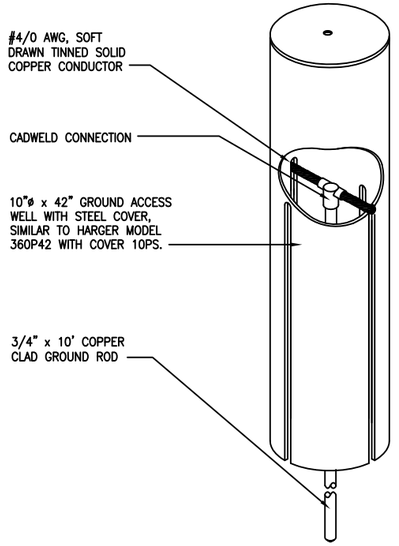
   REFER TO DWGS. TELECOM DRAWINGS FOR ADDITIONAL INFORMATION.
5. TRANSFORMER GROUND RING SHALL CONSIST OF MINIMUM 1/0 BARE COPPER CONDUCTOR BURIED MINIMUM 12" FROM EDGE OF TRANSFORMER FOUNDATION AND 18"-24" BELOW FINAL GRADE. PROVIDE MINIMUM OF TWO (2) 10'-0"X 3/4" COPPER CLAD GROUND RODS DRIVEN AT OPPOSITE CORNERS. PROVIDE ADEQUATE GROUNDING WHIP FOR BOLTED CONNECTION TO TRANSFORMER FRAME GROUND. PROVIDE EXOTHERMIC WELDS OF GROUND RING TO GROUND RODS AND GROUNDING WHIP TO RING. DO NOT CONNECT TO BUILDING SERVICE GROUND.
6. PROVIDE ENGRAVED NAMEPLATE ON ALL GROUND CABLE CONNECTIONS AT THE BUS BAR AND AFFIX WITH WIRE TIES.



GROUND ROD DETAIL
SCALE: NONE

GENERAL NOTES:

1. A GROUNDING JUMPER SHALL BE PROVIDED AROUND THE WATER OR GAS METER AND BACKFLOW PREVENTER.
2. PVC CONDUIT IS THE PREFERRED METHOD OF PROTECTION FOR THE GROUNDING CONDUCTORS. DISCUSS WITH PSU ENGINEERING SERVICES FOR ANY DEVIATIONS.



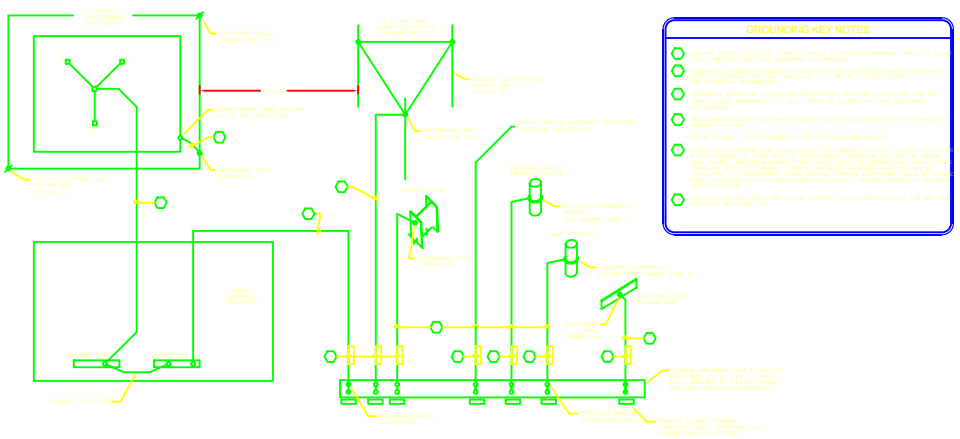
GROUND ROD ACCESS WELL DETAIL
SCALE: NONE

REVISION: 1.1

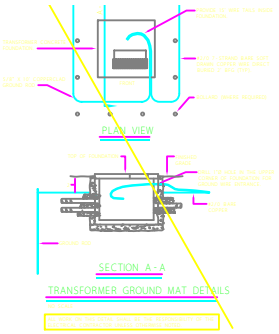
REVISION LOG		DATE
1.0	ORIGINAL	10/2014
1.1	EDIT GROUND BAR CALLOUT DETAIL	02/2016

PSU OPP STANDARD DETAIL

TITLE: TYPICAL GROUNDING DETAILS		DETAIL #: 260526-D01
SCALE: NONE	PAGE #1 OF 1	DATE: 10/20/2014



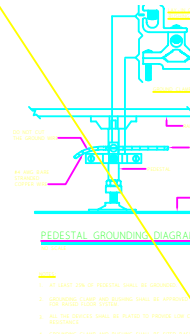
ELECTRIC POWER GROUNDING DETAIL



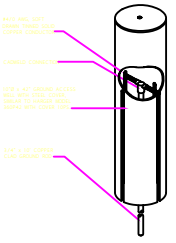
PLAN VIEW

SECTION A-A

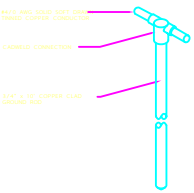
TRANSFORMER GROUND MAT DETAILS



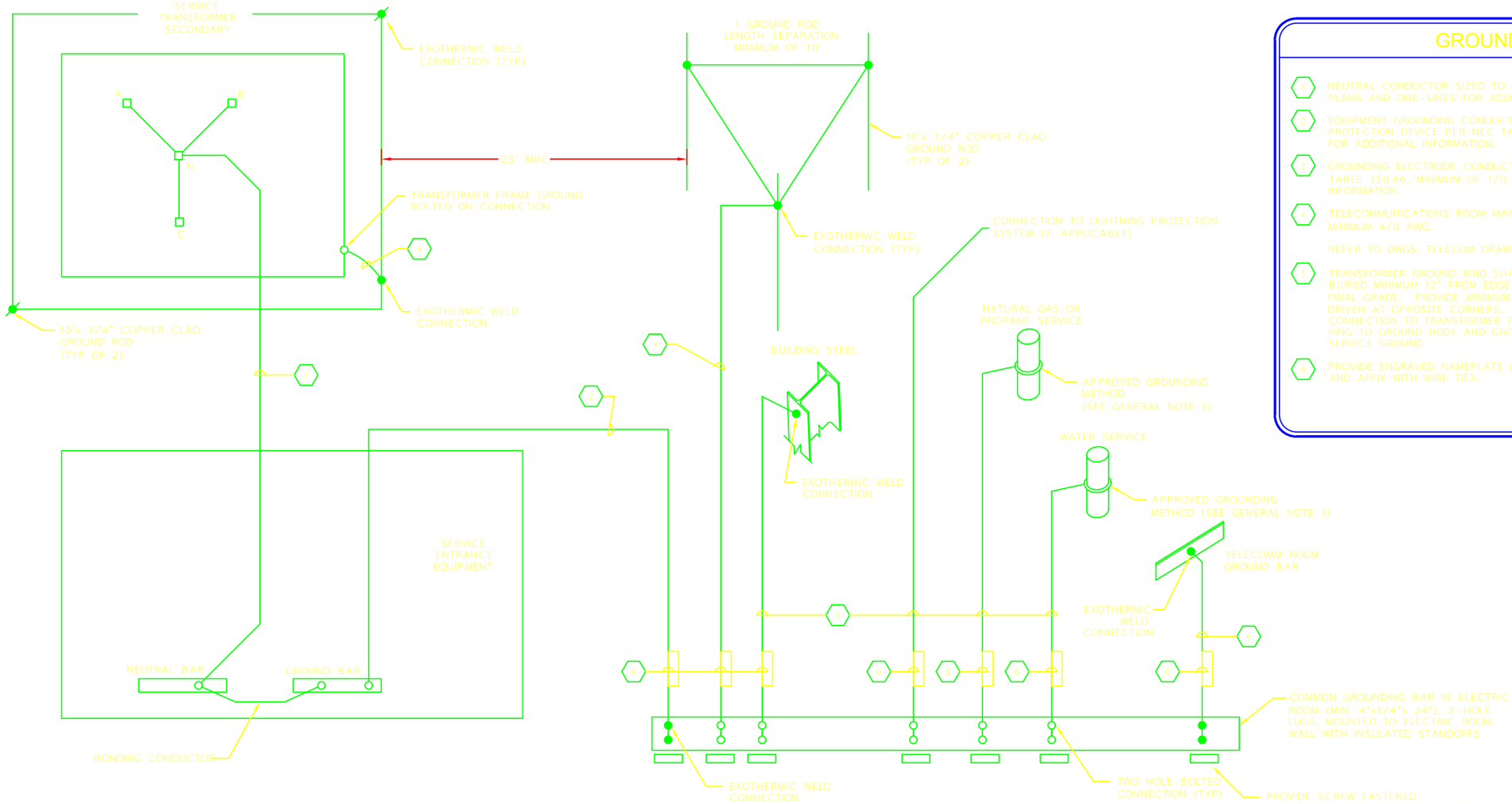
PEDESTAL GROUNDING DIAGRAM



GROUND ROD ACCESS WELL DETAIL



GROUND ROD DETAIL



GROUNDING KEY NOTES

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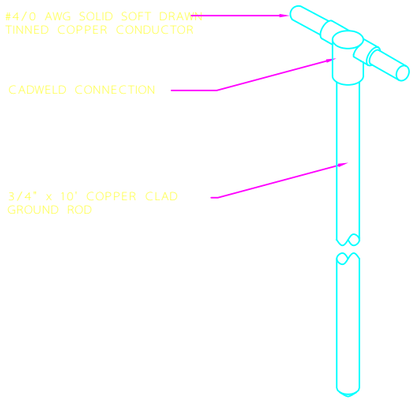

GROUND ROD DETAIL

SCALE: NONE

GENERAL NOTES:

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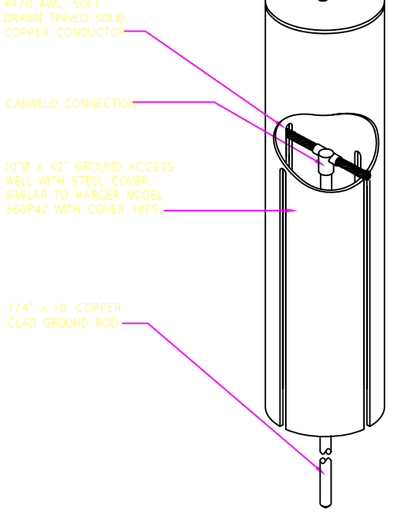
2. PVC CONDUIT IS THE PREFERRED METHOD OF PROTECTION FOR THE GROUNDING CONDUCTORS. DISCUSS WITH PSU ENGINEERING SERVICES FOR ANY DEVIATIONS.



GROUND ROD ACCESS WELL DETAIL

SCALE: NONE

REVISION: 1.1

REVISION LOG		DATE
1.0	ORIGINAL	10/2014
1.1	EDIT GROUND BAR CALLOUT DETAIL	02/2016

PSU OPP STANDARD DETAIL

TITLE: TYPICAL GROUNDING DETAILS		DETAIL #: 260526-D01
SCALE: NONE	PAGE #1 OF 1	DATE: 10/20/2014

SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

Revise this Section by deleting and inserting text to meet Project-specific requirements.

This Section uses the term "Architect." Change this term to match that used to identify the design professional as defined in the General and Supplementary Conditions.

Verify that Section titles referenced in this Section are correct for this Project's Specifications; Section titles may have changed.

General Notes:

1. *This guide specification is intended to provide the Design Professional with a basic guideline of minimum OPP requirements.*

2. *The guide specification shall be carefully reviewed and edited with respect to application-specific project requirements. Proposed modifications shall be reviewed with OPP Staff.*

3. *Finalized version shall be included in the project contract documents.*

Editing Notes

1. *This OPP Guide specification must only be altered by notation (i.e. deleted text with strikethrough and additional text with double underline). This shall be accomplished by using Tools /Track Changes / Highlight Changes, and select "Track changes while editing" in MS Word or equivalent.*

2. *The Review Submittal Specification section shall be provided in electronic form for OPP Review.*

3. *Leave the following Note ("For Construction Document Review, Design Submittal") as part of the Review Submittal, to aid any Reviewer to understand WHY there are strikeouts and underlines. Also, leave any “DESIGNER NOTE” placed in this Guide Spec.*

4. *AFTER comments are received from PSU and incorporated, the strikeouts and underlines shall be removed, and the REVIEWER NOTEs deleted, before the spec is issued for Bidding.*

NFPA 70 and IEEE C2 include basic grounding requirements for electrical safety. This Section supplements those requirements with additional grounding requirements and with optional grounding methods and materials for both power and electronic systems that go beyond basic minimum safety requirements.

See "Sustainable Design Considerations" Article in the Evaluations for a discussion of sustainable design requirements that may impact the editing of this Section.

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

Retain or delete this article in all Sections of Project Manual.

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

Retain one of two paragraphs below.

A. Section includes grounding and bonding systems and equipment.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

1.4 INFORMATIONAL SUBMITTALS

Retain "As-Built Data" Paragraph below to require Contractor to provide Drawings that locate significant grounding features. Section 017823 "Operation and Maintenance Data" and Section 017839 "Project Record Documents" require submittals to be included in those documents for use by maintenance forces throughout the life of Project.

A. As-Built Data: Plans showing dimensioned as-built locations of grounding features specified in "Field Quality Control" Article, including the following:

1. Test wells.
2. Ground rods.
3. Ground rings.
4. Grounding arrangements and connections for separately derived systems.

Coordinate "Qualification Data" Paragraph below with qualification requirements in Section 014000 "Quality Requirements" and as may be supplemented in "Quality Assurance" Article.

B. Qualification Data: For testing agency and testing agency's field supervisor.

Retain "Field quality-control reports" Paragraph below if Contractor is responsible for field quality-control testing and inspecting.

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

Retain "Operation and Maintenance Data" Paragraph below if specifying test wells, separately derived systems, or ground ring or other grounding for sensitive electronic equipment.

A. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

Retain subparagraph below for projects requiring a high reliability for electrical systems. NETA MTS provides more easily interpreted recommendations for frequency of tests and inspections than NFPA 70B.

a. Instructions for periodic testing and inspection of grounding features at test wells, ground rings, and grounding connections for separately derived systems based on NETA MTS.

1) Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
2) Include recommended testing intervals.

1.6 QUALITY ASSURANCE

Retain "Testing Agency Qualifications" Paragraph below if Contractor selects testing agency or if Contractor is required to provide services of a qualified testing agency in "Field Quality Control" Article. Qualification requirements are in addition to those specified in Section 014000 "Quality Requirements."

A. Testing Agency Qualifications: Certified by NETA.

PART 2 - PRODUCTS

Manufacturers and products listed in SpecAgent and Masterworks Paragraph Builder are neither recommended nor endorsed by the AIA or ARCOM. Before inserting names, verify that manufacturers and products listed there comply with requirements retained or revised in descriptions and are both available and suitable for the intended applications. For definitions of terms and requirements for Contractor's product selection, see Section 016000 "Product Requirements."

2.1 MANUFACTURERS

A. 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:

1. Burndy; Part of Hubbell Electrical Systems.
2. ERICO International Corporation.
3. Harger Lightning & Grounding.
4. O-Z/Gedney; a brand of Emerson Industrial Automation.
5. Thomas & Betts Corporation; A Member of the ABB Group.

2.2 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

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

2.3 CONDUCTORS

Retain "Insulated Conductors" Paragraph below to require one of two preferred conductor materials permitted by NFPA 70; delete to allow Contractor to use any material that complies with Code. See "Grounding Products" Article in the Evaluations for discussion on alternative materials.

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 B 3.
2. Stranded Conductors: ASTM B 8.
3. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules

Retain "Grounding Bus" Paragraph below if size of grounding bus and mounting details are not indicated on Drawings. The dimension in option is recommended by BICSI for telecommunications bus bar. Refer to PSU grounding detail located here.

C. Grounding Bus: Predrilled rectangular bars of annealed copper, minimum 1/4 inches by 4 inches by 24 inches in cross section, with 9/32-inch holes spaced 1-1/8 inches apart with 2-hole long barrel lugs, mounted on insulators. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V and shall be Lexan or PVC, impulse tested at 5000 V. Ground bus wall mounted adjacent to the service entrance equipment.

Retain one of two paragraphs below: RMC is acceptable alternative for PVC conduit as listed below. PVC is preferred and RMC must be approved by owner.

D. Exposed grounding conductors shall be installed in PVC conduit.

E. Exposed grounding conductors shall be installed in RMC conduit. Grounding hubs shall be installed on each end of the conduit and connected to the grounding conductor.

2.4 CONNECTORS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.

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

C. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

D. Beam Clamps: Mechanical type, terminal, ground wire access from four directions, with dual, tin-plated or silicon bronze bolts.

E. Cable-to-Cable Connectors: Compression type, copper or copper alloy.

F. Cable Tray Ground Clamp: Mechanical type, zinc-plated malleable iron.

G. Conduit Hubs: Mechanical type, terminal with threaded hub.

H. Ground Rod Clamps: Mechanical type, copper or copper alloy, terminal with hex head bolt.

I. Lay-in Lug Connector: Mechanical type, copper rated for direct burial terminal with set screw.

Retain "Service Post Connectors" Paragraph to allow use of split-bolt connectors.

J. Service Post Connectors: Mechanical type, bronze alloy terminal, in short- and long-stud lengths, capable of single and double conductor connections.

K. Signal Reference Grid Clamp: Mechanical type, stamped-steel terminal with hex head screw.

L. Straps: Solid copper, copper lugs. Rated for 600 A.

Coordinate bolt material with clamp type and material.

M. Tower Ground Clamps: Mechanical type, copper or copper alloy, terminal one-piece clamp.

N. U-Bolt Clamps: Mechanical type, copper or copper alloy, terminal listed for direct burial.

O. Water Pipe Clamps:

1. U-bolt type with malleable-iron clamp and copper ground connector.

2.5 GROUNDING ELECTRODES

Grounding electrodes include ground rods, ground rings, metal underground water pipes, metal building frames, concrete-encased electrodes, and pipe and plate electrodes. Retain "Applications" and "Installation" articles to specify where these items are required; coordinate with Drawings.

Copper-clad steel ground rods are the most common grounding electrode. See the Evaluations for discussion on alternative materials. Sectional rods are used when electrodes longer than 10 feet (3 m) are required.

A. Ground Rods: Copper-clad steel; 3/4 inch 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.

Coordinate "Underground Grounding Conductors" Paragraph below with Drawings and with Section 260543 "Underground Ducts and Raceways for Electrical Systems."

B. Underground Grounding Conductors: Install bare copper conductor, No. 1/0 AWG minimum.

1. Bury at least 24 inches below grade.

Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.

2. Install bus horizontally, on insulated spacers 2 inches minimum from wall, 6 inches above finished floor unless otherwise indicated.
3. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.
4. Install common bare copper main ground bus, wall mounted adjacent to the service entrance equipment.
5. Identify each connection to the ground bus with an engraved nameplate. Run bare copper cable (minimum 1/0 AWG) from bus to ground rod bed.

C. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground or Below Grade Connections: Exothermically welded connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.
5. Connections between the service entrance equipment and the ground bus at the ground bus: Exothermically weld connectors.
6. Connections to Telecom Ground Bus(es): Exothermically weld connectors on both ends.
7. Connections to Water Service, Gas Service, Ground Rods, and Building Steel: Bolted Connectors.
8. Lightning Protection Systems (when provided): Bolted Connectors.
9. Step-down transformer(s) within the main electrical room (when provided) at ground bus: Bolted connectors.

3.2 GROUNDING AT THE SERVICE

A. Equipment grounding conductors and grounding electrode conductors shall be connected to the ground bus. Install a main bonding jumper between the 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.

3.3 GROUNDING SEPARATELY DERIVED SYSTEMS

Retain "Generator" Paragraph below to require a grounding electrode at the generator. This electrode is not an NFPA 70 requirement.

A. Ground each separately derived system neutral to main building ground system unless otherwise indicated.

B. Generator: Install grounding electrode(s) at the generator location. The electrode shall be connected to the equipment grounding conductor and to the frame of the generator.

3.4 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Comply with IEEE C2 grounding requirements.

Grounding practices of the local utility company may differ from requirements in "Grounding Manholes and Handholes," "Grounding Connections to Manhole Components," and "Pad-Mounted Transformers and Switches" paragraphs below. Although grounding specified in this article is not for the utility company's use and does not have to comply with its standards, it is possible that the utility company may be requested to repair or maintain the line in the future. For this reason, it may be desirable to design some grounding features according to the utility company's standards. Utility companies, for economic reasons, often design to a standard lower than what is appropriate for Project requirements. Alternatively, because of their experience with conditions in their service area, utility companies may design to a higher standard than is required by Code. In addition to Project requirements, evaluate the local utility company's practices and revise paragraphs accordingly. This evaluation is particularly important if Project's underground lines connect with utility lines. Coordinate with Drawings and with Section 260543 "Underground Ducts and Raceways for Electrical Systems."

B. Grounding Manholes and Handholes: Install a driven ground rod adjacent to manhole or handhole floor. If necessary, install ground rod before manhole is placed and provide No. 2/0 AWG bare, tinned-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 insulating tape or heat-shrunk insulating sleeve. Seal opening with waterproof, nonshrink grout.

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. 2/0 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 according to written instructions by manufacturer of splicing and termination kits.

Retain and revise "Pad-Mounted Transformers and Switches" Paragraph below to exceed NFPA 70 requirements. If concrete pad is for equipment to be supplied by utility company, revise paragraph to comply with utility company's grounding standards or delete and indicate on Drawings.

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 copper conductor not less than No. 2/0 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 12 inches from the foundation.

3.5 EQUIPMENT GROUNDING

NFPA 70 permits two types of equipment grounding conductors: metallic raceway or cable sheath that encloses supply conductors, and a separate grounding conductor of insulated wire or cable installed with supply conductors. Installation of a separate insulated equipment grounding conductor provides an additional degree of safe operation when compared to relying on raceway or cable sheath for ground continuity. NFPA 70 requires separate insulated equipment grounding conductors in some situations and not in others. Retain and revise one of first two paragraphs below to require insulated equipment grounding conductors that exceed NFPA 70 requirements. Coordinate with Drawings.

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

B. Install ground conductor in all conduits carrying conductors.

C. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:

Retain applicable subparagraphs below.

1. Feeders and branch circuits.
2. Lighting circuits.
3. Receptacle circuits.
4. Single-phase motor and appliance branch circuits.
5. Three-phase motor and appliance branch circuits.
6. Flexible raceway runs.
7. Armored and metal-clad cable runs.
8. Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.
9. X-Ray Equipment Circuits: Install insulated equipment grounding conductor in circuits supplying x-ray equipment.

D. 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.

E. 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.

"Poles Supporting Outdoor Lighting Fixtures" Paragraph below may supplement equipment grounding conductor and may be in excess of NFPA 70 requirements. Retain if necessary and coordinate with Drawings. If using fiberglass pole, omit ground.

F. 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. Fiberglass poles are exempt from this requirement.

G. Metallic Fences: Comply with requirements of IEEE C2.

1. Grounding Conductor: Bare copper, not less than No. 1/0 AWG.
2. Gates: Shall be bonded to the grounding conductor with a flexible bonding jumper.
3. Barbed Wire: Strands shall be bonded to the grounding conductor.

3.6 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. Ground Bonding Common 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 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.

Retain "Test Wells" Paragraph below to require test wells; delete if indicated on Drawings.

D. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Section 260543 "Underground Ducts and Raceways for Electrical Systems," and shall be at least 12 inches deep, with cover.

1. Install at least one test well for each service unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.

E. 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 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 a bolted clamp.

If connections specified in "Grounding and Bonding for Piping" Paragraph below circumvent dielectric fittings intended to isolate interior piping systems from ground, other action may be necessary to prevent electrolytic corrosion.

F. 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 a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Provide jumper around dielectric 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 a bolted connector.
3. Backflow Preventer: Use braided-type bonding jumpers to electrically bypass backflow preventer. Connect to pipe with a bolted connector.
4. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

Retain and revise "Bonding Interior Metal Ducts" Paragraph below to exceed NFPA 70 requirements, and comply with NFPA 70 recommendations for a higher standard of safety or electromagnetic interference suppression if needed.

G. 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.

H. 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.

Consult with owner on use of ground rings.

I. Ground Ring/Ground Triad: Install a grounding conductor, electrically connected to each building structure ground rod and to each indicated item, extending around the perimeter of area or item indicated.

1. Install copper conductor not less than No. 1/0 AWG for ground ring and for taps to building steel.
2. Do not bury until owner approves installation and GIS location is documented.
3. Bury ground ring not less than 24 inches from building's foundation.

J. Telecom Room: Install separate 4/0 AWG ground wire from ground bus to telecom room.

3.7 FIELD QUALITY CONTROL

Retain one of first four paragraphs below. Retain first "Testing Agency" Paragraph below if Owner will hire an independent testing agency.

Retain "Testing Agency" Paragraph below to require Contractor to hire an independent testing agency.

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

Retain "Manufacturer's Field Service" Paragraph below to require a factory-authorized service representative to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

Retain "Perform tests and inspections" Paragraph below to require Contractor to perform tests and inspection and retain option to require Contractor to arrange for assistance of a factory-authorized service agent.

C. Perform tests and inspections

Retain "Tests and Inspections" Paragraph below to describe tests and inspections to be performed.

D. 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 a calibrated torque wrench according to manufacturer's written instructions.
3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal and at ground test wells. Make tests at ground rods before any conductors are connected.

    a. Measure ground resistance no fewer 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.

Coordinate subparagraph below with "Informational Submittals" Article; revise to suit Project.

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 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.

See Section 014000 "Quality Requirements" for retesting and reinspecting requirements and Section 017300 "Execution" for requirements for correcting the Work.

E. Grounding system will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

G. Report measured ground resistances that exceed the following values:

See the Evaluations for discussion on appropriate ground-resistance values. Typical maximum permitted values are listed below for different grounding applications; retain applicable subparagraphs and revise to suit Project. Coordinate with requirements in Sections specifying equipment to be grounded.

1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
2. Power and Lighting Equipment or System with Capacity of 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.
7. Systems serving Data Center Equipment: 3 ohms.
8. Point to point grounding resistance between main grounding bus and all major electrical equipment frames: 0.5 ohms.

H. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Engineer promptly and include recommendations to reduce ground resistance.

END OF SECTION 260526