SECTION 26 00 50
GENERAL PROVISIONS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment and incidentals as shown on the Drawings, specified, and required to complete the electrical Work.

B. Coordination:
   1. Review installation procedures, drawings and schedules under other Sections and coordinate with other trades the installation of electrical items that must be installed with or within formwork, walls, partitions, ceilings and panels.
   2. CONTRACTOR shall be responsible for the installation of all conduits, inserts, and other items to be embedded in the concrete, or built into walls, partitions, ceilings, or panels constructed by other contractors. CONTRACTOR shall provide other contractors with detailed plans or sketches of the location of said conduits and other built-in items as may be required. CONTRACTOR shall keep himself fully informed of the construction where conduits and other built-in items are to be installed. CONTRACTOR shall install said conduits and other built-in items in such a manner and within such time periods as will not unnecessarily delay the work of the other contractors.

C. General:
   1. Interpretation of Drawings:
      a. Dimensions shown on the Drawings that are related to equipment are based on the equipment of one manufacturer. Conform the dimensions of the equipment furnished to the space allocated for that equipment.
      b. The Drawings show the principal elements of the electrical Work. They are not intended as detailed working drawings for the electrical Work, but as a complement to the Specifications to clarify the principal features of the electrical systems.
      c. It is the intent of the Drawings and Specifications that all equipment and devices, furnished and installed under this Contract, be properly connected and interconnected with other equipment and devices so as to render the installations complete for successful operation, regardless of whether all the connections and interconnections are specifically mentioned in the Specifications or shown on the Drawings.
      d. It also is the intent of the Contract Documents that similar products be provided by the same manufacturer for uniformity on the Project.

D. Related Sections: CONTRACTOR shall coordinate the requirements of the Work in this Section along with the requirements of the Sections listed below which includes, but is not necessarily limited to, Work that is directly related to this Section.
   1. Section 01 33 00, Submittals.
   2. Section 01 78 23, Operation and Maintenance Data.
   3. Section 03 41 20, Precast Concrete Booster Pump Station (BPS) Building.
   4. Section 26 01 37, Underground Duct Banks.
   5. Section 40 60 04, Process Control System General Requirements.

E. Utilities:
   1. CONTRACTOR shall furnish and install empty conduits for telephone service. Plywood backboards shall be furnished and installed for telephone service, as required by City. Plywood backboards shall be painted with approved fire-retardant paint. CONTRACTOR shall make all arrangements for the telephone lines and pay all fees.

1.2 QUALITY ASSURANCE

A. Requirements of Regulatory Agencies:
   1. Permits: Obtain all permits and pay fees required to commence Work and, upon completion of the Work, obtain and deliver to ENGINEER a Certificate of Inspection and Approval from the State Board of Fire Underwriters or other authority having jurisdiction.
   2. Codes: Material and equipment shall be installed in accordance with the current standards and recommendations of the National Electrical Code (2017), the National Electrical Safety Code and with local codes which apply. Where discrepancies arise between codes, the most restrictive regulation shall apply.
   3. Tests by Independent Regulatory Agencies: Electrical material and equipment shall be new and shall bear the label of the Underwriters' Laboratories, Inc., or other nationally-recognized, independent testing laboratory, wherever standards have been established and label service regularly applies.
   4. Utilities:
   5. Arizona Public Service: Work in connection with the electric service and utility metering shall be done in strict conformance with the requirements of APS.
   6. City, Information Technology Department:

B. Reference Standards: Electrical material and equipment shall conform in all respects to the latest approved standards of the following:
   1. National Electrical Manufacturers Association.
   2. The American National Standards Institute.
   3. The Institute of Electrical and Electronic Engineers.
   4. Insulated Power Cable Engineers Association.
   5. National Electrical Code (NEC).
   6. National Electrical Safety Code (NESC).
   7. City Electrical Code.
   8. City, Information Technology Department.

C. Wiring Coordinator:
   1. Retain the services of a Wiring Coordinator who shall prepare complete point-to-point interconnection wiring diagrams. The diagrams shall identify all external interconnecting wiring associated with all new and modified existing equipment.
   2. Qualifications: Coordinator shall have experience in the development of diagrams of the type specified and shall have served in a similar role on a project of similar size and complexity.
      a. Present qualifications and approach for the project at Pre-submittal Meeting specified under Section 40 60 04, Process Control System General Requirements.
      c. Prepare the items listed below for presentation at the Pre-submittal Meeting. Submit copies to ENGINEER three weeks prior to date of meeting.
      d. List of projects where the Wiring Coordinator developed point-to-point wiring diagrams.
      e. Samples of diagrams that were developed for the listed projects.
      f. Example wiring diagram proposed for the Work with a preliminary list of drawings to be produced.
      g. Plan of how information will be obtained and documented.
   3. Responsibilities:
      a. Develop diagrams for performance of the Work and to document terminations. Prepare diagrams in accordance with the requirements specified under this Section. The diagrams shall be in addition to loop diagrams specified in Section 40 60 04, Process Control System General Requirements.
      b. Use information obtained from approved Shop Drawings, Record Drawings and field inspections as required to complete the diagrams.
      c. Attend Pre-submittal Meeting and periodic coordination and progress meetings specified in Section 40 60 04, Process Control System General Requirements.

1.3 SUBMITTALS

A. Refer to General Conditions.

B. Shop Drawings shall include the following information to the extent applicable to the particular item:
   1. Manufacturer's name and product designation or catalog number.
   2. Electrical ratings.
   3. Conformance to applicable standards or specifications of ANSI, ASTM, ICEA, IEEE, ISA, NEC, NEMA, NFPA, OSHA, UL, or other organizations.
   4. Dimensioned plan, section, elevations and panel layouts showing means for mounting, conduit connection, and grounding.
   5. Materials and finish specification, including paints.
   6. List of components including manufacturer's names and catalog numbers.
   7. Internal wiring diagram and drawings indicating all connections to components and numbered terminals for external connections.

1.4 PROJECT CLOSEOUT

A. Operation and Maintenance Data: Submit complete manuals including:
   1. Copies of all Record Drawings and Wiring Diagrams, test reports, maintenance data and schedules, description of operation, and spare parts information.
   2. Furnish Operation and Maintenance Manuals in conformance with the requirements of Section 01 33 04, Operation and Maintenance Manuals.

B. Record Drawings:
   1. System Record Drawings: Include the following:
      a. One line wiring diagram of the distribution system.
      b. Actual in place conduit and cable layouts with schedule of conduit sizes and number and size of conductors.
      c. Layouts of the power and lighting arrangements and the grounding system.
      d. Control schematic diagrams, with terminal numbers and all control devices identified, for all equipment.
   2. Point-to-Point Interconnection Wiring Diagram Drawings: Include the following:
      a. External wiring for each piece of equipment, panel, instrument and other devices and conduit wiring to control stations, lighting panels and motor controllers.
      b. Numbered terminal block identification for each wire termination.
      c. Identification of the assigned wire numbers for all interconnections.
      d. Identification of all conduit wiring by the conduit tag in which the wire is installed.
      e. Terminal and pull boxes through which wiring is routed.
      f. Identification of all equipment and the Shop Drawing transmittal numbers for equipment from which the wiring requirements and termination information was obtained.
   3. The Record Drawings shall reflect final equipment and field installation information.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Delivery of Materials: CONTRACTOR shall instruct the manufacturers and vendors as to the maximum shipping sizes of equipment that can be accommodated at the site.

1.6 JOB CONDITIONS

A. Existing Conditions:
   1. CONTRACTOR shall examine the site and existing facilities in order to compare them with the Contract Documents with respect to the conditions of the premises, location of and connection to existing facilities and any obstructions which may be encountered.
   2. CONTRACTOR shall perform the Work with due regard to safety and in a manner that will not interfere with the existing equipment or in any way cause interruption of any of the functions of the plant.

3. Work shall be carried out with a minimum amount of disruption to the operation of the existing plant and with prior approval of OWNER. CONTRACTOR shall submit, for approval by OWNER, a detailed written procedure for work which affects operation of the existing plant, a detailed procedure for modifying any existing electrical equipment, and anticipated time required to complete the Work and the required shutdown time, if any.
4. Where the Work of CONTRACTOR ties in with existing installations, CONTRACTOR shall take prior precautions and safeguards in connecting the Work with the existing operating circuits so as to prevent any interruption to the existing operating circuits. The tying in of Work, installed under this Contract, with the existing circuits shall be performed only in the presence of OWNER. Advance notice will be required before any equipment is removed from service. CONTRACTOR shall notify OWNER, in writing, of his intention to do such work, providing full details.

B. Demolition:
   1. The demolition of electrical power distribution equipment, instrumentation/ control equipment, conduit, wire and appurtenances shall be in accordance with Section 02 41 00, Demolition.

1.7 CONTROL CABINETS AND PANELS

A. All control cabinet and panel materials shall be as follows, unless otherwise specified or noted on the Drawings. All outdoor panels shall be provided with sunshade structures.
   1. NEMA 12 for dry, indoor non-corrosive areas.
   2. In all locations except wet or corrosive, NEMA 4X 304 stainless steel. For wet or corrosive locations, NEMA 4X 316 stainless steel.
   3. NEMA 7 for explosion proof areas.

1.8 ELECTRICAL EQUIPMENT

A. All electrical equipment shall be capable of operating successfully at full-rated load, without failure, with an ambient outside air temperature of 25°F to 131°F and an elevation of 1,200 feet (MSL).

B. All electrical devices and equipment shall have ratings based on 75°C terminations.

1.9 AREA CLASSIFICATIONS

A. Materials and equipment shall conform to the area classification(s) shown on the Drawings, specified and required.

B. Wet/Corrosive Locations: The following areas shall be considered wet/corrosive locations:
   1. All outdoor areas.
   2. All indoor areas below grade, unless otherwise specified.
   3. Indoor areas above grade where shown on the Drawings.
   4. Chemical containment and storage areas.
   5. Materials, equipment, and incidentals in areas identified as wet locations shall meet NEC and NEMA requirements for wet or corrosive locations. All equipment enclosures including pull boxes installed in wet or corrosive locations shall be NEMA 4X, Type 316 stainless steel, unless otherwise indicated. Conduits shall be PVC coated galvanized rigid steel and shall be terminated at enclosures with watertight, threaded hubs.

C. Corrosive Locations: The following areas shall be considered corrosive locations:
   1. Chlorine Shed.
   2. Materials, equipment, and incidentals in areas identified as corrosive shall meet NEC and NEMA requirements for corrosive locations. Conduit systems shall be PVC coated galvanized rigid steel and enclosures shall meet NEMA 4X requirements. Conduits shall be terminated at enclosures with watertight, threaded hubs.

1.10 SCHEMATIC DIAGRAMS

A. Schematic diagrams are provided for CONTRACTOR'S guidance in fulfilling the operational intent of the Contract Documents.

B. It shall be CONTRACTOR'S responsibility to meet all safety and electrical codes, and to provide all equipment, appurtenances and specialty items required to provide for complete and operable systems.

C. Review of control schemes submitted by CONTRACTOR shall not relieve CONTRACTOR of his contractual responsibility to provide complete and successfully operating systems.

PART 2 - PRODUCTS

2.1 NAMEPLATES

A. Material: Laminated phenolic, incised to show 1/4-inch high letters, Arial. The letters shall be black with white background or match existing.

B. Border: Minimum 1/8-inch around engraved print with extra length for fastening devices.

C. Fasteners: Secured with #4-40, round-head, stainless steel, self-tapping screws.

2.2 WIRE MARKERS

A. Refer to Section 26 01 22, 600 Volt Cable.

2.3 CONDUIT TAGS

A. Refer to Section 26 01 31, Rigid Conduit.

B. Refer to Section 26 01 32, Flexible Conduit.

PART 3 - EXECUTION

3.1 EQUIPMENT IDENTIFICATION

A. Provide identification of each electrical item, in addition to the manufacture's nameplates, to identify the item's function and the equipment or system which it serves or controls.

B. Identify equipment by means of nameplates. Re-label existing equipment whose designation has been changed.

C. Color code and identify wires and cables by means of wire markers. Identify power conductors by circuit number, labeled at power source and at the equipment, and phase. Identify each control, signal, and status wire by a unique number. Numbering system shall reflect the actual designations used in the Work and shall be documented on the point-to-point wiring diagrams. Coil spare wiring neatly. Tag each spare wire with conduit number and wire number.

D. Conduit Tags:
   1. Conduit tags shall be yellow, 1-1/2-inches round, aluminum tags. Engraved with the conduit number as shown on the Conduit and Cable Schedule. Print shall be 1/4-inch Gothic. The conduit tags shall be manufactured by Brady, Catalog No. 49900, or equal.
   2. Each tag shall be attached with nylon-coated 48-mil stainless steel wire and fasteners, as manufactured by Brady, Catalog No. 23310 or equal, and brass wire clamps, double ferrule design, as manufactured by Brady Catalog No. 23312, or equal, to secure the stainless-steel wire.

E. Identify pull and terminal boxes with nameplates. Identify each box by a unique number. Numbering system shall reflect the actual designations used in the field and as documented on wiring diagrams.

+ + END OF SECTION + +

SECTION 26 00 61
GROUNDING SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown on the Drawings, specified and required to furnish and install complete grounding for the electrical systems, structures and equipment.

1.2 QUALITY ASSURANCE

A. Reference Standards: Comply with applicable provisions and recommendations of the following, except where otherwise shown or specified:
   1. NEC Article 250, Grounding.
   2. UL Standard No. 467, Electrical Grounding and Bonding Equipment.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Manufacturer's technical information for grounding materials proposed for use.
   2. Listing of grounding connector types identifying where they are to be used.
   3. Layouts of each structure ground grid.
   4. Test point construction details.
   5. Ground resistance test procedure.
   6. Results of ground resistance tests at each test point.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Bare Ground Cable:
   1. Material: Annealed, bare, stranded copper, No. 6 AWG minimum size or as otherwise shown on the Drawings.
   2. Product and Manufacturer: Provide ground cable of one of the following:
      a. Cablec Corporation.
      b. General Cable Corporation.
      c. Rome Cable Company.

B. Ground Rods:
   1. Material: Copperclad rigid steel rods, 3/4-inch diameter, ten feet long.
   2. Product and Manufacturer: Provide ground rods of by one of the following:
   3. Copperweld, Bimetallics Division.
   4. ITT Blackburn Company.

C. Grounding Connectors:
   1. Material: Pressure connectors shall be copper alloy castings, designed specifically for the items to be connected, and assembled with Durium or silicone bronze bolts, nuts and washers. Welded connections shall be by exothermic process utilizing molds, cartridges and hardware designed specifically for the connection to be made.
   2. Product and Manufacturer: Provide grounding connectors of one of the following:
   3. Pressure Connectors:
      a. O.Z./Gedney, Division of General Signal Corporation.

b. Burndy Corporation.

4. Welded Connections:
   a. Cadweld by Erico Products, Incorporated.
   b. Therm-O-Weld by Burndy Corporation.

PART 3 - EXECUTION

3.1 STRUCTURE GROUND SYSTEM

A. Provide ground grids as shown on the Drawings.

B. Install No. 4/0 bare copper cable around the exterior perimeter of structures, minimum 2 feet-6 inches below grade, unless otherwise shown on the Drawings.

C. Install ground rods where shown on the Drawings. Install additional ground rods, if necessary, to attain a resistance to ground of less than five ohms for each ground grid.

D. For structures with steel columns, install No. 4/0 ground cable from grid to each column around the perimeter of the structure. Connect cable to steel using exothermic welds.

E. Connect grids to a continuous underground water pipe system, when practical.

F. Provide accessible test points for measuring the ground resistance of each grid.

G. Weld all buried connections, except for test points.

3.2 EQUIPMENT GROUNDING

A. Ground all electrical equipment in compliance with the National Electrical Code.

B. Equipment grounding conductors shall be bare stranded copper cable of adequate size installed in metal conduit where necessary for mechanical protection. Ground conductors, pulled into conduits with non-grounded conductors, shall be insulated. Insulation shall be green.

C. Panel Grounding:
   1. A minimum size of 4 AWG bare stranded copper cable shall be installed between the ground grid and the panel enclosure grounding lug. The mounting frame for panels shall be grounded to the ground grid.
   2. A 4 AWG insulated green stranded copper cable shall be installed between the ground grid and the isolated DC Ground Bus located on the enclosure sub-panel. This ground shall be installed in all panels that provide an isolated DC Ground Bus.

D. All conduits entering enclosures shall be grounded. A separate green insulated ground conductor sized per conduit schedule as shown on DRAWINGS or NEC requirements shall be pulled into conduits and connected utilizing grounding conduit bushings.

E. Connect to piping by welding or brazing. Use copper bonding jumpers on all gasketed joints.

F. Connect to equipment by means of lug compressed on cable end. Bolt lug to equipment frame using holes or terminals provided on equipment specifically for grounding. Do not use holddown bolts. Where grounding provisions are not included, drill suitable holes in locations designated by ENGINEER.

G. Connect to motors by bolting directly to motor frames, not to sole plates or supporting structures.

H. Connect to service water piping by means of copper clamps. Use copper bonding jumpers on gasketed joints.

I. Scrape bolted surfaces clean and coat with a conductive oxide- resistant compound.

3.3 TESTING

A. CONTRACTOR shall test and provide documented results on the completed ground systems for resistance to ground using an electrical ground resistance tester. The grounding system maximum resistance shall not exceed five ohms under normally dry conditions when measured by the resistance tester. Resistance values above five ohms shall be brought to the ENGINEER'S attention.

B. Test all grounded cables and metal parts for continuity of connection.

C. Test shall be witnessed by the ENGINEER and OWNER.

+ + END OF SECTION + +

SECTION 26 01 21
INSTRUMENTATION CABLE

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as shown on the Drawings, specified and required to furnish and install instrumentation, telephone cables and security system fiber cables.
   2. The types of cable include the following:
      a. Shielded Instrument Cable.
      b. Unshielded Instrument Cable.
      c. Telephone Cable.
      d. Intercom and Paging System Cable.

1.2 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Manufacturer's technical information for instrumentation cable proposed for use.
   2. Manufacturer’s technical information for telephone cable and underground splicing for approval by the City of Peoria, Information Technology Department.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Single Shielded Pair Instrument Cable:
   1. Tinned copper, nineteen strand, PVC insulated conductors, No. 16 AWG minimum, twisted with aluminum-polyester shield, stranded tinned 16 AWG copper drain wire and PVC black or gray outer jacket. Wire conductor colors shall be black (-neg) and red (+pos). 600 Volt Tray Cable (TC) rated.
   2. Product and Manufacturer: Provide one of the following:
      a. Belden Company (No. 9342).
      b. Okonite Company.
      c. Dekoron Wire and Cable Company.

B. Multipaired Shielded Instrument Cable:
   1. Bare, soft annealed copper, seven strand, tinned copper conductors, PVC insulated conductors, No. 16 AWG minimum, twisted in pairs with aluminum-mylar shield over each pair, tray cable rated, silicone rubber fiberglass fire barrier tape, tinned copper drain wire, pairs shall be individually numbered, aluminum mylar overall shield, PVC outer jacket. Color shall be black and red. Rated for 600 volts. Multi conductor cable shall only be utilized in cable tray applications or unless specified on drawings.
   2. Product and Manufacturer: Provide one of the following:
      a. Belden, No. 1043B.
      b. Or equal.

C. Multipaired Unshielded Instrument Cable:
   1. Tinned copper conductors, No. 16 AWG seven strand, PVC insulated, 16 twisted pairs. Rated for 600 volt. Conductor colors shall be black and white. Overall Shield with 100 percent coverage and tinned copper drain wire. Jacket shall be PVC and UL Type TC. Multi conductor cable shall only be utilized in cable tray applications or unless specified on drawings.

2. Product and Manufacturer: Provide one of the following:
3. Belden, No. 1073B.
4. Or equal.

D. Telephone Cable:
1. Bare, solid annealed copper, No. 22 AWG twisted pairs with solid polyolefin insulation, color coded to telephone industry standards. Cable core shall be filled with a water proofing compound and wrapped with a non-hygroscopic core tape. Shielding shall be constructed of 0.005-inch solid copper. Cable shall be finished with a black polyethylene jacket. Cable shall contain the number of pairs as shown on the Drawings.
2. Product and Manufacturer: Provide one of the following:
   a. Anixter.
   b. Or equal.

E. Intercom and Paging System Cable:
1. Cable for the connection of the remote staff stations associated with the intercom or paging system shall be single pair shielded audio and data cable insulated for 600 volt, as manufactured by Belden, No. 8719, Mohawk equivalent, or equal.
2. Where paging system cables are shown on the Drawings, two single pairs of the specified cable shall be installed in the indicated conduit, one shall serve as a spare.
3. Product and Manufacturer: Provide one of the following:
4. Belden, No. 8719.
5. Mohawk.
6. Or equal.

F. Cable Terminals:
1. Provide ferule compression fittings or UL listed fork type copper compression terminals with nylon insulation for termination of cable at all terminal blocks.
2. Product and Manufacturer: Provide one of the following:
3. T&B Sta-Kon.
4. Burndy Insulug.

G. Cable Markers:
1. Provide only heat shrinkage type cable identification, which shall be type-written.
2. Product and Manufacturer: Provide the following:
3. By W.H. Brady Company. (Part # PSPT-500-1W for a twisted pair shielded cable)

PART 3 - PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in conduit separate from power cables, unless otherwise noted.

B. Ground shield of shielded cables at one end only and as recommended by instrument manufacturer. When multiple shielded cables are terminated on a designated analog terminal strip an insulated green with yellow strip wire is used to jumper between the shield terminals and at the end of the terminal strip terminate the shields to the isolated DC ground bar mounted in the panel.

C. Terminate stranded conductors with pre-insulated crimp type spade or barrel compression fitting terminals properly sized to fit fastening device and wire size.

D. Install and terminate vendor furnished cable in accordance with vendor equipment requirements.

E. CONTRACTOR shall coordinate the installation and termination of the telephone cables with the Tribal, Information Technology Department.

F. Install in conformance with the National Electrical Code.

3.2 TESTING

A. Test all 600 volt wiring in accordance with the requirements of Section 26 01 22, 600 Volt Cable.

B. Test shielded instrumentation cable shields with an ohmmeter for continuity along the full length of the cable and for shield continuity to ground. The tests shall be witness by the OWNER and ENGINEER.

C. Connect shielded instrumentation cables to a calibrated 4 to 20 mADC signal transmitter and receiver. Test at 4, 12 and 20 milliamp transmitter settings.

D. Telephone cables shall be tested in accordance with and in the presence of the Tribal, Information Technology Department. A written proposed schedule from CONTRACTOR shall be submitted a minimum of seven days prior to the testing of each telephone cable for inspection coordination.

+ + END OF SECTION + +

SECTION 26 01 22
600 VOLT CABLE

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish and install 600 volt cable.
   2. The types of cable required include the following:
      a. Insulated cable for installation in raceways.
      b. Direct burial cable.
      c. Direct burial cable duct.
      d. Cable for installation in trays.

B. Related Sections: CONTRACTOR shall coordinate the requirements of the Work in this Section along with the requirements of the Sections listed below which includes, but is not necessarily limited to, Work that is directly related to this Section.
   1. Section 26 01 61, Grounding Systems.
   2. Section 26 01 21, Instrumentation Cable.

1.2 QUALITY ASSURANCE

A. Requirements of Regulatory Agencies: Comply with applicable provisions of Regulatory Agencies below and others having jurisdiction:
   1. Codes: Install cable in accordance with the National Electrical Code and applicable local codes.
   2. Tests by Independent Regulatory Agencies: Cable shall bear the label of the Underwriters' Laboratories, Inc.

B. Reference Standards: Comply with applicable provisions and recommendations of the following, except where otherwise shown or specified:
   1. ASTM B 3, Soft or Annealed Copper Wire.
   2. ASTM B 8, Concentric-Lay-Stranded Copper Conductors, Hard, Medium-hard or Soft.
   3. ICEA S-66-524, Cross-linked-thermosetting- polyethylene-insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
   4. National Electrical Code.
   5. UL Standard No. 44, Wires and Cables, Rubber-Insulated.
   6. UL Standard No. 83, Wires and Cables, Thermoplastic-Insulated.
   7. IEEE Standard 971.
   8. Factory Production Tests:
   9. All wire and cable shall be factory tested in accordance with the requirements of Underwriters' Laboratories.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Manufacturer's literature, specifications, and engineering data for 600 volt insulated cable proposed for use.
   2. Manufacturer's literature for cable markers.

B. Test Records: Submit for review copies of written records of field insulation resistance test results.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Insulated Cable In Raceways:
   1. Material: Single conductor copper cable conforming to ASTM B 3 and B 8 with flame-retardant, moisture and heat resistant cross-linked polyethylene or thermoplastic insulation rated 90°C in dry locations and 75°C in wet locations and listed by UL as Type XHHW-2. Multi conductor cable shall only be utilized in cable tray applications or unless specified on drawings.
   2. Application: Use Type XHHW-2 for all sizes, unless otherwise indicated.
   3. Wire Sizes: Not smaller than No. 12 AWG for power and lighting and No. 14 AWG for 120 volt control circuits
   4. Stranding: All 600 volt cable shall be stranded.
   5. Product and Manufacturer: Provide one of the following:
      a. Okonite Company.
      b. Ace Wire and Cable Corporation.
      c. The Southwire Company.
      d. or Equal

B. Cable for Installation in Trays:
   1. Material: Factory assembled cable, multi-conductor as required by the Drawings, Type XHHW-2 bearing the UL label, Type TC and specifically approved for installation in cable trays and meeting the flame test requirements of IEEE 1202.
   2. Product and Manufacturer: Provide one of the following:
      a. The Southwire Company.
      b. The Okonite Company.
      c. Service Wire

C. Direct Burial Cable:
   1. Single or multiconductor, stranded copper conductors, 60-mils butadiene styrene or ethylene propylene insulation, overall jacket of neoprene or PVC. Rated at 600 volts.
   2. Product and Manufacturer: Provide one of the following:
      a. The Okonite Company.
      b. American Insulated Wire Corporation.

D. Direct Burial Cable Duct:
   1. Material: Multi conductor stranded copper cables; 600 volt cross-linked polyethylene insulated, factory assembled in a coilable, medium density polyethylene duct suitable for direct burial in earth for operation at a maximum conductor temperature of 90°C.
   2. Product and Manufacturer: Provide one of the following:
      a. Cablecon by Integral Corporation.
      b. Tamaqua Duct System by Tamaqua Cable Products Corporation.

E. Cable Connectors, Solderless Type:
   1. For wire sizes up to and including No. 6 AWG, use compression type. Alarm and control wire shall be terminated using forked type connectors at terminals. If terminal block is crimp type, then the wire shall be terminated with a crimped barrel lug or solder dipped.
   2. Product and Manufacturer: Provide one of the following:
      a. T & B Sta-Kon.
      b. Burndy Hylug.
   3. For wire sizes No. 4 AWG and above, use either compression type or bolted type with silver-plated contact faces.

4. For wire sizes No. 250 kcmil and larger, use connectors with at least two cable clamping elements or compression indents and provision for at least two bolts for joining to apparatus terminal.
5. Properly size connectors to fit fastening device and wire size.

F. Cable Splices:
1. For wire sizes No. 8 AWG and larger, splices shall be made up with compression type copper splice fittings. Splices shall be taped and covered with materials recommended by the cable manufacturers, to provide insulation equal to that on the conductors.
2. For wire sizes No. 10 AWG and smaller, splices may be made up with preinsulated spring connectors.
3. For wet locations, splices shall be waterproofed. Compression type splices shall be waterproofed by a sealant-filled, thick wall, heat shrinkable, thermosetting tubing or by pouring a thermosetting resin into a mold that surrounds the joined conductor. Spring connector splices shall be waterproofed with a sealant-filler.
4. Product and Manufacturer: Provide one of the following:
   a. Compression-Type Splices:
   b. Burndy Hylink.
   c. T&B Color-Keyed Compression Connectors.
   d. Spring Connectors:
   e. Buchanan B-Cap.
   f. T&B Wire Connector.

G. Cable Markers:
1. Provide only heat shrinkage type cable identification, which shall be type-written.
2. Product and Manufacturer: Provide the following:
   a. By W.H. Brady Company. (Part # PSPT-187-1W for a single conductor)

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install all cables complete with proper identification and terminations at both ends. Check and correct for proper phase sequence and proper motor rotation.

B. Pulling:
1. Use insulating types of pulling compounds containing no mineral oil.
2. Pulling tension shall be within the limits recommended by the wire and cable manufacturer.
3. Use a dynamometer where mechanical means are used.
4. Cut off section subject to mechanical means.

C. Bending Radius: Limit to a minimum of six times cable overall diameter.

D. Slack: Provide maximum slack at all terminal points.

E. Splices:
1. Where possible, install cable continuous, without splice, from termination to termination.
2. Where required, splice where shown on the Drawings or as approved by the ENGINEER and also where required for cable installation. All splices below grade, in manholes, handholes and wet locations shall be waterproofed.
3. Splices are not allowed in conduits.
4. All splices shall be pre-approved by ENGINEER.

F. Identification:
1. Each cable and conductor shall be identified in each pullbox, manhole and each termination point with circuit identification markers, which shall include the conduit number and wire number. The markers shall be self-laminating vinyl on white background and shall be printed using a Brady "XC Plus" printer or equal.

G. Phase Identification/Color Coding:
   1. All three phase circuits shall be identified, which shall include the conduit number and phase, at switchgear, motor control centers, manholes (5 KV), cables and panelboards as "PHASE A"," PHASE B", and "PHASE C". All conductors not identified with a tag number shall be identified with a tag indicating the source.
   2. Three phase 480 volt systems shall be color coded as follows:
      a. Phase A - Brown.
      b. Phase B - Orange.
      c. Phase C - Yellow.
      d. Neutral (if applicable) - White.
   3. Single phase, 120/240 volt circuits shall be color coded as follows:
      a. Phase A - Black.
      b. Phase B - Red.
      c. Neutral - White.
   4. Three phase, 208 volt systems shall be color coded as follows:
      a. Phase A - Black.
      b. Phase B - Red.
      c. Phase C - Blue.
      d. Neutral - White.
   5. No. 6 AWG and Smaller: Provide colored conductors.
   6. No. 4 AWG and Larger: Apply general purpose, flame retardant tape at each end, wrapped in overlapping turns to cover an area of at least 2-inches.
   7. All field wiring color shall be black unless otherwise noted.

3.2 TESTING

A. Test each electrical circuit after permanent cables are in place to demonstrate that the circuit and connected equipment perform satisfactorily and that they are free from improper grounds and short circuits.

B. Individually test 600 volt cable mechanical connections after installation and before they are put in service with a calibrated torque wrench. Values shall be in accordance with manufacturers' recommendations.

C. Individually test 600 volt cables for insulation resistance between phases and from each phase to ground. Test after cables are installed and before they are put in service with a Megger whose rating is suitable for the tested circuit. Tests shall meet with the applicable specifications of IPCEA S-66-524 and NEMA WC7-1971. Tests shall be witnessed by the ENGINEER.

D. The insulation resistance for any given conductor shall not be less than the value recommended by the IPCEA or a minimum of one megohm for 600 volt and less service, if not IPCEA listed. Any cable not conforming to the recommended value or which fails when tested under full load conditions shall be replaced with a new cable for the full length.

E. Install in accordance with the National Electrical Code and applicable local code.

F. Where existing cables are spliced to cables provided under this Contract, the existing cables shall be tested prior to splicing. Test cables at 1,000 volts DC for one minute. The entire spliced cable installation shall be re-tested after the splice is completed. Any existing cable which fails or has a value less than two megohms shall be brought to the ENGINEER'S attention and the splicing shall not proceed. Tests shall be witnessed by the ENGINEER.

+ + END OF SECTION + +

SECTION 26 01 31
RIGID CONDUIT

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
1. CONTRACTOR shall provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish and install conduit and fittings to provide complete, coordinated and grounded raceway systems.
2. Conduit routings for various systems within buildings and other areas may not be shown on the Drawings, but shall be established by CONTRACTOR based upon single line, riser and interconnection diagrams and other information shown on the Drawings. CONTRACTOR shall provide for the proper installation of all conduits for each system.
3. Contractor shall submit conduit routing and tagging meeting all specifications of Submittals Section 1.3-A and Section 2.1-G below to Engineer/Owner for review and approval prior to construction.
4. The conduit types and the installation methods shall conform to the following:
   a. PVC coated rigid steel conduit for exposed indoor conduit runs
   b. PVC coated rigid steel conduit for exposed conduit runs in all outdoor areas.
   c. PVC coated rigid steel for non-encased underground conduit
   d. Schedule 40 PVC for masonry walls, concrete encased duct bank runs or conduit runs embedded in structural concrete slabs.
   e. Electrical metallic tubing shall only be used in the following locations:
      1) Electrical building interior.

B. Coordination:
1. Conduit runs shown are diagrammatic. Coordinate conduit installation with piping, ductwork, lighting fixtures and other systems and equipment and locate so as to avoid interferences.
2. For conduits to be embedded in concrete slabs, confirm adequate slab thickness and coordinate location of conduits with placement of reinforcing steel, water stops and expansion joints.

C. Related Sections/Divisions: CONTRACTOR shall coordinate the requirements of the Work in all Sections of the Divisions listed below along with the requirements which includes, but is not necessarily limited to work that is directly related to this Section.
1. Division 01, General Requirements
2. Division 02, Existing Conditions
3. Division 03, Concrete
4. Division 26, Electrical

1.2 QUALITY ASSURANCE

A. Reference Standards: Comply with applicable provisions and recommendations of the following, except where otherwise shown or specified.
1. NEC 2017 Article 344, Rigid Metal Conduit.
2. NEC 2017 Article 352, Rigid Nonmetallic Conduit.
3. UL Standard No. 6, Rigid Metal Electrical Conduit.
4. UL Standard No. 651, Schedule 40 and 80 PVC Conduit.
5. ANSI C80.4, Fittings for Rigid Metal Conduit and Electrical Metal Tubing
6. NEMA TC2, Electrical Plastic Tubing, Conduit and Fittings.
7. NEMA TC3, PVC Fittings for Use with Rigid PVC Conduit and Tubing.
8. NEMA RN 1, Polyvinyl Chloride (PVC) Externally Coated Rigid Steel Conduit and Intermediate Metal Conduit

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Manufacturer's catalog cuts for the conduit, fittings, supports, conduit identification tags, orange electrical ID tape, and warning ribbon proposed for use. Provide engraved samples of conduit identification tags.
   2. Construction details of conduit racks and other conduit support systems.
   3. Layout drawings showing proposed routing of exposed conduits, conduits embedded in structural concrete and conduits directly buried in earth. Drawings shall show locations of intermediate termination panels (ITP's), pull boxes and penetrations in walls and floor slabs. Drawings of embedded conduits shall include cross-sections showing the thickness of the concrete slabs and the locations of conduits with respect to reinforcing steel and waterstops. Tag conduits per conduit schedule shown on drawings.
   4. Drawing shall be electronically produced to maintain quality and clarity of presentation when re-produced, even when reduced to half size (11" x 17").
   5. Provide manufacturer's proof of certification for PVC coated rigid steel conduit for all installers.

B. Drawings: Show the actual routing of exposed and concealed conduit runs on the Record Drawings.

PART 2 - PRODUCTS

2.1 MATERIALS

A. PVC Coated Rigid Steel Conduit, Elbows and Couplings:
   1. Material: Rigid, heavy wall, mild steel, interior coating of 2-mil thick urethane, tapered threads, carefully reamed ends, 3/4-inch NPS minimum size for exposed, 1 inch for embedded, encased, or otherwise inaccessible, with a factory exterior coating of 40-mil thick polyvinyl chloride.
   2. Color: All PVC coated materials shall be standard dark gray..
   3. Tools: Power drives, chucks, z-wrenches, vises, and cutting or bending tools shall follow recommendations for tooling in manufacturer's installation guide. Use touch-up compounds recommended by the manufacturer for repair of minor damage to interior urethane or exterior PVC factory coatings.
   4. Manufacturer: Provide conduit and fittings of one of the following:
      a. Robroy Industries, "Perma-Cote".
      b. Robroy Industries, "Plasti-Bond".
      c. OCAL Inc.

B. PVC Coated Conduit Fittings and Outlet Bodies:
   1. Material and Construction: Cast gray iron alloy, cast malleable iron bodies and covers with a factory coating of 40-mil thick polyvinyl chloride, an interior coating of 2-mil thick urethane and Form 8 tongue-in-groove V-seal gasket on sizes ½" through 2". Conduit or fittings having areas with thin or no coating shall be unacceptable. Do not use "LB" fittings for conduit sizes of 1¼" or larger. Use type "LBD" fittings wherever the use of fittings for conduit sizes of 1¼" or larger is unavoidable. All units shall be threaded type with five full threads. Material shall conform to ANSI C80.4.
   2. Use: Provide conduit fittings and outlet bodies in all corrosive locations.
   3. Manufacturer: Provide PVC coated conduit fittings and outlet bodies of one of the following:
      a. Robroy Industries, "Perma-Cote".
      b. Robroy Industries, "Plasti-Bond".
      c. OCAL Inc.

C. Non-metallic Conduit and Fittings:
   1. PVC Plastic Conduit:
      a. Material: Schedule 40 PVC plastic, 90°C rated, conforming to NEMA TC-3 and UL No. 514 and 651.

b. Fittings: Form elbows, bodies, terminations, expansions and fasteners of same material and manufacturer as base conduit. Provide cement and primer by same manufacturer as base conduit.
c. Manufacturer: Provide conduit and fittings of one of the following:
1) PW Eagle
2) Carlon Electrical Products.

D. Electrical Metallic Tubing (EMT) Conduit, Elbows, Fittings, and Couplings:
1. Material: Rigid-type mild steel, galvanized (zinc) exterior, organic lubricated interior, threadless 3/4-inch NPS minimum size.
2. Couplings and connections: Compression or threaded type only. Set screw type shall not be permitted.
3. Elbows: Factory formed of same material specified for EMT conduit.
4. Certifications: Material shall conform to UL-797, ANSI C80.3. Conduit, elbows, couplings, etc. shall bear UL listing and manufacturer's name.
5. Use of EMT type raceway systems shall only be permitted where specified in Paragraph 1.1.A.4.e, above.
6. Manufacturer: Provide EMT conduit, elbows, fittings and couplings of one of the following:
a. Allied Tube and Conduit.
b. LTV Steel Tubular Products Company.
c. Wheatland Tube Company.

E. PVC Coated Conduit Hubs:
1. Material: Threaded conduit hub, vibration proof, weatherproof with captive O-ring seal, zinc metal with insulated throat and factory coating of 40-mil thick polyvinyl chloride and smooth urethane interior coating.
2. Use: Provide for all PVC coated conduit terminations to boxes, cabinets and other enclosures located in all areas.
3. Locknuts are not allowed. Use hubs only.
4. Manufacturer: Provide one of the following:
a. Robroy Industries, "Perma-Cote".
b. Robroy Industries, "Plasti-Bond".
c. OCAL Inc.

F. Conduit Bushings:
1. Insulated Bushings: Malleable iron body with plastic liner. Threaded type with steel clamping screw. Provide with bronze grounding lug, as required.
2. Use: Provide for all conduit terminations to boxes, cabinets, other enclosures and raceways not requiring a hub..
3. Manufacturer: Provide one of the following:
a. O-Z/Gedney.
b. Appleton Electric Company.
c. Thomas and Betts.

G. Conduit Tags:
1. Conduit tags shall be yellow, 1-1/2-inch diameter, round, aluminum tags, laser engraved, or, if punched, lettering painted a contrasting color, with the conduit number as shown on the Conduit and Cable Schedule. Font shall be 1/4-inch Arial or Helvetica. The conduit tags shall be manufactured by Brady, Catalog No. 49900.
2. Each tag shall be attached with nylon-coated 48-mil stainless steel wire and fasteners, as manufactured by Brady, Catalog No. 38091, and brass wire clamps, double ferrule design, as manufactured by Brady Catalog No. 38090 to secure the stainless steel wire.

H. Warning Ribbon:
1. Provide Brady "Identoline"; Services and Materials "Buried Underground Tape"; or Somerset (Thomas & Betts) "Protect-A-Line". Provide tape with nominal dimension of 6-inches wide, 4-mil thickness permanently imprinted with "CAUTION BURIED ELECTRIC LINE BELOW". Provide underground marking tape 6-inch wide metallic-lined tape with red

polyethylene film on top and with clear polyethylene film on the bottom of the tape for installation above and centered on direct buried cables, electrical ductbanks and conduits without ductbank encasement.

2. Use: Provide over buried conduits
3. Manufacturers: Provide one of the following:
   a. Brady.
   b. Thomas and Betts.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in conformance with National Electrical Code and all applicable local Electrical Code requirements.

B. Supports:
   1. Rigidly support conduits by clamps, hangers or Unistrut channels.
   2. Support single conduits by means of one-hole pipe clamps in combination with one-screw back plates, to raise conduits from the support surface. Support multiple runs of conduits on trapeze type hangers with Type 316 Stainless Steel horizontal members and Type 316 Stainless Steel threaded hanger rods, Kindorff or equal. Rods shall be not less than 3/8-inch diameter.
   3. PVC coated rigid steel conduit runs, beam clamps, U-bolts, pipe straps, clamp back spacers, clamp hangers and supports shall have a factory applied PVC coating or be stainless steel. Hardware shall be Type 316 Stainless Steel.
   4. Right angle beam clamps and U bolts shall be specially formed and sized to snugly fit the outside diameter of the coated conduit.

C. Fastenings: Fasten raceway systems rigidly and neatly to supporting structures by the following methods:
   1. To Wood: Type 316 Stainless Steel wood screws.
   2. To Hollow Masonry Units: Type 316 Stainless Steel toggle bolts.
   3. To Brick Masonry: Type 316 Stainless Steel Price expansion bolts, or equal.
   4. To Concrete: Refer to Section 03 41 20, Precast Concrete Booster Pump Station (BPS) Building.
   5. To Steel: Type 316 stainless steel welded threaded studs, beam clamps or bolts with lock-washers or locknuts.

D. PVC Coated Rigid Steel Exposed Conduit:
   1. Install in strict accordance with manufacturer's recommendations and installation manual. Installers shall be certified by the manufacturer before installation begins.
   2. Install with manufacturer's installation tools and compounds to prevent damage to the PVC coating.
   3. Repair minor damage to interior urethane and exterior PVC coating with manufacturers recommended touch-up compound.
   4. Install parallel or perpendicular to structural members or walls.
   5. Wherever possible, run in groups. Provide conduit racks of suitable width, length and height and arranged to suit field conditions. Provide support at manufacturer's recommended distances, or at every ten feet minimum.
   6. Install on structural members in protected locations.
   7. Locate clear of interferences.
   8. Maintain 6-inches from hot fluid lines and 1/4-inch from walls.
   9. Install vertical runs plumb. Unsecured drop length not to exceed 12 feet.
   10. Provide necessary reducers where equipment furnished cannot accept 3/4-inch conduit.

E. Conduit Embedded in Structural Concrete:
   1. Separation: Three times outer diameter of larger conduit center to center.
   2. Minimum Slab Thickness: Confirm that concrete slab thickness is sufficient for embedding conduits.

a. For embedding conduit sizes up to 1-1/2 inches, the minimum slab thickness shall be 7-inches plus the outer diameter of the conduit or conduits, where conduits cross.
b. For embedding conduits larger than 1-1/2 inches, the minimum slab thickness shall be five times the outer diameter of the conduit where conduits do not cross and six times the outer diameter of the larger conduit where conduits do cross.

3. Concrete shall have a minimum 28-day compressive strength of 2,000 PSI. Concrete used for ductbanks shall be Class E with red color added as specified in Section 03 00 05, Concrete.
4. Run conduits in center of slab, where applicable.
5. Run conduits in spacers to maintain recommended minimum, even spacing.
6. Run conduits above waterstops.
7. Before concrete is placed, make the necessary location measurements of the conduits to be embedded so that the information is available to prepare Record Drawings.
8. All conduits entering or exiting concrete shall be PVC coated galvanized rigid steel, for a minimum of 12-inches from the concrete edge.

F. Underground Conduits that are non-encased: PVC coated rigid steel conduits.
1. Install individual underground conduits a minimum of 24-inches below grade, unless otherwise shown on the Drawings or as required to avoid existing obstructions.
2. Perform all excavation, bedding, backfilling and surface restoration including pavement replacement, where required.
3. Install warning ribbon 12-inches below finished grade over all conduits.
4. Make conduit connections watertight by applying PVC touch-up compound at the sealing sleeve joints.

G. Empty Conduits:
1. Install nylon pull wire in each empty conduit and cap conduits not terminating in boxes with permanent fittings designed for the purpose.
2. Identify each empty conduit with a conduit tag conforming to the requirements of Paragraph 2.1.G., above, showing the conduit number shown on the Drawings.

H. Field Bends: Use manufacturer supplied field bends whenever possible. No indentations. Diameter of conduit shall not vary more than 15 percent at any bend. Maximum total amount of bends shall not exceed 270°. Conduit runs shall be limited to a maximum of 400 feet for every 90 degrees of change in direction.

I. Joints:
1. Make joints tight and ground thoroughly.
2. Use standard tapered pipe threads for conduit and fittings.
3. Cut conduit ends square and ream to prevent damage to wire and cable.
4. Use a degreasing spray to thoroughly clean field cut threads, and internal reams to insure the touch-up compound will adhere to the unprotected steel.
5. Apply urethane touch-up compound to all joints, field cut threads, and internal reams before assembly for corrosion protection and visible identification of proper installation.
6. Use full threaded couplings. Split couplings not permitted.
7. During installation, install with manufacturer's installation tools to prevent damage to PVC coating. Replace conduit with wrench marks.

J. Terminations:
1. Install threaded hubs. Do not use bushings or locknuts.
2. Install conduit hubs on conduits entering boxes, enclosures, cabinets or coming through walls

K. Moisture Protection:
1. Plug or cap conduit ends at time of installation to prevent entrance of moisture or foreign materials.
2. Make underground and embedded conduit connections water-tight.
3. Through Wall Seals and Conduit Sealing Bushings: Install for all conduits passing through concrete slabs, floors, walls or concrete block walls.

a. For conduits and cables in new construction and passing through exterior subsurface walls and exterior concrete walls, use Type WSK and WSCS through wall seals as manufactured by O-Z/Gedneyl.
b. For conduits and cables in new construction and passing through concrete floors and floor slabs, use Type FSK and FSCS floor seals, as manufactured by O-Z/Gedney.
c. For conduits passing through new exterior block walls or through core-drilled holes in existing exterior subsurface walls, exterior concrete walls, floor slabs and roof slabs, use Type CSMI sealing bushing at the inside of the structure and Type CSMC sealing bushing at the outside of the structure. Sealing bushings shall be as manufactured by O-Z/Gedney.
d. For conduits passing through existing interior concrete walls or floors and interior block walls, provide CSMC or CSMI type sealing bushings as manufactured by O-Z/Gedneyl.

4. Drainage: Pay particular attention to drainage for conduit runs. Wherever possible, install conduit runs so as to drain to one end and away from buildings. Avoid pockets or depressions in conduit runs. Where conduits enter buildings below grade, seal inside of conduit to form a watertight seal around cables to prevent the entry of water into building. Sealant shall be Silicone and shall form an elastomeric compression seal. Sealant shall be Fire Barrier 2001 Silicone RTV Foam.
5. Seal all conduit openings within control and instrumentation panels and distribution equipment with Type DUX - Duct Sealing Compound, as manufactured by O-Z/Gedney, to provide a water/bug-tight seal.

L. Corrosion Protection:
1. Conduit Curb:
a. For conduits routed in concrete slabs or floors and stub-ups through the floor, provide a 2-inch high concrete curb, extending 2-inches from the outer surface of the conduit penetrating the floor, to prevent corrosion. For floor-mounted equipment, the concrete equipment base shall be in lieu of the concrete curb.
b. Conduit stub-ups shall be a 90 degree PVC coated rigid steel conduit elbow. PVC coated elbow shall extend slightly above the top of the concrete curb or equipment base. Should the elbow not reach this height, provide PVC coated conduit extension to accommodate requirements. Provide PVC coated coupling/fitting for transition from conduit in slab to elbow.
c. For conduits stubbing up and terminating at equipment enclosure mounted on a concrete equipment base, provide PVC coated insulated grounding bushing on the PVC coated elbow.
d. For conduits stubbing up and extending to boxes, cabinets and other enclosures above the concrete curb in wet and dusty areas, provide PVC coated conduit coupling/fittings between the PVC coated elbow and PVC coated rigid steel conduit for transition between the two conduit types.
e. For conduits stubbing up and extending to boxes, cabinets and other enclosures above the concrete curb or equipment base in corrosive areas, continue the conduit system with PVC coated rigid steel conduit.
f. Conduit into a protected base or equipment enclosure can be PVC with PVC extension risers.

2. Dissimilar Metals: Take every action to prevent the occurrence of electrolytic action between dissimilar metals.

M. Reused Existing Conduits:
1. Pull rag swab through conduits to remove water and to clean conduit prior to installing new cable.
2. Repeat swabbing until all foreign material is removed.
3. Pull mandrel through conduit, if necessary, to remove obstructions.

N. Core drill for individual conduits passing through existing concrete slabs and walls. Obtain authorization from OWNER prior to core drilling. Prior to core drilling, drill sufficient number of small exploratory holes to establish that the area to be core drilled is free of existing embedded

conduits. Seal spaces around conduit in accordance with the wall penetration details as shown on the Drawings.

Commented [PM1]: Section not listed on Consor TOC

O. Non-metallic Conduit:
   1. Install in accordance with manufacturer's recommendations.
   2. Join sections in accordance with manufacturer's installation procedures for push-fit, bell and spigot type joints, if applicable, or with manufacturer's recommended cement and primer.
   3. During installation provide expansion fittings for expansion and contraction to compensate for temperature variations. Expansion fittings shall be watertight and of the type suitable for direct burial.
   4. Make transition to PVC coated galvanized rigid steel conduit before making turns into enclosures, cabinets, termination boxes, pull boxes, etc.
   5. Provide watertight expansion/deflection fittings at all wall and floor penetrations of all buildings and equipment concrete pads.

3.2 TESTING

A. Test conduits by pulling through each conduit a cylindrical mandrel not less than two pipe inside diameters long, having an outside diameter equal to 90 percent of the inside diameter of the conduit.

B. Maintain a record, by number, of all conduits testing clear.

3.3 IDENTIFICATION

A. Tag conduits in accordance with Paragraph 2.1.G, above. Tag all conduits at the ends and in all intermediate boxes, chambers, hand holes and other enclosures. Fasten tags to conduits with nylon-coated 48-mil stainless steel wire. Where this method is not practical, fasten to the adjacent masonry by means of expansion bolts.

B. Use numbers on all conduits as designated in the Cable and Conduit Schedule and record the conduit numbers and the cable content by cable designation, size, quantity, origin and termination of conductors, and name of equipment served. Assign numbers to unidentified conduits such as home runs to panel boards. This information shall be included with the Record Drawings.

+ + END OF SECTION + +

SECTION 26 01 32
FLEXIBLE CONDUIT

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish and install flexible metallic conduit and fittings.

1.2 QUALITY ASSURANCE

A. Reference Standards: Comply with applicable provisions and recommendations of the following, except where otherwise shown or specified.
   1. NEC Article 350, Liquid-Tight Flexible Metal Conduit.
   2. UL Standard No. 360, Liquid-Tight Flexible Steel Conduit.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Manufacturer's catalog cuts and technical information for flexible conduit and fittings proposed for use.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Flexible Conduit (Non-hazardous Areas):
   1. Material: Flexible galvanized steel core with smooth, abrasion resistant, liquid-tight, polyvinyl chloride cover. Continuous copper ground built in for sizes 3/4-inch through 1-1/4-inch. Material shall be UL listed.
   2. Product and Manufacturer: Provide one of the following:
      a. Sealtite UA by Anaconda Metal Hose Division, Anaconda American Brass Company.
      b. Liquatite Type L.A. by Electric-Flex Company.
      c. Or equal.

B. Flexible Conduit (Class 1, Group D, Division 1, Hazardous Areas):
   1. Material: Flexible brass inner core with bronze outer braid. Steel, brass or bronze end fittings. Minimum of 12-inches in length.
   2. Product and Manufacturer: Provide one of the following:
      a. Type ECGJH or ECLK by Crouse Hinds Company.
      b. Type EXGJH or EXLK by Appleton Electric Company.
      c. Or equal.

C. Flexible Conduit Fittings:
   1. Material and Construction: Malleable iron with cadmium finish. Fittings shall adapt the conduit to standard threaded connections, shall have an inside diameter not less than that of the corresponding standard conduit size and shall be UL listed.
   2. Use: Provide on flexible conduit in non-hazardous and Class 1, Division 2 hazardous areas.
   3. Product and Manufacturer: Provide one of the following:
      a. Crouse-Hinds Company.
      b. Appleton Electric Company.
      c. Or equal.

D. PVC Coated Conduit Fittings:
   1. Material and Construction: Malleable iron with standard finish and 40-mil PVC exterior coating. Fittings shall adapt the conduit to standard threaded connections, shall have an inside diameter not less than that of the corresponding standard conduit size.
   2. Use: Provide on flexible conduit in areas designated as corrosive locations.
   3. Product and Manufacturer: Provide one of the following:
      a. Robroy Industries.
      b. Permacote Industries.
      c. OCAL Incorporated.
      d. Or equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install at motors, transformers and equipment which are subject to vibration or require movement for maintenance purposes. Provide necessary reducer where equipment furnished cannot accept 3/4-inch size flexible conduit. Limit flexible conduit length to three feet maximum.

B. All exterior flexible conduits shall be painted, conforming to the requirements of Division 09, Finishes.

C. Install in conformance with National Electrical Code and the applicable local Electrical Code requirements.

+ + END OF SECTION + +

SECTION 26 01 34
EXPANSION/DEFLECTION FITTINGS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish and install conduit expansion and deflection fittings.

1.2 QUALITY ASSURANCE

A. Reference Standards: Comply with applicable provisions and recommendations of the following, except where otherwise shown or specified:
   1. NEC Article 300, Wiring Methods.
   2. UL Standard 514, Electrical Outlet Boxes and Fittings.
   3. UL Standard 467, Electrical Grounding and Bonding Equipment.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Manufacturer's catalog cuts and technical information for expansion and deflection fittings proposed for use.
   2. Listing of locations where fittings are to be installed.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Cast gray iron alloy or bronze end couplings, malleable iron or hot dipped galvanized body, stainless steel clamps and tinned copper braid bonding jumper. Fitting to be watertight, corrosion-resistant UL listed and compatible with the conduit system.

B. Features:
   1. Expansion/Deflection Fittings.
      a. Axial expansion or contraction up to 3/4-inch.
      b. Angular misalignment up to 30 degrees.
      c. Parallel misalignment up to 3/4-inch.
   2. Expansion Fittings.
      a. Expansion/Contraction, 8-inch total movement.

C. Product and Manufacturer: Provide one of the following:
   1. Type DX for expansion/deflection or AX for expansion only by O-Z Gedney Company.
   2. Type XD for expansion/deflection or XJ for expansion only by Crouse Hinds Company.
   3. Type DF for expansion/deflection or XJ for expansion only by Appleton Electric Company.
   4. Or equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install fittings in conformance with the National Electrical Code and Applicable local Electrical Code.

B. Install expansion fittings on exposed conduit runs crossing structural expansion joints and where necessary to compensate for thermal expansion and contraction. Install expansion fittings on exposed conduit runs exceeding 200 feet.

C. Install expansion/deflection fittings on embedded conduit runs crossing structural expansion joints. Install fittings above waterstops.

D. Install expansion/deflection fittings for underground conduit runs at penetrations of buildings, manholes, handholes and outdoor concrete equipment pads.

E. Where required in non-metallic conduit and duct systems, provide rigid metal conduit nipples and metal rigid to PVC adapters for connection to fittings. Ensure that joints exposed to water are made watertight.

+ + END OF SECTION + +

SECTION 26 01 35
PULL BOXES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish and install pull boxes.

1.2 QUALITY ASSURANCE

A. Reference Standards: Comply with applicable provisions and recommendations of the following, except where otherwise shown or specified:
   1. NEC Article 370, Boxes, Conduit Bodies, and Fittings.
   2. UL Standard No. 50, Electrical Cabinets and Boxes.
   3. UL Standard No. 886, Electrical Outlet Boxes and Fittings for Use in Hazardous Locations.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Manufacturer's technical information for pull boxes proposed for use.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Pull Boxes: Provide boxes based upon location in accordance with NEMA requirements and as required for the area classification specified in Section 26 05 00, General Provisions.
   1. Material and Construction:
      a. Cast gray iron alloy with hot-dip galvanized finish or cast malleable iron bodies and covers.
      b. Neoprene gaskets. Gaskets shall be of an approved type designed for the purpose. Improvised gaskets are not acceptable.
      c. Stainless steel cover bolts.
      d. External mounting lugs.
      e. Drilled and tapped conduit holes.
      f. Boxes where conduits enter a building below grade shall have 1/4-inch drain hole.
   2. Product and Manufacturer: Provide pull boxes of one of the following:
      a. Appleton Electric Company.
      b. O-Z/Gedney Company.
      c. Hoffman Engineering Company.
      d. Or equal.
   3. Large boxes not generally available in cast construction may be fabricated of copper-free aluminum alloy or Type 316 stainless steel as required by location.
   4. Boxes for installation in areas classified as hazardous locations shall be explosion-proof and shall comply with the requirements of UL Standard No. 886.
   5. For flush-mounted pullboxes in slabs or pavement, provide vehicular traffic-bearing covers, where shown on the Drawings.
   6. Pull boxes embedded in concrete slabs shall be cast iron. Pull boxes located in wet, corrosive or outdoor areas shall be NEMA 4X, Type 316 stainless steel. All other areas shall be NEMA 12.
   7. All boxes shall be identified in accordance with Section 26 00 50, General Provisions.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Mount boxes so that sufficient access and working space is provided and maintain a minimum of 1/4-inch from walls.

B. Securely fasten boxes to walls or other structural surfaces on which they are mounted. Provide independent stainless steel or FRP supports where no walls or other structural surface exists.

C. Install pull boxes where shown on the Drawings. In addition, install pull boxes in conduit runs containing more than three 90 degree bends and in runs exceeding 200 feet.

D. Provide removable, flame-retardant, insulating cable supports in all boxes with any dimension exceeding three feet.

E. Field apply PVC touch up to scratched PVC boxes damaged as a result of installation. All touch up work shall be in strict conformance with manufacturer's recommendations and instructions.

F. Size pull boxes in accordance with the requirements of the National Electrical Code.

+ + END OF SECTION + +

SECTION 26 01 36
OUTLET BOXES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish and install outlet boxes for mounting wiring devices and lighting fixtures.

1.2 QUALITY ASSURANCE

A. Reference Standards: Comply with applicable provisions and recommendations of the following, except where otherwise shown or specified:
   1. NEC Article 370, Boxes, Conduit Bodies, and Fittings.
   2. UL Standard No. 514, Electrical Outlet Boxes and Fittings.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Manufacturers technical information for outlet boxes proposed for use.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Device Boxes:
   1. Material: Cast gray iron alloy, or cast malleable iron, with zinc electroplate finish in wet locations and zinc-coated sheet steel in dusty locations. Cast boxes shall be hub type and include external mounting lugs. In corrosive locations, boxes shall include a factory applied 40-mil PVC coating. In dusty locations, where conduit is installed concealed, boxes shall be steel galvanized and shall include suitable extension rings and covers, as required.
   2. Device Cover Plates:
      a. Stainless steel Type 302 alloy for indoor finished areas.
      b. Gasketed spring door type for wet and corrosive locations. Plates in corrosive locations shall include a factory applied 40-mil PVC coating.
      c. Integral with device for hazardous locations.
      d. Stainless steel screws and hardware.
   3. Manufacturer: Provide device boxes of one of the following:
      a. Crouse-Hinds Company.
      b. Appleton Electric Company.
      c. Or equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Fasten boxes rigidly and neatly to supporting structures.

B. For units mounted on masonry or concrete walls, provide suitable 1/2-inch spacers to prevent mounting back of box directly against wall.

C. Leave no open conduit holes in boxes. Close unused openings with capped bushings.

D. Label each circuit in boxes and identify in accordance with Section 26 01 22, 600 Volt Cable.

E. Install in conformance with National Electrical Code and the applicable local Electrical Code.

+ + END OF SECTION + +

SECTION 26 01 37
UNDERGROUND DUCT BANKS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish and install underground duct banks.

B. Coordination: Duct bank routing on the Drawings is diagrammatic. Coordinate installation with piping and other underground systems and structures and locate clear of interferences.

C. Related Sections: CONTRACTOR shall coordinate the requirements of the Work in this Section along with the requirements of the Sections listed below which includes, but is not necessarily limited to, Work that is directly related to this Section.
   1. Division 03, Concrete.
   2. Section 26 01 31, Rigid Conduit.
   3. Section 26 01 38, Manholes and Handholes.

1.2 QUALITY ASSURANCE

A. Reference Standards: Comply with applicable provisions and recommendations of the National Electrical Code and National Electrical Safety Code.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Layouts showing the proposed routing of duct banks and the locations of manholes, handholes and areas of reinforcement.
   2. Profiles of duct banks showing crossings with piping and other underground systems.
   3. Typical cross sections.
   4. Installation procedures.

B. Record Drawings: Include the actual routing of underground duct runs on Record Drawings.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Duct: Schedule 40 PVC conduit and fittings in accordance with Section 26 01 31, Rigid Conduit.

B. Galvanized Rigid Steel Conduit: Galvanized rigid steel conduit and fittings in accordance with Section 26 01 31, Rigid Conduit, if required.

C. Reinforcement: In accordance with Section 03 15 19, Anchorage to Concrete.

D. Concrete: In accordance with Division 03, Concrete.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide excavation and backfilling required for ductbank installation.

B. Make duct bank installations and penetrations through foundation walls watertight.

C. Top of duct banks shall be a minimum of 24-inches below grade, unless otherwise approved by the ENGINEER.

D. Assemble duct banks using non-magnetic saddles, spacers and separators. Position separators to provide 3-inch minimum concrete separation between the outer surfaces of the ducts. Provide side forms for each duct bank.

E. Provide a 3-inch minimum concrete covering on both sides, top and bottom of concrete envelopes around conduits. Concrete covering size shall be as shown on the Drawings. Add red dye to concrete for easy identification during subsequent excavation. Red dye concrete shall include the entire duct bank, top and bottom.

F. Firmly fix ducts in place during placing of concrete. Carefully place and vibrate the concrete to ensure filling of all spaces between ducts.

G. Make bends with sweeps of not less than 48-inch radius or five degree angle couplings.

H. Make a transition from non-metallic to galvanized rigid steel conduit where duct banks enter buildings, manholes, handholes and outdoor pads. Provide expansion/ deflection fittings in accordance with Section 26 01 34, Expansion/Deflection Fittings. Terminate ducts in insulated grounding bushings. Continue ducts inside buildings with rigid steel conduit.

I. Reinforce all duct banks.
   1. Unless otherwise shown on the Drawings, reinforce with No. 4 longitudinal steel bars placed at each corner and along each face at a maximum parallel spacing of 18-inches on centers, and No. 3 tie-bars transversely placed at 18-inch maximum longitudinal intervals.
   2. Maintain a maximum clearance of 1-inch from bars to the edge of the concrete encasement.

J. Where ducts enter structures such as manholes, handholes, pullboxes, transformer and switchgear compartments, or buildings, terminate the ducts in suitable end bells, insulated bushings or couplings on steel conduits.

K. Do not backfill with material containing large rock, paving materials, cinders, large or sharply angular substances, corrosive material or other materials which can damage or contribute to corrosion of ducts or cables or prevent adequate compaction of fill.

L. Slope duct runs for drainage toward manholes and away from buildings with a slope of approximately 3-inches per 100 feet.

M. Install a bare stranded copper duct bank ground cable in each duct bank envelope. Make ground electrically continuous throughout the entire duct bank system. Connect ground cable to building and station ground grid or to equipment ground buses. In addition, connect ground cable to steel conduit extensions of the underground duct system. Provide ground clamp and bonding of each steel conduit extension, where necessary to maintain continuity of the ground system. Terminate ground cable at last manhole or handhole for outlying structures.

N. After completion of the duct bank and prior to pulling cable, pull a mandrel, not less than 12-inches long and with a cross section approximately 1/4-inch less than the inside cross section of the duct, through each duct. Then pull a rag swab or sponge through to make certain that no particles of earth, sand or gravel have been left in the duct.

O. Install a warning ribbon approximately 12-inches below finished grade over all underground duct banks carrying cables of 120 volts and higher. The identifying ribbon shall be a PVC tape, 3-inches wide, yellow color, permanently imprinted with "CAUTION BURIED ELECTRIC LINE BELOW" in black letters.

P. Plug and seal empty spare ducts entering buildings and structures. Seal watertight all ducts in use entering buildings and structures with 0-Z/Gedney Type DUX duct sealing compound or equal.

Q. Reused Existing Ducts:
   1. Pull rag swab through duct to remove water and to clean duct prior to installing new cable.
   2. Repeat swabbing until all foreign material is removed.
   3. Pull mandrel through duct, if necessary, to remove obstructions.

R. Install duct banks in conformance with National Electrical Code, applicable local Electrical Code and National Electrical Safety Code.

+ + END OF SECTION + +

SECTION 26 01 38
MANHOLES AND HANDHOLES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
1. CONTRACTOR shall provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish and install manholes and handholes.

B. Coordination: Coordinate manhole and handhole installation with piping, sheeting and other underground systems and structures and locate clear of interferences.

C. Related Sections: CONTRACTOR shall coordinate the requirements of the Work in this Section along with the requirements of the Sections listed below which includes, but is not necessarily limited to, Work that is directly related to this Section.
1. Division 03, Concrete.
2. Section 26 01 37, Underground Duct Banks.

1.2 QUALITY ASSURANCE

A. Reference Standards: Comply with applicable provisions and recommendations of the following, except where otherwise shown or specified:
1. National Electrical Code.
2. National Electrical Safety Code.
3. ASTM A 48, Gray Iron Castings.
4. ANSI A14.3, Safety Requirements for Fixed Ladders.
5. OSHA.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
1. Manufacturer's technical information for manholes, handholes and accessories proposed for use.
2. Drawings showing interior and exterior dimensions and details of openings, jointing, inserts and reinforcing.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Material and Construction:
1. Precast or cast-in-place type of reinforced concrete.
2. Minimum interior dimensions as shown on the Drawings.
3. Duct entrances sized and located to suit duct banks.

B. Accessories:
1. Frames and Covers:
   a. Material: Cast iron conforming to ASTM A 48, Class 30A.
   b. Covers: Watertight, sealed type marked "ELECTRICAL" in raised 2-inch letters. Identify covers as shown on the Drawings.
   c. Frame shall be grouted on the manhole or handhole.
   d. Product and Manufacturer: Provide frames and covers of one of the following:
      1) Neenah Foundry Company.

2) Campbell Foundry Company.

2. Frames and Covers:
   a. Material: Covers and frames shall be cast aluminum alloy, Class H-20 highway rated.
   b. Covers: Watertight, sealed type marked "ELECTRICAL" in raised 2-inch letters. Identify covers as shown on the Drawings.
   c. Frame shall be grouted on the manhole or handhole.
   d. Product and Manufacturer: Provide frames and covers of one of the following:
      1) Neenah Foundry Company.
      2) Campbell Foundry Company.
3. Pulling Irons:
   a. Material: Galvanized steel.
   b. Cast in the wall opposite to the centerline of each incoming duct bank and 12-inches below centerline of bottom line of ducts.
   c. Product and Manufacturer: Provide one of the following:
      1) Catalog No. 8119 by A.B. Chance Company.
      2) Catalog No. DU2T3 by McGraw Edison Company.
4. Cable Racks:
   a. Material: Galvanized steel.
   b. Cable racks shall adequately support cables with space allowed for future cables.
   c. Each rack shall be a vertical assembly of 24-inch cable racks extending from within 6-inches of the manhole roof slab to within 6-inches of the manhole floor.
   d. Product and Manufacturer: Provide one of the following:
      1) Catalog No. J-5125 by Joslyn Manufacturing Company.
      2) Catalog No. C203-1125 by A.B. Chance Company.
5. Cable Hooks:
   a. Material: Galvanized steel.
   b. Length: 7-1/2-inch minimum.
   c. Product and Manufacturer: Provide one of the following:
      1) Catalog No. J-5132A by Joslyn Manufacturing Company.
      2) Catalog No. C203-1132 by A.B. Chance Company.
6. Insulators:
   a. Material: Porcelain.
   b. Product and Manufacturer: Provide one of the following:
      1) Catalog No. J-5122 by Joslyn Manufacturing Company.
      2) Catalog No. C203-1120 by A.B. Chance Company.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install manholes and handholes where shown on the Drawings. Verify final locations in field. CONTRACTOR shall be responsible for all excavation and backfilling required for installation.

B. Complete installation of manholes and handholes so that structures are watertight. Apply foam sealant to all penetrations.

C. Cable Supports in Manholes:
1. Attach cable racks with 3-inch by 3/8-inch diameter "tamp-in" studs mounted in 1-inch holes drilled into walls of manholes in the absence of inserts. Apply PVC coating to all racks.

2. Provide cable hooks to support each cable on each rack along the cable run within the manholes. Apply PVC coating to all hooks.
3. Individually support each cable at each hook on porcelain insulators. Provide sufficient slack for each cable.
4. Securely tie each cable in place at each insulator block to prevent excessive movement of insulators, cables, or fireproof tape. Tie cables with non-metallic 3/4-inch strapping tape as manufactured by 3M or tie down with nylon straps.

D. Grounding: Install a 3/4-inch by 10-foot copper-clad ground rod for each manhole. Bond all exposed metal manhole accessories and the concrete reinforcing rods with No. 4 AWG minimum bare copper wire and connect to the ground rod and to the duct bank ground cable.

E. Sump: Provide a 12-inch by 12-inch by 6-inch sump in manhole floor.

F. Provide grading rings for manholes when required to adjust cover to proper grade. Grading ring shall be minimum of 12-inches in height, constructed on the roof slab or cone section on which the manhole frame and cover shall be placed. The height of the grading ring shall be such as is necessary to bring the frame to the proper grade.

G. Metal Pullbox: Install NEMA 4X stainless steel wall mounted pullbox inside manholes/handholes where analog signal cables are mixed with power cables. Route conduits for analog cables directly into and out of metal pullbox so that no analog cables are exposed.

+ + END OF SECTION + +

SECTION 26 01 41
RECEPTACLES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish and install receptacles.

B. Related Sections: CONTRACTOR shall coordinate the requirements of the Work in this Section along with the requirements of the Sections listed below which includes, but is not necessarily limited to, Work that is directly related to this Section.
   1. Section 26 01 36, Outlet Boxes.

1.2 QUALITY ASSURANCE

A. Reference Standards: Comply with applicable provisions and recommendations of the following, except where otherwise shown or specified:
   1. National Electrical Code.
   2. UL Standard No. 1010, Electrical Receptacle - Plug Combinations for Use in Hazardous Locations.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Manufacturer's technical information for receptacles proposed for use.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Receptacles for Non-Hazardous Locations:
   1. Duplex grounding receptacle, two pole, three wire, 125 volt AC, 20 amperes.
      a. Product and Manufacturer: Provide one of the following:
         1) Catalog No. 5362, for dry indoor locations and Catalog No. 53CM62, for wet and corrosive locations, by Harvey Hubbell Incorporated.
         2) Catalog No. 5362, for dry indoor locations and Catalog No. 5362-CR, for wet and corrosive locations, by Arrow-Hart Incorporated.
         3) Or equal.
   2. Single grounding receptacle, corrosion resistant, two pole, three wire, 125 volt AC, 20 amperes.
      a. Product and Manufacturer: Provide one of the following:
         1) Catalog No. 53CM61, by Harvey Hubbell Incorporated.
         2) Catalog No. 5361-CR, by Arrow-Hart Incorporated.
         3) Or equal.

B. Ground Fault Receptacles:
   1. Duplex receptacle, two pole, three wire, 125 volt AC, 20 amperes.
   2. Product and Manufacturer: Provide one of the following:
      a. Catalog No. GF5362, by Harvey Hubbell Incorporated.
      b. Catalog No. GF5342, by Arrow-Hart Incorporated.

C. Power and Special Receptacles: Provide receptacles with number of poles and voltage and current rating as shown on the Drawings. Coordinate with equipment plugs. Provide matching plug for each receptacle.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install receptacles at locations as shown on the Drawings in outlet or device boxes in accordance with Section 26 01 36, Outlet Boxes, in non-hazardous locations.

B. Install receptacles in PVC coated galvanized rigid steel conduit systems in hazardous locations.

C. Install receptacles with ground pole in the down position.

D. Mount receptacles 18-inches above finished floor in non-hazardous locations and 4 feet-6 inches above finished floor in hazardous locations, unless otherwise noted.

E. Identify each conductor with the circuit number and the lighting panel number. Identification shall conform to the requirements of Section 26 01 22, 600 Volt Cable.

F. Identify each receptacle with a permanent self-adhesive label. Approximate size 3/8” x 1¼”. The label shall include the panel name and circuit number.

G. Product and Manufacturer: Provide one of the following:
   1. Catalog No. PTL-45422 by Brady.
   2. Or Equal

H. Install in conformance with National Electrical Code and the applicable local Electrical Code.

+ + END OF SECTION + +

SECTION 26 01 43
DISCONNECT SWITCHES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish and install disconnect switches.

B. Related Sections/Divisions: CONTRACTOR shall coordinate the requirements of the Work in all Sections of the Divisions listed below along with the requirements which includes, but is not necessarily limited to work that is directly related to this Section.
   1. Division 01, General Requirements
   2. Division 26, Electrical

1.2 QUALITY ASSURANCE

A. Reference Standards: Comply with applicable provisions and recommendations of the following, except where otherwise shown or specified:
   1. National Electrical Code.
   2. UL Standard No. 98, Enclosed Switches.
   3. NEMA KS-1, Enclosed Switches.
   4. NEMA 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Manufacturer's technical information for disconnect switches proposed for use.
   2. Snap Switches (for disconnect switches on 120 volt, single phase circuits) coordinate with Section 26 01 42, Snap Switches.
   3. Listing of the switches to be furnished with an identification of their location, rating and NEMA enclosure type.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Service Disconnect Switches:
   1. Type: Fused, heavy-duty, single throw, quick-make, quick-break mechanism, visible blades in OFF position and safety handle.
   2. Rating: Voltage, current and short circuit ratings and number of poles as shown on the Drawings. Switch shall bear a UL label certifying suitability for use as service equipment.
   3. Provide auxiliary dry contacts to indicate switch position.

B. Single Throw, Circuit Disconnect Switches:
   1. Type: Fused or unfused, horsepower rated, heavy-duty, single throw, quick- make, quick-break mechanism, visible blades in the OFF position and safety handle.
   2. Rating: Voltage and current ratings and number of poles as required for motor or equipment circuits being disconnected. Switches shall bear a UL label.
   3. Provide auxiliary dry contacts to indicate switch position.

C. Enclosures:
   1. NEMA 12 for dry, indoor non-corrosive areas.

2. In all other locations except wet or corrosive, NEMA 4X 304 stainless steel. For wet or corrosive locations, NEMA 4X 316 stainless steel.

D. Identification:
1. Identify all enclosures in accordance with Section 26 05 00, General Provisions.
2. Nameplate identifying equipment, include identification of the equipment served and source of power, for which switches serve as the disconnecting means.

E. Product and Manufacturer: Provide one of the following:
1. Square D Company.
2. General Electric Company.
3. Allen Bradley.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Mount equipment so that sufficient access and working space is provided for ready and safe operation and maintenance.

B. Securely fasten equipment to walls or other structural supports on which they are mounted. Provide independent stainless steel supports where no wall or other structural surface exists.

C. Furnish one set of spare fuses for each fused disconnect switch to be installed.

D. Install in conformance with National Electrical Code and the applicable local Electrical Code.

+ + END OF SECTION + +

SECTION 26 02 15
POWER SYSTEM STUDY

PART 1 - GENERAL

1.1 DESCRIPTION

A. General:
   1. CONTRACTOR shall prepare a short circuit and coordination study for the electrical power system. The short circuit and coordination study reports shall provide an evaluation of the electrical power systems and the model numbers and settings of the protective devices.

B. Scope:
   1. Provide a complete short circuit study, equipment interrupting or withstand evaluation, and a protective device coordination study for the indicated new components of the existing Plant power distribution system. The study shall include all portions of the electrical power distribution system. Normal system operating method, alternate operation, and operations which could result in maximum fault conditions shall be thoroughly addressed in the study. The study shall assume all motors operating at rated voltage with the exception that motors identified as "standby" shall not be included. Electrical equipment bus impedance shall be assumed zero. Short circuit momentary duties and interrupting duties shall be calculated on the basis of maximum available fault current at the switchgear busses and motor control centers. The phase over-current and ground-fault protection shall be included as well as settings for all other adjustable protective devices.
   2. An equipment evaluation study shall be performed to determine the adequacy of circuit breakers, controllers, surge arresters, busways, switches, and fuses by tabulating and comparing the short circuit ratings of these devices with the available fault currents.
   3. Any problem areas or inadequacies in the equipment shall be promptly brought to the ENGINEER'S attention.

1.2 REFERENCES

A. This Section contains references to the following documents. They are a part of this Section as specified and modified. In case of conflict between the requirements of this Section and those of the listed documents, the requirements of this Section shall prevail.

Reference	Title
IEEE 141-86	Recommended Practice for Electric Power Distribution for Industrial Plants
IEEE 242-86	Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems

1.3 SCHEDULE

A. The approved reports shall be completed and a copy sent to the switchgear manufacturer sixty days before the switchgear is shipped to the project site. The report shall be provided to the ENGINEER thirty days before the switchgear is shipped to the project site.

PART 2 - PRODUCTS

2.1 REPORTS

A. The product shall be a certified report summarizing the short circuit and coordination study and conclusions or recommendations which may affect the integrity of the electric power distribution system. As a minimum, the report shall include the following:

1. The equipment manufacturer's information used to prepare the study.
2. Assumptions made during the study.
3. Short circuit calculations listing short circuit levels at each bus.
4. Coordination study time-current curves including the instrument transformer ratios, model numbers of the protective relays, and the relay settings associated with each breaker.
5. Comparison of short circuit duties of each bus to the interrupting capacity of the equipment protecting that bus.
6. All data which was used as input to the report. This data shall include cable impedances, source impedances, equipment ratings, etc.

PART 3 - EXECUTION

3.1 GENERAL

A. Provide a short circuit and coordination study on the electrical power distribution system, as specified. The study shall be performed in accordance with IEEE Standards 141 and 242 and shall utilize the ANSI method of short circuit analysis in accordance with ANSI C37.010. The study shall be performed using actual equipment data for all equipment. The coordination study shall use the data from the manufacturer of protective devices.

3.2 QUALIFICATIONS

A. The short circuit and coordination report shall be performed by an electrical testing service who is regularly engaged in power system studies. The studies shall be signed and sealed by a Registered Professional Electrical Engineer. The Registered Professional Electrical Engineer shall be licensed in the applicable state.

3.3 SHORT CIRCUIT STUDIES

A. CONTRACTOR shall be responsible to obtain and verify all data needed to perform the studies.

B. As a minimum, each short circuit study shall include the following:
   1. One-Line Diagram:
      a. Location and function of each protective device in the system, such as relays, direct-acting trips, fuses, etc.
      b. Type designation, current rating, range or adjustment, manufacturer's style and catalog number for all protective devices.
      c. Power, voltage ratings, impedance, primary and secondary connections of all transformers.
      d. Type, manufacturer, and ratio of all instrument transformers energizing each relay.
      e. Nameplate ratings of all motors and generators with their subtransient reactances. Transient reactances of synchronous motors and generators and synchronous reactances of all generators.
      f. Sources of short circuit currents such as utility ties, generators, synchronous motors, and induction motors.
      g. All significant circuit elements such as transformers, cables, breakers, fuses, reactors, etc.
      h. Emergency as well as normal switching conditions.
      i. The time-current setting of existing adjustable relays and direct-acting trips, if applicable.
   2. Impedance Diagram:
      a. Available MVA or impedance from the utility company.
      b. Local generated capacity impedance.

c. Bus impedance.
d. Transformer and/or reactor impedances.
e. Cable impedances.
f. Equipment impedances.
g. System voltages.
h. Grounding scheme (resistance grounding, solid grounding, or no grounding).

3. Calculations:
   a. Determine the paths and situations where short circuit currents are the greatest. Assume bolted faults and calculate the 3-phase and line-to-ground short circuits of each case.
   b. Calculate the maximum and minimum fault currents.

3.4 COORDINATION STUDY

A. As a minimum, the coordination study for the power distribution system shall include the following on 5-cycle, log-log graph paper:
   1. Time-current curves for each protective relay or fuse showing graphically that the settings will provide protection and selectivity within industry standards. Each curve shall be identified, and the tap and time dial settings shall be specified.
   2. Time-current curves for each device shall be positioned to provide for maximum selectivity to minimize system disturbances during fault clearing. Where selectivity cannot be achieved, the ENGINEER shall be notified as to the cause.
   3. Time-current curves and points for cable and equipment damage.
   4. Circuit interrupting device operating and interrupting times.
   5. Indicate maximum fault values on the graph.
   6. Sketch of bus and breaker arrangement.

+ + END OF SECTION + +

SECTION 26 02 31

480 VOLT STANDBY POWER GENERATOR SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:

1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals as required to furnish and install diesel engine-generator sets complete with all appurtenances as shown on the Drawings, specified and required for complete operational diesel engine generator standby power systems where required by the Drawings.

B. In order to centralize responsibility, it is required that the entire engine generator and all equipment and services provided under this Section be furnished by a single supplier or manufacturer who shall assume full responsibility for the completeness of the systems. The supplier shall be authorized to perform warranty service on the complete system.

C. Related Sections: CONTRACTOR shall coordinate the requirements of the Work in this Section along with the requirements of the Sections listed below which includes, but is not necessarily limited to, Work that is directly related to this Section.

~~1. Section 01 65 50, Product Delivery, Storage, and Handling.~~

~~2.~~1. ~~Section~~Division 03 ~~00 05~~, Concrete.

~~3. Section 03 15 19, Anchorage to Concrete.~~

~~4. Section 26 04 12, Automatic Transfer Switches.~~

Commented [PM1]: This spec is not included yet, do we need it?

D. The manufacturer of the equipment specified herein shall be required to review and satisfy all relevant requirements of other Sections of the Contract Documents.

E. Warranty: The equipment supplied under this Section shall be covered by a single warranty against defects in material and workmanship for a period of five years or 3000 hours of operation. Warranty shall provide for free replacement or repair of parts for the five years or 3000 hours of operation period, and free labor for the first two years. A warranty statement including these features shall be provided as part of the OWNER'S operation and maintenance manuals. Warranty shall be administered by the same company that supplied the equipment.

F. Electrical connections shall be furnished by CONTRACTOR.

G. The equipment shall be installed by CONTRACTOR.

1.2 QUALITY ASSURANCE

A. Manufacturer's Qualifications:

1. Manufacturer shall have a minimum of five years of experience of producing substantially similar equipment and shall be able to show evidence of at least five installations in satisfactory operation for at least five years.

B. The manufacturer shall have complete parts and service facilities and a factory trained service staff available on a 24-hour basis.

C. Requirements of Regulatory Agencies: Comply with applicable provisions of regulatory agencies below and others having jurisdiction:

1. Local Ordinances: The manufacturer shall submit proof that the engine generator sets meet all requirements with respect to noise control and emission. Exhaust emissions and sound levels shall not exceed the values given under Products, in this Section. Certified test reports shall be provided.
2. Permits: CONTRACTOR shall obtain and pay for all required permits, fees and inspections by authorities having jurisdiction.

3. Applicable Local and State Building Codes and Ordinances.
4. Underwriters' Laboratories Incorporated (UL).
5. Industrial Risk Insurance (IRI).
6. National Fire Protection Association (NFPA).
7. National Electric Code (NEC).

D. Source Quality Control:
1. All equipment shall be new, of current domestic production of a national firm which manufactures the engine-generator set as a matched unit, and the manufacturer together with its authorized representative, shall have full responsibility for the performance of the generator set and its accessories. Unit shall be designed for outdoor installation.
2. The engine generator set shall be factory assembled and tested to determine that it is free from electrical or mechanical defects and that it meets design specifications.
3. Supplier shall maintain a parts and service facility, employ factory trained technicians, and offer 24-hour emergency service. Supplier shall be the authorized dealer of the manufacturer offering standard production equipment built and prototype tested in accordance with NFPA 110 and shall be authorized to administer the warranty for all components of the standby generator system specified herein.
4. UL inspection and labeling.
5. Industrial Risk Insurers inspection and labeling.
6. Perform the following tests and inspections at factory.
    a. Pressure test at five psi.
    b. UL inspection and labeling.

E. Reference Standards: Comply with applicable provisions and recommendations of the following, except where otherwise shown or specified.
1. NFPA 30, Flammable and Combustible Liquids.
2. NFPA 31, Standard for the Installation of Oil-Burning Equipment.
3. NFPA 37, Standard for the Installation and use of Stationary Combustion Engines and Gas Turbines.
4. NFPA 70E Electrical Safety Requirements for Employee Workplaces.
5. NFPA 99 Health Care Facilities.
6. NFPA 101 Life Safety Code.
7. NFPA 110 Emergency and Standby Power Systems.
8. NEC Article 701, Legally Required Standby Systems.
9. NEMA MG1, Motors and Generators.
10. UL Standard No. 1008 Standard for Safety.
11. UL Standard No. 142 Steel Above Ground Tanks.
12. UL Standard No. 2085, Insulated Aboveground Tank for Flammable and Combustible Liquids.
13. ULC/ORD 142.23, Aboveground Waste Oil Tank.

F. Performance Tests:
Factory Tests: Standard production tests shall be performed at the factory after assembly to verify proper operation and performance. CONTRACTOR shall notify the OWNER and ENGINEER at least two weeks in advance of the test.
1. The equipment supplied shall have been prototype tested and reports shall be provided with the submittals.
2. Field testing shall be performed by a factory trained serviceman as coordinated by CONTRACTOR.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:

1. Standby power generators.
    a. Bill of Material, covering all equipment submitted.
    b. Qualifications of the engine-generator manufacturer and of the authorized distributor in accordance with Paragraph 1.2.A of this Section. Verify the availability of 24-Hour emergency service capability.
    c. Manufacturer's published rating sheet. NFPA-110 test verification. Altitude and temperature derating procedures. Frequency and voltage regulation. Cooling system capability. Full rated load pickup capability.
    d. Installation requirements: Radiator airflow and backpressure capacity, combustion air requirement, fuel consumption, fuel circulation, heat rejection, exhaust flow, exhaust back-pressure calculations, battery requirements. ISO container pad layout dimensional data with provision for cable entry and termination.
    e. Engine performance data. Configuration, cubic inch displacement, rated RPM, type of aspiration, voltage of electrical system, oil and coolant capacities, exhaust volume and temperature, and motor starting capability in KVA at 90 percent sustained voltage.
    f. Exhaust emission data provided on the current application form of the Air Pollution Control District (APCD). Exhaust and crankcase emission control equipment devices.
    g. Description of battery set and battery charger.
    h. Generator data sheet including, as a minimum, design type, continuous and standby rating in KW, voltage, phase, frequency, winding insulation class and temperature rise, coupling, voltage and frequency regulation capability, AC wave form total harmonic distortion from no load to full linear load and surge KW capacity.
    i. Control panel features and performance. Meters and gauges. Safety alarm and shutdown devices. Cranking control. Indicator lamps and horn. Control switches.
    j. Exhaust silencer attenuation rating.
    k. Jacket water heater system.
    l. Generator control panel front views, wiring diagrams, instrument and relay data, description of operation.
    m. Generator set seismic restraint devices.
        1) Agency pre-qualification.

        2) Dimensional data.

        3) Seismic restraint calculations.

    n. Enclosure details.
        1) Exhaust system mounting.

        2) Overall dimensions.

        3) Sound attenuation data for conformance to specified requirements and to APCD requirements.

    o. Fuel storage system.
        1) Compliance with UL.

        2) Secondary containment.

        3) Alarm and indicator devices.

        4) Dimensional data.

        5) Fuel capacity and hours of operation at rated load.

6) Seismic restraint devices and calculations for the fuel tank configuration.

p. Schematic and wiring diagrams for all major components. Interconnection diagram for all major components.
q. Complete details of generator enclosure.
r. Shop and field-testing procedures.
s. Warranty certificate and administration authorization by the supplier in accordance with Paragraph 1.1.E., above.

2. Above-ground fuel oil storage tank.
   a. Manufacturer's literature, illustrations, specifications, engineering data, materials of construction, dimensions, and cross-section cuts.
   b. Drawings showing fabrication methods, assembly, installation details, and accessories including construction of tank, piping layouts, calibration charts, and sizing of all fittings.
   c. Piping sump details, dimensions, including installation details.

B. Operation and Maintenance Manuals:
   1. Submit complete installation, operation and maintenance manuals including test reports, maintenance data and schedules, description of operation and spare parts information.
   2. Furnish Operation and Maintenance Manuals in conformance with the requirements of Section 01 78~~33~~ ~~0~~43, Operation and Maintenance Data~~Manuals~~.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Deliver materials to the site to ensure uninterrupted progress of the Work. Deliver anchor bolts and anchorage devices which are to be embedded in cast-in-place concrete in ample time to prevent delay of the Work.

B. All boxes, crates and packages shall be inspected by CONTRACTOR upon delivery to the site. CONTRACTOR shall notify ENGINEER of any loss or damage exists to equipment or components. Replace loss and repair damage to new condition in accordance with manufacturer's instructions.

C. Store materials to permit easy access for inspection and identification. Keep all materials off the ground, using pallets, platforms or other supports. Protect steel members and packaged materials from corrosion and deterioration.

PART 2 - PRODUCTS

2.1 GENERAL

A. The following generator sets are required:
   1. Number Required: Reference Single line diagram for number of required Generator sets.
   2. Ratings:
      a. kW Rating per Single Line Diagram. 0.8 power factor, 480 volts, 3 phase, 4 wire, 60 Hz. when equipped with all accessories. Ratings are based on standby operation.
   3. Cooling System: Radiator type, unit mounted.

B. Ambient Conditions:
   1. Maximum Ambient Temperature: 120°F.
   2. Altitude: 1000 feet above sea level.

2.2 ENGINE-GENERATOR SET

A. Engine Type:
   1. Four cycle, radiator cooled diesel, 1800 RPM, maximum bore-to-stroke ratio of unity
   2. and maximum crankshaft operating speed of 1800 RPM. Two cycle engines are not acceptable.

B. Engine Construction:
   1. Steel backed bearings.
   2. Crank Case: Reinforced cast iron.
      Crank Shaft: Forged alloy steel with hardened journals, finished and dynamically balanced.
   3. Cylinder Head: Cast iron.
   4. Pistons: Aluminum alloy with chrome faced rings.
   5. Replaceable cylinder liners and valve seat inserts for engines rated over 200 horsepower.
   6. Single block construction. Bolted, multiple blocks are not acceptable.

C. Cooling System:
   1. Cooling system shall employ an engine-mounted radiator capable of cooling the engine when operating under full load conditions in an ambient temperature of 50°C.
   2. Engine shall be provided with a thermostatic valve placed in the jacket water outlet between the radiator and the engine to maintain proper jacket water temperature. An integral engine driven circulating pump shall be provided to circulate water through the engine cooling system.
   3. Coolant: System shall be filled with a 50 percent solution of ethylene glycol.
   4. High engine temperature shutdown.
   5. Loss of coolant shutdown.
   6. Engine coolant heaters, thermostatically controlled capable of keeping the jacket water at a minimum temperature of 90°F in an ambient temperature of 20°F. The coolant heaters shall operate at 208 volts, single phase. Provide a suitably rated control system for the required coolant heater.
   7. The radiator shall include duct adaptors for the connection of radiator discharge ducting.

D. Fuel System:
   1. Suitable for operation on No. 2 diesel fuel oil. System to include fuel filters, fuel pump, dry element air cleaners, an electronic governor, and the following:
   2. Governor: Electronic, speed droop externally adjustable, isochronous to five percent.
   3. Fuel/Water Separator.

E. Subbase Fuel Storage: The packaging shall include a double wall, sub-base mounted, UL142 listed fuel tank. The tank shall be sized to provide 24 hours of run time.
   2. The tank shall include fuel suction and return connections, normal and emergency vents, secondary containment emergency vent and rupture basin sensor, mechanical fuel level indication and a stub-up area convenient for electrical conduit entry.
   3. The fuel tank shall use an electric fuel sensor to provide an analog indication of fuel level. The controller shall have a warning indication on low fuel level and provide optional shutdown functionality for low, low fuel level.
   4. The fuel tank must be supplied by the engine-generator set manufacturer and be installed before shipment.

F. Exhaust System:
   1. Flexible stainless steel exhaust connectors and hospital critical silencing mufflers, GT
   2. exhaust systems, or equal as shown on the Drawings. Include condensate drain valve. All piping and mufflers shall be installed and insulated by Contractor. Back pressure shall not exceed 20-inches of water.

G. Starting System:
   1. DC system complete with engine mounted batteries, locally mounted charger and connecting cables between batteries and engine and between charger and batteries.
   2. Batteries: Lead-acid or nickel-cadmium, engine cranking type, rated in accordance with engine manufacturer's requirements for a minimum of three 15 second cranking cycles at firing speeds without recharging. Batteries to be sized to accommodate DC power requirements of the control panel and any other accessories requiring DC power.
   3. Engine mounted alternator rated 75 amps minimum.
   4. Charger: Automatic float charger, current limited, with DC ammeter and voltmeter, equalizing switch and capable of recharging the batteries to full charge in not more than six

hours after three crank cycles, the charger shall be integrally mounted on the engine-generator set or wall and operate on 120 volts AC input.

H. Alternator:
1. Revolving field, 4-pole, brushless excitation, 2/3 pitch, open drip-proof self-ventilated enclosure, Class H insulation, output blocking diode, skewed stator, dynamically balanced rotor, full amortisseur windings, epoxy coating on rotor and stator for abrasion and humidity protection, microprocessor-controlled voltage regulator and anti-condensation heater. The alternator shall have the following characteristics:
2. Voltage Regulation: One percent from no load to full load.
3. Voltage Adjustment: Five percent in generator control panel.
4. Excitation: Include a permanent magnet pilot exciter, in addition to the standard exciter, to sustain fault current to three times full load rating.
5. Rated for 80°C temperature rise.

I. Control Panel:
1. Panel shall be furnished generator set mounted and shall contain the controls, instruments, lights, and other devices necessary to manually and automatically start, stop and protect the diesel engine-generator unit. Controls and alarms shall operate from battery power. The panel shall be mounted on vibration isolators. Panel installed in the interior of enclosure. All signals and alarms listed below shall be monitored by the CCS. Panel shall include the following:
   a. "RUN/OFF/AUTO" selector switch with terminals for two-wire remote start-stop signal from one or more automatic transfer switches.
   b. AC Volts, two percent accuracy, in percent of rated.
   c. AC amps, two percent accuracy, in percent of rated.
   d. VM/AM phase selector switch.
   e. Kilowatts, in percent of rated.
   f. Frequency, 0.5 percent accuracy.
   g. DC voltage readout.
   h. Engine coolant temperature readout.
   i. Engine oil pressure readout.
   j. Running time readout.
   k. Readouts and dry contact outputs for the following conditions:
      1) Overcrank (Shut Down).
      2) High coolant temperature (Warning Alarm).
      3) High high coolant temperature (Shut Down).
      4) Low coolant temperature (Warning Alarm).
      5) Low oil pressure (Warning Alarm).
      6) Low low oil pressure (Shut Down).
      7) High generator temperature (Warning Alarm).
      8) Low fuel level day tank (Warning Alarm).
      9) Battery voltage low (Warning Alarm).
      10) Battery voltage high (Warning Alarm).
      11) Generator running.
      12) Overspeed (Shut Down).
      13) Anticipatory low oil pressure (Warning Alarm).
      14) Anticipatory high water temperature (Warning Alarm).
      15) Manual emergency stop (Shut Down).
      16) Not in automatic (Warning Alarm).
      17) System ready.
      18) Battery charger fault (Warning Alarm).
      19) High high generator temperature (Shut Down).
      20) Low fuel level storage tank (Warning Alarm).
      21) Liquid in diesel fuel containment basin. This signal shall also be retransmitted to a remote panel.
      22) Battery weak at time of cranking (Warning Alarm).

23) Overcurrent (Warning Alarm).
24) Overcurrent (Shut Down).
25) High AC voltage (Shut Down).
26) Low AC voltage (Shut Down).
27) Under frequency (Shut Down).

2. Ground fault (Shut Down).
3. Lamp test momentary push button controls and wiring.
4. Reset Control: Manual or remote restarts shall not be permitted and alarm lamps
5. shall remain in the alarm state until manual reset is accomplished even if the alarm condition has been corrected.
6. Emergency stop pushbutton switch for shutdown independent of cooldown timer.
7. Cooldown timer.
8. Main circuit breaker, rated as shown on the Drawings.
9. The following output signals shall be provided for interfacing with the site control system:
   a. Generator running.
   b. Generator common warning alarm.
   c. Generator common shutdown.
   d. Generator Not-In-Auto

J. Engine Generator Set Control:
1. The control shall have automatic remote start capability. The panel mounted switch
2. shall stop the engine in the "STOP" position, start and run the engine in the "RUN" (unloaded) position, and allow the engine to start and run by closing a remote contact, and stop by opening the remote contact when in the "AUTO" position. In the "AUTO" position, one or more automatic transfer switches shall signal the engine generator to start upon loss of normal (utility) power. After the generator reaches approximately 90 percent of rated voltage, the automatic transfer switch shall transfer to the emergency position after a preset time delay.
3. The control shall include a cycle cranking function. The cranking cycle, nonadjustable
4. shall consist of an automatic crank period of approximately 15 seconds duration followed by a rest period of approximately 15 seconds duration. Cranking shall cease upon engine starting and running. Two means of cranking termination shall be provided, one as a backup to the other. Failure to start after three cranking cycles (75 second) shall shut down and lock out the engine, and visually indicate an overcrank shutdown on the panel.
5. A solid-state time delay stop, adjustable from one to five minutes (factory set at five
6. minutes), shall maintain the availability of the emergency source in the event that the normal power source fails shortly after retransfer and shall permit the engine-generator set to run unloaded for a cooldown period prior to shut down.

K. Generator Base:
1. Base shall be a structural steel frame of adequate rigidity for generator and engine alignment.

L. Engine-Generator Set Mounting:
1. Vibration Isolators: Steel springs in combination with rubber pads.
2. Anchor Bolts: Type 316 stainless steel
3. Anchor Bolts, Toggle Bolts and Concrete Inserts.
4. A template shall be furnished by the manufacturer for setting anchor bolts, pipe
5. sleeves, and nuts for mounting the spring type isolators specified to the concrete foundation. Bolts and nuts shall be furnished for bolting the isolators to the channel frame base of the engine-generator set.

M. Vibration Isolation: Provide flexible connections between engine-generator set and fuel lines, exhaust system, conduit containing power or control cables and other externally connected support systems.

N. Exhaust characteristics shall be furnished for compliance with Air Pollution Control District (APCD) regulations. Certified test reports shall be furnished for approval by the Air Pollution Control District and for the ENGINEER'S information.

O. The sound pressure level developed by the generator set shall be a maximum 85 dBA at three feet when measured in accordance with IEEE Standard 85, Test Procedure for Airborne Sound Measurement on rotating electrical machines.

P. Spare Parts:
   1. Provide the following spare parts for each generator set:
      a. Two sets - fuel filters (primary and secondary).
      b. One set - air filters.
      c. One dozen - light bulbs for control panel monitor lights.
      d. Two - fuses for control circuit.
      e. Two sets - lube oil filters.
      f. One set - fan belts.
   2. Spare parts shall be packed in sturdy containers with clear indelible identification
   3. markings and shall be stored in a dry, warm location until transferred to the OWNER at the conclusion of the Project.

Q. Product Manufacturer: Provide one of the following:
   1. MTU.
   2. Cummins
   3. Caterpillar.

2.3 SURFACE PREPARATION AND PAINTING

A. Standby generator set, all ferrous metals of the equipment, appurtenances, etc., shall receive shop primer and shop finish coating conforming to the requirements of Section 09 96 00 , Painting. If any damage to the paint system occurs, the equipment shall be repainted as directed by the ENGINEER.

B. Surface preparation and painting shall conform to the requirements of Section 09 96 00, High Performance Industrial Coatings.

C. All surfaces which are to remain unpainted shall receive a heavy application of grease or other rust-resistant coating. This coating shall be maintained during storage and until the equipment is placed into operation.

D. CONTRACTOR shall certify, in writing, that the shop primer and shop finish coating system conform to the requirements of Section 09 96 00, High Performance Industrial Coatings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Engine-Generator Set Mounting:
   1. A template shall be furnished by the manufacturer for setting anchor bolts, pipe
   2. sleeves, and nuts for mounting the spring type isolators specified to the concrete foundation. Bolts and nuts shall be furnished for bolting the isolators to the channel frame base of the engine-generator set.
   3. Vibration Isolation: Provide flexible connections between engine-generator set and
   4. fuel lines, exhaust system, conduit containing power or control cables and other externally connected support systems.

B. Load test each generator, utilizing a resistive load bank if necessary, as follows:
   1. 1/2 hour at half load.
   2. 1/2 hour at 3/4 load.
   3. Four hours at rated full load.

3.2 MANUFACTURER'S SERVICES

A. A factory trained representative shall be provided for installation supervision, start-up and test services and operation and maintenance personnel training services. The representative shall make a minimum of 3 visits, to the site. The first visit shall be for assistance in the installation of equipment. The second visit shall be for checking the completed installation and start-up of the system. The third visit shall be for training of Operations and Maintenance Personnel. Manufacturer's representative shall test operate the system in the presence of the ENGINEER and verify that the standby power generators conform to requirements. Representative shall revisit the job site as often as necessary until all trouble is corrected and the installation is entirely satisfactory.

B. All costs, including travel, lodging, meals and incidentals, shall be considered as included in CONTRACTOR'S bid price.

+ + END OF SECTION + +

SECTION 26 02 71
DRY TYPE TRANSFORMERS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish and install dry type transformers.

B. Related Sections: CONTRACTOR shall coordinate the requirements of the Work in this Section along with the requirements of the Sections listed below which includes, but is not necessarily limited to, Work that is directly related to this Section.
   1. Section 03 00 05, Concrete, for concrete pad.
   2. Section 26 05 00, General Provisions.

1.2 QUALITY ASSURANCE

A. Reference Standards: Comply with applicable provisions and recommendations of the following, except where otherwise shown or specified.
   1. ANSI C89.1, Specialty Transformers.
   2. ANSI C89.2, Dry-Type Transformers for General Applications.
   3. UL Standard No. 506, Specialty Transformers.
   4. UL Standard No. 1561, including UL K factor listed.
   5. NEMA ST-20, Sound Levels.
   6. National Electrical Code.
   7. Applicable local Electrical Code.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Manufacturer's technical information for transformers proposed for use, including pad layout, materials, dimensions, etc.
   2. Listing of the transformers to be furnished with their ratings and proposed locations identified.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General:
   1. Type: Low-temperature rise, dry type, general purpose.
   2. Rating: KVA, primary voltage and connection, secondary voltage and connection, frequency and number of phases shall be as shown on the Drawings.
   3. Taps: Full capacity, two 2-1/2 percent primary taps above normal and a minimum of two 2-1/2 percent primary taps below normal.
   4. Sound Level: ANSI C89.1 standard.
   5. Enclosure: UL listed for either indoor or outdoor use.
   6. Insulation: Class 220°C, 115°C rise.
   7. Identification: Identify transformers in accordance with Section 26 05 00, General Provisions, identifying the transformer identification number, primary and secondary power identification and voltages.

B. Non Linear Load, K Factor Rated Transformer:

1. Type: 100 percent non-linear rated, specifically designed to handle non-linear loads with double size neutral. Transformer shall include an electrostatic shield grounded to the transformer core.
2. UL K Factor: K=13.
3. Impedance: Three percent minimum, five percent maximum.

C. Product and Manufacturer: Provide one of the following:
1. ABB.
2. Jefferson.
3. Square D Company.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install transformers on walls or floors at locations shown on the Drawings. Install floor mounted transformers on raised concrete bases. Provide sufficient access and working space for ready and safe operation and maintenance.

B. Mount transformers so that vibrations are not transmitted to the structural parts of the building or to other equipment. Make connections to transformers with flexible conduit.

C. Adjust tap settings to provide proper voltage at panelboards.

D. Ground transformer properly and install in conformance with the National Electrical Code and the applicable local Electrical Code.

+ + END OF SECTION + +

SECTION 26 02 82
TRANSIENT VOLTAGE SURGE SUPPRESSION

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish and install transient voltage surge suppressors (TVSS) as a minimum for all 480 VAC and above switchboards and motor control centers above 1,000 amp rating and where shown on the Drawings.
   2. These Specifications describe the electrical and mechanical requirements for a system of electrical transient voltage surge suppression filter components integrating both transient voltage surge suppression and electrical high frequency noise filtering.

B. Related Sections: CONTRACTOR shall coordinate the requirements of the Work in this Section along with the requirements of the Sections listed below which includes, but is not necessarily limited to, Work that is directly related to this Section.
   1. Section 26 04 23, Motor Control Centers.

1.2 QUALITY ASSURANCE

A. Manufacturer's Qualifications:
   1. Manufacturer shall have a minimum of five years experience of producing substantially similar equipment, and shall be able to show evidence of at least five installations in satisfactory operation for at least five years.

B. Referenced Standards. Comply with applicable provisions and recommendations of the following, except as otherwise shown or specified.
   1. ANSI/IEEE (C62.41-1991 and C62.45-1987).
   2. NEC (240-21, 110-9).
   3. NEMA (LS 1-1992 Guidelines).
   4. NFPA (70).
   5. UL Standard No. (198, 248-1, 1283, 1449 Second Edition).
      a. Each system component shall be UL Standard No. 1283, Listed as an Electromagnetic Interference Filter.
      b. Each system component shall be UL Standard No. 1449, Second Edition, Listed as a Transient Voltage Surge Suppressor.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Electrical and mechanical drawings for each type of unit that shows electrical ratings, dimensions, weights, mounting provisions, connection details and layout diagrams.
   2. Provide verification that the TVSS device complies with the required UL Standard No. 1449 SVRs.
   3. Provide actual let through voltage test data in the form of oscillograph results for both the ANSI/IEEE C62.41 Category C3 (combination wave) and B3 (ringwave) tested in accordance with ANSI/IEEE C62.45.
   4. Provide spectrum analysis of each unit based on MIL-STD-220A test procedures between 50 kHz and 200 kHz verifying the device's noise attenuation exceeds 50 dB at 100 kHz.

B. Operation and Maintenance Data:
   1. Submit complete installation, operation and maintenance manuals including test reports, maintenance data and schedules, description of operation and spare parts information.

2. Furnish Operation and Maintenance Manuals in conformance with the requirements of Section 01 78 23, Operation and Maintenance Data.

PART 2 - PRODUCTS

2.1 GENERAL

A. Unit Operating Voltage: The operating voltage shall be as shown on the Drawings.

B. Maximum Continuous Operating Voltage (MCOV): The MCOV shall be greater than 115 percent of the nominal system operating voltage.

C. Protection Modes: For a wye configured system, the device must have directly connected suppression elements between line-neutral (L-N), line-ground (L-G), and neutral-ground (N-G). For a delta configured system, the device must have suppression elements between line to line (L-L) and line to ground (L-G).

D. The maximum UL Standard No. 1449 SVR for the device must not exceed the following:
   1. Line to Neutral: 800 volts.
   2. Line to Ground: 800 volts.
   3. Neutral to Ground: 800 volts.
   4. Line to Line: 1500 volts.

E. The let through voltage based on IEEE C62.41 and C62.45 recommended procedures for Category C3 surges (20 kV, 10kA) shall be less than 900 volts.

F. The let through voltage based on IEEE C62.41 and C62.45 recommended procedures for the ANSI/IEEE Cat. B3 ringwave (6 kV, 500 amps) shall be less than 200 volts.

G. Surge Current Capacity: For branch applications, total surge current per phase (based on an 8x20 microsecond waveform) that the device is capable of surviving shall not be less than 250 kA per phase, or 125 kA per mode on L-G, L-N and N-G modes (Wye system); L-L and N-G (Delta system).

H. Let Through Voltage at the Motor Control Center Stabs: Upon request, the manufacturer must provide suppression test results measured at the motor control center bucket stabs.

2.2 DESIGN

A. Each circuit shall include arrays of fused Metal Oxide Veristors (MOV) to suppress the transient voltage surges.

B. Balanced Suppression Platform: The surge current shall be equally distributed to all MOV components to ensure equal stressing and maximum performance. The surge suppression platform must provide equal impedance paths to each matched MOV. Designs incorporating TVSS modules which do not provide a balanced impedance path to each MOV shall not be acceptable.

C. Electrical Noise Filter: Each unit shall include a high performance EMI/RFI noise rejection filter. Noise attenuation for electric line noise shall be 55 dB at 100 kHz using the MIL-STD-220A insertion loss test method. The unit shall be complimentary listed to UL Standard No. 1283. Products not able to demonstrate noise attenuation of 55 dB @ 100 kHz shall be rejected.

D. Internal Connections: No plug-in component modules or printed circuit boards shall be used as surge current conductors. All internal components shall be hardwired with connections utilizing low impedance conductors and compression fittings.

E. Safety and Diagnostic Monitoring. Each unit shall be equipped with 200 kAIC internal fuses. Each unit shall provide the following three levels of monitoring:
   1. Continuous monitoring of fusing system.
   2. Internal infrared sensor system for monitoring individual MOVs (including neutral to ground). The system must be capable of identifying open circuit failures not monitored by conventional fusing systems.
   3. Thermal detection circuit shall monitor for overheating in all modes due to thermal runaway.

F. A green/red solid state indicator light shall be provided on each phase. The absence of a green light and the presence of a red light, shall indicate which phase(s) have been damaged. Fault detection shall activate a flashing trouble light. Units which can not detect open circuit damage, thermal conditions, and over current will not be accepted.

G. Warranty: The manufacturer shall provide a full five year warranty from the date of shipment against any TVSS part failure when installed in compliance with manufacturer's written instructions and any applicable national or local electric code.

H. Product and Manufacturer: Provide one of the following:
   1. ABB
   2. Square "D" Company
   3. Liebert
   4. Or equal.

2.3 ACCESSORIES

A. The unit must be equipped with transient event counter and audible alarm.

B. Remote Status Monitor. The TVSS device must include Form C dry contacts (one N.O. and one N. C.) for remote annunciation of unit status to CCS. The remote alarm shall change state if any of the three monitoring systems described detect a fault condition.

C. Push-To-Test Feature. Each suppression unit shall incorporate an integral test feature which verifies the operational integrity of the unit's monitoring system.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Suppressors shall be installed inside the motor control center at the manufacturer's factory.

B. To facilitate removal and inspection, the suppressor shall be mounted within a standard motor control center bucket.

C. The suppressor shall be mounted in a standard 12-inch NEMA 1 compartment. Conductor length between the suppressor and the stab shall be less than 5-inches. All units shall be internally fused with 200 kAIC. All status indicators and monitors shall be mounted on the front of the motor control center compartment for easy visibility.

+ + END OF SECTION + +

SECTION 26 04 25
VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment, and incidentals required to furnish and install variable frequency drives (VFD), complete and operational with controls and accessories as shown on the Drawings and as specified. Type 316 stainless steel anchor bolts shall be included and shall be furnished in this Section.

B. Related Sections: CONTRACTOR shall coordinate the requirements of the Work in this Section along with the requirements of the Sections listed below which includes, but is not necessarily limited to, Work that is directly related to this Section.
   1. Section 01 78 23, Operation and Maintenance Data.
   2. Section 04 22 00, Concrete Masonry Unit.
   3. Section 26 04 23, Motor Control Centers.
   4. Section 40 60 65, Process Control System Panels and Enclosures.
   5. Section 40 60 66, Process Control System Panel Instruments and Devices.

C. Coordination: CONTRACTOR shall coordinate speed control, starting and acceleration torque requirements with the driven equipment. CONTRACTOR shall submit an acceptance letter from the driven equipment and motor manufacturers stating that each VFD will fully meet all starting and operating requirements of the respective driven equipment/motor combination. CONTRACTOR shall be responsible for coordinating all VFD units with the driven equipment to obtain successful operation throughout the driven equipment speed range.

1.2 QUALITY ASSURANCE

A. Manufacturer's Qualifications:
   1. Manufacturer shall have a minimum of five years experience of producing substantially similar equipment, and shall be able to show evidence of at least five installations in satisfactory operation for at least five years. Prototypes or newly introduced drive unit models will not be acceptable.

B. The manufacturer shall demonstrate, in writing, the Quality Assurance Program in use to certify key components. In-house manufacture of key components is desirable, and will be considered in evaluating acceptance.

C. Reference Standards: Comply with applicable provisions and recommendations of the following, except as otherwise shown or specified.
   1. National Electrical Code.
   2. Standards of National Electrical Manufacturers Association.
   3. Institute of Electrical and Electronic Engineers.
   4. American Gear Manufacturers Association.
   5. Applicable local Electrical Code.
   6. National Fire Protection Association 79, Electrical Standard for Industrial Machinery.

D. For the equipment specified herein, the manufacturer shall be ISO 9000, 9001 or 9002 certified.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Manufacturer's literature, illustrations, specifications, and engineering data which indicate performance, dimensions, materials, size and weight.

2. Fabrication, assembly and installation drawings, and wiring diagrams.
3. Complete list of components and catalogue identification.
4. List of in-house manufactured key components.
5. Quality Assurance Program description.
6. Complete description of schematic and wiring diagrams and functional operation.
7. Recommended spare parts list.

B. Operation and Maintenance Manuals:
1. Submit complete installation, operation and maintenance manuals including test reports, maintenance data and schedules, description of operation and spare parts information.
2. Furnish Operation and Maintenance Manuals in conformance with the requirements of Section 01 78 23, Operation and Maintenance Data.
3. Furnish list of final parameters and function selections programmed into each drive control module.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Deliver materials to the site to ensure uninterrupted progress of the Work. Deliver anchor bolts and anchorage devices which are to be embedded in cast-in-place concrete in ample time to prevent delay of the Work.

B. All boxes, crates and packages shall be inspected by CONTRACTOR upon delivery to the site. CONTRACTOR shall notify ENGINEER of any loss or damage exists to equipment or components. Replace loss and repair damage to new condition in accordance with manufacturer's instructions.

C. Store materials to permit easy access for inspection and identification. Keep all materials off the ground, using pallets, platforms or other supports. Protect steel members and packaged materials from corrosion and deterioration.

D. Store all electrical and electronic equipment, control panels, and like equipment and materials in heated buildings which have a concrete or wooden floor, a roof, and fully closed walls on all sides. Protect electrical and electronic equipment from contamination by dust, dirt and moisture. Maintain humidity at levels recommended by manufacturer for electric and electronic equipment.

E. Energize space heaters during storage.

1.5 SHOP TESTS

A. Each variable frequency drive (VFD) shall be tested at the manufacturer's facility.

B. In addition to the manufacturer's standard tests, each VFD, including all instruments, controls, solid state components, systems, and internal and external equipment which are a part of the VFDs shall be assembled, tested and thoroughly checked for proper operation of all functions and features. Simulated signals and loads shall be employed that shall simulate actual signals and loads, if they are a part of the final installation and are not included in this Section.

C. If the test results indicate that any VFD unit does not conform to specified and/or guaranteed performance, the unit shall be modified and retested, at no additional cost to OWNER, until full compliance with specified and guaranteed performance can be demonstrated. OWNER and/or ENGINEER shall be permitted to witness the retest.

D. No equipment shall be shipped until the ENGINEER has approved all test reports.

PART 2 - PRODUCTS

2.1 GENERAL

A. CONTRACTOR shall furnish and install variable frequency drive units, AC PWM inverter type, 460 volts, sine coded with carrier frequency adjustment, 3 phase, 60 hertz input with output suitable for and coordinated with the driven equipment furnished under the appropriate Sections in Division 11, Equipment. Drives rated 75 horsepower and above shall utilize 18 pulse converter inputs and phase shifting transformer to reduce harmonic output.

B. The drives shall have the following characteristics:
   1. Output voltage (Maximum): 460 volts.
   2. Frequency accuracy: ±0.5 percent (at 25°C ±10°C).
   3. Frequency range: 3 to 67 hertz, selectable by switch to 120 hertz (Except where otherwise indicated).
   4. Volts per hertz ratio (V/HZ) adjustable for 3 to 60 hertz.
   5. Overload capacity shall be one minute at 125 percent of continuous constant torque rated nameplate current. The inverter shall be designed to not be internally shutdown within the 125 percent overload operating range.
   6. Constant torque rated for motor nameplate horsepower without revision of inverter unit manufacturer's nameplated published constant torque rating.

C. VFD's shall meet all requirements as outlined in the latest edition of IEEE 519 for total harmonic voltage and current distortion and as indicated in this Section. Individual or simultaneous operation of the VFDs shall not add more than three percent total harmonic voltage distortion while operating. Maximum allowable total harmonic current distortion limits for each VFD shall not exceed five percent as calculated and measured at the point of common coupling. The point of common coupling for all harmonic calculations and field measurements for both voltage and current distortion shall be defined as the nearest upstream MCC. A preliminary harmonic analysis must be submitted by the VFD manufacturer with Shop Drawings which includes all voltage and current harmonics up to the 99th harmonic; for this purpose cable lengths can be estimated on a conservative basis by CONTRACTOR. Compliance shall be verified with onsite field measurements of both the voltage and current harmonic distortion at the defined point of common coupling with and without the VFD's operating.

D. Product and Manufacturer: Provide one of the following:
   1. Eaton CPX series.
   2. ABB, ACS550 series.
   3. Allen Bradley Co., PowerFlex 753 series.
   4. Schneider Electric ATV660 series.
   5. Approved Equal.

2.2 DETAILS OF CONSTRUCTION

A. All individually mounted VFD's shall be housed in NEMA 1 wall or floor mounted cabinets configured as shown on the Drawings. All other VFD's shall be housed within motor control centers (VFD's in motor control centers shall be built by the same manufacturer as the motor control centers) and configured as shown on the Drawings. VFD units shall be individually fed from circuit breakers located in the motor control centers as shown on the Drawings. Conduit and cable entrances shall be from either top or bottom. VFD's shall be located as shown on the Drawings. CONTRACTOR is cautioned to verify space limitations for units with bypass contactors. Space shall be verified for future units.

B. The VFD units shall require front access only and shall be suitable for against-the-wall installation. Bypass contactors, where required, shall be integral to VFD enclosure along with the overload relay.

2.3 OPERATIONAL DESCRIPTION

A. Operational sequences shall be as shown on the Drawings and described in the applicable Sections of Division 40, Instrumentation and Controls.

2.4 OPTIONAL VFD COMPONENTS

A. All VFD units shall be furnished with no less than the following:
   1. Input circuit breaker with current limiting fuses interlocked with the unit door. Circuit breaker shall be padlockable in the "OPEN" position.
   2. Fused control power transformer.
   3. Motor contactor where required by the Drawings.
   4. By-pass contactor with overload relay with external or programmable reset where required by the Drawings.
   5. Input line reactor (inductor), three percent.
   6. Speed control to be integral on the programmable control module.
   7. Process follower to accept 4 to 20mA DC signal input.
   8. Output signal of 4 to 20mA DC proportional to speed.
   9. All additional devices as shown on the Drawings and specified herein.

2.5 MANUFACTURER

A. The VFD's listed in this Division and in other Divisions shall be the product of one manufacturer. The VFD assembler shall be the manufacturer of the power inverter.

2.6 TRANSIENT CONDITIONS

A. The drives shall be capable of accepting a supply variation of 460 volts plus five percent or minus ten percent at 60 hertz plus or minus two hertz as a standard design feature.

B. The drives shall be of the diode bridge rectifier front-end type to minimize electrical noise generation and to operate at not less then 95 percent power factor over the full operating range.

C. For sustained or momentary power outages the drives shall have a safe shutdown design with automatic ramp-up return to normal operation, upon restoration of power.

D. For momentary voltage dips which shut down the drive, means shall be provided for automatic ramp-up return to full, controlled operation upon restoration of full line voltage.

2.7 ENVIRONMENT

A. The drive shall be capable of operating under any combination of the following conditions without mechanical or electrical damage:
   1. Ambient temperature: 0 to 50°C.
   2. Relative humidity: 0 to 95 percent non-condensing.
   3. Vibration: 0 to 0.5G.

2.8 CONTROL REQUIREMENTS

A. Current limit circuitry shall automatically phase back voltage and frequency to decrease current to 125 percent of the drive rated capacity.

B. The drive and inverter shall be UL listed and labeled by a nationally recognized testing laboratory.

C. The variable speed drive system shall include a diode bridge converter, filter network and a transistorized inverter section. Base driver signals used to control firing of the power transistors shall be designed with optically coupled isolators.

2.9 PROTECTIVE AND OPERATIONAL CHARACTERISTICS

A. The drives shall have the following protective and operational characteristics in addition to those previously described:

1. Adjustable current limit.
2. Overcurrent trip (125 percent).
3. Short circuit trip (hall-effect current transformer).
4. DC bus overvoltage trip.
5. DC bus fuses.
6. Line undervoltage trip (-30 percent) with automatic restart on voltage recovery.
7. Momentary power failure trip (greater than ten milliseconds) with automatic restart.
8. Line input 3-pole circuit breaker with current limiting fuses or current limiting circuit breaker and door interlock.
9. 4 to 20 mADC output signal proportional to speed.
10. LED display of the following:
    a. Overcurrent trip at 125 percent.
    b. Internal component short circuit.
    c. Output short circuit.
    d. Overload (when soft stall not selected).
    e. Overvoltage on DC bus.
    f. Overvoltage on input.
    g. Undervoltage.
    h. Overheat.
    i. Ground Fault.
    j. Initial parameter mismatch.
11. Electronic motor overload relay.
12. An internal microprocessor shall monitor the load on the drive and in the event of an overload it shall, based on the microprocessor's calculation of the true inverse time overload characteristic, either trip out or phase back the voltage and speed as selected by an internal jumper.
13. Acceleration time: 1 to 20 seconds adjustable.
14. Dynamic braking: 12 percent standard.
15. Ramp to stop: 1 to 20 seconds adjustable.
16. Speed control integral to the programmable control module.
17. Frequency meter integral to the programmable control module.
18. Local/Computer operation solid-state selector switch to be integral to the programmable control module.
19. General fault, run, and stop indication pilot lights mounted on door or integral to the programmable control module. The display must indicate the type of alarm, not part of a general alarm. If programmable control module is not capable of providing indication, provide fault indication pilot lights mounted on the door for each alarm/shutdown condition.
20. Motor and bypass contactors and power unit isolation circuit breaker or contactor as shown on the Drawings or described in the Specifications. Contactors shall be NEMA integral size. Half sizes and IEC rated contactors shall not be acceptable. NEMA dual rated contactors shall not be acceptable.
21. Isolated contacts for remote indication of "RUNNING", “Computer Mode Selection”, VFD Fault and all other alarm conditions, as required by the Drawings.
22. Normal/bypass selector switch (for units with by-pass contactors) if feature is not available from the programmable control module.
23. Fault reset button on door if fault reset feature is not available from the programmable control module.

B. The drive units shall be able to withstand phase-to-phase and phase-to-ground shorts without damage to the drive unit.

C. The drive shall include the solid-state features described above on plug-in circuit boards with microprocessor and on-board diagnostic circuitry with LED readouts as listed above.

D. The drive shall have integral transformers to supply all required control voltages including space heaters, where required. The control transformer and entire drive unit shall be de-energized when the line disconnect switch or circuit breaker is opened.

E. Fault trip conditions, except short time or momentary line voltage loss or line voltage momentary dip, shall lock out the control. Resetting of control after fault trip shall be manual by a door-mounted pushbutton.

F. Auto restart shall be a standard feature of the drive as follows:
   1. Auto restart shall be enabled or disabled by programming or jumper selection.
   2. On auto restart selection, the microprocessor shall determine, in the event of a fault, if a restart should be attempted. A restart shall be attempted under the following conditions:
      a. Undervoltage (UP): Every time as soon as voltage returns to a safe level. Fault relay shall not be activated.
      b. Input Overvoltage (OPS): Every time as soon as voltage returns to a safe level. Fault relay shall be activated for the duration of the high voltage condition.
      c. Overcurrent (OC): Five attempts in 30 seconds. After the fifth OC, the drive shall trip out and latch the fault relay.

G. A restart shall not be attempted for any other type of fault and the drive shall trip out immediately, activate the fault relay, and make the information available on the programmable control module display until the drive is manually reset.

H. An undervoltage condition of less than 30 ms duration shall not affect drive operation. If main power falls below 85 percent of rated voltage for longer than 30 ms while control power is retained, the drive shall forcibly decelerate the load in an attempt to force a higher bus voltage through regeneration to allow the drive to "ride through" the undervoltage condition for up to 70 additional milliseconds for a total "ride through" of up to 100 ms for very high inertia loads. The manufacturer shall provide an option that allows control power to be maintained for 100 ms in the event of a power failure. If the drive drops out, it shall automatically restart upon restoration of full rated voltage, as previously described.

2.10 FACTORY TESTS

A. The testing procedure shall be the manufacturer's standard procedure to assure maintenance free service. The OWNER shall be given 14 days notice prior to start of factory testing so that the OWNER, at his option, may witness the testing.
   1. All final assemblies shall be tested at full load with application of line-to-line and line-to-ground bolted faults. The VFD shall trip electronically without device failure.
   2. After all tests have been performed; each VFD shall undergo a 40-hour burn-in test. The VFD's shall be burned in at 100 percent inductive or motor load for 40 hours without an unscheduled shutdown.
   3. After the burn-in cycle is complete, each VFD shall be put through a 30 minute cycling motor load test before inspection and shipping.
   4. Certification that all of the testing above has been performed shall be provided by the VFD manufacture, upon request.

B. All equipment, devices, instrumentation, and personnel required to perform the tests shall be supplied by the manufacturer. Upon satisfactory completion of the test, the manufacturer shall submit two certified copies of the test report to the ENGINEER. Component failure during testing will require repeating any test associated with the failure or modified components to demonstrate proper operation.

2.11 PAINTING

A. Units shall receive manufacturer's standard finish paint system prior to shipment.

B. Machined, polished, and non-ferrous surfaces shall be coated with corrosion prevention compound.

C. Painting shall conform to the requirements of Division 09, Finishes.

D. All internally electronic components, devices terminations and other items shall be coated with an epoxy based conformal coating system.

PART 3 - EXECUTION

3.1 START-UP AND TEST

A. Make adjustments required to place system in proper operating condition.

B. A manufacturer's representative shall check and approve the installation before operation. He shall test operate the system in the presence of the ENGINEER and verify that the units conform to requirements. He shall revisit the jobsite as often as necessary until all trouble is corrected and the installation is entirely satisfactory.

3.2 MANUFACTURER'S SERVICES

A. A factory trained representative shall be provided for installation supervision, start-up and test services and operation and maintenance personnel training services. The representative shall make a minimum of 2 visits, minimum 8 hours on-site for each visit, to the site. The first visit shall be for assistance in the installation of equipment. The second visit shall be for checking the completed installation and start-up of the system. Manufacturer's representative shall test operate the system in the presence of the ENGINEER and verify that the variable frequency drives conform to requirements. Representative shall revisit the job site as often as necessary until all trouble is corrected and the installation is entirely satisfactory.

B. All costs, including travel, lodging, meals and incidentals, shall be considered as included in CONTRACTOR'S bid price.

+ + END OF SECTION + +

SECTION 26 04 42
LIGHTING, INSTRUMENTATION AND DISTRIBUTION PANELBOARDS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope:
   1. CONTRACTOR shall provide all labor, materials, equipment and incidentals as shown on the Drawings, specified and required to furnish and install lighting, instrumentation and distribution panelboards.
   2. Installation of new circuit breakers in existing panelboards shall be included in this Section and shall be rated as specified herein.

B. Related Sections: CONTRACTOR shall coordinate the requirements of the Work in this Section along with the requirements of the Sections listed below which includes, but is not necessarily limited to, Work that is directly related to this Section.
   1. Section 26 05 00, General Provisions.

1.2 QUALITY ASSURANCE

A. Reference Standards: Comply with applicable provisions and recommendations of the following, except where otherwise shown or specified:
   1. NEC Article 408, Switchboards and Panelboards.
   2. NEMA PB1, Panelboards.
   3. NEMA 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
   4. UL Standard 50, Electrical Cabinets and Boxes.
   5. UL Standard 67, Electric Panelboards.
   6. UL Standard 698, Circuit Breaker Panelboard Assembly.
   7. UL Standard 943, Ground Fault Circuit Interrupters.

1.3 SUBMITTALS

A. Shop Drawings: Submit for approval the following:
   1. Manufacturer's technical information for panelboards proposed for use.
   2. Listing of the panelboards to be furnished with an identification of their proposed location, and number and rating of branch circuit breakers.
   3. Lighting, instrumentation and distribution panelboards load calculations.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Panelboards:
   1. Rating: Voltage rating, current rating, number of phases, number of wires and number of poles shall be as shown on the Drawings.
   2. Circuit Breakers: Molded case, bolt-in thermal magnetic type with number of poles and trip ratings as shown on the Drawings.
   3. Main and branch circuit breakers shall be fully rated with interrupting capacities as follows:
      a. 35,000 amps for 480/277 volt circuit breakers.
      b. 22,000 amps for 120/240 volt circuit breakers.
   4. Bus Bars: 98 percent conductivity copper, tin plated. All 4 wire panelboards shall have a solid neutral bar. All panels shall have ground bus.

5. Main: All panelboards shall have a main circuit breaker, unless Drawings specifically call for main lugs only.
6. Branch circuit breakers connected for sequence phasing.
7. Construction: Code grade steel, NEMA 12, ample gutter space, flush door, flush snaplatch and lock for dry indoor locations. NEMA 4X stainless steel for outdoor or damp indoor locations.
8. Trim: Surface or flush, as required.
9. Directory: White card, minimum card stack 90 lb., maximum size 8" x 5", placed in a 9" x 5 ½" self adhesive vinyl pocket. Directory information to be a copy of the as-built panel schedule as provided on the contract drawings.
10. Identification: Nameplate identifying the panel number and voltage.
11. Product and Manufacturer: Provide panelboards of one of the following:
    a. Square D Company.
    b. General Electric Company.
    c. Or Approved Equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Mounting: Install panelboards at locations shown on Drawings. Set cabinets so that top branch circuit breaker is not over six feet above the floor.

B. Arrange circuits to balance the loads on the panelboards.

+ + END OF SECTION + +