SECTION 16020 - ELECTRICAL WORK

PART 1 - GENERAL

1.1 GENERAL CONDITIONS

A. By executing the Contracting, the Contractor represents that he has visited the site, familiarized himself with the local conditions under which the work is to be performed, and correlated his observations with the requirements of the Contract Documents.

B. PERMITS, FEES, AND NOTICES

1. Unless otherwise provided in the Contract Documents, the Contractor shall secure and pay governmental fees, licenses, and inspections necessary for the proper execution and completion of the work which are customarily secured after execution of the Contract and which are legally required at the time bids are received.
2. The Contractor shall give all notices and comply with all laws, ordinances, rules, regulations and lawful ordinances of any public authority bearing on the performance of the work.

1.2 CUTTING AND PATCHING OF THE WORK

A. The Contractor shall be responsible for all cutting, fitting and patching that may be required to complete the work or to make its several parts fit together properly.

B. Where conflicts occur between the plans and specifications the more restrictive applies.

1.3 SCOPE OF WORK

A. Work to be done under this section includes, but is not limited to, furnishing of all labor, material, equipment and services necessary for proper completion of all electrical work as shown on the drawings and specified herein. In general, this consists of wiring for light and power, provision of wiring telephone and miscellaneous electric systems, and the installation of lighting fixtures and any other equipment as hereinafter specified. Electrical work shall be furnished with all wiring, conduit, fittings, equipment and connections, as specified or required, to make a complete and functioning system.

B. Omission of express reference to any parts necessary for, or reasonably incidental to, a complete installation shall not be construed as releasing Contractor from furnishing such parts. The electrical system as supplied shall be complete and functioning, with all electrical items furnished in operable condition.

1.4 ORDINANCES AND REGULATIONS

A. All apparatus and materials installed under this Contract shall be designed to comply with, and be installed in accordance with the National Electrical Code. Also, with any and all of the requirements of the legally constituted authorities having jurisdiction, including all local ordinances, safety orders of the State Division of Industrial Safety, State and Local Fire Marshal.

B. It is recognized that the Code specifies minimum standards and whenever Drawings or Specifications call for materials, workmanship, arrangement or construction of quality or standards higher than the Code, Drawings or Specifications shall take precedence. In the event that Drawings or Specifications call for a quality or standard lower than the Code, the Code shall govern.

1.5 VERIFICATION OF DIMENSIONS

A. All scaled and figured dimensions are approximate and are given for estimate purposes only. Before proceeding with any work, carefully check and verify all dimensions, sizes, etc., and assume full responsibility for the fitting in of all the equipment and materials to other parts of the equipment, and to the structure.

B. All discrepancies between Electrical, Structural and Mechanical drawings shall be reported to the Engineer.

1.6 EXAMINATION OF DRAWINGS

A. Carefully study all Drawings, Specifications, etc., pertaining to work, and if any of the work is laid out or as indicated is contrary to, or conflicts with, any local, city, state, or national ordinances, the same shall be reported to the Engineer before submitting bid.

B. By the act of submitting a proposal for the work included in this Section, the Contractor is deemed to have made such study and is familiar with and accepts all conditions at the site.

1.7 STANDARDS OF MATERIAL AND WORKMANSHIP

A. All material shall be new and listed by the Underwriters' Laboratories as conforming to its standards in every case where such a standard has been established for the particular type of materials in question. All work shall be executed in a workmanlike manner, and shall present a neat appearance when completed.

B. Each length of conduit, outlet, switch, or junction box must bear the manufacturer's name or trademark plainly stamped on or in the metal or attached thereto.

1.8 PRELIMINARY OPERATION

A. The electrical system shall not be energized and no equipment shall be operated prior to the completion of testing.

PART 2 - PRODUCTS

2.1 CONDUIT

A. Flexible Steel Conduit

1. Shall be used in runs from adjacent junction boxes to motors, and in locations where, for structural or other reasons, it is impractical to use steel tube and where approved by the Architect. In these cases, the flexible conduit shall be American Brass "Sealtite Flexible," or Columbia "Flex-Seal," type UA with Appleton Flexible fittings series ST or equal Kellum.

B. Rigid Galvanized Steel Conduit: ANSI C80.1.Conduit

1. Conduit to be standard I.P.S., hot-dipped galvanized or sheradized threaded steel conduit with zinc-coated threads and protective caps.
2. Fittings to be threaded-type galvanized malleable iron or heavy steel, water and concrete tight. Use grounding-type Locknuts (Type GL) and insulated bushings (Type GB) for all connectors at cabinets, boxes and gutters. Set screw connectors are not acceptable. Conduit bodies shall be malleable iron or steel. Die cast bodies shall not be used.
3. Bushings and locknuts shall be malleable iron with sharp clean-cut threads.
4. When RGS conduit is buried in or in contact with earth, it shall have a plastic jacket, a bitumastic coating, or half-lapped with 20 mil pipe wrapping tape with sealant applied to all joints.

C. Electrical Metallic Tubing (EMT)

1. Shall be used in dry places such as stud partitions and furred ceiling spaces, continuous from outlet to outlet to panelboard. The connectors used shall be of watertight type. No EMT larger than 2 inches ID shall be used. No setscrew type fittings will be acceptable.

D. Rigid Nonmetallic Conduit

1. Rigid polyvinyl chloride shall be Schedule 40 PVC, 90°C. Plastic conduit joints shall be made up in accordance with the manufacturer's recommendations. Conduit joint couplings shall be made watertight.

2.2 WIRE AND CABLE

A. Shall be 600 volt, manufactured by General Cable Corporation, Alcan Products Corporation, American Insulated Wire Corp., Southwire Company, Okonite, or approved equal. All wire shall be delivered to job in unbroken packages, and each package shall bear the manufacturer's labels, showing date of manufacture, description of product, and footage within the package.

B. All wire in accordance with the National Electric Code and 600 volt class. Wire smaller than No. 6, may be solid conductor; No. 6 and larger wires shall be stranded conductor. Minimum wire size No. 12 AWG, unless noted otherwise. All wire shall be copper.

C. Wires shall be marked as per the NEC requirements.

D. Colored plastic tape may be used in lieu of continuously colored conductor insulation for conductors larger than No. 6. Each conductor shall have at least 3-one inch band (separated by 4 inches) at every terminations and splice.

E. Splices and taps shall not be made in any conductor except at outlet boxes, pull boxes, junction boxes and panelboards. Boxes shall be approved for use.

F. Furnish and install nylon pull cord in every empty raceway installed hereunder, to facilitate the future installation of wires. Identify each terminus of pull cord with linen tags with complete information as to service and the location of the other terminus of wire.

G. Wiring shall be color coded in accordance to the amendments to the NEC adopted by Pima County.

2.3 OUTLETS, JUNCTION BOXES, AND SWITCH BOXES

A. Shall be galvanized code gage steel of a type and size to satisfy the specifications and requirements at each outlet. Galvanized malleable iron boxes shall be used in the exposed wiring in the building, and where exposed to weather.

B. General purpose junction boxes and device boxes shall be one-piece galvanized pressed steel knockout type with similar cover, and not less than 4-inch square. No sectional boxes shall be permitted, except at single pole switch locations with only 2 conductors.

C. All gang boxes for devices shall be designed specifically for the number of devices indicated.

D. Boxes for exterior devices shall be cast FD type with gasketed covers.

E. Boxes located within hazardous locations shall comply with Specification Section 16113.

2.4 CABINETS AND ENCLOSURES

A. Steel enclosure with continuous hinge cover and flush latch. Finish inside and out with manufacturer's standard enamel.

B. Galvanized steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel. Hinged doors in front cover with flush latch and concealed hinge. Key latch to match panelboards. Include metal barriers to separate wiring of different systems and voltage, and include accessory feet where required for freestanding equipment..

2.5 DISCONNECTS

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. General Electric.

2. Siemens.
3. Cutler-Hammer.
4. Square D.

B. Provide motor rated snap switch, with thermal overload element, complete with pilot light and single pole toggle switch for all fractional horsepower motors.

C. Disconnecting devices, when not included with electrically operated equipment furnished under other section of specifications shall be provided under this Section.

2.6 PANELBOARDS

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. General Electric Company, GE Consumer & Industrial – Electrical Distribution.
2. Siemens Energy & Automation, Inc.
3. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
4. Square D; a brand of Schneider Electric.

B. Panel directories shall be updated and typed indicating exactly what each circuit controls.

C. Interrupting rating shall be equal to or greater than integrated equipment rating shown on the plans. Series ratings are not approved.

D. Panelboard directories shall have a metal frame with plastic cover mounted on inside of cabinet door. Directory shall be a typed list of circuit showing exactly what each circuit controls. Odd numbering down left side and even numbering down right side.

E. Provide new typed panelboard directory for panels being revised or rewired.

2.7 LIGHTING

A. All lighting fixtures shall be furnished complete with mounting accessories to suit the specific service intended.

B. Fixtures scheduled to be surface mounted shall be furnished and installed employing supports, toggle bolts and any other accessories, which, in the opinion of the Owner's representative are required to adequately support the fixtures.

C. HID and fluorescent fixtures shall comply with UL 1598.

D. Factory Applied Labels: Comply with UL 1598. Include recommended lamps and ballasts. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. "USE ONLY" and include specific lamp type.

2. Lamp type, wattage, bulb type (ED17, BD56, etc.) and coating (clear or coated) for HID luminaries.
3. ANSI ballast type (M98, M57, etc.) for HID luminaires.
4. CCT and CRI for all luminaires.

2.8 BALLASTS

A. HID high pressure sodium ballasts shall be electromagnetic type, with solid state igniter/starter. Igniter/starter shall have an average life in pushing mode of 10,000 hours at an igniter/starter case temperature of 90 degree C.

1. Minimum starting temperature shall be minus 40 degree F to 130 degree F. Outdoor fluorescent ballast shall also meet this requirement.

B. HID ballasts shall be individually fused with Bussman type "GLR" or "GMF" fuses in an "HLR" holder. Fuse ratings shall be as recommended by the fixture manufacturer for the voltage, number and type of lamps. Fuses shall be externally accessible.

2.9 LAMPS

A. Provide lamps for each fixture. Lamps shall be compatible with the ballasts as the ballast manufacturer recommends.

B. Provide pilot, annunciator and other miscellaneous lamps for products furnished as a part of the electrical work.

C. HID Lamps

1. High Pressure Sodium Lamps: ANSI C78.42, CRI 21 (minimum), color temperature 1900 K, and average rated life of 24,000 hours, minimum.

PART 3 - EXECUTION

3.1 INSTALLATION OF CONDUIT

A. Unless otherwise noted, all wiring of every description shall be run in conduit, including low voltage work. Conduit, except as otherwise specifically noted, shall be run concealed. Exposed conduit shall be run parallel with supporting wall, beam, or ceiling and with each other, with right angle runs consisting of metal fittings (LB condulets shall not be used for conduits larger than 1-1/4 inches ID) or symmetrical bends. All runs of conduit shall be installed in such a manner as to avoid trapped condensation. No junctions or splices in wire shall be made in condulets.

B. All controls apparatus, outlet boxes, junction and pull boxes, and other similar equipment shall be installed and maintained in accessible positions and locations.

C. All conduit supports shall be spaced not over 8 feet 0 inches on center, or supported to the building construction with approved pipe straps, spaced not to exceed 8 foot 0 inch intervals, or

approved hangers. Install clamps within 1 foot from boxes. Conduit larger than 1-1/2 inch shall be supported with approved pipe straps.

D. A nylon pull cord shall be installed in all wiring raceways which do not have conductors pulled by this Contract.

E. Conduit generally shall be RGS with threaded-type fittings unless specified otherwise on drawing. Conduit to motors shall be flexible steel.

F. Install conduit parallel to structure.

3.2 JUNCTION AND PULLBOXES

A. Pullboxes shall be installed in all conduit runs wherever indicated, and where necessary, in order to facilitate the pulling of wires or cables. All junction and pullboxes shall be as specified elsewhere in this specification or on drawings. Boxes shall be securely supported independent of conduit supports.

3.3 OUTLET BOXES

A. For local switch outlets use 4 inch square boxes with switch plaster rings for one or two gangs, and special gang boxes with gang cover for more than two switches.

B. For convenience outlets, switch, telephone, and intercommunication system outlets, use 4 inch square or larger, pressed steel boxes with plaster rings. Handy boxes may not be used.

3.4 TAGGING AND LABELING

A. All branch circuits shall be left tagged in the panelboards for the purpose of distinguishing the various circuits. Tag all feeders and mains in all pullboxes, in the panels, and in the switchboard. Use tags of plastic sticky back type, plainly pre-marked with indelible ink.

B. Self-adhesive vinyl labels for raceways carrying circuits at 600V or less shall be preprinted, flexible label laminated with a clear, weather and chemical resistant coating and matching wraparound adhesive tape for securing ends of legend label.

C. Snap-around, color-coding bands for raceways carrying circuits 600V or less shall be slit, pretensioned, flexible, solid colored acrylic sleeve, 2 inches long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

D. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

E. Coordinate installation of identifying devices with location of access doors and panels.

F. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each size raceway.

3.5 UNDERGROUND-LINE WARNING TAPE

A. Common trenching and tape laying methods are hand, static plow, and vibratory plow. Revise options in this article if only specific trenching methods are allowed.

B. Tape:

1. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
2. Printing on tape shall be permanent and shall not be damaged by burial operations.
3. Tape material and ink shall be chemically inert, and not subject to degrading when exposed to acids, alkalis, and other destructive substances commonly found in soils.

3.6 GROUNDING

A. Connect all electrical equipment to ground system as directed. All conduits entering panels and the panels themselves shall be adequately grounded to building ground system.

B. All electrical apparatus, either stationary or portable, must be adequately grounded by this Contractor, either by direct connection from frame of the apparatus or an approved ground wire connected securely to the conduit, or by an approved grounded flexible cord through an approved cap and receptacle.

C. Refer to specification section 16450.

3.7 CLEANING AND PAINTING

A. Respective Contractors or subcontractors for various phases of electrical work shall clear away all debris, surplus materials, etc., resulting from their work or operations, leaving job and equipment furnished under any or all Contracts in a clean and first class condition.

B. Exterior and interior reflecting and transmitting surfaces of lighting fixtures shall be cleaned so as to be reasonably free from construction debris and dust.

C. Finish painting of all exposed electrical material and equipment is the sole responsibility of this Contractor.

3.8 SUBMITTALS & SUBSTITUTIONS

A. Submit shop drawings, brochures and schedules.

3.9 GUARANTEE

A. Fully guarantee all materials and work under this Section, for a period of two years from the date of final acceptance by the Owner, against imperfect workmanship or failure or malfunction of materials and/or equipment due to faulty or imperfect workmanship. Give this guarantee in wiring to the Owner at the time of issuing final certificate. Work found to be defective within this period shall be replaced without cost to the Owner.

END OF SECTION 16020

SECTION 16075 - ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Identification for raceways.
2. Identification of power and control cables.
3. Identification for conductors.
4. Underground-line warning tape.
5. Warning labels and signs.
6. Instruction signs.
7. Equipment identification labels.
8. Miscellaneous identification products.

1.3 ACTION SUBMITTALS

A. Product Data: For each electrical identification product indicated.

1.4 QUALITY ASSURANCE

A. Comply with ANSI A13.1.

B. Comply with NFPA 70.

C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.

D. Comply with ANSI Z535.4 for safety signs and labels.

1.5 COORDINATION

A. Coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual; and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.

B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

C. Coordinate installation of identifying devices with location of access panels and doors.

D. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 CONDUCTOR IDENTIFICATION MATERIALS

A. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

B. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

C. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches (50 mm) long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

D. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.

2.2 FLOOR MARKING TAPE

2.3 UNDERGROUND-LINE WARNING TAPE

A. Tape:

1. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
2. Printing on tape shall be permanent and shall not be damaged by burial operations.
3. Tape material and ink shall be chemically inert, and not subject to degrading when exposed to acids, alkalis, and other destructive substances commonly found in soils.

B. Color and Printing:

1. Comply with ANSI Z535.1 through ANSI Z535.5.
2. Inscriptions for Red-Colored Tapes: ELECTRIC LINE, HIGH VOLTAGE.

3. Inscriptions for Orange-Colored Tapes: COMMUNICATIONS CABLE or OPTICAL FIBER CABLE.

2.4 WARNING LABELS AND SIGNS

A. Comply with NFPA 70 and 29 CFR 1910.145.

B. Self-Adhesive Warning Labels: Factory-printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.

C. Baked-Enamel Warning Signs:

1. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application.
2. 1/4-inch (6.4-mm) grommets in corners for mounting.
3. Nominal size, 7 by 10 inches (180 by 250 mm).

2.5 EQUIPMENT IDENTIFICATION LABELS

A. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm).

B. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm). Overlay shall provide a weatherproof and UV-resistant seal for label.

C. Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with white letters on a dark-gray background. Minimum letter height shall be 3/8 inch (10 mm).

D. Engraved, Laminated Acrylic or Melamine Label: Punched or drilled for screw mounting. White letters on a dark-gray background. Minimum letter height shall be 3/8 inch (10 mm).

2.6 CABLE TIES

A. General-Purpose Cable Ties: Fungus inert, self extinguishing, one piece, self locking, Type 6/6 nylon.

1. Minimum Width: 3/16 inch (5 mm).
2. Tensile Strength at 73 deg F (23 deg C), According to ASTM D 638: 12,000 psi (82.7 MPa).
3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
4. Color: Black except where used for color-coding.

B. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self extinguishing, one piece, self locking, Type 6/6 nylon.

1. Minimum Width: 3/16 inch (5 mm).
2. Tensile Strength at 73 deg F (23 deg C), According to ASTM D 638: 12,000 psi (82.7 MPa).
3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
4. Color: Black.

C. Plenum-Rated Cable Ties: Self extinguishing, UV stabilized, one piece, self locking.

1. Minimum Width: 3/16 inch (5 mm).
2. Tensile Strength at 73 deg F (23 deg C), According to ASTM D 638: 7000 psi (48.2 MPa).
3. UL 94 Flame Rating: 94V-0.
4. Temperature Range: Minus 50 to plus 284 deg F (Minus 46 to plus 140 deg C).
5. Color: Black.

2.7 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Select paint system applicable for surface material and location (exterior or interior).

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Verify identity of each item before installing identification products.

B. Apply identification devices to surfaces that require finish after completing finish work.

C. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.

D. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot (15-m) maximum intervals in straight runs, and at 25-foot (7.6-m) maximum intervals in congested areas.

E. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.

F. Cable Ties: For attaching tags. Use general-purpose type, except as listed below:

1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

G. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8 inches (150 to 200 mm) below finished grade. Use multiple tapes where width of multiple lines installed in a common trench exceeds 16 inches (400 mm) overall.

H. Painted Identification: Comply with requirements in painting Sections for surface preparation and paint application.

3.2 IDENTIFICATION SCHEDULE

A. Accessible Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive vinyl labels with the wiring system legend and system voltage. System legends shall be as follows:
1. Power.

B. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use color-coding conductor tape to identify the phase.

1. Color-Coding for Phase Identification, 600 V or Less: Use colors listed below for ungrounded feeder and branch-circuit conductors.

a. Color shall be factory applied.
b. Colors for 208/120-V Circuits:

1) Phase A: Black.
2) Phase B: Red.
3) Phase C: Blue.

In general, color-coding shall meet the amendments to the NEC as adopted by Pima County.

C. Power-Circuit Conductor Identification, More than 600 V: For conductors in vaults, pull and junction boxes, manholes, and handholes, use nonmetallic plastic tag holder with adhesive-backed phase tags, and a separate tag with the circuit designation.

D. Install instructional sign including the color-code for grounded and ungrounded conductors using adhesive-film-type labels.

E. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.

1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.

2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual.

F. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable.

1. Limit use of underground-line warning tape to direct-buried cables.
2. Install underground-line warning tape for both direct-buried cables and cables in raceway.

G. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch- (10-mm-) high letters for emergency instructions at equipment used for emergency operations.

H. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and the Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.

1. Labeling Instructions:

   a. Indoor Equipment: Engraved, laminated acrylic or melamine label. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high label; where two lines of text are required, use labels 2 inches (50 mm) high.
   b. Outdoor Equipment: Engraved, laminated acrylic or melamine label.
   c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
   d. Unless provided with self-adhesive means of attachment, fasten labels with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.

2. Equipment to Be Labeled:

   a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be engraved, laminated acrylic or melamine label.
   b. Enclosures and electrical cabinets.
   c. Switchboards.
   d. -button stations.
   e. Contactors.
   f. Monitoring and control equipment.

END OF SECTION 16075

SECTION 16113 - ELECTRICAL HAZARDOUS LOCATIONS

PART 1 - GENERAL

1.1 SCOPE

A. Provide all labor, materials, equipment and services to perform all operations required for the complete installation and related work as required in all Contract Documents.

B. This section valid only when considered in total with other Contract Documents. Cross references are for convenience and their inclusion in or omission from any particular section in no way limits scope of particular section or intent of any Contract Document.

1.2 RELATED WORK

1.3 SUBMITTALS

A. Starters.

B. Push Buttons and Control Devices.

C. Disconnect Switches.

D. Motors and Rotating Electrical Equipment.

E. Boxes, Fittings and Flexible Connections.

PART 2 - PRODUCTS

2.1 Provide products for installations in hazardous locations that are classified for the area in which they will be installed.

2.2 Acceptable manufacturers of fittings and devices in hazardous locations are Appleton, Crouse Hinds, Killark and Square "D" or engineer approved equal.

PART 3 - EXECUTION

3.1 Wiring, conduit, starters, push buttons, control devices, fittings and any other electrical equipment installed in areas which are indicated as hazardous or in areas classified as hazardous under Article 500, 501, etc., of the National Electrical Code or the NFPA, shall meet all requirements for these classifications.

3.2 All conduit in an exposed hazardous area shall be standard weight rigid galvanized steel (RGS) conduit and make up joints and connections with threaded fittings having at least five fully engaged threads. Rigid PVC Schedule 40 may be used underground if all sections of the PVC is under two (2) feet of cover as per the NEC. The risers from underground PVC shall be RGS half-lapped with 20 mil pipe wrap where the RGS is in contact with earth or concrete and up to a minimum of 6 inches above grade.

3.3 Use approved flexible metal conduit with approved fittings for flexible connections. Include a separate conductor for grounding.

3.4 Wiring in locations shall conform to the NFPA 70 for Class I, Division 2 hazardous locations as applicable.

3.5 Provide seals in all conduits entering or leaving hazardous areas. Locate seals in each conduit run entering an enclosure for switches, circuit breakers, fuses, relays, resistors or any other apparatus which might produce arcs, sparks or high temperatures. Install seals as close as practicable, but not more than 18 inches from these enclosures.

3.6 Use sealing compound unaffected by surrounding atmosphere or liquids and having a melting point of not less than 93 degrees.

3.7 Use pull and junction boxes approved for installation in hazardous areas.

3.8 Use outlet boxes for devices in hazardous areas integral with the device and factory sealed.

3.9 Do not make up splices and taps in sealing fittings.

3.10 Enclosures for switches, circuit breakers, motor controllers, fuses, push buttons, relays and similar devices shall be approved together with the enclosed apparatus as a complete assembly for use in hazardous areas. Drain fittings shall be provided for enclosures, conduits, motors, etc.

3.11 Motors, generators and other rotating electrical equipment shall be specifically approved for such locations.

END OF SECTION 16113

SECTION 16450 – ELECTRICAL GROUNDING SYSTEM

PART 1 - GENERAL

1.1 SCOPE

A. The Electrical System shall be grounded in accordance with article 250 of the National Electrical Code. All conduit systems, cabinets, junction boxes, motor frames, electrically operated and/or controlled cooling-heating units, miscellaneous equipment, etc., shall be grounded by being connected to a common-neutral grounding system.

B. Resistance between any point on the ground network system and any object in the vicinity, including earth and floors, shall not exceed 25 ohms. Ground resistance measurements of all ground rods shall be made in normally dry weather, not less than 24 hours after rainfall. The Contractor shall submit measured ground resistance to Engineer.

C. If this resistance cannot be obtained with a single rod, additional rods not less than 6 feet on center, or if sectioned type rods are used, additional sections may be coupled and driven with the first rod. If the resistance exceeds 25 ohms measured not less than 48 hours after rainfall, the Engineer shall be notified immediately.

1.2 RELATED WORK

A. The requirements of Section 16020, "Electrical Work," govern the Work specified in this section, where applicable.

1.3 CLOSEOUT SUBMITTALS

A. Instructions for periodic testing and inspection of grounding features at test wells, ground rings based on NFPA 70B.

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

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Thompson Lightning Protection.

B. ERICO.

C. Approved Equal.

2.2 CONDUCTORS

A. All exposed grounding conductors such as bars, straps, cables, flexible jumpers, braids, shunts, etc., shall be bare copper unless specifically noted or approved otherwise.

B. Cable size shall be as required by NEC Code, Section 250, stranded, soft drawn or soft annealed, unless otherwise shown on Plans or specified.

2.3 CONNECTORS AND CLAMPS

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. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, pressure type with at least two bolts.

1. Pipe Connectors: Clamp type, sized for pipe.

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

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

2.4 SOLDER

A. Solder prohibited for connections, except for high voltage cable metallic tape shields.

2.5 MOLDED FUSION WELDS

A. Process shall be "Cadwell," "Metalweld," and Thermoweld."

B. Thermo welding inside clean rooms shall be done utilizing Cadwell Exolon low emission welding process (or approved equivalent).

2.6 HARDWARE

A. All hardware shall be silicon bronze alloy.

B. Make: "Durium," "Everdur."

2.7 GROUND RODS

A. Provide copper clad steel ground rods of 3/4-inch minimum diameter and 10 feet minimum length where driven grounds are called for on drawings.

B. Provide ground rods and pigtails from ground rods to steel columns as shown. Pigtails shall be a minimum #2 stranded copper cable (bare) unless otherwise noted and cadwelded to steel columns and to ground rod. Ground rods shall be minimum of two feet below floor slab.

C. Where more than one ground rod is required, separate by the driven depth of the rods.

D. Ground rods shall not be closer to the building than their driven length.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Bare copper bars, ground rods, cables, fittings, etc., shall not be installed in cinder fill nor shall be covered with soil containing cinders or other corrosive material.

B. Cables shall be installed with enough slack to prevent breaking stresses.

C. All grounding conductors subject to mechanical damage shall be protected by rigid steel conduit or other suitable steel guards and in all cases where so protected shall be permanently and effectively grounded to said enclosure at each end of its length.

D. Where grounding conductors pass through floor slabs, walls, etc., and not encased in metal conduit, they shall be sleeved in transite, fiber, or approved non-metallic conduit.

E. All grounding connections shall have surfaces thoroughly cleaned and brightened up just prior to actually making the connection. Touch-up damaged painted surfaces. Use Nolox or equivalent on all connections. Use "Star" or Belleville-type washers on all bolted connections at lugs.

F. Splices in wire or cable grounding conductors are prohibited.

G. All control transformers shall have one leg of the low voltage side grounded.

H. Make all grounding connections which are to be buried or otherwise normally inaccessible using thermal welds or by using a mechanical connector and brazing over completely. Thermal welds which have puffed up or shown covex surfaces (indicating improper cleaning at the surfaces) are not acceptable. No mechanical connector is required at the thermal weldments.

3.2 GROUND ENHANCEMENT MATERIAL

A. If it is not possible to meet the ground resistance specifications using the system of ground rods, counterpoise loops, etc., or where called for on the plans, provide and install ground enhancement materials as specified herein.

B. Ground Enhancement shall meet all EPA requirements for non-pollution.

C. Ground Enhancement Material shall be ERICO GEM, a Bominate Clay mixture or approved equivalent.

D. For counterpoise installation, spread out enough ground enhancement material in trench bottom to uniformly cover bottom of trench 1-inch deep. Place ground conductor on top of ground enhancement material, securing conductor with earth staples every 3 to 4 feet. Spread more ground enhancement material over ground conductor to completely cover the conductor 1-inch deep. Backfill & compact trench.

E. For ground rod installations, auger a 3-inch or larger diameter hole to a depth of 6 inches less than the length of the ground rod. Place ground rod into augured hole and drive one foot into bottom of the hole. Make connections to ground rod. Pour mixed ground enhancement material into hole around ground rod and fill to top of ground rod. Tamp around ground rod to compact. Backfill hole with soil.

3.3 RACEWAY SYSTEMS

A. All metal supports, metal deck, electrified floor systems, frames, brackets, braces, etc. For any part of the raceway system: panels, switches, boxes, starters, controls, etc., which are not rigidly secured to and in contact with the raceway system, or which are subject to and loosening, shall be bonded to the raceway system, the size of the bonding conductor in accordance with the latest accepted edition of the NEC Table 250-122.

B. Termination of rigid conduit at all boxes, cabinets, and enclosures shall be made up tightly with a double locknut arrangement and a bushing, bushings being of the insulated type where required by NEC.

C. Conduit which runs to or from all boxes, cabinets, or enclosures having concentric or eccentric knockouts which partially perforate the metal around the conduit and hence impair the continuity of system ground circuits shall be provided with bonding jumpers sized in accordance with the latest accepted edition of the NEC Table 250-66 connected between a grounding-type bushing/locknut on the conduit and a groundbus or stud inside the box, cabinet, or enclosure and attached thereto.

D. Where flexible metallic conduit and/or liquid tight conduit is used, a bonding jumper shall be provided, sized in accordance with NEC, or as noted on the drawings.

E. Provide a green ground conductor in all raceways sized according to NEC, or as noted on the drawings.

F. The ground terminal on all convenience receptacles shall be bonded to the box and to the branch circuit-grounding conductor with a bonding jumper to provide good continuity back to the source.

G. Where conduit enters or leaves any electrical enclosure with removable coverplates, provide conduit grounding bushings and bonding jumpers sized in accordance with latest accepted edition of the NEC Table 250-122 between the grounding bushings and the enclosure rigid frame or ground bus.

3.4 INSTALLATION, ATTACHMENT TO STRUCTURAL STEEL

A. Location of attachment bonds of ground conductors shall be at points not subject to mechanical damage, but if possible where accessible for inspection.

B. Attach by molded fusion welding process unless welding is prohibited.

C. Where welding is prohibited, attach by bolting, 7/16-inch hole in steel, 3/8-inch silicon bronze bolt, bolt end peened, steel surface bright and flat prior to bolting, just prior to bolting contact surfaces shall be lightly coated with Vaseline or "NO-OX-ID-A Special." Use Star or Belleville washers and torque connections per SAE.

3.5 SERVICE GROUND

A. Provide a ground rod grid at service entrance as shown on the drawings.

B. Ground the service entrance switchboard ground bus to the building water service and building steel with conductors sized per the latest accepted edition of the NEC Table 250-66.

END OF SECTION 16450