PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The general conditions, Division 26, and Basic Electrical Materials and Methods (Section 260500) are part of this section and the contract for this work and apply to this section as fully as if repeated herein.

B. Reference to other sections: The applicable requirements from other Division 26 sections required for a complete and operational system shall form a part of the electrical work and each section shall be thoroughly reviewed by the Contractor for application to all other sections.

1.2 SCOPE

A. Permanently and effectively ground conduit systems, supports, cabinets, switchboards, equipment cases, motor frames, lighting standards, landscape lighting, etc., and system neutral conductors per National Electrical Code.

B. Grounding details, symbols and singlelines shown on plans are schematic only. If additional equipment, such as ground rods, clamps, conductors, etc., is required per National Electrical Code furnish and install without additional cost to Owner.

C. Section includes grounding and bonding systems and equipment, plus the following special applications:
   1. Underground distribution grounding.

1.3 QUALITY ASSURANCE AND STANDARDS

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

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

1.4 SUBMITTALS

A. Submit shop drawings per Section 260500 for review.

B. Manufacturer’s data on grounding and bonding products and associated accessories.

C. Informational Submittals
   1. As-Built Data: Plans showing dimensioned as-built locations of grounding features specified in "Field Quality Control" Article, including the following:
      a. Ground rods.
      b. Grounding arrangements and connections for separately derived systems.

D. Closeout Submittals
   1. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals.

a. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
   1) Instructions for periodic testing and inspection of grounding features at grounding connections for separately derived systems based on NETA MTS.
      a) Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
      b) Include recommended testing intervals.

1.5 ACCEPTABLE MANUFACTURERS

A. Burndy Corporation

B. Cadweld Division

C. Crouse-Hinds

D. Thomas and Betts Corporation

E. Okonite Company

F. Tecto Weld

PART 2 - PRODUCTS

2.1 GROUNDING MATERIAL

A. Rod Electrode: Material to be copper clad steel rod, 3/4 inch diameter with minimum 10 feet length.

B. Mechanical Connectors: Material shall be copper and of sound continuity when installed.

C. Exothermic Connectors: Material shall be of low emission, electric-start type and of sound continuity when installed.

D. Bare Ground Conductors
   1. Conductor shall be 7-strand annealed copper.
   2. Individual members of stranded conductor shall meet the requirements of ASTM B-3.
   3. Stranded conductors shall be assembled in accordance with the requirements of ASTM B-8.
   4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
   5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.

E. Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

F. Insulated Conductor (Equipment grounding conductor)

1. Size in accordance with CEC Article 250 unless otherwise shown as oversized.

G. Grounding Well Components
1. Well Pipe: Material shall be 8 inch diameter by 24 inch long concrete pipe with belled end.
2. Well Cover: Material shall be cast iron with the text "GROUND" embossed on cover.

H. Ground Bus Bar
1. ASTM B187, 98% conductivity copper bus bar, size 4 inches wide by 1/4inch thick by 24 inches long. 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.

I. Terminal Lugs
1. For 4/0 AWG and smaller conductors: Copper compression lugs.
2. For 250kcmil and larger: Aluminum mechanical lugs.

J. Bonding Plates, Connectors, Terminals and Clamps
1. Bonding Plates, Connectors, Terminals and Clamps: Provide electrical bonding plates, connectors, terminals, lugs and clamps as recommended by bonding plate, connector, terminal and clamp manufacturers for indicated applications.
2. 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.
3. Bolted Connectors for Conductors and Pipes: Copper or copper alloy.
4. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
5. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless exothermic-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

K. Jumpers
1. Copper braided or leaf-type flexible jumper, size as necessary.

L. Bus Bar Insulators
1. Fiberglass reinforced polyester insulator with 2 inch diameter threaded holes at both ends for bus bar installation.

M. Electrical Grounding Connection Accessories
1. Electrical Grounding Connection Accessories: Provide electrical insulating tape, heat-shrinkable insulating tubing, welding materials, bonding straps, as recommended by accessories manufacturers for type service indicated.

N. Field Welding
1. Field Welding: Comply with AWS Code for procedures, appearance, and quality of welds; and for methods used in correction welding work. Provide welded connections where grounding conductors connect to underground grounding and plate electrodes.

O. Grounding Resistors
1. Provide a low-resistance grounding resistor in compliance with the latest IEEE-32 standard.
2. Temperature rise shall not exceed 760 degrees C above an ambient temperature of 30 degrees C for a ten-second duration.
3. Neutral grounding relays shall be set to protect the resistor and clear the fault within ten-seconds.
4. For resistors above 600V, an applied high potential test shall be performed equal to 2.25 times the rated voltage, plus 2000 volts.
5. Grounding resistors shall be UL or CSA listed and labeled.

PART 3 - EXECUTION

3.1 GENERAL

A. Install electrical grounding and bonding systems as indicated, in accordance with manufacturer's instructions and applicable portions of CEC, NECA's Standard of Installation, and in accordance with recognized industry practices to ensure that products comply with requirements.

B. Coordinate with other electrical work as necessary to interface installation of electrical grounding and bonding system work with other work.

C. Ground each separately-derived system neutral to nearest cold water piping and electrically continuous building steel.

D. Connect together system neutral, service equipment enclosures, electrically continuous building steel, exposed non-current carrying metal parts of electrical equipment, metal raceway systems, grounding conductor in raceways and cables, receptacle ground connectors, and plumbing systems.

E. Apply corrosion-resistant finish to field-connections, buried metallic grounding and bonding products, and places where factory applied protective coatings have been destroyed, which are subjected to corrosive action.

3.2 APPLICATIONS

A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.

B. Underground Grounding Conductors: Install bare copper conductor, No. 2/0 AWG minimum.
1. Bury at least 24 inches below grade.
2. Duct-Bank Grounding Conductor: Bury 12 inches above duct bank when indicated as part of duct-bank installation.

~~C. Isolated Grounding Conductors: Green-colored insulation with 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.~~

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

1. Install bus horizontally, on insulated spacers 2 inches minimum from wall, 6-24 inches above finished floor unless otherwise indicated.
2. 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.

~~E.~~D. Conductor Terminations and Connections:
1. Pipe and Equipment Grounding Conductor Terminations (above ground and accessible): Bolted connectors.
2. Pipe and Equipment Grounding Conductor Terminations (underground and inaccessible locations): Exothermic connectors.
3. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
4. Connections to Ground Rods at Test Wells: Bolted connectors.
5. Connections to Structural Steel: Welded connectors.

3.3 GROUNDING AT THE SERVICE

A. Provide service ground bar consisting of a copper bus bar with a minimum of six ground studs,. See details on drawings. ~~Terminate all ground conductors at service ground box. Locate at accessible location in main electrical room or as otherwise indicated. Engrave cover "Service Ground Electrode". Where additional ground boxes are indicated, provide similar construction.~~

B. Ufer Ground (Concrete-Encased Grounding Electrode): Fabricate according to NFPA 70; use a minimum of 30 feet of bare copper conductor not smaller than size shown in Service Ground Conductor Table.
1. Extend full length and embed along bottom of building concrete foundation in direct contact with earth, supported to provide 2” concrete encasement minimum. If concrete foundation is less than 30 feet long, coil excess conductor within base of foundation.
2. Bond grounding conductor to reinforcing steel in at least four locations.
3. Extend to foundation reinforcing steel.

C. Provide, in accessible location, exothermic bond to a minimum of two steel columns or to reinforcing of two concrete columns with insulated ground conductor in steel conduit to service ground box.

D. 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. Bond metal grounding conductor conduit or sleeve to conductor at each end.
2. Water Meter Piping: Use bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

~~E. Extend neutral and equipment ground from service switchboard or switchgear (ahead of service mains and neutral bus link) with insulated conductor in steel conduit to ground box.~~

~~F.~~E. Extend separately derived system grounds to ground bus bar when located in same building as service. In separate buildings, provide separate service grounds.

~~G.~~F. Service Ground Conductor: Per the NEC

~~Service (or Transformer Secondary) Amperes~~	~~Embedded AWG~~	~~Cold Water & Service Ground Conduit - AWG~~
~~400A and Less~~	~~1/0~~	~~1" – 1/0~~
~~500A - 800A~~	~~2/0~~	~~1" – 2/0~~
~~900A - 2000A~~	~~4/0~~	~~1" – 4/0~~
~~2500A & Larger~~	~~500 KCMIL~~	~~1 ¼" – 500 KCMIL~~

~~H.~~G. Where required to obtain specified resistance to ground, drive additional ground rods, number as required, and connect to ground bus bar with insulated conductor in steel conduit.

~~I. Where ground loop is provided in main electrical room, extend both ends of loop conductor to service ground box in steel conduit.~~

3.4 GROUNDING SEPARATELY DERIVED SYSTEMS

A. Ground transformers and uninterruptible power supplies from neutral bus or bushing to main service ground at service ground box. In electrical rooms remote from the service ground, provide separately derived system grounds

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.

C. For electrical rooms in contact with grade, provide 25' length of bare copper conductor embedded along bottom of closest 30' or longer building concrete foundation and extend to ground main ground bar~~box~~ located in electrical room, as described for service ground. Bond ~~from ground box~~main ground bar to cold water pipe (2" minimum), and to steel beam or column with insulated conductor in steel conduit.

D. For electrical rooms above grade, provide ground as for rooms on grade to ~~ground box~~main ground bar located in the closest electrical room on grade or in location as indicated. Extend transformer and/or generator ground to grade level ~~ground box~~main ground bar.

E. Where foundation embedded ground is not practical, provide, where acceptable to enforcing agency, a minimum of four driven rods located at the corners of the room and made accessible through hand holes. Loop a bare copper cable (sized for largest transformer) below the slab. Ground from ~~ground box~~main ground bar to cold water pipe (2" minimum) and steel beam or column with insulated conductor in steel conduit.

3.5 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Comply with IEEE C2 grounding requirements.

~~B. 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.~~

~~C.~~B. 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.

~~D.~~C. 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.

3.6 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits.
1. Terminate each end on suitable lug, bus, bushing or device.
2. For parallel feeders or circuits, run ground in each conduit. Refer to schedule on drawings.
3. For lighting circuits, connect ground wire to fixture ground lead where available or bond to fixture housing by mechanical means.
4. Connect grounding conductors to ground busses in panels, motor control centers and switchboards, and to terminals on devices, and bond to all equipment.
5. Bond feeder grounds to all metallic pull and junction boxes if feeder is spliced in the junction box.
6. Provide copper ground conductor, sized not less than following (up to 600V systems):

Circuit Device Setting (Amperes)	Up to 20	25 to 60	70 to 100	110 to 200	225 to 500	550 to 600	700 to 800
Ground Conductor Size (AWG)	12	10	8	6	2	1	1/0

B. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

C. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install 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.

~~D. Gas and Sprinkler Piping Systems: Install a separate insulated equipment grounding conductor to each system. Bond conductor to piping, connected equipment, and components.~~

~~E. 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.~~

~~F.~~D. 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.

~~G.~~E. Poles Supporting Outdoor Lighting Fixtures: Install grounding conductor with branch-circuit conductors.

3.7 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 Rods: Drive rods until tops are 2 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. For grounding electrode system, install at least three 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.

C. 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. Test Wells: 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.

D. 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.

~~E. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Installbonding jumper to bond across flexible duct connections to achieve continuity.~~

~~F.~~E. Install ground clamps specifically designed for grounding purposes. Where grounded conductor is in conduit, use ground clamp which grounds both conductor and conduit. Strap metal is not acceptable for grounding and bonding.

~~G.~~F. Grounding bushing shall be used wherever conduits are grounded.

~~H.~~G. Motors or equipment rated at 480V shall have bonded ground jumpers from feeder conduit to motor frame.

~~I.~~H. Provide grounding well pipe with cover at rod locations where indicated. Install well pipe top flush with finished grade.

~~J. Isolated Ground~~
   ~~1. Provide isolated grounding conductor for circuits supplying isolated ground receptacles. Ground conductor will be sized per CEC unless otherwise noted to be of larger size.~~
   ~~2. Isolated ground conductor shall be routed through panel and to transformer ground for 208V or 120V systems. Isolated ground shall be routed to distributed rod electrode for 480V or 277V systems.~~

3.8 GROUND RESISTANCE TESTING

A. Perform tests and inspections as stipulated in Section 260400 “Acceptance Testing”.

END OF SECTION