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.

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.

1. GENERAL
   * + 1. RELATED DOCUMENTS

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

* + - * 1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section
      1. SUMMARY

Retain one of two paragraphs below.

* + - * 1. Section includes grounding and bonding systems and equipment.
        2. Section includes grounding and bonding systems and equipment, plus the following special applications:

Retain one or more subparagraphs below for special grounding applications.

Underground distribution grounding.

Ground bonding common with lightning protection system.

Foundation steel electrodes.

* + - 1. SUBMITTALS
         1. Submittals for this section are subject to the re-evaluation fee identified in Article 4 of the General Conditions.
         2. Manufacturer’s installation instructions shall be provided along with product data.
         3. Submittals shall be provided in the order in which they are specified and tabbed (for combined submittals).
         4. Product Data: For each type of product indicated.
         5. Submittals for this section are subject to the re-evaluation fee identified in Article 4 of the General Conditions.

Retain "Coordination Drawings" 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.

* + - * 1. Coordination Drawings: Plans showing dimensioned locations of grounding features specified in "Field Quality Control" Article, including the following:

Test wells.

Ground rods.

Ground rings.

Grounding arrangements and connections for separately derived systems.

<**Insert items**>.

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.

* + - * 1. Field quality-control reports.
      1. 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.

* + - * 1. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals.

Coordinate subparagraph below with "Coordination Drawings" paragraph in "Informational Submittals" Article. Retain subparagraph below to require Contractor to provide Drawings that locate significant grounding features.

Plans showing as-built, dimensioned locations of system described in "Field Quality Control" Article, including the following:

Test wells.

Ground rods.

Ground rings.

Grounding arrangements and connections for separately derived systems.

<**Insert items**>.

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.

Instructions for periodic testing and inspection of grounding features at [**test wells**] [**ground rings**] [**grounding connections for separately derived systems**] <**Insert locations**> based on [**NETA MTS**] [**NFPA 70B**] <**Insert reference**>.

Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.

Include recommended testing intervals.

* + - 1. 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.

* + - * 1. Testing Agency Qualifications: Certified by NETA.

1. PRODUCTS

Manufacturers and products listed in SpecAgent and Masterworks Paragraph Builder are neither recommended nor endorsed by the AIA or Deltek. 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.

* + - 1. SYSTEM DESCRIPTION
         1. 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.
         2. Comply with UL 467 for grounding and bonding materials and equipment.
      2. MANUFACTURERS
         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:

Blackburn/T&B Corp.

Burndy; Hubbell Incorporated, Construction and Energy.

O-Z/Gedney; Emerson Electric Co., Automation Solutions, Appleton Group.

Or equal.

* + - 1. 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.

* + - * 1. Insulated Conductors: [**Copper**] [**or**] [**tinned-copper**] wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.
        2. Bare Copper Conductors:

Retain one or more conductor types below. Coordinate with Sections that include provisions for grounding.

Solid Conductors: ASTM B3.

Stranded Conductors: ASTM B8.

Tinned Conductors: ASTM B33.

Sizes and types of conductors in four subparagraphs below are typical examples. 28-kcmil bonding cable in "Bonding Cable" subparagraph below is slightly larger than No. 6 AWG.

Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.

Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.

Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

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.

* + - * 1. Grounding Bus: Predrilled rectangular bars of annealed copper, [**1/4 by 4 inches**] <**Insert dimensions**> in cross section, with 9/32-inch holes spaced 1-1/8 inches apart. 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.
      1. CONNECTORS
         1. 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.
         2. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

Retain one of two "Bus Bar Connectors" paragraphs below.

* + - * 1. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless [**compression**] [**exothermic**]-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.
        2. Bus-Bar Connectors: Compression type, copper or copper alloy, with two wire terminals.
        3. Beam Clamps: Mechanical type, terminal, ground wire access from four directions, with dual, tin-plated or silicon bronze bolts.
        4. Cable-to-Cable Connectors: Compression type, copper or copper alloy.
        5. Cable Tray Ground Clamp: Mechanical type, zinc-plated malleable iron.
        6. Conduit Hubs: Mechanical type, terminal with threaded hub.
        7. Ground Rod Clamps: Mechanical type, copper or copper alloy, terminal with [**hex head bolt**] [**socket set screw**].
        8. Ground Rod Clamps: Mechanical type, copper or copper alloy, terminal with hex head bolt.
        9. Lay-in Lug Connector: Mechanical type, [**aluminum**] [**copper rated for direct burial**] terminal with set screw.

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

* + - * 1. Service Post Connectors: Mechanical type, bronze alloy terminal, in short- and long-stud lengths, capable of single and double conductor connections.
        2. Signal Reference Grid Clamp: Mechanical type, stamped-steel terminal with hex head screw.
        3. Straps: Solid copper, [**cast-bronze clamp**] [**copper lugs**]. Rated for 600 A.

Coordinate bolt material with clamp type and material.

* + - * 1. Tower Ground Clamps: Mechanical type, copper or copper alloy, terminal [**one**] [**two**]-piece clamp.
        2. U-Bolt Clamps: Mechanical type, copper or copper alloy, terminal listed for direct burial.
        3. Water Pipe Clamps:

Mechanical type, two pieces with [**zinc-plated**] [**stainless-steel**] bolts.

Material: [**Tin-plated aluminum**] [**Die-cast zinc alloy**].

Listed for direct burial.

U-bolt type with malleable-iron clamp and [**copper ground connector**] [**copper ground connector rated for direct burial**].

* + - 1. 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 are required.

* + - * 1. Ground Rods: [**Copper-clad**] [**Zinc-coated**] [**Stainless**] steel [**, sectional type**]; [**3/4 inch by 10 feet**] [**5/8 by 96 inches**].

Retain "Chemical-Enhanced Grounding Electrodes" paragraph below if allowed by authorities having jurisdiction to enhance grounding performance. See the Evaluations.

* + - * 1. Chemical-Enhanced Grounding Electrodes: Copper tube, straight or L-shaped, charged with [**nonhazardous electrolytic chemical salts**] <**Insert enhancement material**>.

Termination: Factory-attached No. 4/0 AWG bare conductor at least 48 inches long.

Backfill Material: Electrode manufacturer's recommended material.

* + - * 1. Ground Plates: 1/4 inch thick, hot-dip galvanized.

1. EXECUTION
   * + 1. APPLICATIONS
          1. Conductors: Install solid conductor for [**No. 8**] <**Insert number**> AWG and smaller, and stranded conductors for [**No. 6**] <**Insert number**> 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."

* + - * 1. Underground Grounding Conductors: Install bare [**tinned-**]copper conductor, [**No. 2/0**] <**Insert number**> AWG minimum.

Bury at least 30 inches below grade.

Retain "Duct-Bank Grounding Conductor" subparagraph below to require duct-bank grounding conductor to be installed with, but external to, duct bank.

Duct-Bank Grounding Conductor: Bury 12 inches above duct bank when indicated as part of duct-bank installation.

* + - * 1. Grounding Conductors: Green-colored insulation with continuous yellow stripe.
        2. Isolated Grounding Conductors: Green-colored insulation with more than one continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.

Retain "Grounding Bus" paragraph below if grounding bus is required. Coordinate with Drawings.

* + - * 1. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.

Install bus horizontally, on insulated spacers 2 inches minimum from wall, 6 inches above finished floor unless otherwise indicated.

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.

* + - * 1. Conductor Terminations and Connections:

Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.

Underground Connections: Welded connectors except at test wells and as otherwise indicated.

Connections to Ground Rods at Test Wells: Bolted connectors.

Connections to Structural Steel: Welded connectors.

* + - 1. GROUNDING AT THE SERVICE
         1. 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.
      2. GROUNDING SEPARATELY DERIVED SYSTEMS

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

* + - * 1. 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.
      1. GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS
         1. 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."

* + - * 1. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 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 from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, nonshrink grout.
        2. 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. 4 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.

* + - * 1. 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 tinned-copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches from the foundation.
      1. 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.

* + - * 1. Install insulated equipment grounding conductors with all feeders and branch circuits.
        2. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:

Retain applicable subparagraphs below.

Feeders and branch circuits.

Lighting circuits.

Receptacle circuits.

Single-phase motor and appliance branch circuits.

Three-phase motor and appliance branch circuits.

Flexible raceway runs.

Armored and metal-clad cable runs.

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.

X-Ray Equipment Circuits: Install insulated equipment grounding conductor in circuits supplying x-ray equipment.

* + - * 1. 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.
        2. 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.
        3. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.
        4. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

"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.

* + - * 1. 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.

See the Evaluations for discussion of fence grounding.

* + - * 1. Metallic Fences: Comply with requirements of IEEE C2.

Grounding Conductor: Bare [**, tinned**] copper, not less than [**No. 8**] <**Insert number**> AWG.

Gates: Shall be bonded to the grounding conductor with a flexible bonding jumper.

Barbed Wire: Strands shall be bonded to the grounding conductor.

* + - 1. FENCE GROUNDING

Retain this article if fences and gates require grounding. See the Evaluations for other considerations.

Retain "Fence Grounding" paragraph below if fence other than that enclosing electrical distribution equipment is to be grounded.

* + - * 1. Fence Grounding: Install at maximum intervals of [**1500 feet**] <**Insert a lesser distance if grounding resistance is high**> except as follows:

Fences within 100 Feet of Buildings, Structures, Walkways, and Roadways: Ground at maximum intervals of [**750 feet**] <**Insert a lesser distance if grounding resistance is high**>.

Gates and Other Fence Openings: Ground fence on each side of opening.

Bond metal gates to gate posts.

Coordinate subparagraph below with Drawings for projects where intentional discontinuities are provided in metal-fencing conductivity to localize lightning effects to the vicinity of strokes.

Bond across openings, with and without gates, except at openings indicated as intentional fence discontinuities. Use No. 2 AWG wire and bury it at least 18 inches below finished grade.

* + - * 1. Protection at Crossings of Overhead Electrical Power Lines: Ground fence at location of crossing and at a maximum distance of 150 feet on each side of crossing.

Coordinate "Fences Enclosing Electrical Power Distribution Equipment" paragraph below with electrical design. Plans and details on Electrical Drawings may revise or illustrate application of requirement below or may require grounding that exceeds minimum requirements in IEEE C2. Fences enclosing electrical substations are often bonded to a station grounding mat.

* + - * 1. Fences Enclosing Electrical Power Distribution Equipment: Ground as required by IEEE C2 unless otherwise indicated.
        2. Grounding Method: At each grounding location, drive a grounding rod vertically until the top is 6 inches below finished grade. Connect rod to fence with No. 6 AWG conductor. Connect conductor to each fence component at grounding location.
        3. Bonding Method for Gates: Connect bonding jumper between gate post and gate frame.

Retain "Bonding to Lightning-Protection System" paragraph below if fencing terminates at a building or other structure equipped with lightning-protection system.

* + - * 1. Bonding to Lightning-Protection System: If fence terminates at lightning-protected building or structure, ground the fence and bond the fence grounding conductor to lightning-protection down conductor or lightning-protection grounding conductor, complying with NFPA 780.
      1. INSTALLATION
         1. 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.
         2. 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.
         3. Ground Rods: Drive rods until tops are 2 inches below finished floor or final grade unless otherwise indicated.

Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.

Use exothermic welds for all below-grade connections.

Retain subparagraph below if grounding installation requirements are not indicated on Drawings. subparagraph exceeds NFPA 70 requirements.

For grounding electrode system, install at least [**three**] <**Insert number**> rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.

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

* + - * 1. 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.

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.

* + - * 1. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.

Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.

Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.

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.

* + - * 1. Grounding and Bonding for Piping:

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. Bond metal grounding conductor conduit or sleeve to conductor at each end.

Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.

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.

* + - * 1. 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.
        2. 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.

See the Evaluations for discussion on ground rings.

* + - * 1. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each [**steel column**] [**indicated item**], extending around the perimeter of [**building**] [**area or item indicated**].

Install tinned-copper conductor not less than [**No. 2/0**] <**Insert number**> AWG for ground ring and for taps to building steel.

Bury ground ring not less than [**24 inches**] <**Insert dimension**> from building's foundation.

Retain one of two "Concrete-Encased Grounding Electrode (Ufer Ground)" paragraphs below to require concrete-encased grounding electrode. Concrete shall be in direct contact with the earth. Concrete installed with insulation, vapor barriers, films, or similar items separating the concrete from the earth is not considered to be in "direct contact" with the earth.

* + - * 1. Concrete-Encased Grounding Electrode (Ufer Ground): Fabricate according to NFPA 70; use a minimum of [**20 feet**] <**Insert dimension**> of bare copper conductor not smaller than [**No. 4**] <**Insert number**> AWG.

If concrete foundation is less than [**20 feet**] <**Insert dimension**> long, coil excess conductor within base of foundation.

Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building's grounding grid or to grounding electrode external to concrete.

* + - * 1. Concrete-Encased Grounding Electrode (Ufer Ground): Fabricate according to NFPA 70; using electrically conductive coated steel reinforcing bars or rods, at least 20 feet long. If reinforcing is in multiple pieces, connect together by the usual steel tie wires or exothermic welding to create the required length.
        2. Connections: 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.

Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.

Make connections with clean, bare metal at points of contact.

Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.

Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.

Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

* + - 1. 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.

* + - * 1. 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.

* + - * 1. Manufacturer's Field Service: Engage a Company Service Advisor 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.

* + - * 1. Perform tests and inspections [**with the assistance of a Company Service Advisor**].

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

* + - * 1. Tests and Inspections:

After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.

Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.

Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal [**, at ground test wells**] [**, and at individual ground rods**]. Make tests at ground rods before any conductors are connected.

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.

Perform tests by fall-of-potential method according to IEEE 81.

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

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.

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

* + - * 1. Prepare test and inspection reports.
        2. 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.

Power and Lighting Equipment or System with Capacity of 500 kVA and Less: [**10**] <**Insert value**> ohms.

Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: [**5**] <**Insert value**> ohms.

Power and Lighting Equipment or System with Capacity More Than 1000 kVA: [**3**] <**Insert value**> ohms.

Power Distribution Units or Panelboards Serving Electronic Equipment: [**1**] [**3**] <**Insert value**> ohm(s).

Substations and Pad-Mounted Equipment: [**5**] <**Insert value**> ohms.

Manhole Grounds: [**10**] <**Insert value**> ohms.

<**Insert application and maximum ground-resistance value**> ohms.

* + - * 1. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION 260526