SECTION 26 05 10

ELECTRICAL WORK – GENERAL

PART 1 - GENERAL

1.01 DESCRIPTION

A. Provide complete and operational systems for both normal and standby electric power systems, normal and emergency lighting systems, grounding systems and other specified systems, including the installation and wiring of miscellaneous equipment and devices. Perform all work and testing as indicated and in compliance with Contract Documents.

1. Provide conduit, wiring and connections for power, control, lighting, instrumentation and alarms for equipment furnished by others unless otherwise specified and indicated.

2. Provide temporary circuits, overcurrent devices, conduit and wiring, and other equipment required during construction and change-over from existing to proposed electric system. Perform work at the convenience of the Owner.

3. Raceways supports and equipment anchoring shall be provided as specified in the Division 26 sections which form a part of the Contract Documents.

4. The equipment enclosure classification of the plant areas are indicated on the drawings. Provide all equipment, devices and material meeting the requirements for these area classifications unless otherwise noted or specified.

5. Review the electrical underground system and the civil yard piping. Install the electrical underground system in a manner that avoids conflicts with manholes, catch basins, etc. provided under other Divisions of the specifications

1.02 REFERENCES

A. National Fire Protection Association (NFPA):

1. 70: National Electrical Code (NEC).

1.03 SEQUENCING AND SCHEDULING

A. Coordinate electrical equipment installation with other building components.

B. Arrange for chases, slots and openings in the building structures during the progress of construction to allow for the electrical installation.

C. Coordinate installing required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

D. Sequence, coordinate and integrate the installation of electrical materials and equipment for efficient flow of the work.

E. Coordinate the installation of large equipment prior to closing in the building.

1.04 QUALITY ASSURANCE

A. Provide in accordance with Section 01 43 00 “Quality Requirements” and as specified.

B. Install electrical work in conformance with latest rules and requirements of National Fire Protection Association Standard No. 70 (National Electrical Code) and in accordance with requirements of State and Local Codes.

1.05 QUALIFICATIONS OF ELECTRICAL SUBCONTRACTOR

A. The Electrical Subcontractor shall have been engaged in work of a similar nature to this contract for the past 5 years.

B. The Electrical Subcontractor shall have a minimum of five projects of equal or greater size with the type of equipment specified under this project.

1.06 SUBMITTALS

A. Submit the following in accordance with Section 01 33 00 “Submittals”:

1. The following defines a minimum for all Division 26 shop drawing and data submittals:

a. Submit shop drawings delineated by specification number with all information for one piece of equipment provided as one package.

b. Provide PDF versions with electronic bookmarks.

c. Provide with a copy of the specification section with exceptions noted including explanation.

d. Partial submittals will be returned without action.

e. Submit bills of material: Include a numbered list of all components, with manufacturer's name, catalog number, rating, and other identification. Place item number or similar identification on all other drawings where item appears.

f. Submittal shall include:

(1) Manufacturer’s drawings

(2) Panel layout

(3) Equipment layout

(4) Schematic diagram

(5) One line diagram

(6) Control sequence diagrams

(7) Interconnection diagrams

(8) Wiring diagrams

(9) Catalog data

g. Submit only completed drawings showing all local and remote devices associated with each item.

h. Mark shop drawings and data submitted showing only items applicable to specific contract.

i. Where additions and modifications are made to existing equipment, provide drawings which include both retained existing equipment and new work.

j. Submit time-current characteristic curves for all submitted protection devices such as circuit breakers and fuses.

k. Submit other documentary or descriptive information as required for each assembly to demonstrate compliance with the applicable contract documents.

2. Shop drawings and data are required for the following list:

a. Conduit and Fittings

b. Wire and Cable

c. Wiring Devices

d. Transformers

e. Low Voltage Switchboards

f. Low Voltage Switchgear

g. Manholes, Handholes, and Associated Equipment and Devices

h. Grounding Equipment and Devices

i. Panelboards

j. Lighting Fixtures and Accessories

k. Lighting Control Panels

l. Lightning Protection System

m. Intrusion Alarm System

n. Fire Alarm System

o. Card Access System

p. Surveillance System

q. Control Stations

r. Enclosures

s. Control Panels

t. Safety Switches

u. Mats

v. 600 Volt Motor Control Centers and Motor Controls

w. Switchboards

x. Field Acceptance Test Reports

y. Record Drawings

3. Submit instruction manuals for installation, operation, and maintenance of equipment, and parts list for equipment listed below. Specifically mark standard publications forming a part of this contract. Cross out, blank out, or otherwise delete non-applicable items. Submittals which do not clearly indicate items and features provided shall be rejected.

   a. Low Voltage Switchgear

   b. Lightning Protection System

   c. Intrusion Alarm System

   d. Fire Alarm System

   e. Card Access System

   f. Surveillance System

g. 600 Volt Motor Control Centers

h. Switchboards

1.07 NAMEPLATES AND LABELING

A. Provide nameplates and labels as specified in Section 26 05 53 “Electrical Identification”.

1.08 INTERFERENCE AND ERRONEOUS LOCATIONS

A. Locations of electrical equipment, devices, outlets, and similar items, as indicated, are approximate only. Exact locations shall be determined during construction.

B. Verify in field, all data and final locations of work installed under other sections of specifications, required for placing of electrical work.

C. In case of interference with other work or erroneous locations with respect to equipment or structures, furnish all labor and materials to complete the work.

1.09 SEISMIC DESIGN REQUIREMENTS

A. Conform to the requirements indicated on the structural drawings and as specified in Section 01 41 20 and in Division 26.

B. All raceways and equipment installed under Division 26 shall use earthquake resistant supporting systems as specifically required in each applicable section.

1.10 APPROVAL AND MARKING EQUIPMENT

A. Ensure that devices and materials are listed and/or labeled by UL, wherever standards have been established by that organization. Where a UL listing is not available for equipment, submit certified test reports of a Nationally Recognized Testing Laboratory (NRTL), approved by the local inspecting authority, indicating that equipment is in conformance with local code requirements or any other applicable requirements. Tests and inspections for approval of equipment shall be performed at no additional cost to Owner.

B. Clearly mark equipment, devices and material with name or trademark of manufacturer and rating in volts and amperes and other pertinent information on a nameplate.

1.11 ELECTRIC SERVICE

A. Electrical power system for the facility operates at 277/480-volt, 3-phase, 4-wire, 60 Hertz.

1. Provide electrical low voltage distribution system that operates on 208/120-volt, 3-phase, 4-wire, 60 Hertz obtained from the power system by dry-type transformer(s).

B. Earth and rock excavation, backfill, concrete masonry, concrete reinforcement, and construction joints required for electrical work is included under this section and shall conform to requirements specified under applicable sections of Contract for General Construction.

1.12 EQUIPMENT SPECIFIED ELSEWHERE

A. Certain items of control equipment and other equipment are indicated on electrical drawings for connection, but are specified in other sections pertaining to plumbing, heating, ventilating and air conditioning, mechanical process, instrumentation, etc. Such items are not furnished as part of electrical work.

1.13 INCOMING SERVICE

A. Contact the following organization for coordinating the incoming power requirements for the project:

Provo Power
Jonathan Saluone
(801) 852-6831

B. The organization identified above will furnish and install:

1. Pad-mounted transformers and sectionalizer cabinet(s).

2. Primary cable.

3. Connection of all primary cables.

4. Metering equipment.

C. The contractor shall provide the following in accordance with the contract documents:

1. Concrete pad for transformers and sectionalizer cabinet(s).

2. Primary and secondary ductlines.

3. Secondary cables of sufficient length for termination at the transformer.

4. Connection of all secondary cables.

5. Grounding at transformer pads.

6. Provide cabinets for metering equipment and current transformers.

D. The final, complete installation shall comply with all state and local statutory requirements having jurisdiction. The Contractor shall arrange for all necessary permits, pay all fees and arrange for all required inspections by local authorities. In general, all work shall comply

with the requirements of the National Electrical Code, all state codes and the codes and ordinances of the city or town in which the work is to be done.

PART 2 - PRODUCTS

(Not Used)

PART 3 - EXECUTION

3.01 PROTECTION OF ELECTRICAL EQUIPMENT

A. Store equipment in compliance with manufacturer's recommendations and as specified herein.

B. Protect electrical equipment from the weather, especially from water dripping or splashing upon it, at all times during shipment, storage, and construction.

C. Do not store equipment outdoors.

D. Where equipment is installed or stored in moist areas, or unheated buildings, provide acceptable means to prevent moisture damage. Provide uniformly distributed source of heat in electrical equipment to prevent condensation and damage to electrical insulation systems.

3.02 DEFECTIVE OR DAMAGED EQUIPMENT

A. Damaged equipment shall not be used. Equipment damaged in shipment, storage, installation or through other means shall be replaced without additional cost to the Owner.

B. All equipment showing signs of water damage shall be rejected regardless of dielectric test results.

C. All electrical equipment is considered "in storage" regardless of location until first energized. Manufacturer's recommendations for storage precautions, conditions and care shall be followed.

3.03 STARTING EQUIPMENT DATA LIST

A. Obtain data from the equipment supplier shop drawing submittals or equipment nameplates, and prepare a complete tabulation of all motors over 1/3 hp, electric heaters over 3 kW, and starting equipment for both, to be furnished on the project.

1. Include in tabulation firm the following information:

a. Name and identification of equipment.

b. Manufacturer.

c. Horsepower or kilowatt rating.

d. Voltage.

e. Phase.

f. Speed.

g. Full load current.

h. Locked rotor current or code letter.

i. Type of enclosure (open drip-proof, totally enclosed, fan cooled, etc.).

j. NEMA size of starter or contactor.

k. Overload heater size.

l. Type of starter (full-voltage, reduced-voltage, autotransformer, etc.).

m. Breaker trip setting or fuse size.

n. Voltage of starter operating coil.

o. If starter is at a motor control center, list motor control center number.

2. Final acceptance of the electrical system is contingent upon submittal of the complete motor and electric heater tabulation.

3. Arrange tabulation in groups by MCC or building location.

4. Furnish six copies of the tabulation to the Engineer when a submission is made.

3.04 DRAWINGS AND SPECIFICATIONS

A. Drawings and specifications are typical of work to be done and of the arrangement desired. Provide accessories and appurtenances which the Engineer deems functionally necessary for a complete installation, whether or not explicitly indicated or described.

3.05 RECORD DRAWINGS

A. The Contractor shall maintain a master set of record drawings showing the changes and deviations from the contract drawings.

B. A minimum of 30 days prior to application for Final Payment, submit two sets of drawings for approval that are marked to show the as-installed equipment, devices, raceway locations and wiring. The markings on the drawings are to be neat, clean and legible.

3.06 CONTRACT CLOSEOUT

A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 26 05 20

ELECTRIC WIRES AND CABLES

PART 1 - GENERAL

1.01 DESCRIPTION

A. Provide wires and cables for complete electrical systems as indicated and in compliance with Contract Documents.

1.02 REFERENCES

A. ASTM International (ASTM):

1. B3: Soft or Annealed Copper Wire.

2. B8: Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.

3. B33: Tinned Soft or Annealed Copper Wire for Electrical Purposes.

B. Insulated Cables Engineers Association, Inc. (ICEA)/National Electrical Manufacturer's Association (NEMA):

1. S-61-4021/WC 5: Thermoplastic Insulated Wire & Cable.

2. S-66-524/NEMA WC 7: Cross-Linked-Thermosetting-Polyethylene Insulated Wire and Cable.

3. S-68-516/WC 8: Ethylene-Propylene-Rubber-Insulated Wire & Cable.

C. National Fire Protection Association (NFPA):

1. 70: National Electrical Code (NEC).

D. American National Standards Institute (ANSI)/Telecommunications Industry Association (TIA)/Electronic Industries Association (EIA):

1. ANSI/TIA/EIA-568-B; Commercial Building Telecommunications Cabling Standards.

E. Underwriters Laboratories, Inc. (UL):

1. 44: Thermoset-Insulated Wires and Cables.

2. 83: Thermoplastic-Insulated Wires and Cables.

3. 854: Service Entrance Cables.

1.03 SUBMITTALS

A. Submit the following shop drawings in accordance with Section 01 33 00.

B. Submit shop drawings and manufacturer's product data in accordance with the requirements of Section 26 05 10 “Electrical Work – General”.

1.04 DELIVERY STORAGE AND HANDLING

A. Comply with the requirements specified in Section 01 66 10.

B. Deliver wire and cables in full reels protected against injury. Deliver reels with factory attached UL approved tags showing the manufacturers name and the type of insulation, size, and length of wire in each coil or reel.

C. Accept wire and cable on site in manufacturer's packaging. Inspect for damage.

D. Store and protect in accordance with manufacturer's instructions.

E. Protect from weather. Provide adequate ventilation to prevent condensation.

1.05 DESIGN CRITERIA

A. Wire for lighting, single phase circuits shall be Type XHHW or THWN-THHN.

B. Wire for three phase circuits shall be Type XHHW.

C. Service conductors shall be 600V rated type RHW.

D. Single conductor wire for control, indication and metering shall be Type THWN-THHN No. 12 or 14 AWG, stranded.

E. Multiconductor control cable shall be used for the underground system and shall be No. 12 or 14 AWG, stranded with overall jacket.

F. Wire for process instrumentation shall be twisted shielded pairs No. 16 AWG, stranded with overall jacket.

G. Ground wires shall be Type THW, green. Bare ground wires shall be soft drawn copper, 98 percent conductivity.

H. Wire for power circuits installed in duct banks shall be type RHW.

I. Multiconductor cables used in cable tray shall be TC-ER and VW-1 rated.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. 600V Cable:

1. Okonite.

2. Southwire.

3. American Insulated Wire.

B. Variable Frequency Drive Cables:

1. Belden Wire and Cable.

2. Southwire

3. Okonite

C. Multiconductor Tray Cables:

1. Belden Wire and Cable.

2. Southwire

3. Okonite

D. Control and Metering Wire:

1. Belden Wire and Cable.

2. Alpha Wire.

3. Coleman Cable.

E. Cable Fireproofing Tape:

1. MAC Products, Inc.

2. 3M Electrical Products.

2.02 MATERIALS AND COMPONENTS

A. Furnish copper conductors. Material and stranding of conductors to conform to ASTM B3, ASTM B33, and to ASTM B8, for the appropriate class.

B. Uncoated, soft or annealed copper wire conforming to ASTM B3.

C. Wires and Cables for Maximum 600-Volt Power Circuits: For No. 8 AWG gauge and smaller provide type THWN/THHN or RHW. Where used in lighting or receptacle branch circuits provide No. 12 AWG gauge and No. 10 AWG gauge as solid conductor. Provide other wire with Class C stranding. Provide No. 6 AWG gauge and larger as XHHW-2 with Class B stranding. Provide wires and cable conforming to UL 83.

D. Variable Frequency Drive (VFD) Cables – for use on load side of AFD units: 100% Ground Flexible VFD, 3 Conductor Tinned Copper XLPE Insulation M4 Color Code + Symmetrical Segmented Ground Bare Copper Stranded, Overall Dual Copper Tapes Helically Applied Shield, Black PVC Outer Jacket, 2000V TC-ER, 90C Dry/Wet, 2000V Flexible Motor Supply Cable, WTTC, 1000V CSA AWM I/II A/B, 2000V RW90 TC, Sunlight Resistant, UL Direct Burial, Oil Resistant. Refer to plans for conductor size.

E. Multiconductor Tray Cables – Type TC-ER Control Cable 600 Volt Copper Conductors, Ethylene Propylene Rubber (EPR) Insulation XHHW-2 Chlorinated Polyethylene (CPE) Jacket, Control Cable Conductor Identification Method 1 Table 2. VW-1 Rated.

F. Wires and Cables for Control, Indicating, Metering, or Alarm Circuits: Single and multiconductor control cable, copper conductors, Class B or C stranding. Insulation; 600-volt polyethylene, polyvinylchloride, or EPR. Continuous rating of 90C dry and 75C wet. Color coding conforming to Table K-2, ICEA/NEMA S-61-4021/WC 5.

G. Shielded Cable for Instrumentation Wiring: 7-strand copper conductors, size No. 16 AWG. Insulate conductors individually with color coded polyethylene or polyvinylchloride. Twist pairs with varying lay (if more than one pair) and cover with cable tape and 100 percent coverage aluminum foil or tape shield and tinned copper drain wire. Jacket: flame-retardant polyvinylchloride. Where multi-conductor TSP cables are called for, each pair shall be individually shielded, continuous number coded, and the cable assembly shall have an overall shield and overall flame retardant PVC jacket. Cables: rated 600 volts, 90 degrees C, suitable for pulling in conduit and laying in cable tray, interlocked aluminum armor and outer PVC jacket.

H. RTD and Multi Conductor Shielded Cable: Three or more copper conductors, stranded, minimum #18 AWG, PVC insulated for 600V, 100 percent coverage aluminum foil or tape shield, separate bare stranded copper drain wire, interlocked aluminum armor and outer PVC jacket, overall flame-retardant PVC jacket with NEC and UL approval. Suitable for pulling in conduit and laying in cable tray.

I. Category 6A Cable: Category 6A cable shall consist of 4 twisted pairs, solid stranded, #24 AWG, of different lay and ground wires, enclosed by an overall conductive mylar backed aluminum foil shield. This shall be enclosed by an overall thermoplastic jacket. The cable shall meet the applicable requirements of ANSI/TIA 568 C.2. Provide cable with interlocked aluminum armor, rip cord, PVC inner and outer jackets, UL verified to Category 6A, insulated for 300V, and suitable for pulling in conduit and laying in cable tray.

PART 3 - EXECUTION

3.01 GENERAL

A. Perform work in accordance with the National Electrical Code.

B. Provide power cable identification as follows:

System Voltage	Neutral	Phase A	Phase B	Phase C
208/120V	White	Black	Red	Blue
240/120V	White- Gray Stripe	Black- Blue Stripe	Red- Blue Stripe	None
480/277V	Gray	Brown	Orange	Yellow

C. Use green to identify insulated ground conductors.

NOTE: Colored insulation, tapes or sleeves may be used to provide color coding. Insulated ground conductors must have green covering.

D. Permanently post means of identification of grounded and ungrounded conductors for each nominal voltage system at each panelboard and motor control center.

E. In power and multiconductor cables manufactured without a grounding conductor identify one of the multiconductors as the equipment grounding conductor at each cable end and at every point where the conductors are accessible.

3.02 INSTALLATION OF WIRING

A. Unless otherwise indicated, use no conductor smaller than No. 12 AWG for power, No. 14 AWG for control, and No. 16 AWG for shielded applications.

B. Install conductors continuous from outlet to outlet and make no splices except within outlet or junction boxes.

C. Install cable in underground raceway system without splices. There shall be no splices between connection points unless otherwise indicated.

D. Draw all conductors contained within a single conduit at the same time.

E. Apply wire pulling compound to conductors being drawn through conduits. Use pulling compound, Minerallac No. 100, Y-er-Eas, Yellow 77, High Performance Polywater Cable Lubricant or acceptable equivalent.

F. Use no cable bend with radius of less than eight times its diameter.

G. Wires and cables installed without prior submittal review are subject to removal at no additional expense.

H. Use TSP cable for all low-level analog signals such as 4-20 mA, pulse type circuits 24 VDC and under, and other signals of a similar nature.

I. Use RTD cable for connections between RTDs and transmitters or control system RTD inputs.

3.03 CONDUCTOR IDENTIFICATION

A. Label each wire at both termination points. Carry individual conductor or circuit identification throughout, with circuit numbers or other identification clearly stamped on terminal boards and printed on directory cards in distribution cabinets and panelboards.

B. Identify each wire in junction boxes, cabinets, and terminal boxes where total number of control, indicating, and metering wires is three or more and no terminal board is provided, including all power wire. Where no termination is made use a plastic-coated, self-adhesive, wire marker and where termination is made use a, plastic, pre-printed sleeve wire marker.

C. In cases similar to above where terminal boards are provided for the control, indicating, and metering wires, identify all wires including motor leads and other power wires too large for connection to terminal boards, by sleeve wire markers as specified above.

D. In manholes and handholes, identify each power wire by laminated plastic tag located so it is easily seen. Control wires to be bundled and marked as listed in conduit and wire schedule.

3.04 CONNECTORS, TERMINAL LUGS AND BOARDS

A. For wiring of circuits consisting of No. 10 or No. 12 AWG solid wires, such as for lighting branch circuits, use self-insulated pressure type connectors for all splices or joints.

B. Terminate all wires connected to terminal boards, terminal blocks, or to other similar terminals by means of ring and tongue, nylon self-insulated, tin-plated copper pressure terminals.

C. Terminal boards shall be 600 volts and rated for 125 percent of the ampacity of the connected circuit. They shall have screw terminals, with white marking strips for wire identification, of the 4-, 6-, 8-, or 12-pole type, as necessary.

D. Wire connections for which terminals are not supplied, for example, at solenoids or motor terminal junction boxes:

1. 10 AWG and smaller: Use self-insulated pressure-type connectors.

2. 8 AWG and larger: Use insulated, mechanical type with set screw or follower bearing directly on the wire. Split bolt connectors are not acceptable.

E. Clearly and permanently mark terminal strips with ink or indelible pencil. Mark each wire consistently throughout entire system, using notation of wires given on manufacturer's wiring diagrams wherever possible.

3.05 FIELD TESTING

A. Submit results of all cable tests on forms indicating cable size, voltage, and date with name of tester and witness.

B. Test all field conductors for instrumentation and controls systems for opens, shorts, and grounds. Resistance values shall not be less than those recommended by the cable manufacturer.

C. Provide a record of each instrumentation cable continuity verification and resistance value.

3.06 CONTRACT CLOSEOUT

A. Provide in accordance with Section 01 77 00 “Execution and Closeout Requirements”.

END OF SECTION

SECTION 26 05 26

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 DESCRIPTION

A. Provide a single, complete, integrated grounding system, including conductors, raceways, and connections, as indicated and in compliance with Contract Documents, and in accordance with the National Electrical Code Article 250 and the National Electrical Safety Code, and the applicable Provincial Electrical Safety Codes and Regulations.

B. Include grounding of switchgear, substations, motor control centers, electric equipment enclosures etc., outdoor substations, transformers, switch structures, etc.; ground grid systems with ground rod and water pipe connections; structural steel, and lightning protection system.

C. Include grounding conductors completely inter-connecting water supply pipe, ground rods, ground grid, substation, switchgear and motor control center ground buses, other distribution equipment, and other groundable equipment.

D. The following documents form part of the Specifications to the extent stated. Where differences exist between codes and standards, the one affording the greatest protection shall apply.

E. Unless otherwise noted, the referenced standard edition is the current one at the time of commencement of the Work.

F. Refer to Division 01 Section "General Requirements" for the list of applicable regulatory requirements.

G. Refer to specific Division 26 Sections for additional referenced codes and standards.

1.02 REFERENCES

A. American National Standards Institute (ANSI)/Institute of Electrical and Electronics Engineers (IEEE):

1. ANSI/IEEE C2: National Electrical Safety Code.

B. ASTM International (ASTM):

1. B3: Standard Specification for Soft or Annealed Copper Wire.

2. B8: Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.

3. B33: Standard Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes.

C. Institute of Electrical and Electronics Engineers (IEEE):

1. Standard 81: Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potential of a Ground System.

2. Standard 142: Recommended Practice for Grounding of Industrial and Commercial Power systems.

D. National Fire Protection Association (NFPA):

1. 70: National Electrical Code.

2. 780: Lightning Protection Code.

E. Underwriters Laboratories (UL):

1. 467: Standard for Grounding and Bonding Equipment.

1.03 SUBMITTALS

A. Submit the following shop drawings in accordance with Section 01 33 00 “Submittals”:

B. Submit shop drawings and manufacturers' product data in accordance with requirements of Section 26 05 10 “Electrical Work – General”.

C. Submit catalog and dimensional data for the following:

1. Ground rods

2. Exothermic welding

3. Connecting hardware

D. Submit grounding system test results.

PART 2 - PRODUCTS

2.01 MANUFACTURER’S COMPLIANCE

A. Manufacturer's acceptance contingent upon products' compliance with the specifications.

2.02 MANUFACTURERS

A. Ground Rods:

1. ERICO Products Inc.

2. Galvan Electrical Products.

3. Nehring Electrical Works.

B. Exothermic Welding:

1. ERICO Products, Inc.

2. American Brass Mfg. Co.

3. Orgo-Thermit, Inc.

C. Connecting Hardware:

1. American Brass Mfg. Co.

2. Thomas and Betts

3. Anderson Electric Corp.

2.03 MATERIALS AND COMPONENTS

A. Conductors:

1. Provide copper grounding conductors bare or insulated, sized as indicated. When not indicated on the drawing provide in accordance with the NEC. Provide protection of conductors in locations where physical damage would result from direct exposure.

2. Ground and bond wires for substations, main panels and distribution points, and ground rod connections shall be annealed bare copper conforming to ASTM B3, stranded, with 98 percent conductivity.

3. Equipment ground conductors run with circuit conductors and grounding electrode conductor shall be 600-volt with green insulation, unless noted otherwise on the Contract documents.

4. Unless noted otherwise, all conductors No. 8 AWG and larger shall be stranded, Class B in accordance with ASTM B8.

a. Uninsulated conductors shall be bare copper in accordance with ASTM B3, tinned in accordance with ASTM B33.

b. Use tinned-coated in corrosive environments including when buried in earth or embedded in concrete.

B. Ground Bus:

1. Provide a 4 by 1/4 inch (100 by 6 mm) copper bar complete with bolted type connectors as indicated.

2. Bus bar shall have 18 pre-drilled holes, two standoff insulators, two stainless steel mounting brackets and four stainless steel assembly bolts and lock washer.

C. Connectors and Fasteners:

1. Provide ground clamps which are UL listed for use on copper or brass pipes.

2. Provide ground clamps, for use on iron pipes, of galvanized or malleable iron, or of standard noncorrosive material for use on iron pipes.

3. Provide ground clamps, for use on pipes, with rigid metal base providing good contact by proper seating on the pipe. Do not use strap type clamps.

D. Ground Rods:

1. Ground rods shall conform to the requirements of NFPA 70 and UL Standard 467.

2. Ground rods shall be copper-clad steel rods not less than 3/4 inch (19 mm) in diameter and not less than 10 feet (3 m) long per section.

3. Ground rods shall be clean and smooth with the following characteristics:

a. Cone-shaped point on the first section.

b. Die-stamped near the top with the name or trademark of the manufacturer and the length of the rod in millimeters or feet.

PART 3 - EXECUTION

3.01 EXOTHERMIC WELDING

A. Welding shall be by the exothermic process.

B. Within the welding procedure, include the proper mold and powder charge and conform to the manufacturer’s recommendations.

C. Welding processes shall be the exothermic fusion type that will make a connection without corroding or loosening.

D. The welding process shall join all strands and not cause the parts to be damaged or weakened.

E. Completed connection or joint shall be equal or larger in size than the conductors joined and have the same current-carrying capacity as the largest conductor.

F. Paint buried ground connection with a bitumastic paint.

3.02 INSTALLATION OF GROUNDING AND BONDING CONDUCTORS

A. Install grounding conductors so that they will not be exposed to physical damage. Install connections firm and tight. Arrange conductors and connectors so no strain on connections.

B. Run grounding conductors associated with direct burial cables in common trenches above cables except as indicated otherwise.

C. Bury equipment grounding conductors 30 inches deep. Bring loops or taps up for connection to equipment or other items to be grounded.

D. Where raceways are used to contain and protect grounding conductors, install in accordance with Section 26 05 33 “Raceway and Boxes for Electrical Systems” and Section 26 05 43 “Underground Ducts and Raceways for Electrical Systems”.

E. Where bare grounding conductors are contained within metallic raceways, bond ends of raceways to conductors.

F. Install loop type, low impedance, grounding system interconnecting all components so at least two grounding connections are provided for each major item of electrical equipment. Ensure that severing of any single grounding conductor in this system does not remove grounding protection on any major item.

G. Connect structural steel to the external perimeter loop of grounding conductors installed around all sides of building foundation, buried at least 30 inches below grade. Connect to each vertical column by loop or tap. Connect two opposite points on external loop to two different points on grounding system.

H. Buried and concealed ground connections shall use exothermic welding.

I. Make accessible connections to structural members by exothermic welding process or by bolted connector. Connections to equipment or ground bus by bolted connectors.

J. All metallic conduits, terminating at manholes and handholes, shall be grounded using UL approved grounding type bushings.

3.03 INSTALLATION OF GROUND RODS

A. Install ground rods in manholes in accordance with requirements specified under the section Underground Distribution Systems. Connect each grounding conductor entering a manhole to ground rod by exothermic weld.

B. Install ground rods where indicated. Install the top of the rod 12 inch (300 mm) below the ground surface.

C. Make connection to overall grounding system as indicated. All connections to below grade grounding components shall be made using exothermic welds.

D. Ensure that final resistance of interconnected ground system is 5 ohms, or less. Measure ground resistance in normally dry conditions, and not less than 48 hours after rainfall.

3.04 EQUIPMENT GROUNDING

A. Ground each piece of electrical equipment by means of a grounding conductor installed in raceway feeding that piece of equipment. Grounding conductors installed in conduit with insulated conductors to be furnished with green, 600-volt insulation. Ground conductors are in addition to and not to be considered as the neutral wire of the system.

B. Connect power transformer cases and neutrals to grounding system. Connect neutral ground connection at transformer terminal. Provide two separate, independent, diagonally opposite, connections for power transformers so removal of one connection will not impair continuity of other.

C. Connect two separate ground connections from ground grid to ground bus of switchgear assemblies, motor control centers, switchboards and all outdoor substation and transformer equipment. Ensure that each connection for item of equipment is from different section of ground grid.

D. Connect a grounding conductor between panelboard and grounding system. Where a grounding bar is furnished with panelboard, connect grounding conductor to bar.

E. Conduits entering metal enclosures shall utilize bonding type locknuts and grounding bushings. Locknuts that gouge into the metal enclosures are not acceptable.

F. Where conduits are not effectively grounded by firm contact with a grounded enclosure, apply grounding bushings on at least one end of conduit run. Conduit connections shall be wrench tight.

G. Install a separate grounding conductor from ground system to motors of 100 horsepower and larger, in addition to raceway system. Ground motor ground connection to motor frame, independent of mounting bolts or sliding base. Ground motor to nearest point on grounding system, unless otherwise indicated.

H. Connect grounding conductors from equipment in area where ground bus is required to ground bus. Connect ground bus to grounding system. Mount ground bus on 600 volt pedestal insulators.

I. Connect lightning arresters to ground system by suitable conductors. Where lightning arresters are furnished with electrical equipment and grounding connections are not

inherently provided, ensure that suitable separate grounding conductor connects lightning arresters with system ground.

J. Connect generator neutral to grounding system by a grounding conductor. Connect grounding conductor to generator disconnect enclosure and generator neutral on generator side of disconnect. Ground generator frame to ground grid.

K. Ground each area lighting pole by ground rod driven near base of standard, in accordance with requirements of National Electric Safety Code. Connect ground rods to grounding conductor brought with street lighting feeder cable.

L. Connect individual ground rods to the grounding loop using the direct burial grounding cable by exothermic weld. All connections to below grade grounding components shall be made using exothermic welds, unless the connections are made in hazardous areas which prohibit the use of exothermic weld connections.

M. Bond individual cable tray sections with bonding jumpers.

3.05 SIGNAL GROUNDING

A. Ground signal surge protection and shields of twisted, shielded cable using a signal bonding conductor. The signal bonding conductor shall be a continuous path from the instrument surge protection or shield to the grounding electrode conductor. The signal bonding conductor shall be isolated from the equipment grounding conductor for its entire path.

B. Where convenient several signal bonding conductors may be combined, providing that all the following conditions are met:

1. The combined signal bonding conductor shall have the equivalent cross section of the conductors that it was combined from or three times the cross section of the largest conductor that it was combined from, whichever is less.

2. The combined signal bonding conductor shall be isolated from the equipment grounding conductor.

3. Where two signal bonding conductors are combined use a three-port insulated splice.

4. Where three or more signal bonding conductors are combined, use a copper bus mounted on 600-volt insulators. Attach each conductor to the bus using an insulated ring tongue lug and screw terminal.

3.06 FIELD TESTING

A. Test grounding systems for ground resistance. Total resistance from any point on the ground network to the building counterpoise must not exceed 5 ohms.

B. Ground resistance and counterpoise tests must be made during dry weather and no sooner than 48 hours after rainfall. Conditions of soil and weather shall be documented on test forms.

C. Conduct tests using the ratio method that measures the ratio of the resistance to earth of an auxiliary test electrode to the series resistance of the electrode under test and a second auxiliary electrode. Perform measurements in accordance with IEEE Standard 81.

D. Indicating instrument must be self-contained and include a direct-current generator, synchronized current and potential reversers, crossed-current and potential coils, direct-reading ohmmeter, series resistors, and range-selector switch. Calibrate direct-reading ohmmeter for ranges of 0 to 20 ohms and 0 to 200 ohms.

E. Place auxiliary grounding electrodes in accordance with instrument manufacturer's recommendations but not less than 50 feet (15 m) apart, in accordance with IEEE Standard 81.

F. Perform continuity test on all power receptacles to ensure that the ground terminals are properly grounded to the facility ground system.

G. Submit copies of test reports on ground system to the Owner.

3.07 CONTRACT CLOSEOUT

A. Provide in accordance with Section 01 77 00 "Execution and Closeout Requirements".

END OF SECTION

SECTION 26 05 29

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 DESCRIPTION

A. Provide supports from building structure for electrical items by means of hangers, supports, anchors, sleeves, inserts, seals, and associated fastenings as indicated and in compliance with Contract Documents.

1.02 REFERENCES

A. National Fire Protection Association (NFPA):

1. 70: National Electrical Code (NEC).

1.03 SUBMITTALS

A. Submit the following shop drawings in accordance with Section 01 33 00 “Submittals”.

B. Submit shop drawings and manufacturers' product data in accordance with the requirements of Section 26 05 10 “Electrical Work – General”.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Stainless steel.

2.02 MANUFACTURED SUPPORTING DEVICES

A. Raceway Supports: Clevis hangers, riser clamps, conduit straps, threaded C-clamps with retainers, ceiling trapeze hangers, wall brackets, and spring steel clamps.

B. Fasteners: Types, materials, and construction features as follows:

1. Expansion Anchors: Stainless steel wedge or sleeve type.

2. Toggle Bolts: All stainless-steel springhead type.

3. Powder-Driven Threaded Studs: Stainless steel, designed specifically for intended service.

4. Nuts, Washers, and Bolts: Stainless steel.

C. Conduit Sealing Bushings: Factory fabricated watertight conduit sealing bushing assemblies suitable for sealing around conduit passing through concrete floors and walls. Construct seals with stainless steel sleeve, stainless steel body, neoprene sealing grommets or rings, metal pressure rings, pressure clamps, and cap screws.

D. U Channel Systems: Stainless steel channels, with 9/16-inch (14 mm) diameter holes, at minimum of 8 inch (200 mm) on center, in top surface. Provide fittings and accessories that mate and match with U channel and are of same manufacture.

2.03 U CHANNEL SYSTEMS

A. Manufacturers, Stainless Steel Channel.

1. Unistrut Corp.

2. Power-Strut.

3. B-Line Systems, Inc.

B. Provide Type 316 stainless-steel channel with corresponding accessories.

C. Channels, with 9/16-inch (14 mm) diameter holes, at minimum of 8 inch (200 mm) on center, in top surface.

D. Provide fittings and accessories that mate and match with U channel and are of same manufacture.

E. Provide channel of the proper material to match equipment classifications.

2.04 FABRICATED SUPPORTING DEVICES

A. Shop or field fabricate supports or manufacture supports assembled from U-channel components.

B. Brackets: Fabricated of angles, channels, and other standard structural shapes. Connect with welds and machine bolts to form rigid supports.

2.05 FIRE RESISTANT JOINT SEALERS:

A. Manufacturers:

1. “Dow Corning Fire Stop Foam,” Dow Corning Corp.

2. “Pensil 851,” General Electric Co.

B. Two part, foamed-in-place, silicone sealant formulated for use in through penetration fire stopping around cables, conduit, pipes, and duct penetrations through fire-rated walls and floors.

C. Sealants and accessories shall have fire-resistance ratings indicated, as established by testing identical assemblies in accordance with ASTM E814, by Underwriters' Laboratories, Inc., or other testing and inspection agency acceptable to authorities having jurisdiction.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install supporting devices to fasten electrical components securely and permanently in accordance with NEC requirements.

B. Coordinate with structural system and with other electrical installation.

C. Raceway Supports: Comply with NEC and following requirements:

1. Conform to manufacturer's recommendations for selection and installation of supports.

2. Strength of each support shall be adequate to carry present and future load multiplied by safety factor of at least 4. Where this determination results in safety allowance of less than 200 lbs (890 N), provide additional strength until there is minimum of 200 lbs (890 N) safety allowance in strength of each support.

3. Install individual and multiple (trapeze) raceway hangers and riser clamps as necessary to support raceways. Provide U-bolts, clamps, attachments, and other hardware necessary for hanger assembly and for securing hanger rods and conduits.

4. Support parallel runs of horizontal raceways together on trapeze-type hangers.

5. Support individual horizontal raceways by separate pipe hangers. Spring steel fasteners may be used in lieu of hangers only for 1 inch (25 mm) and smaller raceways serving lighting and receptacle branch circuits above suspended ceilings only. For hanger rods with spring steel fasteners, use 1/4 inch (6 mm) diameter or larger threaded steel. Use spring steel fasteners that are specifically designed for supporting single conduits or tubing.

6. In vertical runs, arrange support so load produced by weight of raceway and enclosed conductors is carried entirely by conduit supports with no weight load on raceway terminals.

D. Sleeves: Install in concrete slabs and walls and other fire-rated floors and walls for raceways and cable installations. For sleeves through fire rated wall or floor construction, apply UL listed firestopping sealant in gaps between sleeves and enclosed conduits and cables.

E. Conduit Seals: Install seals for conduit penetrations of slabs below grade and exterior walls below grade and where indicated. Tighten sleeve seal screws until sealing grommets have expanded to form watertight seal.

F. Conduit extending through roof shall pass through ceiling box at roof line.

1. Provide 14 gage (1.9 mm) minimum copper box complete with watertight soldered seams and flanged to serve as pitch pocket for each conduit.

2. Install conduit and pitch pocket in advance of roofing work.

G. Fastening: Unless otherwise indicated, fasten electrical items and their supporting hardware securely to building structure, including but not limited to conduits, raceways, cables, cable trays, busways, cabinets, panelboards, transformers, boxes, disconnect switches, and control components in accordance with following:

1. Fasten by means of wood screws or screw type nails on wood, toggle bolts on hollow masonry units, concrete inserts or expansion bolts on concrete or solid masonry, and machine screws, welded threaded studs, or spring tension clamps on steel. Threaded studs driven by powder charge and provided with lock washers and nuts may be used instead of expansion bolts and machine or wood screws. Do not weld conduit, pipe straps, or items other than threaded studs to steel structures. In partitions of light steel construction, use sheet metal screws.

2. Holes cut in concrete shall not cut main reinforcing bars. Fill holes that are not used.

3. Load applied to any fastener shall not exceed 25 percent of proof test load. Use vibration and shock resistant fasteners for attachments to concrete slabs.

3.02 CHANNELS

A. Support electrical components as required to produce same structural safety factors as specified for raceway supports.

B. Install metal U channel racks for mounting cabinets, panelboards, disconnects, control enclosures, pull boxes, junction boxes, transformers, and other devices.

C. Equipment mounted on U-channel support stands shall use single or double channel with enough supports to withstand winds up to 90 mph. The use of angle supports extending from the front or rear of the support structure is a tripping hazard and is strictly prohibited.

D. Install Type 316 stainless steel for mounting of electrical equipment in outdoor areas and on below grade, outside building and structure walls.

E. Install stainless steel channels for interior building mounting of electrical equipment except for those locations listed above and unless otherwise indicated.

3.03 CONTRACT CLOSEOUT

A. Provide in accordance with Section 01 77 00 “Execution and Closeout Requirements”.

END OF SECTION

SECTION 26 05 33

RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 DESCRIPTION

A. Provide complete raceway systems, with matching accessories, fittings, boxes, and other hardware as indicated and in compliance with Contract Documents. When non-metallic raceway systems are specified, provide green insulated grounding conductor sized per National Electrical Code (NEC) requirements.

B. All raceway runs are indicated diagrammatically to outline general routing of raceway. Unless specifically identified for installation in concrete walls or slabs, raceways shall be run exposed with raceway supporting systems. Avoid interfering with pipes, ducts, structural members, or other equipment. Any installation deviations from the contract requirements shall be corrected at no cost to Owner.

C. Provide raceway systems in accordance with the following:

1. Within finished walls or ceilings, use EMT raceway systems.

2. In NEMA 12 or NEMA 1 areas, use galvanized rigid steel raceway systems.

3. In NEMA 4 areas, and where subject to wetting or wash down, use PVC coated rigid steel raceway systems.

4. In exterior building applications, use PVC coated rigid steel raceway systems.

5. In chemical areas and those areas designated NEMA 4X, use PVC coated rigid steel raceway systems.

6. Inside concrete slabs or walls, use PVC Schedule 40 raceway systems. Use PVC-coated rigid steel for all bends and where the conduit exits the concrete.

D. All raceway systems shall be installed in accordance with the criteria described in this section. Any proposed deviations from these requirements shall be submitted to the Engineer in writing for review and disposition.

1. Use Type 316 stainless steel support systems for exterior application and in NEMA 4 and NEMA 4X areas.

2. All NEMA 1 and NEMA 12 areas shall use stainless steel support systems.

E. Aluminum conduit and boxes are not acceptable products.

F. All raceways shall be supported to NEC requirements. Raceways 2 inch (50 mm) outside diameter or greater shall be independently supported in a manner to meet the criteria.

1.02 REFERENCES

A. National Electrical Manufacturers Association (NEMA):

1. RN-1: Polyvinylchloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit

2. TC-2: Electrical Plastic Tubing (EPT) and Conduit (EPC-40 and EPC-80)

3. TC-3: Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing

B. National Fire Protection Association (NFPA):

1. 70: National Electrical Code (NEC).

C. Occupational Safety & Health Act (OSHA).

1. Regulation 1910.7

D. Underwriter's Laboratories, Inc. (UL):

1. 1: Electrical Flexible Metal Conduit

2. 6: Rigid Metal Electrical Conduit

3. 94: UL Standard for Safety Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

4. 360: Electrical Liquid-Tight Flexible Steel

5. 651: Schedule 40 and 80 PVC Conduit

6. 1684: UL Standard for Safety Reinforced Thermosetting Resin Conduit (RTRC) and Fittings

1.03 SUBMITTALS

A. Submit the following shop drawings in accordance with Section 01 33 00 “Submittals”.

B. Submit shop drawings and manufacturers' product data in accordance with the requirements of Section 26 05 10 “Electrical Work – General”.

1.04 1.04 QUALITY ASSURANCE

A. Provide in accordance with Section 01 43 00 “Quality Requirements” and as specified.

B. Items provided under this section shall be listed and labeled by UL or other Nationally Recognized Testing laboratory (NRTL).

1. Term “NRTL” shall be as defined in OSHA Regulation 1910.7.

2. Terms “listed” and “labeled” shall be as defined in NFPA 70, National Electrical Code, Article 100.

C. Regulatory requirements:

1. National Electrical Code (NEC): Components and installation shall comply with National Fire Protection Association (NFPA) 70.

1.05 SEISMIC DESIGN REQUIREMENTS:

A. Conform to the requirements indicated on the structural drawings and as specified in Section 01 41 20.

B. It shall be the responsibility of manufacturer and supplier along with the Electrical Contractor to conform to the seismic design requirements for this project and for the work of this specification section.

C. Install supports for raceway systems greater than 2 inches (50 mm) in diameter to meet the seismic requirements indicated and specified.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Rigid Metal Conduit, intermediate metal conduit and polyvinylchloride-coated rigid steel conduit.

1. Triangle/PWC, Inc.

2. Perma-Cote Industries.

3. Republic Steel Corporation.

4. Robroy Industries.

5. Allied Tube and Conduit.

B. Polyvinylchloride (PVC) Conduit:

1. Triangle/PWC, Inc.

2. Robroy Industries.

3. Carlon Electrical Sciences, Inc.

C. Flexible Conduit:

1. American Flexible Conduit Company.

2. Anamet, Inc.

3. Electri-Flex Company.

4. International Metal Hose Company.

D. Boxes and Fittings:

1. O.Z./Gedney Company.

2. Crouse-Hinds Electrical Construction Materials.

3. Appleton Electric Company.

E. Support Systems:

1. Michigan Hanger Co., (O-Strut).

2. Thomas & Betts (Superstrut).

3. Unistrut Corp.

2.02 MATERIALS AND COMPONENTS

A. Rigid Metal Conduit:

1. Provide galvanized rigid metal conduit, each with a coupling on one end and thread protector on other end.

2. Hot-dip galvanize rigid steel conduit over entire length, along interior and exterior surfaces, including threads. Conduit shall conform to UL 6.

B. Flexible-Metal Conduit:

1. Provide flexible-metal conduit for use in dry areas and match fittings, size, and material to rigid conduit to which it is connected. Flexible-metal conduit shall conform to UL 1.

2. Provide liquid-tight flexible-metal conduit for use in damp areas consisting of flexible-metal conduit, with liquid-tight, sunlight-resistant jacket extruded over the conduit. Provide stainless steel, braided flexible conduit in NEMA 4X, corrosive areas. On larger than 1-1/4 inch (30 mm), furnish separate external ground wire. Liquid-Tight flexible-metal conduit shall conform to UL 360.

C. Polyvinylchloride (PVC) Conduit:

1. Provide PVC conduit, Schedule 40 and Schedule 80 conforming to NEMA Standard TC-2 and UL-651.

2. Fittings and Conduit Bodies: NEMA TC 3 as recommended by the conduit manufacturer.

D. Polyvinylchloride-Coated Rigid Steel Conduit:

1. Provide polyvinylchloride-coated (PVC-Coated), rigid steel conduit conforming to NEMA Standard RN 1 consisting of hot-dipped galvanized rigid steel conduit, as specified hereinbefore, with a polyvinylchloride jacket bonded to the outside of all conduit surfaces with a nominal thickness of 40 mils meeting the requirements of NEMA RN 1, 3.1. The adhesive strength of the bonding to equal or exceed tensile strength of the coating. Provide couplings and fittings for this conduit conforming to the requirements of NEMA RN 1, 3.5.

2. A two-part urethane coating shall be applied to the interior of all conduit and fittings at a two-mil thickness. The interior coating shall be flexible to allow field bending without cracking or flaking.

E. Boxes:

1. In NEMA 1 and NEMA 12 areas, provide standard, sheet-metal, outlet and junction boxes constructed of code-gauge, galvanized sheet steel. Size each box as required by the NEC.

2. In NEMA 4X areas, exterior and process areas, provide 316 stainless steel junction boxes with stainless steel screw clamp or 3-point latches, stainless steel hinges and welded mounting feet. Bolted on mounting feet are unacceptable. Device boxes shall have integral mounting feet.

3. Provide boxes containing fixture studs for hanging fixtures. Use concrete-tight boxes for installation in concrete. Do not use shallow boxes unless building construction is such that it is impossible to use standard-depth boxes.

4. Provide boxes and covers for polyvinylchloride-coated steel conduit made of galvanized cast iron, with a polyvinylchloride factory-applied coating over the galvanizing. Provide coating thickness of 40 mil (1.0 mm) minimum. Boxes shall have hubs with extruded sleeves extending beyond the hub in the same manner as specified for conduit couplings. Provide cover screws of stainless steel.

5. Provide cast boxes with covers or device plates suitable for the area classification. Use cover screws of stainless steel or high brass for iron boxes.

F. Fittings:

1. Provide cast-iron fittings of malleable iron or a mixture of gray iron and cast steel.

2. Provide suitable expansion fittings where conduits cross expansion joints. Equip these fittings with grounding straps, clamps, and copper bonding jumpers.

3. LB, LR, LL, and Tee conduit fittings shall be Form 4 with clamp covers secured with stainless clamps and screws. Covers secured with screws tapped into the fitting are not acceptable.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Perform all work in accordance with the NEC.

B. Use no conduit less than 3/4-inch (20 mm) in diameter, unless otherwise indicated.

C. Install raceways, boxes, enclosures, and cabinets as indicated, according to manufacturer's printed instructions.

3.02 SEISMIC RESTRAINTS

A. For conduits and other raceways installed in open areas, not adjacent to and secured to structural elements, and 2 inch (50 mm) outside diameter or greater, support such raceways using seismic restraints rated for the applicable project earthquake criteria.

B. Methods of Restraining Raceways:

1. Utilize stainless steel threaded rod with rod stiffeners and transverse channel braces at approximately 45 degrees angle, at 15 feet (4.5 m) on center, maximum, and on one side of rod support.

2. Utilize longitudinal bracing with channel braces at 30 feet (9.1 m) on center, maximum.

3. Strap raceways directly to transverse channel braces, using pipe strap with both ends of strap bolted into the channel brace.

4. Do not rigidly brace raceways to different parts of a building that may respond differently during an earthquake. Seismic restraints shall not limit expansion and contraction of the raceway support system.

5. Provide flexible connections for conduits 2 inch (50 mm) outside diameter or greater than when terminating to fixed equipment to prevent loss of raceway integrity in the event of an earthquake.

3.03 INSTALLATION OF FITTINGS

A. Install expansion fittings wherever conduits cross structural expansion joints. Keep the fittings in line with conduit, and install with regard to temperature so that full working range of expansion is available.

B. Do not install fittings to replace elbows and pull boxes, unless space or other problems make use of fittings necessary. Use oversize fittings whenever large cable is installed, in order to maintain proper bending radius.

C. Terminate ends of all floor conduits installed for future use with couplings and readily removable plugs set flush with finished floor surface. Cap spare wall conduits at wall where they enter building.

D. Equip ends of all conduits with conduit fittings. Fit conduits terminating at motor control center or power distribution equipment, or in box above or below, with grounding type bushings, or solidly ground by locknuts or other acceptable fittings. Connect each grounding bushing to ground bus by a bare or green-covered copper wire. Do not use ground wire smaller than 12 AWG. Install ground wire larger than 12 AWG when required by NEC. Where conduits terminate in unprotected areas or where bonding is required over expansion joint, flexible conduit or equivalent; use ground wires 6 AWG. copper or larger.

E. Terminate conduits entering gasketed sheet-metal boxes or gasketed sheet-metal equipment enclosures with gasketed hubs.

F. Terminate conduits entering nongasketed sheet-metal boxes or enclosures with double locknuts and insulated bushings, or with acceptable equivalent.

G. Join raceways with fittings listed for the purpose. Make joints tight. Use raceway fittings compatible with raceway and suitable for use and location.

1. Make raceway terminations tight. Use bonding bushings or wedges at connections subject to vibration. Use bonding jumpers where joints cannot be made tight.

2. Use insulating bushings to protect conductors.

3. Tighten set screws of threadless fittings with suitable tool.

3.04 INSTALLATION OF RACEWAYS

A. Install exposed raceways parallel or at right angles to walls and ceiling beams. Make all changes in directions with listed bends, elbows, and pull boxes. Space parallel runs uniformly throughout. Secure in place by hangers and fasteners. Ground raceways by connection to properly grounded enclosures, bonding, or other means, to obtain permanent low resistance path to ground throughout installation. Ensure that raceway sections in single run and in parallel runs are of same type and finish.

1. Run parallel or banked raceways together, on common supports where practical.

2. Install raceways level and square and at proper elevations. Provide minimum 7 feet (2 m) headroom.

B. Support raceways concealed above suspended ceilings from slab above ceiling in same manner as exposed raceways. Do not support raceways from ceiling supports.

C. Provide cast-in-place inserts in concrete to support all runs, unless otherwise permitted. Use stainless steel sleeve type concrete anchors for installing boxes, and conduit supports. Provide Type 316 stainless steel nut, bolts, and washers, for use with concrete anchors.

D. Support conduits by hangers or pipe straps spaced according to NEC, but in no case more than 10 feet (3 m) on centers.

E. When specified on the Contract Drawings, install conduits in slabs as close to middle of concrete slabs as practicable without disturbing reinforcement. Do not use conduit with outside diameter exceeding one-third of slab thickness. Do not place conduits closer than three diameters on centers, except at cabinet locations where slab thickness is increased as permitted by Engineer.

F. Where conduits are concealed in bottom floor slab, place in concrete slab and not in fill below slab. Install in middle third of the slab thickness where practical, and leave at least 4 inches (100 mm) of concrete cover.

1. Secure raceways to reinforcing rods and to prevent sagging or shifting during concrete placement.

2. Space raceways laterally to prevent voids in the concrete.

3. Run conduit larger than 1-inch (25 mm) trade size parallel to or at right angles to main reinforcement. When at right angles to reinforcement, place conduit close to slab support.

G. Stub-Up Connections: Extend conduits through concrete floor for connection to freestanding equipment with an adjustable top or coupling threaded inside for plugs, and set flush with the finished floor. Flexible metal conduit may be used 6 inches (150 mm) above the floor. Where equipment connections are not made under this Contract, terminate ends of floor conduits installed for future use with couplings and readily removable plugs 8 inch (250 mm) above finished floor surface. Cap spare wall conduits at wall entrance to building.

H. Provide sleeves passing through exterior walls and slabs which are wall entrance seals of watertight construction. For new construction, furnish watertight seal between slab and sleeve, and between sleeve and conduit or cable similar to O.Z./Gedney Type "FSK". For existing construction, furnish watertight seal for use in core bit drilled holes that provides seal between concrete and conduit or cable similar to O.Z./Gedney Type "CSM1". Use wall-entrance seals of malleable iron with watertight sealing gland which may be tightened any time after installation.

I. Do not use dissimilar metals in conjunction with each other. Use an insulation between adjoining surfaces so as to eliminate direct contact and any resultant electrolysis. Maintain electrical continuity of system. Use bituminous impregnated felt, heavy bituminous coatings, nonmetallic separators or washers, or other acceptable materials as insulation.

J. Install fittings to match raceway being used.

K. Install expansion fittings wherever conduits cross structural expansion joints at connections between buildings. Keep fittings in line with conduit, and install with regard to temperature so that full working range of expansion is available.

L. Where conduits pass through firewalls, grout hole around the conduit to the full depth of the material penetrated.

M. Provide separate raceways, junction boxes, and wireways for all low voltage instrumentation raceways (50 volts and below) from control and power raceways.

N. Terminations: Where raceways are terminated with locknuts and bushings, align the raceway to enter squarely, and install the locknuts with dished part against the box; use two locknuts, one inside and one outside the box. Locknut/busing terminations are only acceptable in NEMA 1 enclosures.

O. Threaded hubs shall be used to terminate conduits in all NEMA 12, NEMA 4X and enclosures used in hazardous areas. When terminating in threaded hubs, screw the raceway or fitting tight into the hub so the end bears against the wire protection shoulder. Where chase nipples are used, align the raceway so the coupling is square to the box, and tighten the chase nipple so no threads are exposed.

P. Install pull lines in all empty raceways. Use monofilament plastic line having not less than 200 lb (890 N) tensile strength. Leave not less than 12 inches (300 mm) of slack at each end of the pull wire.

Q. Keep raceways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot water pipes. Install horizontal raceway runs above water and steam piping.

R. Complete raceway installation before beginning conductor installation.

S. Use temporary closures to prevent foreign matter from entering raceway.

T. Protect stub-ups from damage where conduits rise through floor slabs. Arrange so curved portion of bends are not visible above the finished slab.

U. Where metal conduits rise through floor slabs in wet areas, provide PVC Coated Rigid Steel conduits for a distance of 6 inches (150 mm) above and below slab grade.

3.05 BENDS

A. Make all bends carefully to prevent distortion of circular cross section. Field bend conduit shall have an inside radius of not less than nine diameters.

B. Where bends of less than nine diameters are necessary, use standard factory elbows. Size conduit to permit cable-bending radius within the factory elbow of at least eight times cable diameter.

C. Allow no conduit greater than 50 feet (15.2 meters) to have more than two 90 degree bends or equivalent thereof between pulling points. For conduits less than 50 feet (15.2 meters) in length, allow only three 90 degree bends between pulling points.

3.06 CUTTING, THREADING AND CONNECTING

A. Make all field cuts in conduits squarely, file cut ends, ream to remove rough edges and thread in accordance with NEC. No running thread permitted. Make all connections mechanically strong and tight, and with acceptable connectors. Where conduit surface coating is damaged or removed in the cutting, threading or reaming process, restore the surface to its original condition.

3.07 CONDUIT CLEANING

A. Clean all conduit carefully before and after installation, ream ends free of burrs, and free inside surfaces from all imperfections likely to injure cable.

B. After installation of each complete new conduit run, snake the run with band to which is attached a tube cleaner with cylindrical mandrel of a diameter not less than 85 percent of nominal diameter of conduit. Remove and replace all conduit through which mandrel will not pass.

C. Use a sponge with steel brush to clean steel conduit and use a sponge with nylon brush to clean PVC conduits.

D. After cleaning, protect ends of all conduit with standard caps to prevent entrance of water, concrete, debris, or other foreign substance.

3.08 CONDUIT DRAINAGE

A. Where practicable, pitch conduit to drain to outlet boxes, or install so as to avoid trapping moisture. Where dips are unavoidable in exposed conduits, install fitting with drain hole at low point.

3.09 INSTALLATION OF BOXES

A. Unless otherwise indicated, install sheet metal boxes only in dry, accessible locations. Install cast-metal boxes in exterior concrete or masonry walls, in floor slabs, in basements, all other below grade locations and elsewhere as indicated. Cast metal boxes shall be used

(unless otherwise indicated) where vapor-tight fixtures are required, for all surface mounting of wall switches and receptacles and for all outdoor use. Install pull boxes for motor control centers and large ceiling hung boxes where indicated.

B. Install boxes in conformance with all the requirements of NEC. Install boxes designed for type of construction involved. Support boxes in same manner as required for conduit. Size boxes to provide bending radius for wire or cable of at least eight times diameter or in accordance with NEC, whichever is larger.

C. Center all outlets in panels, or spaces and adjust to structural finish. Where specific locations are not indicated, locate outlets with respect to equipment served.

D. Place all outlet boxes, junction boxes and pull boxes, in accessible locations when they are installed above or behind plastered ceilings, furred spaces, or suspended ceilings. Install access panels of suitable size. Mark all access panels for all boxes so panels can be readily located in future. Mark, using metal tabs or plastic buttons which cannot mark ceilings or walls, appropriate for type of construction being used.

E. All penetrations shall be made from the side or bottom. Top entry is strictly prohibited.

F. Provide NEMA 4X stainless steel boxes with covers and device plates suitable for the area classification. Provide stainless steel screws.

3.10 FLEXIBLE CONNECTIONS TO MOTORS AND EQUIPMENT

A. At all motors and electrically operated equipment to which conduit connections are made, install with a complete connection between end of conduit and terminal box of motor or other equipment.

B. Install the conduits in locations permitting direct connection to motors.

C. Make connections between rigid raceway and motor or equipment subject to vibration and adjustment using flexible conduit. Make each connection with at least one quarter bend so that no vibration can be transmitted beyond flexible connection.

D. Install flexible metal conduit, fittings, and accessories in dry areas in accordance with requirements of NEC.

E. Install liquid-tight flexible metal conduit in damp, wet, process, and corrosive areas. Locate conduit to reduce the possibility of damage to the exterior coating. Use fittings that screw into flexible conduit and provide gaskets.

F. Use maximum of 3 feet (1 m) of flexible conduit for recessed and semi-recessed lighting fixtures and; for equipment subject to vibration, noise transmission, or movement; and for all motors. Use liquid tight flexible conduit in wet, process, or damp locations. Install liquid-tight flexible metal conduit in areas subject to wetting due to fire protection sprinklers or broken or ruptured water line. Locate conduit to reduce the possibility of

damage to the exterior flexible conduit jacket. Use fittings that screw into flexible conduit and provide gaskets. Install separate ground conductor across flexible connections.

3.11 PROTECTION

A. Provide protection and install in accordance with manufacturer printed instructions. The conduit and raceway equipment manufacturers, to ensure that coatings, finishes, and enclosures are without damage or deterioration at completion of project.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.

2. Repair damage to PVC or paint finishes with matching touch-up coating recommended by the manufacturer.

3.12 FINAL SYSTEM ACCEPTANCE

A. Upon completion of installation of system, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finish, including chips, scratches, and abrasions and at no additional cost to the Owner.

B. Label all raceways and boxes in accordance with the requirements of Section 26 05 10 “Electrical Work – General”.

3.13 CONTRACT CLOSEOUT

A. Provide in accordance with Section 01 77 00 “Execution and Closeout Requirements”.

END OF SECTION

SECTION 26 05 36

CABLE TRAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 DESCRIPTION:

A. Section includes cable tray, cable tray accessories, hangers and supports as indicated and in compliance with Contract Documents.

1.02 REFERENCES:

A. ASTM International (ASTM):

1. A123/A123M: Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

2. B633: Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel

3. B766: Standard Specification for Electrodeposited Coatings of Cadmium

B. National Electrical Manufacturers Association (NEMA):

1. VE 1: Metal Cable Tray Systems

C. National Fire Protection Association (NFPA):

1. 70 - National Electrical Code (NEC)

D. Underwriter's Laboratories, Inc., (UL):

1. 486A: UL Standard for Safety Wire Connectors and Soldering Lugs for Use with Copper Conductors

2. 486B: UL Standard for Safety Wire Connectors for Use with Aluminum Conductors

1.03 SUBMITTALS:

A. Submit the following shop drawings in accordance with Section 01 33 00.

B. Submit shop drawings and manufacturers' product data in accordance with the requirements of Section 26 05 10.

C. Product Data for Each Component:

1. Show tray types, dimensions, and finishes.

D. Shop Drawings:

1. Detail fabrication and installation of cable tray, including plans, elevations, sections, details of components, and attachments to other construction elements.

2. Designate components and accessories, including clamps, brackets, hanger rods, splice plates connectors, expansion joint assemblies, straight lengths, and fittings.

3. Coordination drawings, including floor plans and sections drawn to accurate scale. Show accurately scaled cable tray layout and relationships between components and adjacent structural and mechanical elements.

E. Testing:

1. Factory certified test reports of specified products, conforming to NEMA VE 1.

2. Field test reports indicating and interpreting test results relative to compliance with performance requirements.

1.04 SEISMIC DESIGN REQUIREMENTS:

A. Conform to the requirements specified in Section 01 41 20.

B. It shall be the responsibility of manufacturer and supplier along with the Electrical Contractor to conform to the seismic design requirements for this project and for the work of this specification section.

1.05 QUALITY ASSURANCE:

A. Comply with the requirements specified in Section 01 43 00.

B. Comply with NFPA 70, “National Electrical Code” for components and installation.

C. Listing and Labeling: Provide products specified in this Section that are listed and labeled.

1. The Terms “Listed and Labeled”: As defined in the “National Electrical Code”, Article 100.

2. Listing and Labeling Agency Qualifications: A “Nationally Recognized Testing Laboratory” (NRTL) as defined in OSHA Regulation 1910.7.

D. Single-Source Responsibility: Cable tray components shall be product of single manufacturer.

1.06 SEQUENCING AND SCHEDULING:

A. Coordination: Coordinate layout and installation of cable tray with other installations.

1. Revise locations and elevations from those indicated as required to suit field conditions and as accepted by the engineer.

PART 2 - PRODUCTS

2.01 MATERIALS AND FINISHES:

A. Conform to NEMA VE 1.

B. Cable Trays, Fittings, and Accessories: Aluminum conforming to Aluminum Association alloy 6063-T6 for rails, rungs, and trays, 5052-H32 or 6061-T6 for fabricated parts.

C. Cable Trays, Fittings, and Accessories: Stainless steel, Type 304.

D. Fabricate cable tray products with rounded edges and smooth surfaces.

2.02 SIZES AND CONFIGURATIONS:

A. Conform to NEMA VE 1.

B. Ladder-Type Trays: Class 20C unless indicated.

1. Width: Refer to plans for width.

2. Inside Depth: 6-inch.

3. Cross-Rung Spacing: 9-inch.

4. Minimum Fitting Radius: 24-inch.

2.03 CABLE TRAY ACCESSORIES:

A. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, manufactured with same materials and finishes as cable trays.

B. Barrier Strips: Same materials and finishes as cable trays.

C. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

2.04 WARNING SIGNS:

A. Lettering: 1-1/2 inch (40 mm) high, black on yellow background with legend "WARNING! NOT TO BE USED AS WALKWAY, LADDER, OR SUPPORT FOR LADDERS OR PERSONNEL."

B. Materials and Fastening: Conform to Section 26 05 53.

PART 3 - EXECUTION

3.01 EXAMINATION:

A. Examine surfaces to receive cable tray for compliance with installation tolerances and other required conditions. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.02 INSTALLATION:

A. Use cable tray of indicated types and sizes, complete with manufacturer's recommended covers, barrier strips, dropouts, fittings, conduit adapters, hold down devices, grommets, and blind ends.

B. Install cable tray level and plumb according to manufacturer's written instructions, rough-in Drawings, original design, and referenced standards.

C. Remove burrs and sharp edges of cable trays.

D. Fasten cable tray supports securely to building structure as specified in Section 26 05 29 unless otherwise indicated.

1. Locate and install supports according to recommendations of NEMA VE 1.

2. Design supports, including fastenings to structure, to carry greater of calculated load multiplied by safety factor of 4, or calculated load plus 200 lbs (90 kg).

E. Make connections to equipment with flanged fittings fastened to tray and to equipment. Support tray independently of fittings. Do not carry weight of tray on equipment enclosure.

F. Install expansion connectors in cable tray runs that exceed 90 feet (27 m). Space connectors and set gaps according to NEMA VE 1.

G. Make changes in direction and elevation using standard fittings.

H. Make cable tray connections using standard fittings.

I. Locate cable tray above piping except as required for tray accessibility and as otherwise indicated.

J. Working Space: Install cable trays with sufficient space to permit access for installing cables.

K. Barriers: Install barriers to separate cables of different systems, such as power, communications, and data processing, or different insulation levels, such as 600 volts, 5,000 volts, and 15,000 volts.

3.03 GROUNDING:

A. Connect cable trays to ground as instructed by manufacturer. Tighten connectors and terminals, including screws and bolts, according to equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals according to tightening torques specified in UL Standard 486A-486B.

B. Electrically ground cable trays and ensure continuous electrical conductivity of cable tray system. Use tray as an equipment ground conductor for itself only, not for connected equipment.

3.04 WARNING SIGNS:

A. After installation of cable trays is completed, install warning signs in visible locations on or near cable trays.

3.05 FIELD QUALITY CONTROL:

A. Grounding: Test cable trays to ensure electrical continuity of bonding and grounding connections.

B. Correct malfunctioning units at site, where possible, and retest to demonstrate compliance; otherwise, remove and replace with new units and retest.

3.06 CLEANING:

A. Upon completion of installation of system, including fittings, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes, including chips, scratches, and abrasions.

3.07 PROTECTION:

A. Provide final protection and maintain conditions in manner acceptable to manufacturer and Installer to ensure that cable tray is without damage or deterioration at Substantial Completion.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by tray manufacturer.

2. Repair damage to PVC or paint finishes with matching touch-up coating recommended by tray manufacturer.

3.08 CLOSEOUT ACTIVITIES:

A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 26 05 43

UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 DESCRIPTION

A. Provide complete underground distribution system as indicated and in compliance with Contract Documents.

B. Conform to lines, grades, elevations, and dimensions. Resolve interferences with other underground conduit, piping or equipment, either new or existing with the Engineer. Match components suitable for proper installation.

C. Provide concrete encasement of duct system where indicated. Include forms and reinforcing in installation. Perform work in accordance with Section 26 05 10 “Electrical Work – General”.

D. Provide Schedule 40 polyvinylchloride (PVC) conduit for power and control circuits and furnish and install PVC coated rigid steel conduits for instrumentation, and communication circuits.

1.02 REFERENCES

A. National Fire Protection Association (NFPA):

1. 70: National Electrical Code (NEC).

1.03 SUBMITTALS

A. Submit shop drawings and manufacturers' product data in accordance with requirements of Section 26 05 10 “Electrical Work – General”.

B. Provide "Record" drawings.

PART 2 - PRODUCTS

2.01 MANUFACTURER'S COMPLIANCE

A. Manufacturer's acceptance contingent upon products' compliance with specifications.

2.02 MANUFACTURERS

A. Polyvinylchloride (PVC) Conduit:

1. Specified in Section 26 05 33 “Raceway and Boxes for Electrical Systems”.

B. PVC Coated Rigid Steel Conduit, Galvanized:

1. Specified in Section 26 05 33 “Raceway and Boxes for Electrical Systems”.

2.03 MATERIALS AND COMPONENTS

A. Conduit Spacers: Furnish conduit spacers made of plastic to maintain spacing between conduits.

B. Concrete: Minimum compressive strength, 3,000 psi (20 MPa).

C. PVC coated rigid steel conduit shall be used underground for bends and when exiting the concrete.

PART 3 - EXECUTION

3.01 INSTALLATION OF CONDUITS

A. Lay conduits, indicated to be direct buried in the ground, in trench on 3-inch (75 mm) bed of sand and cover with an equivalent 3-inch (75 mm) bed of sand. Ensure that no rocks come in contact with conduit during backfilling. Dig trenches to depth and location indicated.

B. Provide minimum separation of power and control conduits of 3 inch (75 mm) both vertically and horizontally. Build ductbank layer by layer, backfill and compact each layer to provide support for next layer.

C. Separate power and control ducts from instrument ducts by a minimum of 12 inches (300 mm).

D. Backfill ductbank in layers and tamp or "puddle" as directed by the Engineer. Provide yellow ductbank marker tapes, reading "Caution - Electrical Lines Below", over entire length of ductline. Locate tapes 12 inches (300 mm) below grade. Provide a tape for every 12 inches (300 mm) of width of ductline.

E. Install conduit, indicated to be encased in concrete with spacers and reinforcing, as specified and as indicated. Concrete used to encase duct banks shall be dyed red in the truck before placement. Provide at least 3000-pound concrete.

F. Install conduit runs following routing on drawing and running in straight lines. Where deviation from a straight line becomes necessary, install bends of radius which allow for rodding and installation of cable.

G. Accomplish changes in direction of runs exceeding total of 10 degrees, either vertical or horizontal, by long sweep PVC coated rigid steel bends having minimum radius of curvature of 25 feet (8 m) Manufactured bends can be used at ends of short runs of 100 feet (30 m) or less, and then only at or close to the end of run. Provide long sweep bends made

up of one or more curved or straight sections and/or combinations thereof. Install manufactured bends with minimum radius of 36 inch (1,000 mm) where larger radius cannot be used.

H. Lay ductlines to minimum slope of 4 inch (100 mm) per 100 feet (30 m) and slope to manholes and handholes, as indicated. Ductlines are to slope away from buildings.

I. Install spacers at intervals of approximately 4 feet (1200 mm) and stagger between tiers of ducts to provide not less than 12 inches (300 mm) of longitudinal separation. Install base spacers to provide at least 3 inches (75 mm) between bottom of trench and underside of bottom conduits. Completely fill space with concrete. Firmly wire conduits and spacers together before concrete is placed.

J. Ductbanks shall be formed, unless trench conditions allow for neat placement of concrete with specified clearances.

K. Prior to placing of concrete, remove all dirt, sand, and any other debris from between conduits and from trench bottoms. Hold conduits in place to prevent floating or accidental movement.

L. Stagger joints in conduits at least 6 inches (150 mm). Do not allow couplings to rest on bottom of trench. Install couplings for plastic conduit in accordance with manufacturer's recommendations.

M. Install concrete encasements so minimum clearance of 12 inches (300 mm) from concrete to parallel pipes, lines, structures, etc., is maintained. Where ducts cross, minimum clearance of 6 inches (150 mm) is required. Do not allow the top of concrete to be less than 30 inches (750 mm) below finished grade or paving. Submit special conditions which may require lesser clearances or special conditions which may require greater than 30 inches (750 mm) depth to Engineer for acceptance.

N. Where a connection is made to existing ductline, bond or dowel concrete encasement to existing encasement. Use waterstop between ductpours and between manholes or buildings and ductwork as indicated.

O. Do not use power-driven vibrators for spading of concrete around ducts.

P. Roll and grade backfill, and restore surface to condition equal to the site finish grade, or as otherwise indicated.

Q. Locate ductbank markers at ends of all ductbanks except at manholes or handholes, at approximately every 200 feet (65 m) along duct run, and at each change in direction of duct run. Place markers approximately on ductbank. Install markers 6 inches (150 mm) square or round section by 3 feet (1 m) long made of Class B concrete. Imprint the letter "D" or cast it on top of the marker. Install top of duct markers flush in paved areas, protruding no more 2-inches above finished grade in unpaved areas. In finished lawns, allow marker to protrude 1/2-inch (12 mm).

R. Keep conduits clean of concrete, dirt, and other substances during the course of construction. After the ductlines have been completed, pull a standard flexible mandrel not less than 12 inches (300 mm) long, having a diameter approximately 1/4-inch (6 mm) less than the inside diameter of the conduit, through each conduit, after which pull a brush with stiff bristles through each conduit to make certain that no particles of earth, sand, or gravel have been left in the line. Replace conduit runs that do not allow the passage of the mandrel at no additional cost to the Owner. Pneumatic rodding may be used to draw in the lead wire. Install in spare conduits a pull wire or rope, and plug and seal spare conduits after cleaning.

3.02 RECORD DRAWINGS OF UNDERGROUND WORK

A. Furnish one set of marked copies of contract drawings, showing exact routing and depths of all underground conduit, duct handholes and manholes. Furnish scaled plot plans, showing principal outline of buildings and structures. Reference conduits, ducts, and manholes, and all bends deviating from straight line, dimensionally from fixed objects or structures.

3.03 CONTRACT CLOSEOUT

A. Provide in accordance with Section 01 77 00 “Execution and Closeout Requirements”.

END OF SECTION

SECTION 26 05 53

ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Identification of electrical materials, equipment, and installations as indicated and in compliance with Contract Documents.

1.02 REFERENCES

A. American Society of Mechanical Engineers (ASME):

1. A13.1: Scheme for the Identification of Piping Systems

B. Institute of Electrical and Electronics Engineers (IEEE):

1. ANSI/IEEE C2: National Electrical Safety Code.

C. National Fire Protection Association (NFPA):

1. 70: National Electrical Code (NEC).

1.03 SUBMITTALS

A. Submit the following shop drawings in accordance with Section 01 33 00 “Submittals”.

1. Submit shop drawings and manufacturers' product data in accordance with the requirements of Section 26 05 10 “Electrical Work – General”.

B. Product Data:

C. Submit for each type of product specified.

D. Miscellaneous: Schedule of identification nomenclature to be used for identification signs and labels.

1.04 QUALITY ASSURANCE

A. Comply with the requirements specified in Section 01 43 00 “Quality Requirements”.

PART 2 - PRODUCTS

2.01 RACEWAY AND CABLE LABELS

A. Manufacturer's Standard Products: Where more than one type is listed for specified application, selection is Installer's option, but provide single type for each application category. Use colors prescribed by ASME A13.1, NFPA 70, or as specified elsewhere.

B. Components and installation shall comply with NFPA 70.

C. Conform to ASME A13.1, Table 3, for minimum size of letters for legend and minimum length of color field for each raceway or cable size.

1. Color: Black legend on orange field.

2. Legend: Indicates voltage.

D. Adhesive Labels: Preprinted, flexible, self-adhesive vinyl. Legend is over-laminated with clear, wear and chemical resistant coating.

E. Pre-tensioned, Wraparound Plastic Sleeves: Flexible, preprinted, color coded, acrylic bands sized to suit diameter of line it identifies and arranged to stay in place by pre-tensioned gripping action when placed in position.

F. Colored Adhesive Tape: Self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inch wide (0.08 mm thick by 25 to 51 mm wide).

G. Underground Line Warning Tape: Permanent, bright colored, continuous printed, vinyl tape with following features:

1. Size: Not less than 6 inch wide by 4 mils thick (152 mm wide by 0.102 mm thick).

2. Compounded for permanent direct burial service.

3. Embedded continuous metallic strip or core.

4. Printed Legend: Indicates type of underground line.

H. Tape Markers: Vinyl or vinyl cloth, self-adhesive, wraparound type with preprinted numbers and letters.

I. Aluminum, Wraparound Marker Bands: Bands cut from 0.014 inch (0.4 mm) thick aluminum sheet, with stamped or embossed legend, and fitted with slots or ears for permanently securing around wire or cable jacket or around groups of conductors.

J. Plasticized Card Stock Tags: Vinyl cloth with preprinted and field printed legends. Orange background, except as otherwise indicated, with eyelet for fastener.

K. Aluminum Faced Card Stock Tags: Wear resistant, 18 point minimum card stock faced on both sides with embossable aluminum sheet, 0.002 inch (0.05 mm) thick, laminated with moisture resistant acrylic adhesive, and punched for fastener. Preprinted legends suit each application.

L. Brass or Aluminum Tags: Metal tags with stamped legend, punched for fastener. Dimensions: 2 by 2 inch (51 by 51 mm) by 0.05 inch (1.3 mm).

2.02 ENGRAVED NAMEPLATES AND SIGNS

A. Manufacturer's Standard Products: Where more than one type is listed for specified application, selection is Installer's option, but provide single type for each application category. Use colors prescribed by ASME A13.1, NFPA 70, or as specified elsewhere.

B. Engraving stock, melamine plastic laminate for Interior Use, 1/16-inch (1.6 mm) minimum thick for signs up to 20 square inches (129 sq cm), 1/8 inch (3.2 mm) thick for larger sizes.

1. Engraved Legend: Black letters on white face.

2. Punched for mechanical fasteners.

C. Exterior, Metal Backed, Butyrate Signs: Wear resistant, non-fading, preprinted, cellulose acetate butyrate signs with 0.0396 inch (1 mm), galvanized steel backing, with colors, legend, and size appropriate to application. One quarter (1/4)-inch (6.4 mm) grommets in corners for mounting.

D. Fasteners for Plastic Laminated and Metal Signs: Self tapping stainless steel screws or No. 10/32 stainless steel machine screws with nuts, flat washers and lock washers.

2.03 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Cable Ties: Fungus-inert, self-extinguishing, 1 piece, self-locking, Type 6/6 nylon cable ties with following features:

1. Minimum Width: 3/16-inch (5 mm).

2. Tensile Strength: 50 lb (222 N) minimum.

3. Temperature Range: -40 to 185 degrees F (-40 to 85 degrees C).

4. Color: As indicated where used for color coding.

B. Paint: Alkyd-urethane enamel. Primer as recommended by enamel manufacturer.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install identification devices according to manufacturer's written instructions.

B. Install labels where indicated and at locations for best convenience of viewing without interference with operation and maintenance of equipment.

C. Lettering, Colors, and Graphics: Coordinate names, abbreviations, colors, and or designations used for electrical identification with corresponding designations used in Contract Documents or required by codes and standards. Use consistent designations throughout Project.

D. Sequence of Work: Where identification is to be applied to surfaces that require finish, install identification after completion of finish work.

E. Self-Adhesive Identification Products: Clean surfaces of dust, loose material, and oily films before applying.

F. Identify feeders over 600 Volt with "DANGER-HIGH VOLTAGE" in black letters 2 inch (51 mm) high, stenciled with paint at 10 feet (3 m) intervals over continuous, painted orange background. Identify following:

1. Entire floor area directly above conduits running beneath and within 12 inch (305 mm) of basement or ground floor that is in contact with earth or is framed above unexcavated space.

2. Wall surfaces directly external to conduits concealed within wall.

3. All accessible surfaces of concrete envelope around conduits in vertical shafts, exposed in building, or concealed above suspended ceilings.

4. Surface of exposed conduits.

G. Install painted identification as follows:

1. Clean surfaces of dust, loose material, and oily films before painting.

2. Prime Surfaces: For galvanized metal, use single component, acrylic vehicle coating formulated for galvanized surfaces. For concrete masonry units, use heavy duty, acrylic resin block filler. For concrete surfaces, use clear, alkali resistant, alkyd binder type sealer.

3. Apply 1 intermediate and 1 finish coat of silicone alkyd enamel.

4. Apply primer and finish materials according to manufacturer's instructions.

H. Install Caution Signs for Enclosures Over 600 Volt: Use pressure sensitive, self-adhesive label indicating system voltage in black, preprinted on orange field. Install on exterior of door or cover.

I. Install Circuit Identification Labels on Boxes: Label externally as follows:

1. Exposed Boxes: Pressure sensitive, self-adhesive plastic label on cover.

2. Concealed Boxes: Plasticized card stock tags.

3. Labeling Legend: Permanent, waterproof listing of panel and circuit number or equivalent.

J. Identify Paths of Underground Electrical Lines: During trench backfilling, for exterior underground power, control, signal, and communications lines, install continuous underground plastic line marker located directly above line at 6 to 8 inch (150 to 200 mm) below finished grade. Where multiple lines installed in common trench or concrete envelope do not exceed an overall width of 16 inch (400 mm), use single line marker.

1. Install line marker for underground wiring, both direct buried and in raceway.

K. Color Code Conductors: Secondary service, feeder, and branch circuit conductors throughout secondary electrical system.

1. Field applied; color coding methods may be used in lieu of factory coded wire for sizes larger than 10 AWG.

a. Colored, pressure sensitive plastic tape in half lapped turns for distance of 6 inch (150 mm) from terminal points and in boxes where splices or taps are made. Apply last 2 turns of tape with no tension to prevent possible unwinding. Use 1 inch (25 mm) wide tape in colors as specified. Adjust tape bands to avoid obscuring cable identification markings.

b. Colored cable ties applied in groups of 3 ties of specified color to each wire at each terminal or splice point starting 3 inch (76 mm) from terminal and spaced 3 inch (76 mm) apart. Apply with special tool or pliers, tighten to snug fit, and cut off excess length.

2. 208/120 Volt System – As follows:

a. Phase A: Black.

b. Phase B: Red.

c. Phase C: Blue.

d. Neutral: White.

e. Ground: Green.

3. 480/277 Volt System – As follows:

   a. Phase A: Brown.

   b. Phase B: Orange.

   c. Phase C: Yellow.

   d. Neutral: White.

   e. Ground: Green.

L. Power Circuit Identification: Use metal tags or aluminum wraparound marker bands for cables, feeders, and power circuits in vaults, pull boxes, junction boxes, manholes, and switchboard rooms.

   1. Legend: 1/4-inch (6.4 mm) steel letter and number stamping or embossing with legend corresponding to indicated circuit designations.

   2. Fasten tags with nylon cable ties; fasten bands using integral ears.

M. Apply identification to conductors as follows:

   1. Conductors to Be Extended in Future: Indicate source and circuit numbers.

   2. Multiple Power or Lighting Circuits in Same Enclosure: Identify each conductor with source, voltage, circuit number, and phase. Use color coding for voltage and phase indication of secondary circuit.

   3. Multiple Control and Communications Circuits in Same Enclosure: Identify each conductor by its system and circuit designation. Use consistent system of tags, color coding, or cable marking tape.

N. Apply warning, caution, and instruction signs and stencils as follows:

   1. Install warning, caution, and instruction signs where indicated or required to ensure safe operation and maintenance of electrical systems and of items to which they connect. Install engraved, plastic laminated instruction signs with accepted legend where instructions or explanations are needed for system or equipment operation. Install butyrate signs with metal backing for outdoor items.

   2. Emergency Operating Signs: Install engraved laminate signs with white legend on red background with minimum 3/8-inch (9 mm) high lettering for emergency instructions on power transfer, load shedding, and or emergency operations.

O. Install identification as follows:

   1. Apply equipment identification labels of engraved plastic laminate on each major unit of equipment, including central or master unit of each system. This includes

communication, signal, and alarm systems, unless units are specified with their own self-explanatory identification. Except as otherwise indicated, provide single line of text with 1/2-inch (13 mm) high lettering on 1-1/2 inch (38 mm) high label; where 2 lines of text are required, use lettering 2 inch (51 mm) high. Use black lettering on white field. Apply labels for each unit of following categories of equipment.

a. Panelboards, electrical cabinets, and enclosures.

b. Access doors and panels for concealed electrical items.

c. Electrical switchgear and switchboards.

d. Motor control centers.

e. Motor starters.

f. Push button stations.

g. Power transfer equipment.

h. Contactors.

i. Remote controlled switches.

j. Control devices.

k. Transformers.

l. Adjustable Frequency Drives.

m. Battery racks.

n. Power generating units.

2. Apply designation labels of engraved plastic laminate for disconnect switches, breakers, push buttons, pilot lights, motor control centers, and similar items for power distribution and control components above, except panelboards and alarm/signal components where labeling is specified elsewhere. For panelboards, provide framed, typed circuit schedules with explicit description and identification of items controlled by each individual breaker.

3.02 CONTRACT CLOSEOUT

A. Provide in accordance with Section 01 77 00 “Execution and Closeout Requirements”.

END OF SECTION

SECTION 26 05 70

ELECTRICAL SYSTEM STUDIES

PART 1 - GENERAL

1.01 DESCRIPTION

A. Provide electrical system studies as indicated and in compliance with Contract Documents.

1. Provide a short circuit, protective device coordination and arc-flash study for the electrical distribution systems constructed under this contract. The study shall consider the electrical utility system upstream protective devices down to the 208Y/120V transformer secondary. The study shall include calculations used to verify the short circuit ratings of the electrical distribution equipment to be provided under this contract and to identify the required settings of associated protective devices.

a. Provide a report summarizing the coordination study including: one-line of system, relay and breaker setting tabulation, relay, circuit breaker, and fuse protective device coordination and short circuit calculation, all prepared by an independent specialty firm. Device calibration and settings are to be based on the results of this coordination study.

B. The Contractor shall employ the services of a specialty firm, subject to review, with the specified demonstrated capability for calibrating and setting protective devices as specified herein.

C. Changes and additions of equipment characteristics based on the actual equipment supplied may be suggested by the results of the short circuit and protective device coordination studies. Submit suggested changes and additions as a part of the study. Field settings of devices, adjustments, and minor modifications to equipment that are required to accomplish conformance with the accepted short circuit and protective device coordination studies shall be provided at no additional cost.

D. The Contractor shall be responsible for providing and installing arc flash hazard equipment labels in accordance with electronic label templates provided with the electrical system study. Labels shall be provided for all electrical distribution equipment rated 120 VAC and above including but not limited to switchgear, switchboards, transformers, panelboards, disconnect switches, and vendor-supplied control panels containing power distribution equipment.

E. Provide the following scenarios as a minimum:

1. Water Treatment Plant on Utility.

2. Pump Station/Clearwell on Utility.

3. Water Treatment Plant only on Generators.

4. Pump Station/Clearwell only on Generators.

5. Water Treatment Plant and Pump Station/Clearwell combined on Generators.

1.02 REFERENCES

A. Institute of Electrical and Electronics Engineers (IEEE):

1. C37.010: Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis

2. 242: IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems.

3. 519: IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power System.

4. 1584: IEEE Guide for Performing Arc-Flash Hazard Calculations

B. National Fire Protection Association (NFPA):

1. 70E: Standard for Electrical Safety Requirements for Employee Workplaces.

C. National Electrical Manufacturer's Association (NEMA):

1. Z535: Safety Alerting Standards

1.03 SUBMITTALS

A. Submittals of electrical distribution equipment affected by the study are not to be submitted until successful review and approval of Short Circuit Study.

B. The approved remaining reports shall be completed, and a copy sent to the electrical distribution equipment manufacturer 45 days before the equipment is shipped to the Work site. The report shall be provided to the Engineer no later than 90 days before the equipment is shipped to the Work Site. Shipment and delivery of equipment will not be accepted at the Work site until the study has been completed, submitted, and approved by the Engineer.

C. Submit the following in accordance with Section 01 33 00.

1. Short circuit and protective device coordination study for review and acceptance, concurrent with the preliminary shop drawing submission for the main electrical distribution system equipment and overcurrent protective devices. Submit an initial

study for comment and a final study, with all electronic files, at the completion of the project.

a. The study shall be performed using the latest edition of one of the following commercial software programs.

(1) EasyPower

(2) SKM System Analysis

b. The study shall consider the effects of motor contribution during fault conditions, at various buses in the system.

c. The study shall include cable sizes, cable lengths and raceway types for considering the effects of cables impedance in the system based on information to be provided by the Contractor.

d. The maximum fault contribution at the incoming source(s) shall be documented via correspondence from the authority responsible for this source(s).

e. Transformer inrush points and damage curves shall be plotted on coordination curves.

f. Obtain from the engine generator supplier, reactance values, protective device type and data and generator decrement curves.

g. Plot on common drawings, single line diagrams and the curves for each protective device to verify proper selectivity and protection for all components of the system for both the normal utility and standby generator source. Label each device uniquely.

h. Identify recommended settings for all devices.

i. Devices which do not provide full selectivity and coordination are not to be used as a recommended device in the study.

2. Voltage drop motor starting study to determine system voltage dip or power in rush limitations at all locations of the distribution system due to the starting of the largest equipment.

3. This study shall consider starting when the system is powered from the utility and from the standby generator sources.

4. Voltage and current total harmonic analysis study at all points of common coupling and main distribution buses for cases when system powered from utility and standby generator sources.

5. After review of coordination study, the Contractor shall set all devices based on the study.

6. Qualifications of specialty testing and/or study firm, as specified.

7. Arc Flash Hazard Labels

   a. Submit all arc flash hazard equipment labels prior to printing and application to electrical equipment.

   b. Label Construction

      (1) Material: Vinyl, in accordance with NEMA/ANSI Z535.

      (2) Size: 4-inches x 6-inches.

      (3) Outdoor Life: 5 years.

      (4) Min/Max Service Temperature: -40°F to 200°F.

      (5) The labels shall be printed using a thermal transfer printer.

      (6) Labels shall be resistant to chemicals, moisture, and UV light.

1.04 QUALIFICATIONS OF SPECIALTY FIRM:

A. A. Submit evidence of the following:

1. Firm's experience:

   a. Specialty firm shall have been in the business of the type of work specified, for at least the past five years.

   b. The firm shall have a minimum of five projects of equal or greater size, service, and the type of equipment specified.

   c. At least the following information must be submitted:

      (1) The number of years the firm has been in the business of performing coordination studies.

      (2) Summary of five previously performed studies including:

         (a) A brief description of each study.

         (b) Name of owner of installation on which study was performed with address, telephone number, and contact person.

         (c) Date of study.

(3) List of projects and contact persons for which protective device settings were performed.

(4) Any other information indicating the firm's experience, ability to perform the work, and business status.

B. Firm shall have a licensed Professional Electrical Engineer supervise all work and seal all reports.

PART 2 - PRODUCTS

(Not Used)

PART 3 - EXECUTION

3.01 SHORT CIRCUIT STUDY

A. Perform a short circuit study in accordance with ANSI Standard C37.010 to verify the adequacy and correct application of circuit protective devices and other electrical system components.

B. The study shall address the case when the system is being powered from the utility source as well as from the on-site generating facilities. Minimum and maximum possible fault conditions shall be covered in the study.

C. Include the fault contribution of all motors. Horsepower shown in the Contract Documents may be used to calculate fault contribution of motors. In the short circuit study VFDs shall be replaced by conductors of the same size as the branch circuit conductors.

D. Calculate short-circuit momentary duties and interrupting duties on the basis of an assumed bolted 3-phase short circuit at each bus. The short circuit tabulations shall include X/R ratios, asymmetry factors, kVA and symmetrical fault-current. Where ground fault protection is specified, provide a ground fault current study for the same system areas, including the associated zero sequence impedance diagram. Include in tabulation form, fault impedance, X/R ratios, asymmetry factors, motor contribution, short circuit kVA, and symmetrical and asymmetrical fault currents.

E. The studies shall include representation of the site power system, the base quantities selected, impedance source data, calculation methods and tabulations, one-line diagrams, conclusions and recommendations.

3.02 PROTECTIVE DEVICE COORDINATION STUDY:

A. Provide a protective device time current coordination study with coordination plots of current limiting devices, plus tabulated data, including ratings and settings selected. In the study, balance shall be achieved between the competing objectives of protection and

continuity of service (with emphasis on continuity of service) for the system specified, taking into account the basic factors of sensitivity, selectivity and speed.

B. Provide separate plots for utility and generator operation as applicable. Show maximum and minimum fault values in each case. Multiple power sources shown in one plot is not acceptable.

C. Each primary protective device required for a delta-to-wye-connected transformer shall be selected so the characteristic or operating band is within the transformer parameters, which, where feasible, shall include a parameter equivalent to 58 percent of the ANSI withstand point to afford protection for secondary line-to-ground faults. Separate low voltage circuit breakers from each other and the associated primary protective device, by a 16 percent current margin for coordination and protection in the event of line-to-line faults. Separate protective relays by a 0.4 second time margin when the maximum 3 phase fault flows to assure proper selectivity. The protective device characteristics or operating bands shall be terminated to reflect the actual symmetrical and asymmetrical fault-currents sensed by the device. Provide the coordination plots for 3 phase and phase-to-ground faults on a system basis. Include all devices down to largest branch circuit feeder circuit breaker. Include all adjustable setting ground fault protective devices.

D. Identify discrepancies in the conclusions and recommendations of the report. Upon resolution of discrepancies and recommendation, update all associated analyses and revise the affected studies.

E. The coordination plots shall graphically indicate the coordination proposed for the several systems centered on full scale log forms. The coordination plots shall include complete titles, representative one-line diagrams and legends, associated upstream power system relays, fuse or system characteristics, significant motor starting characteristics, significant generator characteristics, complete parameters for power, and substation transformers, complete operating bands for low voltage circuit breaker trip devices, fuses, and the associated system load protective devices. The coordination plots shall define the types of protective devices selected, together with the proposed coil taps, time-dial settings and pick-up settings required. The short-time region shall indicate the relay instantaneous elements, the magnetizing inrush, and ANSI transformer damage curves, the low voltage circuit breaker and instantaneous trip devices, fuse manufacturing tolerance bands, and significant symmetrical and asymmetrical fault-currents.

F. The thermal limit of all feeder cables to each bus and large motors, where applicable in the study, shall be shown.

G. No more than six devices shall be shown on one coordination plot. Of these six curves, two (the largest upstream device and the smallest downstream device) shall repeat curves shown on other coordination plots in order to provide cross reference. Give each unique protective device curve in the study a study-unique number or letter identifier to permit cross reference between plots. Do not use identifier letters or numbers more than once.

H. Each primary protective device required for delta-wye connected transformer shall be selected so that the characteristic or operating band is within the transformer parameters, which, where feasible, shall include a parameter equivalent to 58 percent of the ANSI withstand point to assure protection for secondary line-to-ground faults.

I. Include a detailed description of each protective device identifying its type, function, manufacturer, and time-current characteristics. Tabulate recommended device tap, time dial, pickup, instantaneous, and time delay settings. Include C.T. ratio, burden and all other calculations required for the determination of settings.

3.03 MOTOR STARTING/RUNNING STUDY:

A. Provide a motor starting study for all large electric motors and drives over 100 Hp in size to determine voltage dip or power inrush limitations at selected locations due to starting of motors. Define minimum system voltages and compare to standard equipment voltage capabilities.

B. Provide a complete independent set of current-time characteristic curves for all motors 100 Hp (75 kW) and above indicating coordination between the protective relays and the thermal characteristics of the motor.

C. Obtain from the motor supplier the necessary information to perform the study. Certified curves for “Safe Time vs. Current at 100 percent Voltage” and “Accelerating Time vs. Current at 100 percent Voltage” are absolutely necessary and shall become part of the final report.

D. Provide recommended settings for all motor protective devices supplied under this contract.

3.04 ARC FLASH HAZARD ANALYSIS:

A. Perform arc flash hazard analysis for the following items:

1. Panelboards

2. Control panels with voltage over 50 Volts

3. Motor control centers

4. Transformers that have auxiliary electrical devices operating at over 50 Volts

5. Automatic transfer switches

B. Methods of performing analysis:

1. Use NFPA 70E article 130 tables if the short circuit study shows that the condition for those tables are met.

2. Otherwise use IEEE 1584 calculations

a. If the conditions fall within the IEEE 1584 parameters use the IEEE 1584 calculations based on actual OCPD curves and settings.

b. If the conditions do not fall within the 1584 parameters, use the Lee method.

C. Label each item for which the calculations were performed with the following information:

1. Limited approach boundary

2. Information required by NFPA 70E, 130.2(D)(2).

3. Restricted approach boundary

4. Personal protective equipment required within restricted approach boundary

5. Flash protection boundary

6. Personal protective equipment required within flash protection boundary

7. Prohibited approach boundary

3.05 FIELD TESTING

A. Provide in accordance with Section 01 43 00 and as specified.

B. Integrate results of this study with functional testing of the contract electrical equipment in accordance with Section 26 05 10 “Electrical Work – General”.

3.06 CONTRACT CLOSEOUT

A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 26 05 90

ELECTRICAL CONTROLS AND MISCELLANEOUS ELECTRICAL EQUIPMENT

PART 1 - GENERAL

1.01 DESCRIPTION

A. Provide and connect the electrical control equipment and miscellaneous electrical equipment, including such instruments and devices indicated and specified. Device enclosures for electrical equipment as indicated and in compliance with Contract Documents.

B. Control panel enclosures and devices specified herein are provided under those specification sections which invoke this section for control panel requirements or as indicated on electrical drawings.

1.02 REFERENCES

A. ASTM International (ASTM):

1. D178: Standard Specification for Rubber Insulating Matting

B. National Electrical Manufacturers Association (NEMA):

1. 250: Enclosures for Electrical Equipment (1000 volts maximum).

2. ICS 1: Industrial Control and Systems General Requirements

3. ICS 2: Industrial Controls and Systems Controllers, Contactors, and Overload Relays Rated 600 Volts.

4. ICS 4: Terminal Blocks for Industrial Use.

C. National Fire Protection Association (NFPA):

1. 70: National Electrical Code (NEC).

D. Underwriter's Laboratories, Inc. (UL):

1. 467: Standard for Grounding and Bonding Equipment.

2. 486A: UL Standard for Safety Wire Connectors and Soldering Lugs for Use with Copper Conductors.

3. 486B: UL Standard for Safety Wire Connectors for Use with Aluminum Conductors.

4. 489: Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures.

5. 823: Standard for Safety Electric Heaters for Use in Hazardous (Classified) Locations.

1.03 SUBMITTALS

A. Submit shop drawings and manufacturers' product data in accordance with the requirements of Section 26 05 10 “Electrical Work – General”.

B. Wiring diagrams to show control interface points provided with other equipment.

C. Shop drawings to include:

1. Outline drawings with elevations.

2. Equipment arrangement drawings.

3. Anchor bolt location drawings.

4. Electrical schematics and wiring diagrams.

5. Electrical fuse/circuit breaker characteristic.

6. Equipment performance curves and data.

7. Bill of installation/assembly materials.

8. Equipment weights.

9. Completed manufacturer’s data sheets.

10. Sustainable design submittals.

1.04 QUALITY ASSURANCE

A. Comply with the requirements specified in Section 01 43 00 “Quality Requirements”.

B. Sustainability Standards Certifications.

1.05 DELIVERY STORAGE AND HANDLING

A. Comply with the requirements specified in Section 01 66 10 “Deliver, Storage and Handling”.

PART 2 - PRODUCTS

2.01 MANUFACTURERS FOR ELECTRICAL DISTRIBUTION EQUIPMENT

A. Siemens.

B. Eaton

C. ABB

D. Schneider/Square D.

E. Appleton Electric Company.

F. Crouse-Hinds Company.

G. O-Z/Gedney.

2.02 SAFETY DISCONNECT SWITCHES

A. Provide heavy duty type, safety switches, with external operating handles, 3 PST, rated 600 volt, 60 Hertz with ampere rating as indicated, and having provisions for padlocking.

B. Provide fuses for safety switches as indicated.

C. Heavy duty safety switches to be UL listed, File E 2875 and 154828, and meet or exceed NEMA Standard KS1.

D. Provide auxiliary electrical interlocks for motor heaters or other motor control circuits, including variable frequency drives (VFD), starter control where indicated.

E. Provide the following type rating, unless noted otherwise on the plans.

Indoor Use	NEMA Type 12 SST
Outdoor Use	NEMA Type 4X SST
Indoor or Outdoor Use, Corrosive Area	NEMA Type 4X SST

2.03 CONDUIT AND WIRING

A. Provide conduit and wiring necessary to make connections between instrument panels, consoles, cabinets and external equipment and devices.

2.04 PUSHBUTTON AND SELECTOR SWITCH STATIONS

A. Provide HAND-OFF-AUTO switches, push buttons, tumbler switches and other accessory devices as necessary for the control of motors and other electrical equipment or devices.

B. Provide pushbutton and selector switch stations designed for heavy-duty service and with momentary or maintaining contacts as indicated or as necessary for starting and stopping of equipment with 10 amp contact ratings.

C. Provide heavy duty switches and pushbuttons, Square D Company, Class 9001 or approved equal. Indicating lights to be led cluster type.

D. At stations provide nameplates with white letters on black background.

E. Provide safety lockout station with position indication located near motor to prevent application of current. Where pumps are located on lower levels than driving motors, furnish safety lockout station near each pump or other item of equipment.

F. Provide galvanized cast iron enclosures for NEMA Type 4 watertight stations.

G. Provide fiberglass reinforced polyester NEMA Type 4X enclosures for stations located in highly corrosive areas. Provide gaskets and Type 316 stainless steel screws, to prevent entry of chemicals.

2.05 MANUAL MOTOR STARTERS

A. Provide manual motor starters where indicated and for 120 volt, 60 Hertz fractional horsepower motors.

B. Provide each manual motor starter with overload heater or heaters of suitable capacity for motor running overcurrent protection for motor it controls. Provide manual starters as single or 2 pole, as necessary, and with toggle mechanisms indicating OFF and ON positions.

C. Manual starters to be located within sight of motors, as defined by NFPA 70 National Electric Code (NEC).

2.06 MANUAL MOTOR SWITCHES

A. Provide manual motor switches where indicated and for 480 volt, 3-phase, 60 Hertz fractional horsepower motors, such as motor operated valves.

B. Provide each manual motor switch with overload heater or heaters of suitable capacity for motor running overcurrent protection for motor it controls. Provide manual motor switches as single, 2- or 3-pole, as necessary, and with toggle mechanisms indicating OFF and ON positions. Switches shall be NEMA 4 rated.

C. Manual motor switches to be located within sight of motors, as defined by NFPA 70 National Electric Code (NEC).

2.07 WALL MOUNTED COMBINATION STARTERS

A. Unless otherwise indicated, provide each combination starter with motor circuit protector and full voltage magnetic starter. Provide starters in an enclosure that meets the requirements of the enclosure schedule. Provide motor circuit protectors and starters as specified in Section 26 24 19 “Motor Control Centers”.

B. Provide control transformer for the control circuit of each motor controller, rated 120/240 volts, single phase, 3 wire, 60 Hertz, of adequate VA capacity for operation of supplied equipment with spare 100 VA.

C. Provide control transformer with current limiting primary fuses and secondary fuse.

D. Provide LED cluster type indicating lights of heavy duty, oiltight unit rated at 120 volts.

E. Provide heavy duty, oiltight type pushbuttons to provide momentary contacts or maintained contacts for starting and stopping the motor.

F. Refer to plans for control diagrams.

2.08 SOLID-STATE REDUCED VOLTAGE STARTER

A. Unless otherwise indicated, provide each solid-state reduced voltage starter with circuit breaker. Provide starters in an enclosure that meets the requirements of the enclosure schedule. Provide starters as specified in Section 26 24 19 “Motor Control Centers”.

B. Provide control transformer for the control circuit of each motor controller, rated 120/240 volts, single phase, 3 wire, 60 Hertz, of adequate VA capacity for operation of supplied equipment with spare 100 VA.

C. Provide control transformer with current limiting primary fuses and secondary fuse.

D. Provide LED cluster type indicating lights of heavy duty, oiltight unit rated at 120 volts.

E. Provide heavy duty, oiltight type pushbuttons to provide momentary contacts or maintained contacts for starting and stopping the motor.

2.09 WALL MOUNTED CIRCUIT BREAKERS

A. Provide manually operated circuit breakers, ambient compensated, providing thermal magnetic inverse time limit overload and instantaneous short circuit protection. Provide overload protection on all poles; trip settings as indicated.

B. Provide circuit breakers as specified under Section 26 24 19 “Motor Control Centers”.

C. Provide time-current characteristic curves for each size of circuit breaker furnished.

D. Provide circuit breakers housed in NEMA type enclosure indicated, having external operating handles with provisions for padlocking.

2.10 CONTROL PANELS AND ELECTRICAL ENCLOSURES

A. Provide control panels as specified in Section 26 27 17 “Control Panels”.

2.11 RUBBER MATS

A. Provide rubber mats conforming to ASTM D-178 Type I, Class I: Mats shall be at least 4 feet wide and have a length at least equal to the panelboard, switchboard motor control center, or switchgear before which they are to be placed. Furnish two spare mats, each 4 feet long as spares.

B. Place mats in front of switchboards, panelboards, motor control centers and switchgear. Place mats behind electrical assemblies with rear access.

2.12 CONTACTORS AND RELAYS

A. Provide mechanically held, heavy duty type contactors (relays) for lighting control, rated 30 amps, 600 volts, with number of poles as indicated.

B. Provide contactor in the required NEMA enclosure suitable for wall mounting. Provide circuit breaker or fuse protection on each ungrounded pole. Provide contactor similar to Square D Company, Class 8903, Type LX or approved equal.

C. Provide control power transformer with primary and secondary fuse protection. Control power to be 120 volts, single phase.

D. Provide timing relays by Allen Bradley, Series 700 or equal.

E. Provide industrial grade relays, NEMA rated, Square D Company, Class 8501 or equal.

2.13 NAMEPLATES

A. Provide nameplates for equipment (including pushbutton and selector switch stations) listed in this section and other controls furnished under this contract, to designate the equipment controlled and their function.

B. Nameplates shall be laminated black bakelite with 1/4-inch (6 mm) high, white, recessed letters. Securely attach to the equipment with Type 316 stainless steel screws, or rivets. Adhesives, glue or cements will not be permitted.

C. Provide all junction boxes, pull boxes, disconnect switches and control panels with a nameplate to designate the system wiring contained within.

D. Install nameplates in a location near or on the equipment or devices.

2.14 HATCH POSITION/INTRUSION SWITCH

A. Heavy duty turret head lever arm type switch. Provide an offset type lever arm with sufficient length to contact hatch lid.

B. Rated NEMA 6P

C. Rated 120 VAC, 6 amps.

D. Application:

1. Roof Hatches

2. Tank Hatches

E. Manufacturer:

1. Schneider Electric/Square D

2. Approved Equal

PART 3 - EXECUTION

3.01 WIRING OF MISCELLANEOUS DEVICES

A. Make electrical connections required for recording and indicating instruments, and miscellaneous devices. Provide electrical supplies to metering, instrumentation, control, and alarm systems.

B. Connect HAND-OFF-AUTO switches, safety switches, tumbler switches, and other accessory devices as indicated or necessary for control of motors and other electrical equipment or devices.

C. Install conduit and wiring and make electrical connections between all instrument panels, consoles, cabinets, and external equipment and devices. Panels, cabinets, etc., are indicated.

3.02 WIRING OF EQUIPMENT FURNISHED UNDER OTHER SECTIONS

A. As specified in Section 26 05 10 “Electrical Work – General”, install conduit, wiring, and connections for equipment and devices furnished under other Sections of specifications, and as indicated.

B. Unless otherwise indicated, control equipment, relays, control wiring, conduit, and connections for control of heating, ventilating, and air conditioning systems are provided as specified in Section 23 09 00 “Instrumentation and Control for HVAC”. Refer to mechanical specifications and drawings for locations of pressure-operated control switches, float switches, butterfly valves, solenoid operated valves, sump pumps, metering instruments, control panels, alarm actuating contacts, indicating lamps, limit switches, and other devices requiring wiring or interconnections with equipment supplied under Electrical Sections of these specifications.

3.03 CLOSEOUT ACTIVITIES

A. Provide in accordance with Section 01 77 00 “Execution and Closeout Requirements”.

END OF SECTION

SECTION 26 08 13

FIELD INSPECTION AND ACCEPTANCE TESTS

PART 1 - GENERAL

1.01 DESCRIPTION

A. Perform electrical system tests to demonstrate that each component of each system is in proper working order and in accordance with applicable codes, manufacturer's instructions, drawings and specifications as indicated and in compliance with Contract Documents. Tests are in addition to, and no substitution for, factory tests of individual equipment.

1. Perform insulation and ground resistance tests before operating tests.

2. Determine proper rotation of motors before permanent connections are made.

B. Testing shall be performed to:

1. Provide initial acceptance tests and recorded data that can be used as a benchmark for future routine maintenance and troubleshooting by facility operating staff.

2. Ensure a successful start-up with a minimum of last-minute interruptions and problems.

3. Determine the suitability of the equipment and systems for energization and placing into operating service.

4. Provide assurance that each system component is not only installed satisfactorily but performs, and will continue to perform, its function in the system with reasonable reliability throughout the life of the facility.

C. Provide all supervision and labor, materials, tools, test instruments or other equipment or services and expenses required to test, adjust, set, calibrate, functionally and operationally check all work and components of the various electrical systems and circuitry throughout the installation. Provide sufficient personnel to assist in any additional checks they may require for acceptance, start-up, run-in and placing the equipment and systems into continuous service.

D. The tests and inspections performed shall in no way relieve the Contractor of the responsibility for the performance of the tests, check outs, and inspections specified under other sections of the specification during construction.

E. The listings and descriptions of the tests, and checks described herein shall not be considered as complete and all inclusive. Additional normal standard construction (and

sometimes repetitive) checks and tests may be necessary throughout the job, prior to final acceptance by the Owner.

F. Pay all costs for tests including expenses incident to retests occasioned by defects and failures of equipment to meet specifications.

1. Replace wiring and equipment found defective, or failing to meet specified requirements, without charge, unless written acceptance for repair is given by Engineer.

2. Unless otherwise specified, the Owner will supply electric power necessary for tests.

1.02 REFERENCES

A. All inspections and tests shall be in accordance with the following applicable codes and standards latest revisions except as provided otherwise herein.

1. All Standard, Special and Supplemental Conditions of the Contract.

2. Association of Edison Illuminating Companies (AEIC).

3. American National Standards Institute (ANSI):

a. Z244-1: American National Standard for Personnel Protection

4. ASTM International (ASTM).

5. Insulated Cable Engineers Association (ICEA).

6. Institute of Electrical and Electronic Engineers (IEEE).

a. C2: National Electrical Safety Code

7. National Electrical Manufacturer's Association (NEMA).

8. International Electrical Testing Association (NETA):

a. ATS: Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.

9. National Fire Protection Association (NFPA):

a. 70: National Electrical Code

b. 70B: Electrical Equipment Maintenance

c. 70E: Electrical Safety Requirements for Employer Workplaces

d. 101: Life Safety Code

e. 780: Lightning Protection Code

10. Occupational Safety and Health Administration (OSHA):

a. Part 1926; Subpart V, 1926.950 through 1926.960

11. State and Local Codes and Ordinances.

B. All inspections and tests shall utilize the following references:

1. Project Design Specifications

2. Project Design Drawings

3. Project Electrical System Studies

4. Manufacturer's instruction manuals applicable to each particular apparatus

1.03 SUBMITTALS

A. Submit test plans and test data in accordance with the requirements of Section 26 05 10 “Electrical Work – General”.

B. Submit test results.

1.04 SCHEDULING

A. The Contractor shall be responsible for the preparation of proposed procedures and schedules for all inspections, tests, settings and calibrations specified or otherwise required prior to or during the check out for start-up and acceptance of all the electrical components, equipment and systems. This work shall be coordinated and to be compatible with both the work of other crafts and the project schedule. The above must be organized and submitted with all proposed testing and check out forms. The procedures shall provide specific instructions for the checking and testing of each component in addition to the system functional checks. Tests and inspections shall be scheduled as the job progresses and may require repetition in greater detail at a later stage of construction. All procedures submitted shall include job safety rules proposed.

B. Equipment shall be inspected and tested to determine its condition. See other applicable sections of the specifications and contract documents for required checks and responsibilities.

C. At any stage of construction and when observed, any electrical equipment or system determined to be damaged, faulty, or requiring repairs shall be reported to the Engineer. Corrective action may require prior approval.

D. Prior to check out and testing for start-up, ensure that all equipment and wiring is properly and permanently identified with nameplates and other identification as specified elsewhere. Check and tighten all terminals and connection points, remove all shipping

blocks and hardware, thoroughly clean all equipment, repair all damaged or scratched finishes, inspect for broken and missing parts and review and collect manufacturer's drawings and instructions for submittal to the Engineer. Make routine checks and tests as the job progresses and as necessary to ensure that all wiring and equipment is properly installed and wired.

E. All testing and checkout work shall be performed with fully qualified personnel skilled in the particular tests being conducted. This is essential for obtaining and properly evaluating data while the tests are in progress and for ensuring that important facts and questionable data are reported.

F. All inspections, tests, and calibrations shall be reported in writing on forms submitted for review under Submittals. The recorded data form shall have the signatures of the persons conducting the tests and authorized witnesses. The forms shall be designed to serve as the test and inspection checklist for inspection requirements. "As-found" and "as-left" test data shall be recorded and reported in writing.

G. The sequence of all tests and checks shall be such that the equipment can be energized immediately after the completion of the applicable tests.

H. When applicable electrical tests and inspections specified herein, or otherwise required are completed and results reported and reviewed then the Contractor may consider that portion of the electrical equipment system or installation electrically complete. The Contractor shall then affix appropriate dated completion or calibration labels to the tested equipment. The Contractor shall notify the Engineer and Owner of electrical completion. If the Engineer or Owner finds completed work unacceptable, the Contractor will be notified in writing of the unfinished or deficient work which shall be corrected by the Contractor. The Contractor shall notify the Engineer in writing when all exceptions have been corrected. If later in-service operation or further testing determines problems attributable to the Contractor, these shall be corrected by the Contractor or suitable arrangements shall be made to suit operating circumstances.

PART 2 - PRODUCTS

2.01 TESTING EQUIPMENT

A. Calibration:

1. Furnish all material, test equipment, and power sources required for testing, calibrating and check out. All calibration and setting checks by the independent testing laboratory shall be performed with laboratory calibrated test instruments of appropriate accuracy. This test equipment shall have calibrations traceable to the National Bureau of Standards. Testing laboratory dated calibration labels shall be visible on all test equipment. Calibrations over 6 months old will not be acceptable on field test instruments. The accuracy of all test instruments shall be at least twice that of the accuracy of the equipment, device, relay or meter under test. All testing instruments shall be checked to insure satisfactory operation prior to proceeding

with the tests. Serial and model numbers of the instruments used shall be recorded on the test forms.

2. Make necessary openings in circuits for testing instruments and place and connect all instruments, equipment, and devices, necessary for the tests. Upon completion of tests, remove instruments and instrument connections and restore all circuits to permanent condition.

2.02 TESTING

A. Coordination:

1. Coordinate activities, and cooperate with others on project, to ensure that systems are energized when required, loads applied, and other requirements of Section are carried out on timely, coordinated basis.

2. Conduct tests in presence of Engineer. Notify Engineer seven calendar days or more in advance when any test to be performed, and do not start tests without Engineer's permission.

3. Other Sections of specifications require services of one or more manufacturer's representatives, to ensure that equipment supplied has been installed properly and adjusted to proper working order. Advise representative of all applicable tests in this Section, so that work will be coordinated, and tests combined where feasible.

4. It is important that equipment warranties or guarantees not be voided by testing and checkout work The checks and tests to normally be supplemental to and compatible with the manufacturer's installation instruction leaflets and literature. Where deviations are apparent, the manufacturer's review shall be obtained prior to testing. Reasonable cooperation shall be extended to permit witnessing by the manufacturer's representative if so requested. Where any questionable repairs, modifications, significant adjustments, tests or checks are to be made, the Contractor shall contact the Engineer to determine if the work should be performed by or with the manufacturer's representative.

B. Preparation:

1. Make up no high and/or medium-voltage connections at service entrance, transformers, substations, motors, medium voltage motor control centers, switchgear and generator permanently until correct phase rotation of all equipment is determined. Install and insulate these connections temporarily, if necessary, while determining proper rotation. Make permanent connections after proper rotation has been established and subsequent to completion of insulation resistance and dielectric tests.

PART 3 - EXECUTION

3.01 INSULATION TESTS OF EQUIPMENT, CABLE, AND CIRCUITS

A. General

1. Perform DC insulation tests of the type specified on electrical equipment, apparatus and cables under any one or more of the conditions described as follows: At the time equipment such as motors, generators, transformers, power circuit breakers and switches, switchgear, motor control centers, bus duct, and similar electrical equipment is :

a. Delivered to the site for care, storage, and/or installation,

b. Prior to energization and/or placing into service and acceptance by the Owner,

c. When damage to the insulation is suspected or known to exist,

d. After repairs or modifications to the equipment affecting the insulation,

e. Routinely as necessary to determine or evaluate the condition of the insulation, especially moisture conditions, to determine the need for drying, cleaning or other maintenance work or protection,

f. Where lightning or other surge conditions are known to have existed on the circuit.

2. Insulation tests are required to be performed by the testing firm at various stages of construction. The equipment, cable and systems that require testing, the maximum test voltages, and the type tests required shall be in accordance with the applicable paragraphs of NETA.

3. List each circuit and measured resistance as test data.

4. Maintain record of all insulation resistance values. Identify conductor, or equipment, date that value was taken and resistance value. Arrange information in suitable neat tabular form and submit to Engineer.

3.02 SPECIFIC TESTS AND INSPECTIONS BY THE CONTRACTOR

A. General:

1. The following specific items of work shall be performed by the Contractor. The list is not all inclusive, nor does it define how the tests and checks are to be made. Refer to applicable sections of NETA and equipment specifications for additional details. The equipment and cable shall be deenergized and isolated as necessary to perform the tests.

2. The Contractor shall perform all tests and inspections as defined in the other sections of this specification. Tests and inspections required by these sections are not necessarily repeated under specific equipment in Paragraph 3.02

3. All equipment received for the job and for which the Contractor is responsible to be stored and cared for per the manufacturer's instructions. It is the Contractor's responsibility to obtain such information even where the instructions are not shipped with the equipment.

B. Equipment Test and Inspection During Construction and Prior to Acceptance Testing:

1. Motors (5 Hp and larger):

a. At the time of motor receipt, each motor shall be visually inspected for any physical damage and the motor meggered as described in Paragraph 1.e below.

b. All voltage motors shall be provided with adequate heating during storage. See Paragraph 3.01 for additional insulation tests for all motors of different voltages.

c. Before energizing any machine, visually inspect for serviceability. Check manufacturer's instruction manual for correct lubrication and ventilation. Verify that proper alignment has been performed. Check nameplate for electrical power requirements.

d. Test run all motors preferably uncoupled or unloaded, before placing into regular service. A check on the motor for rotation, speed, current and temperature rise to be made and results recorded. The proper color codes for phase identifications to be maintained. This may require lead swaps at the motor for proper rotation. A motor phase rotation meter shall be used prior to connection at motor to prevent later swaps.

e. Complete visual inspection and electrical test per NETA ATS. Section 7.15.1

2. Grounding Systems:

a. All grounding loops and major equipment grounds shall be tested to remote earth or directly referenced to an extremely low resistance (approximately 1 ohm) reference ground benchmark. Visual inspection of all systems, raceway and equipment grounds shall be made to determine the adequacy and integrity of the grounding. All ground testing results shall be properly recorded, witnessed, and submitted.

b. Ground tests shall be performed in accordance with NETA ATS, Section 8.13 using a J. G. Biddle Company low resistance, Null balance type, ground testing with ‘ohmmeter with test lead compensation in place. The test instrument shall be the type which compensates for potential and current rod resistances.

c. Test each ground rod and submit tabulation of results to Engineer. Include identification of electrode, date of reading and ground resistance value in results.

d. Test each entire grounding system for continuity of connections and for resistance. Ensure that ground resistance of conduits, equipment cases, and supporting frames does not vary appreciably from that of system as whole and does not exceed 5 Ohms.

e. Where ground test results indicate the need for additional grounding conductors or rods that are not indicated on drawings or specified, additional grounding provisions shall be initiated to obtain the acceptable values. The Contractor shall be responsible for the proper installation of the grounding shown on drawings or specified and for the correction of improper installations as determined by inspections and tests.

3. Power Transformers:

a. At the time of equipment receipt, the exterior to be visually checked for any damage or any defects.

b. Perform complete inspection and electrical tests in accordance with NETA ATS, Section 7.2.

4. Low Voltage Switchgear: Refer to NETA ATS, Section 7.2. Perform all applicable tests and checks as described in NETA ATS, Section 7.2.

5. Protective Relays and Metering:

a. Prior to final check out as described in Paragraph 3.03, visually inspect and correct, where appropriate, all relays, meters, wiring and related circuitry for tightness of connections, physical damage, compliance with specifications and Vendor data, mechanical condition, freedom of movement, and presence of or possibility of moisture, dust, or other contaminants.

b. Clean, check, and pre-set all protective relays.

c. Complete inspection and electrical tests per NETA ATS. Section 7.9.

6. Low Voltage Motor Control Centers:

a. At the time of equipment receipt, the motor control centers shall be visually checked for any damage.

b. Perform inspection checks and electrical tests in accordance with NETA ATS. Section 7.16.2.

C. Distribution Transformers:

1. All 480-volt primary, air-cooled, transformers shall be given an insulation test, by means of a megger, after connections with the primary cables are complete. The supply cable shall be meggered with the primary winding and to the open-air circuit breaker. Secondary leads may be meggered with the secondary windings to the open load breakers.

2. Continuity and correctness of connections of all windings, and ratings shall be checked.

3. Perform inspection checks, and electrical tests in accordance with NETA ATS Section 7.2.3.

D. Wire and Cable:

1. Before energizing, the continuity and insulation resistance of every circuit external to equipment shall be measured with a megger from each wire to all others and ground and test results recorded on forms. Tests shall normally be conducted at voltages 500 volts or lower. High potential testing will normally be performed by the independent testing laboratory as described in Paragraph 3.03.

2. Insulation resistance measurements shall be taken of the following: (Refer to Paragraph 3.01 for additional information.)

   a. Motor Feeders: With motors disconnected, measure and record insulation resistance from load side of contactors or circuit breakers. Repeat this test after motors are connected and just before energizing at lower voltage as limited by the maximum test voltage for the motor.

   b. Motor Control Circuits (600 Volts): With push buttons and overcurrent devices connected, measure and record insulation resistance from phase to ground only. It will be necessary to lift the neutral ground on the control transformers to perform this test. Also, isolate any control elements that should not be meggered.

   c. Lighting Panel Feeders: Measure and record insulation resistance with circuit breakers, lighting transformers and panelboards connected, but with lighting branch circuit breakers or switches open.

   d. Lighting Branch Circuits: Measure and record insulation resistance after all lampholders, receptacles, fixtures, etc., are connected but before lamping.

   e. Feeder Circuits: Measure and record insulation resistance with connections to circuit breakers made up but with breakers open and loads not connected.

3. All cables and wires shall be checked for proper identification numbering and/or color coding.

E. Overhead Conduit Systems:

1. The overhead conduit system shall be checked for proper installation by using the following check list: (This list not to be considered all-inclusive but as a guide for inspection).

a. Conduits are supported on appropriate independent supports (i.e., not on process piping, pipe ways, or piping hangers).

b. Exposed conduits are run in a neat workmanlike manner, parallel or perpendicular to structural members.

c. Conduits are routed as far away from possible fire hazards and heat sources as practical.

d. Conduits are supported at the required intervals.

e. Pull boxes and fittings are installed so that covers are easily removable. Verify that all covers are installed and tightly bolted with gaskets provided where needed.

f. Number of bends in the conduit does not exceed 270 degrees without a pull box installed.

g. Circular cross-sectional area is uniform at conduit bends. Single bends do not exceed 90 degrees.

h. Conduits are terminated in threaded hubs or bushings to prevent damage to wire.

i. Conduits joints have joint compound of the type specified and are tight and conduit ends are properly reamed and threaded not to engage less than 5 threads.

j. Pull fittings are of adequate size such that cable can be installed and replaced at a later date without the bending radius of the cable being less than code or manufacturer's requirements.

k. Seal fittings and/or sealing compound is installed at moisture barriers to prevent entry of moisture into equipment and/or where shown on plans.

l. Drains and conduit seals are installed on vertical conduit runs entering devices, equipment, and enclosures to prevent entrance of moisture.

m. Flexible conduit is installed at motors and other equipment as specified or required. Verify that all cabling and conduit runs are properly identified at each end.

F. Underground Conduit Systems:

1. Underground conduit systems shall be inspected and checked for compliance with standard practices, plans and specifications as the job progresses.

2. Upon construction completion of the underground conduit banks or runs and prior to backfill, the routing and the elevation and depth below grade shall be checked and any deviations from plans and/or specification to be recorded and in addition noted on record drawings.

G. Relay Panels, Operator and Instrument Control Panels, Communications Systems, Static Equipment, Programmable Controllers, Micro-Processors, Battery Systems and Other Miscellaneous Equipment:

1. Upon receipt of equipment, each item shall be inspected for damage, loose or missing parts.

2. Upon completion of equipment installation, all equipment and their control devices shall be visually and functionally tested for tightness of connections and for proper operation. In the case of battery systems, static inverters and the like, manufacturer's recommended test and installation manuals shall be reviewed and complied with. In the case of operator, instrument, and relay panels and cabinets or devices used solely for control, each circuit, where possible, shall be functionally tested for proper operation and conformance with drawings. Where functional testing is deemed undesirable by the Owner's Representative from a safety or plant operational standpoint, then continuity and terminal connection verification checks will be adequate. The Contractor shall insure that instruments and associated components cannot be energized until instructed by the Owner's Representative. For functional, operational, and calibration checks of instrument loops, refer to the instrument installation specifications.

3. Panelboard electrical checks shall be as included in the Wire and Cable section of this specification, Paragraph 3.02.E. Panelboards to be checked for proper circuit identification on the door schedule.

H. Sealing of Openings: The Contractor shall inspect the entire job with the Engineer to ensure that all openings are properly sealed as specified elsewhere.

I. Record Drawings: The Contractor shall maintain a master set or record drawings that shows changes and any other deviations from the base drawing. The markups shall be made as the changes are done. At the conclusions of the job, these master record drawings shall be complete and delivered to the Owner's Representative for forwarding to the design group.

3.03 LOSS OF AC POWER TEST

A. After the satisfactory completion of all electrical system testing, perform a loss of AC power test. The main circuit breaker at the facility shall be placed in the “OPEN” position

by the Contractor using all required safety and personal protective equipment in accordance with NFPA 70E.

B. During this test the representatives from the following organizations shall be present:

1. Contractor

2. Division 40 SCADA System Supplier

3. Engine Generator System Supplier

4. Main Electrical Distribution Equipment Supplier

5. Adjustable Frequency Drive Equipment Supplier

6. Owner Representative

C. The test shall verify that all electrical equipment in the system can withstand the loss of utility AC power. Under standby generator power, all automatically started equipment shall be witnessed to start and accept load without tripping offline or initiating false alarms.

D. The test shall be performed with the facility operated at near or full load.

E. All alarms associated with the loss of utility power and startup of the standby generator system shall be recorded.

1. Any nuisance type alarms associated with microprocessor faults or troubles shall be investigated and action taken to prevent reoccurrence.

2. When all nuisance type alarms have been resolved, the test shall be repeated to verify acceptable operation of the facility electrical system upon loss of utility power.

3.04 CONTRACT CLOSEOUT

A. Provide in accordance with Section 01 77 00 “Execution and Closeout Requirements”.

END OF SECTION

SECTION 26 20 00

ELECTRIC MOTORS

PART 1 - GENERAL

1.01 DESCRIPTION

A. Low voltage electric motors and accessories, furnished under other Sections, and which are a part of equipment assemblies shall be in conformance with the requirements specified in this Section, unless otherwise noted. This section includes performance, and descriptive type specifications.

B. Unless otherwise specified or approved, all electric motors furnished and installed by the Contractor shall conform to the requirements specified herein.

1. Motors connected to Variable Frequency Drives shall be inverter duty rated in accordance with the requirements of NEMA MG-1.

2. Motors rated 1 hp or greater shall be premium efficient type per NEMA MG-1.

1.02 REFERENCES

A. Institute of Electrical and Electronics Engineers (IEEE).

1. 112: Test Procedures for Polyphase Induction Motors and Generators.

B. National Electric Manufacturer's Association (NEMA):

1. MG-1: Motors and Generators.

C. National Fire Protection Association (NFPA):

1. 70: National Electrical Code (NEC).

1.03 SUBMITTALS

A. Shop drawings: Submit the following in accordance with Section 01 33 00 “Submittals”.

B. Submit shop drawings and manufacturers' product data in accordance with the requirements of Section 26 05 10 “Electrical Work – General”.

1. Descriptive literature and motor characteristics.

2. Shop drawings and descriptive data to include:

a. Complete list of all motors to be furnished.

b. Outlines, dimensions, weights, and wiring diagrams.

c. Location of main and accessories boxes with size of conduit entrance.

d. Efficiency and power factor at 1/2, 3/4 and full load.

e. Bearing design data and grease requirements.

f. Nameplate data.

g. Shop test report.

h. Field acceptance test report.

i. Strip heaters KW and voltage ratings.

j. Power factor correction capacitors, where required.

k. Built in overload protection device.

l. Starting restrictions, acceleration time-current curve of motor starting load (100 hp and larger).

m. Thermal damage curve and allowable stall time, full voltage (100 hp and larger).

3. Submit Pump, Motor and VFD Coordination Certificate. Refer to Section 01 33 00 “Submittals” for form.

1.04 QUALITY ASSURANCE

A. Provide in accordance with Section 01 43 00 “Quality Requirements” and as specified.

B. Motors to comply with the latest reference standards listed below.

1. National Electrical Code (NEC).

2. Underwriters Laboratories, Inc. (UL).

3. National Electric Manufacturer's Association (NEMA).

a. NEMA Standard MG-1 - Motors and Generators.

4. Anti-Friction Bearing Manufacturer's Association, Inc. (AFBMA).

5. American National Standard Institute (ANSI).

6. Institute of Electrical and Electronics Engineers (IEEE).

a. IEEE Standard 112 - Test Procedures for Polyphase Induction Motors and Generators.

C. Routine tests shall be performed on representative motors, and shall include the information described on NEMA MG1-12.54 Report of Test Form for Routine Tests on Induction Motors. Efficiency shall be determined in accordance with IEEE Publication No. 112, Method B. Power factor shall be measured on representative motors.

1.05 DELIVERY, STORAGE AND HANDLING

A. Shipping:

1. Ship motors assembled to driven equipment complete except where partial disassembly is required by transportation regulations or for protection of components.

2. Pack spare parts in containers bearing labels clearly designating contents and pieces of equipment for which intended.

3. Deliver spare parts at same time as pertaining materials. Delivery to Owner after completion of work.

B. Receiving and Storage:

1. Inspect and inventory items upon delivery to site.

2. Store and safeguard equipment and material in heated storage facility as recommended by equipment manufacturer and required by Section 01 66 10.

3. Protect motors from moisture at all times.

C. Prolonged Storage:

1. For extended outdoor storage, remove motors from equipment and store separately.

2. If storage is anticipated to be longer than two months, store in accordance with the manufacturer instructions including the following additional steps.

3. Maintain motor space heaters energized.

4. Fill the oil reservoirs of motors with sleeve bearings to the proper level with the specified oil.

5. Motors with anti-friction bearings to receive an initial change of grease and then be re-greased every six months.

6. Remove the motor shaft braces and the rotate motor shaft every two weeks. Replace the shaft braces prior to relocation to the installation site. Under no circumstances should the motor be lifted without the braces in place.

PART 2 - PRODUCTS

2.01 MOTOR MANUFACTURERS

A. General Electric Company.

B. Baldor-Reliance Electric/ABB.

C. TECO-Westinghouse.

D. Toshiba.

E. WEG.

2.02 ELECTRIC MOTOR RATINGS

A. Voltage Ratings:

1. Unless otherwise specified, motors with ratings of 1/2 to 600 hp shall be rated 460 volt (nameplate rating), three-phase, 60 Hertz; motors of 1/3 hp or less to be rated 115-volt, single-phase, 60 Hertz.

B. The following specific motor requirements shall be in the equipment specifications:

1. RPM.

2. Motor enclosure type.

2.03 MOTOR DESIGN REQUIREMENTS

A. Motor heaters shall be supplied on all motors installed outdoors or in unheated areas. Heaters shall be of the cartridge or flexible wrap around type installed within the motor enclosure adjacent to core iron. Heaters shall be rated for 120 volt, single phase with wattage as required. The heater wattage and voltage shall be embossed on the motor nameplate.

B. Unless otherwise specified or permitted all electric motors furnished and installed by the Contractor shall conform to the requirements hereinafter set forth.

C. Motors connected to variable frequency drives shall be inverter duty rated.

D. Every motor shall be of sufficient capacity to operate the driven equipment under all load and operating conditions without exceeding its rated nameplate current or power or its specified temperature limit at rated voltage. Each motor shall develop ample torque for its required service throughout its acceleration range at a voltage 10 percent below nameplate rating. Where indicated on the electrical drawings to be operated on a reduced voltage starter, the motor shall develop ample torque under the conditions imposed by the reduced voltage starting method.

E. The motor shall have sufficient capacity to operate the driven equipment as given in the equipment detail specifications. The motor shall not be required to deliver more than its rated nameplate horsepower, at unity (1.0) service factor, under any condition of mechanical or hydraulic loading.

F. The motor shall be suitable for rated horsepower and full service factor operation at minimum 5000 feet elevation above sea level.

G. Type of Motors:

1. All motors shall be NEMA Design B or of a type having starting characteristics and ruggedness as may be necessary under the actual conditions of operation and, unless otherwise specified, shall be suitable for full-voltage starting.

H. Insulation:

1. All motors shall have Class B or Class F insulation with temperature rise by resistance at full load rating of a Class B insulation in accordance with NEMA Standards for Motors and Generators, NEMA MG1, and based on a maximum ambient temperature of 40 degrees C unless otherwise specified.

2. Insulation systems shall be manufacturer's premium grade, resistant to attack by moisture, acids, alkalies and mechanical or thermal shock for 480 volt motors. Provide 80 degrees C, Class B rise or better by resistance at 100 percent load and provide a Class F insulation system, suitable for an ambient temperature motor operation of 0 to 40 degrees C at no less than 4,500 feet above sea level for inverter duty motors. This temperature rise shall be met when motors are operated and controlled with the VFD(s). The motor insulation system shall have full capability to handle the common mode voltage conditions imposed by the VFD.

3. Motors for outdoor service shall have vacuum/pressure impregnated epoxy insulation for moisture resistance.

4. Insulation for inverter duty motor windings shall meet or exceed the Pulse Endurance Index for magnetic wire and shall not be injured when exposed to repeated pulse type waveforms, repetitive high voltage transients, switching frequency and rate of rise of the pulse. Class H varnish shall be used.

I. Enclosures:

1. Motors shall have a steel or cast iron frame and a cast iron or stamped steel conduit box, as specified below. Conduit box shall be split from top to bottom and shall be capable of being rotated to four positions. Synthetic rubber-like gaskets shall be provided between the frame and the conduit box and between the conduit box and its cover. Motor leads shall be sealed with a non-wicking, non-hygroscopic insulating material. A frame mounted pad with drilled and tapped hole, not less than 1/4-inch diameter, shall be provided inside the conduit box for motor frame grounding.

a. Totally enclosed fan cooled: TEFC motors shall have a steel or cast iron frame, cast iron end brackets, cast iron conduit box, 1.15 service factor at 40 degrees C, tapped drain holes (corrosion resistant plugs for frames 286T and smaller and automatic breather/drain devices for frames 324T and larger) and upgraded insulation by additional dips and bakes to increase moisture resistance.

b. Totally enclosed non-ventilated: TENV motors shall include the same rating and accessories as specified for TEFC motors.

J. Special Purpose Motors:

1. Chemical duty motors shall be provided with severe duty rating. Motors shall be of the corrosion resistant type conforming to motors designated by the manufacturer as Corro-Duty, Mill and Chemical, Custom Severe Duty, or similar quality designation. Severe duty motors shall have a cast iron frame, cast iron end brackets, cast iron conduit box and 1.15 service factor at 40 degrees C and tapped drain holes (corrosion resistant plug for frames 286T and smaller and automatic breather/drain devices for frames 324T and larger).

2. Hermetically sealed air conditioning units, elevators, hoists, cranes and other devices complying with special safety codes shall be furnished with motors, control equipment, accessories and safety devices for approved, safe, and efficient operation, in accordance with the manufacturer's standards and to be rated for the duty cycle as specified for the driven equipment. Minimum service factor 1.15 above 3 hp.

3. Submersible motors shall be manufacturer's standard.

4. Synchronous and wound rotor motors shall be specified elsewhere in the specifications when required.

5. Inverter duty rated: Motors for operation on variable frequency drives shall meet current power quality levels published in NEMA MG1, Part 31. Enclosures shall be equal to those furnished for severe duty or explosion proof motors. Motor shaft and bearings shall be insulated. Internal service factor shall be 1.15 that of the nameplate. Ventilation system shall be designed for maximum heat transfer. Stator laminations shall be stagger-stacked and stamped from high grade electrical steel to minimize eddy-current losses and heat build-up caused by inverter induced harmonics. Rotors shall be configured to minimize skin-effect heating.

K. Auxiliary Devices:

1. Three phase motors shall not be provided with starting capacitors.

2. Single-phase motors requiring switching devices and auxiliary starting resistors, capacitors, or reactors shall be furnished as combination units with such auxiliaries either incorporated within the motor housings or housed in suitable enclosures

mounted upon the motor frames. Each combination unit shall be mounted upon a single base and to be provided with a single conduit box.

3. Motors 200 hp or over, or where specified in other sections, shall have built-in overload protection device.

    a. Winding temperature detectors, shall be factory installed, embedded, bi-metallic switch type or thermistors with relay with leads terminating in the main conduit box. This device shall protect the motor against damage from overheating caused by single phasing, overload, high ambient temperature, abnormal voltage, locked rotor, frequent starts or ventilation failure. The switch shall have normally closed contacts. Not less than three detectors shall be furnished with each motor.

    b. Resistance Temperature Detectors (RTD) shall be factory installed with two stator winding RTDs embedded in each phase, total of six, and one RTD for each bearing, total of two. RTDs shall be 3-wire, 100-ohm platinum, and prewired to an auxiliary terminal box on the motor frame. Lead wires shall be stranded copper wire with Dupont Kapton insulation.

L. General Design of Motors:

1. Motors shall comply with the latest NEMA Standards Publication No. MG1 for Motors and Generators, unless otherwise specified.

2. All polyphase non-explosion proof motors shall be designed for energy efficient operation and meet the requirements of MG1-12.53 a and b.

3. Motor windings shall be braced to withstand successfully the stresses resulting from the method of starting. The windings shall be treated thoroughly with acceptable insulating compound suitable for protection against moisture and slightly acid or alkaline conditions.

4. Bearings shall be of the self-lubricating type, designed to ensure proper alignment of rotor and shaft and to prevent leakage of lubricant.

    a. Bearings for open motors shall be of the sleeve or ball type, as specified under the respective items of mechanical equipment.

    b. Bearings for totally enclosed and explosionproof motors shall be of the ball type.

    c. Bearing minimum L-10 fatigue life in hours at 100 percent load shall be 60,000 (unless a greater value is indicated elsewhere in the specifications set).

    d. Bearing grease shall be of the 120 degrees C thermal capability type.

5. Vertical motors shall be provided with thrust bearings adequate for all thrusts to which they can be subjected in operation.

6. Vertical motors of the open type shall be provided with drip hoods of acceptable shape and construction. When the drip hood is too heavy to be easily removed, provision to be made for access for testing.

7. All three phase two speed motors shall be of the two-winding design.

8. All three phase motors shall be provided with a 1.15 service factor.

9. Three phase motors shall be of cast iron construction including frame and end brackets.

10. Totally enclosed motors shall be provided with automatic breather and drain

11. Motor nameplates shall be stainless steel.

12. Motor Terminal Boxes and Leads:

    a. Motors shall be furnished with oversize conduit terminal boxes to provide for making and housing the connections, and with flexible leads of sufficient length to extend for a distance of not less than 4 inches beyond the face of the box. The size of cable terminals, and terminal box conduit holes shall be as permitted by the Engineer. An acceptable type of solderless lug to be furnished. Totally enclosed and explosionproof motors to have cast-iron terminal boxes.

    b. Leads for space heaters and auxiliary devices shall be brought out into an auxiliary, cast, conduit box on the motor side opposite to the main terminal box. Auxiliary box to have 1 inch threaded conduit openings (minimum) and shall be so constructed that conduit entrance may be placed at top, bottom, or either side.

    c. A grounding terminal shall be provided in the main terminal box and a bronze grounding bolt to be furnished at the conduit side of the motor frame.

M. Motor Efficiencies:

1. Three phase motors rated 1 hp and larger shall be of the premium efficiency, “Design E”, type per Table 12.1 of NEMA MG1 Part 12. Motors shall have a NEMA Nominal Efficiency not less than the values referenced in NEMA MG1. Efficiency values shall be based on tests performed in accordance with IEEE Publication No. 112, Method B. Motors with horsepower or rpm’s not listed shall conform to comparable standards of construction and materials as those for listed motors.

N. Shop Painting:

1. Unless otherwise specified, motors shall be given a shop application of paint filler or enamel sealer, a flat coat of undercoated for enamel, and two coats of enamel or, in lieu of this treatment, other corrosion-resistant treatment customary with the manufacturer.

O. Motor Data:

1. The Contractor shall furnish the Engineer with five certified copies of characteristic curves of each motor furnished, except 115-volt motors. Curves shall be supplied as a part of the driven equipment submittal.

P. Motor Shop Tests:

1. Motor shop tests shall be made in accordance with the IEEE Test Codes as specified in the NEMA MG1 Standards for Motors and Generators. NEMA report-of-test forms to be used in submitting test data.

2. Motor efficiency shall be determined by use of IEEE Standard 112 Test Method B, and by use of MGI-12.53 a and b.

3. For induction motors larger than 100 hp, complete tests of each motor furnished to be made and certified tests data sheets to be submitted, unless witness shop tests are required by the technical specifications pertaining to the equipment. Each motor shall be tested at rated voltage for: efficiency and power factor at 50, 75, and 100 percent of it rated horsepower; for temperature rise, torque, no-load current, starting current, full load current, and dielectric strength; and for compliance with all specified performance requirements.

4. For induction motors 5 hp, up to and including 100 hp, copies of routine tests reports of electrically duplicate motors shall be furnished.

5. For motors 3 hp or less, no test data need be furnished.

Q. Spare Parts:

1. Provide in accordance with Section 01 61 00 and as specified.

2. Furnish one spare bearing of each type for each motor size and type.

2.04 ELECTRICAL INTERFACE

A. All items of electrical equipment that are furnished with process, heating, ventilating, or other equipment shall conform to the requirements specified under the applicable electrical sections of the Division 26 specifications. Enclosures for electrical equipment such as switches, starters, etc., shall also conform to the requirements specified under the applicable electrical sections of the Division 26 specifications.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Verify heaters are energized on motors installed in outdoor or unheated areas.

B. After motor installation but before connection to power wiring, test motor winding insulation in accordance with the applicable Division 26 requirements.

C. After connection to power wiring, check for operating temperature, correct rotation, vibration, alignment and operating current drawn under load.

D. Submit all motor test results for review and record.

3.02 CLOSEOUT ACTIVITIES

A. Provide in accordance with Section 01 77 00 “Execution and Closeout Requirements”.

END OF SECTION

SECTION 26 22 14

DRY-TYPE TRANSFORMERS

PART 1 - GENERAL

1.01 DESCRIPTION

A. Provide copper-wound, dry-type transformers as indicated and in compliance with Contract Documents.

B. Provide transformer windings and enclosures rated for the installation location and in accordance with the requirements herein.

C. Transformers shall be “Energy Star” rated.

1.02 REFERENCES

A. American National Standards Institute (ANSI):

1. Z55.1: Gray Finishes for Industrial Apparatus and Equipment

B. ASTM International (ASTM):

1. D635: Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position.

C. National Electrical Manufacturers Association (NEMA):

1. ST 20: Dry-Type Transformers for General Applications (ANSI C89.2) - withdrawn

D. International Electrical Testing Association (NETA):

1. ATS: Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.

E. National Fire Protection Association (NFPA):

1. 70: National Electrical Code (NEC).

F. Underwriters' Laboratories, Inc. (UL):

1. 506: Standard for Specialty Transformers.

1.03 SUBMITTALS

A. Submit shop drawings and manufacturers' product data in accordance with the requirements of Section 26 05 10 “Electrical Work – General”.

B. Submit shop drawings and manufacturer's product data of the transformer. Information to include:

1. Outline drawings including dimensions.

2. Weight.

3. Ratings and tap configuration.

4. Core and coil material.

5. Insulation system description.

6. Loss data and efficiency.

7. Accessories.

8. Mounting requirements.

9. Nameplate data.

10. Testing data.

C. Submit a Certificate of Compliance indicating conformance to the Seismic Requirements specified. Certificate shall be signed and sealed by a Professional Structural Engineer holding current registration in the state for work of this project.

1.04 SEISMIC DESIGN REQUIREMENTS:

A. Conform to the requirements specified in Section 01 41 20.

B. It shall be the responsibility of manufacturer and supplier along with the Electrical Contractor to conform to the seismic design requirements for this project and for the work of this specification section.

1.05 QUALITY ASSURANCE

A. Provide in accordance with Section 01 43 00 “Quality Requirements” and as specified.

1.06 DELIVERY, STORAGE AND HANDLING

A. Provide in accordance with Section 01 66 10 “Deliver, Storage and Handling”.

B. Deliver transformers individually wrapped for protection and mounted on shipping skids.

C. Accept transformers on site. Inspect for damage.

D. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect units from dirt, water, construction debris, and traffic.

E. Handle and stored in accordance with manufacturer's written instructions. Lift only with lugs provided. Handle carefully to avoid damage to transformer internal components, enclosure, and finish.

1.07 REQUIREMENTS OF REGULATORY AGENCIES

A. Furnish transformers in accordance with NEMA ST 20 and UL 506.

B. Furnish transformers with UL listing mark.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Square D Co.

B. Siemens Inc.

C. General Electric Company.

2.02 TRANSFORMERS

A. In NEMA 1 and NEMA 12 designated areas, furnish general purpose, ventilated, dry-type transformers in indoor-style enclosure. On single-phase transformers and three-phase transformers above 9 KVA, provide not less than two windings per phase.

1. Temperature rise at hottest spot shall conform to NEMA Standards, and shall not bake and peel off the enclosure paint after the transformer has been placed in service.

2. Ventilation openings shall prevent accidental access to live components.

3. Thoroughly clean and paint enclosure at the factory with manufacturer’s prime coat and standard finish.

B. In NEMA 4 or NEMA 4X designated areas, provide transformers with encapsulated windings and stainless-steel enclosures.

C. Auto transformers shall not be used in place of general purpose dry-type transformers.

D. Furnish at least two 2-1/2 percent full capacity taps above and below nominal in high voltage winding for transformers rated above 15 kVA. Two five percent taps below rated voltage for transformers rated 15 kVA and below.

E. Furnish transformers, single-phase or three-phase, as indicated. Furnish transformers with kVA ratings as indicated.

F. Furnish three-phase transformers, Delta-Wye connected as indicated, and conforming to latest NEMA standards. Scott Tee connected transformers are not acceptable above 9 kVA.

G. Isolate core and coil from enclosure using vibration-absorbing mounts.

H. Furnish transformers with primary and secondary voltages and frequency, wye connected, as indicated for secondary windings, with neutral brought out for cable termination.

I. Furnish transformers designed for continuous operation at rated kVA with normal life expectancy as defined in NEMA ST 20.

J. For transformers rated 30 kVA or less, ensure that performance is obtained without exceeding 115 degrees C average temperature rise by resistance or 145 degrees C hot spot temperature rise in 40 degrees C maximum ambient and 30 degrees C average ambient. Do not allow maximum coil hot spot temperature to exceed 185 degrees C.

K. Furnish transformers with 220 degrees C insulation materials with proven reliability for 15 kVA transformers and above. Furnish 185 degrees C insulation on transformers below 15 kVA.

L. Transformers rated greater than 30 kVA shall be provided with low-loss 80 degrees C full load operating temperature rise rating.

M. Furnish transformers made of flame-retardant materials that will not support combustion as defined in ASTM D635.

N. Furnish core mounting frames and enclosures of welded and bolted construction with mechanical rigidity and strength to withstand shipping, erection and short circuit stresses.

1. Cores shall be grain oriented, non-aging, and silicon steel.

2. Coils shall be continuous windings without splices except for tapes.

3. Coil loss and core loss shall be minimum for efficient operation.

4. Primary and secondary tap connections shall be razed or pressure type.

5. Coil windings shall have end fillers or tie downs for maximum strength.

O. Transformers located in areas where fire protection system sprinklers are located shall be provided with NEMA 2 rated enclosure to protect transformer from water falling at an angle of 75 degrees from the vertical.

P. Furnish transformers designed to meet UL thermal overload test of 200 percent of rated current for one half hour.

Q. Furnish transformers not to exceed the 65 degrees C rise established by UL as safe limit for maximum surface enclosure temperature.

R. Furnish transformers with sound level not exceeding:

Average Sound Level in dB

kVA	NEMA ST 20
0-09	40
10-50	45
51-150	50
151-300	55
301-500	60

S. Install transformers with sound levels greater than 50 dB on resilient vibration isolating mounts to prevent amplification of sound. Transformers rated 15 kVA and larger to be provided with rubber washer anti-vibration pads and molded neoprene assemblies to isolate noise from the transformer to the mounting surface.

2.03 SHOP TESTING

A. Submit results of audible-sound-levels tests in accordance with NEMA ST 20 of similar size transformer.

B. Production test each unit in accordance with NEMA ST 20.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Set transformer plumb and level. Install and guard transformers as specified by latest NEC and ANSI standards, and in accordance with manufacturer's printed instructions.

B. Furnish adequate space around transformer to dispose of transformer full load losses by ventilation without creating excessive ambient temperature. Verify working clearances as required by the NEC are met.

C. Unless indicated otherwise on drawings, wall mount with suitable supports, transformers rated 15 kVA and below. Floor mount transformers rated above 15 kVA unless otherwise indicated on the drawings. In addition, all transformers located in NEMA 4 or NEMA 4X designated areas shall be wall mounted on Type 316 stainless steel channel supporting systems with Type 316 stainless steel concrete inserts, minimum 7 feet-6 inches (2.3 m) AFF. Provide all required seismic restraints.

D. Provide lifting lugs and jacking plates on transformer enclosure.

E. Provide concrete pad for all floor mounted transformers.

F. Clean metal parts, excepting cores and core mounting frames, then rust-proof and apply heavy coating of inert primer. Paint coverplates and external metal parts with two finish coats of ANSI Z55.1 No. 61 or 49 Gray.

G. Verify mounting pads are in place to reduce noise.

H. Install grounding and bonding in accordance with the drawings and Section 26 05 26 “Grounding and Bonding for Electrical Systems”.

3.02 FIELD TESTING

A. Inspect and test in accordance with NETA ATS, except Section 4.

B. Perform inspections and tests listed in NETA ATS, Section 7.2.1.

3.03 CONTRACT CLOSEOUT

A. Provide in accordance with Section 01 77 00 “Execution and Closeout Requirements”.

END OF SECTION

SECTION 26 24 13

LOW-VOLTAGE SWITCHBOARDS

PART 1 - GENERAL

1.01 DESCRIPTION

A. Provide a 480 volt, 3-phase, 4-wire, electrical distribution rated switchboard, free-standing construction with circuit breakers, power monitor, distribution class lightning arrestors, surge arrestors, automatic transfer switch, and group-mounted circuit breakers as indicated and in compliance with Contract Documents.

B. Provide services of a factory-trained service engineers, specifically trained to check connections, interwiring to equipment, adjustments and assisting in tests.

1. Provide guidance during installation to check work of installing contractor.

2. Instruct personnel in care and operation of equipment.

3. Test main breaker and all branch breakers including spares; insure proper setting.

4. Inspect installation and adjust as necessary when switchboard is ready to be energized and put into service.

5. Test ground fault system and set all protective devices.

6. Certify that equipment has been inspected and is ready to be placed into service.

1.02 REFERENCES

A. Federal Specifications (FS):

1. QQ-S-365B: General Requirements for Silver Plating, Electro Deposited

2. W-C-375: Molded Case Circuit Breakers.

B. National Electrical Manufacturers Association (NEMA):

1. AB 1: Molded-Case Circuit Breakers, Molded Case Switches, and Circuit-Breaker Enclosures.

2. PB-2: Switchboards.

C. Underwriter's Laboratories (UL):

1. 489: Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures.

2. 91: Switchboards.

1.03 SUBMITTALS

A. Submit shop drawings and manufacturers' product data in accordance with the requirements of Section 26 05 10 “Electrical Work – General”.

B. Manufacturer's certified shop drawings including outlines, schematics and wiring diagrams, coordination curves, certified test data reports, maintenance data, operating instructions and parts list with list of recommended spare parts.

C. Performance Test Reports: Upon completion of installed system, submit in booklet form all field tests performed to prove compliance with specified performance criteria including final settings of devices.

1.04 SEISMIC DESIGN REQUIREMENTS:

A. Conform to the requirements specified in Section 01 41 20.

B. It shall be the responsibility of manufacturer and supplier along with the Electrical Contractor to conform to the seismic design requirements for this project and for the work of this specification section.

1.05 SPARE PARTS

A. Comply with the requirements specified in Section 01 61 00.

B. Provide spare parts as recommended by manufacturer.

C. Package spare equipment in containers bearing labels clearly indicating contents and in what equipment used.

D. Deliver spare parts at same time as equipment. Properly store and safeguard such spare parts until completion of work, at which time deliver to Owner.

1.06 QUALITY ASSURANCE

A. Comply with the requirements specified in Section 01 43 00 “Quality Requirements”.

B. Ensure that conduit size and wire quantity, size, and type are suitable for the equipment supplied. Review the proper installation of each type of device with the equipment supplier prior to installation.

C. Single-source Responsibility: Provide switchboard products that are new, and from the same manufacturer for each building or job. Switchboard components shall be from the same manufacturer or listed as an assembly thereof.

D. The manufacturer shall confirm and state the measure of and the set of the features that support the ease and speed of which corrective maintenance (CM) and preventive

maintenance (PM) can be conducted on the proposed system. The Mean Time To Repair (MTTR), the measure used to quantify the time required to perform CM and Mean Preventive Maintenance Time (MPMT), a measure commonly used to quantify the time required to perform PM are to be confirmed by the manufacturer.

E. Provide services of factory-trained Service Technician, specifically trained on type of equipment specified:

1. Service Technician must be present on site for all items listed below. Person-day requirements listed are exclusive of travel time, and do not relieve Contractor of the obligation to place equipment in operation as specified. Times listed are for each switchboard.

2. Installation: Inspect grouting, location of anchor bolts; setting, leveling, alignment and field erection:

   a. 2 person-days

3. Functional Testing: Check alignment and perform a functional test. Tests to include all items specified.

   a. 2 person-days

4. Testing: Field performance test equipment specified.

   a. 2 person-days

5. Credit to the Owner, all unused service person-days specified above, at the manufacturer’s published field service rate.

6. Any additional time required of the factory trained service technician to assist in placing the equipment in operation, or testing or to correct deficiencies in installation, equipment or material shall be provided at no additional cost to the Owner.

   a. Service-inspections during first year of operation, for use at Owner's request, and exclusive of repair, malfunction or other trouble-shooting service calls:

      (1) 1 person-day - switchboard

1.07 DELIVERY AND STORAGE

A. Shipping:

1. Ship equipment, and materials, except where partial disassembly is required by transportation regulations or for protection, complete with identification and quantity of items.

2. Pack spare parts in containers bearing labels clearly designating contents and pieces of equipment for which intended.

3. Deliver spare parts at same time as pertaining equipment. Delivery to Owner after completion of work.

4. Channel bases:

   a. For front and rear, minimum of 1-1/2 inch (37 mm) by 3 inch (74 mm) standard channel with suitable holes for mounting switchboard, and holes for grouting and flow of concrete.

   b. Shipped in advance with accurate template of switchboard mounting holes or dimension layout drawing for embedding in concrete pad, floor slab, or securing to floor. Coordinate with all contractors.

5. Attach lifting angles to main frame of structure to distribute weight equally. Deflection or distortion is cause for rejection.

6. Provide heavy plastic envelope directly over switchboard to protect against dust, dirt, and moisture. Provide lifting angles outside of envelope.

B. Storage:

1. Inspection and inventory items upon delivery to site.

2. Store and safeguard equipment, material and spare parts.

1.08 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace switchboard that fail in materials or workmanship within specified warranty period.

1. Switchboard Warranty Period: 18 months from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers acceptable contingent upon products' compliance with the specifications:

1. Eaton

2. ABB

3. Siemens Corp.

4. Schneider/Square D.

2.02 SWITCHBOARD EQUIPMENT

A. Structure:

1. Totally enclosed switchboard dead front, free standing, front and rear aligned with front accessibility only required.

2. General purpose switchboard with frame-work of UL gauge formed steel and channels and secured together to support all cover plates, bussing and component devices during shipment and installation. Formed removable closure plates on the front, rear and sides. Closure plates shall be single tool, screw removable.

3. Refer to contract documents for NEMA enclosure type.

4. Ventilation provided when required.

5. Each section includes a single-piece removable top plate.

B. Incoming Line; devoted to the main service entrance utility supply.

1. Utility line section consists of:

a. Device:

(1) Main RMS sensing, disconnect device shall be a solid state, true RMS adjustable trip, insulated case, circuit breaker. The main breaker shall be provided fixed style.

(2) In conjunction with the main device, provide undervoltage capacitor trip, phase failure and phase reversal protection, alarm switch, auxiliary switches, long time, short time, instantaneous trip and selective coordination ground fault protection with downstream ground fault protective devices.

(3) Provide “push to trip” push button on circuit breaker to allow manual trip with risking exposure to live parts.

(4) Provide trip indicator to identify type of fault, and indicate OVERLOAD, SHORT CIRCUIT or GROUND FAULT on display.

(5) Main breaker to be provided with capability of locking in the open position.

(6) The trip unit shall include local setup and readout of trip settings and digital display metering of:

(a) 3-phase volts

(b) frequency

(c) KW

(d) KVA

(e) amps

b. Cable termination suitable for cable entry from below, located at bottom section.

c. Line side terminals fitted with two-hole, compression-type lugs for four copper cable conductors per phase.

d. Provide section for Utility service meter and CTs. Verify size of section with Utility equipment.

e. Tinned bus of suitable rating and bracing.

f. Tinned copper ground bus 1/4-inch x 2 inch (6 mm x 50 mm) extended and tied through to all adjoining sections.

C. Power Monitor:

1. Provide microprocessor-based monitoring device to provide local and remote monitoring of the electrical system.

a. Voltage input of 120 volts using voltage transformers.

b. Current input from current transformers, phase A, B, C and ground.

2. Comply with ANSI C12.16, Class 10.

3. Display data:

a. Current A, B, C, Average, Neutral, Ground.

b. Voltage - Phase to phase

(1) Phase to neutral

(2) Phase to ground

(3) Average values

c. Power - Watts

(1) Vars

(2) VA

(3) Phases A, B, C and System

d. Energy - KWH

(1) KVARH

e. Frequency

f. Demand - System current

(1) KW

(2) KVAR

(3) KVA

g. Power Factor - Phases A, B, C, System

h. Percent THD Current - Phases A, B, C, N

i. Percent THD Voltage:

(1) Phase to phase

(2) Phase to neutral

j. Minimum and maximum values

k. Monitor past events and thresholds.

4. Provide power monitor with Ethernet connection and capable of communicating using Modbus TCP/IP protocol.

D. Group Mounted Branch Sections:

1. The switchboard group-mounted circuit breaker branch devices shall be totally front accessible and front connectable.

2. The circuit breaker connections to the distribution panel bussing shall be such that the connections grip the bus bars firmly under high-fault conditions.

3. Provide wiring gutters of sufficient space to allow cable termination.

4. Provide covers for gutter space and future breaker space with formed sheet steel.

5. Provide circuit breakers as indicated on the one-line diagram.

E. Enclosure - General Requirements:

1. Switchboard shall be completely self-supporting structure of the required number of vertical sections bolted together to form one metal-enclosed switchboard 90 inch (2.29 m) high.

2. Sides, top and rear covers shall be code gauge steel, bolted to the switchboard structure.

3. The frame structure members shall be die-formed, 12-gage steel bolted together and reinforced at corners with rugged gussets internal and external to the structure members.

4. The switchboard shall be completely front accessible for all installation and maintenance activities.

5. At the main service entrance section, the sheet steel panels located on the exterior and side of the section shall be removable for servicing the section.

6. The switchboard frame shall be mounted to sills embedded in a concrete housekeeping pad.

7. The switchboard and devices are fully rated at minimum short circuit rating of 65,000 rms symmetrical Amperes. Refer to contract documents for additional requirements.

8. Switchboard shall include all protective devices depicted on contract drawings and as specified in these specifications with necessary interconnection, instrumentation and control wiring.

9. Main breaker shall be individually mounted.

10. All buses are tin plated copper, supported with high impact, non-tracking insulating material, and braced to withstand mechanical forces exerted during short circuit conditions. All bus connections shall utilize silver plated bus bar surfaces.

11. The current density of the bus shall be determined from UL-891 heat rise testing and shall be rated for 1000 amperes per square inch cross-section.

12. A tinned copper, 1/4-inch x 2 inch (6 mm x 50 mm) ground bus shall furnished and secured to structure.

13. A-B-C type bus arrangement (left-to-right, top-to-bottom, front-to-rear) is to be used throughout to assure convenient and safe testing and maintenance.

14. The vertical main bus bars are furnished for future branch devices. Device mounting bolts and bus connecting straps are supplied with future unit devices. Full height bus bars shall be supplied.

15. All vertical sections comprising the switchboard are rear-aligned.

16. All steel surfaces shall be chemically cleaned and pre-treated with an iron-phosphate pre-treatment or equivalent process, providing a bond between paint and metal surfaces to help prevent the entrance of moisture and formation of rust under the paint. The switchboard exterior shall be finished with ANSI-61 light gray paint. Provide touch-up paint for coatings nicks and scratches after installation and testing.

17. Control wiring, fuse blocks and terminal blocks within the switchboard shall be furnished when required. All control wires leaving the switchboard shall be provided with terminal blocks with numbering strips.

18. All hardware used on conductors shall have a high tensile strength, and a protective finish.

19. Switchboard shall be provided with lifting means, and capable of being rolled or moved into installation position and bolted directly to floor sills.

20. Make provision for conduit and cable entrance from top or bottom as indicated on the drawings.

2.03 SWITCHBOARD SILLS

A. Provide steel channel sills with drilled holes for mounting, aligning and bolting switchboard in place. Method of mounting as indicated. Provide in size recommended by switchboard manufacturer and acceptable to Engineer.

B. Shop paint completed sills with two coats of a polyamide epoxy coating with a minimum dry film thickness of 2.5 mils (0.6 mm) per coat or before setting in place.

1. Surface preparation shall conform to paint manufacturer’s printed instructions.

2. Provide additional coating for field touch-up specified in paragraph 3.01.

2.04 SWITCHBOARD INSTRUMENT TRANSFORMERS

A. Switchboard section for main breaker shall include three 480 to 120-volt potential transformers, and one 480 to 120/240 volt single phase control power transformer. Control and potential transformers to be connected ahead of main circuit breaker and to include current limiting primary fuses. Mount transformers in isolated compartment within secondary bus transition section. Also provide, on main bus for each main breaker four window type 3000/5A current transformers for metering phase and neutral current and one 200/5A current for monitoring ground currents.

B. Tie all instrument transformer outputs to power monitor.

2.05 FEEDER PROTECTIVE DEVICES

A. All feeder protective devices shall be molded case circuit breakers with inverse time tripping characteristics as indicated on the contract documents and in this specification.

B. Circuit breakers shall be operated by a toggle-type handle and shall have a quick-make, quick-break over-center switching mechanism that is mechanically trip-free. Automatic tripping of the breaker shall be clearly indicated by the handle position. Contacts shall be non-welding silver alloy and arc extinction shall be accomplished by means of DE-ION arc chutes. A push-to-trip button on the front of the circuit breaker shall provide a local manual means to exercise the trip mechanism.

C. Circuit breakers shall have a minimum symmetrical interrupting capacity as indicated on the contract documents.

D. Circuit breakers to be either draw-out or fixed mounted, as indicated on contract documents

E. Circuit breakers shall have microprocessor-based rms sensing trip units as specified below:

1. All electronic trip molded case circuit breakers shall be equipped with a true RMS sensing, solid-state tripping system consisting of at least three current sensors microprocessor-based trip device and trip actuator. The trip unit shall use microprocessor-based technology to provide the basic adjustable time-current protection.

2. Provide trip units with integral arc flash reduction mode for 1200A frame and above. The breakers shall have an input for an external switch to set in arc flash reduction mode. Provide a blue LED indicating light on front of enclosure to indicate in arc flash reduction mode. The use of zone selective interlocking to emulate this feature does not meet the intent of these specifications and will not be allowed.

3. System coordination shall be provided by adjusting rotary switches for the following microprocessor-based time-current curve shaping adjustments:

    a. Adjustable long-delay pick-up setting with minimum of 10 settings

    b. Adjustable long-delay time - 0.5 to 24 seconds

    c. Adjustable short-delay pick-up setting – 1.5x to Max allowable by frame

    d. Adjustable short-delay time 0.0 sec up to 0.5 sec depending on frame with selectable flat or I2t curve shaping

    e. Adjustable instantaneous setting 2x to Max allowable by frame

    f. Where indicated, adjustable ground fault current pickup (0.2 – 1.0 x In in 0.10x increments) and time (0.1 – 1.0 sec in 0.10 sec increments), with selectable flat or I2t curve shaping. Provide switch selectable options for GF OFF, GF alarm, or GF trip.

4. Trip units shall be capable of metering phase, neutral, and ground current with an accuracy of +/- 2.0% of the reading.

5. Trip units shall collect and store pertinent information to the trip unit and circuit breaker health and event history. The trip unit shall also include diagnostic features to allow the user to investigate events and dynamically monitor the health of the trip unit and the breaker.

    a. Number of operations (load and no-load)

    b. Number of trips (overload trips, short circuit trips)

    c. Run time

    d. Breaker ambient temperature.

    e. Breaker remaining life - The trip unit shall utilize an algorithm that applies a weighted value to monitored information to determine the remaining life of the breaker. The remaining life of the breaker shall be displayed or communicated in calculated percentage of life remaining.

    f. All breaker health information shall be accessible via micro-USB port on front of trip unit and via embedded communications

6. Trip unit shall perform a waveform capture on trip, alarm, or user-initiated events.

    a. Any breaker trip event shall capture a 10-cycle waveform. The trip unit shall store the most recent trip event waveform.

    b. Any alarm event or user-initiated waveforms shall capture a 1-cycle waveform.

    c. Waveform events shall capture and store all phase, neutral and ground currents.

2.06 SWITCHBOARD FACTORY TESTS

A. The switchboard shall be completely assembled, wired, adjusted, temporarily powered and tested at the factory. Provide test results for acceptance.

B. The fully assembled switchboard shall be given operational, dielectric, and all other standard tests.

2.07 MISCELLANEOUS DEVICES

A. Kirk Key interlocks shall be provided as indicated on the drawings.

B. Arc Flash Reduction Maintenance Switch

1. Provide switch where indicated on the plans or one-line diagrams.

2. Provide selector switch which illuminates BLUE when engaged.

3. Switch shall have a flip-up cover to operate.

4. Switch shall be NEMA 4X rated.

5. Provide label to read “Maintenance Mode” on top with “ON” and “OFF” indication. Label to read “Arc Flash Reduction Maintenance Switch” on bottom.

C. Provide external Surge Protection Devices as indicated on the drawings. Reference Section 26 43 00 “Surge Protection Devices” for requirements.

2.08 WIRING

A. Conductors: Copper; size as required by load, except that no control wire is smaller than 14 AWG. Use insulation that is flame retardant, and moisture and heat resistant.

B. Cables and conductors: Bundled and tie wrapped securely in wireways furnished.

C. Identify internal wiring at terminations by T&B wire markers or equivalent.

D. All spare auxiliary contacts shall be wired to terminal blocks.

E. Terminal Blocks:

1. Rated 600 volt for power with current rating as required by loads.

PART 3 - EXECUTION

3.01 INSTALLATION

A. After inspection, and prior to energizing, provide 250 watts of heat within each Section.

B. Install equipment in accordance with manufacturer’s printed instructions and as indicated and specified. Install equipment on channels set flush with floor or on concrete bases. Interconnect equipment as a complete operating system.

1. After installation, field touch-up the shop painting finish on the channels with a similar and compatible coating, including color.

C. Have installed equipment field-checked by manufacturer's service engineer, who perform following services:

1. Check installed equipment for proper assembly and connections, including interwiring to external equipment.

2. Set adjustable devices per the approved electrical coordination study.

3. Assist Contractor in conducting equipment acceptance tests.

3.02 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, reprogram, and maintain the equipment.

B. Training shall be a minimum of four (4) hours in operation and maintenance for up to five (5) Owner representatives. Schedule training with at least five (5) working days advance notification.

3.03 FIELD QUALITY CONTROL

A. Perform tests and inspections.

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

B. Acceptance Testing Preparation:

1. Test insulation resistance for each bus, component, connecting supply, feeder, and control circuit.

2. Test continuity of each circuit.

C. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers and low-voltage surge arrestors stated in NETA ATS, Paragraph 7.6 Circuit Breakers and Paragraph 7.19.1 Surge Arrestors, Low-Voltage. Certify compliance with test parameters.

2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3. Perform the following infrared scan tests and inspections and prepare reports:

a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchboard. Remove front panels so joints and connections are accessible to portable scanner.

b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchboard 11 months after date of Substantial Completion.

c. Instruments and Equipment:

(1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

D. Switchboards will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results, with comparisons of the two scans. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.04 CONTRACT CLOSEOUT

A. Provide in accordance with Section 01 77 00 “Execution and Closeout Requirements”.

END OF SECTION

SECTION 26 24 13

LOW-VOLTAGE SWITCHBOARDS

PART 1 - GENERAL

1.01 DESCRIPTION

A. Provide a 480 volt, 3-phase, 4-wire, electrical distribution rated switchboard, free-standing construction with circuit breakers, power monitor, distribution class lightning arrestors, surge arrestors, automatic transfer switch, and group-mounted circuit breakers as indicated and in compliance with Contract Documents.

B. Provide services of a factory-trained service engineers, specifically trained to check connections, interwiring to equipment, adjustments and assisting in tests.

1. Provide guidance during installation to check work of installing contractor.

2. Instruct personnel in care and operation of equipment.

3. Test main breaker and all branch breakers including spares; insure proper setting.

4. Inspect installation and adjust as necessary when switchboard is ready to be energized and put into service.

5. Test ground fault system and set all protective devices.

6. Certify that equipment has been inspected and is ready to be placed into service.

1.02 REFERENCES

A. Federal Specifications (FS):

1. QQ-S-365B: General Requirements for Silver Plating, Electro Deposited

2. W-C-375: Molded Case Circuit Breakers.

B. National Electrical Manufacturers Association (NEMA):

1. AB 1: Molded-Case Circuit Breakers, Molded Case Switches, and Circuit-Breaker Enclosures.

2. PB-2: Switchboards.

C. Underwriter's Laboratories (UL):

1. 489: Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures.

2. 91: Switchboards.

1.03 SUBMITTALS

A. Submit shop drawings and manufacturers' product data in accordance with the requirements of Section 26 05 10 “Electrical Work – General”.

B. Manufacturer's certified shop drawings including outlines, schematics and wiring diagrams, coordination curves, certified test data reports, maintenance data, operating instructions and parts list with list of recommended spare parts.

C. Performance Test Reports: Upon completion of installed system, submit in booklet form all field tests performed to prove compliance with specified performance criteria including final settings of devices.

1.04 SEISMIC DESIGN REQUIREMENTS:

A. Conform to the requirements specified in Section 01 41 20.

B. It shall be the responsibility of manufacturer and supplier along with the Electrical Contractor to conform to the seismic design requirements for this project and for the work of this specification section.

1.05 SPARE PARTS

A. Comply with the requirements specified in Section 01 31 00 “Project Management and Coordination Requirements”.

B. Provide spare parts as recommended by manufacturer.

C. Package spare equipment in containers bearing labels clearly indicating contents and in what equipment used.

D. Deliver spare parts at same time as equipment. Properly store and safeguard such spare parts until completion of work, at which time deliver to Owner.

1.06 QUALITY ASSURANCE

A. Comply with the requirements specified in Section 01 43 00 “Quality Requirements”.

B. Ensure that conduit size and wire quantity, size, and type are suitable for the equipment supplied. Review the proper installation of each type of device with the equipment supplier prior to installation.

C. Single-source Responsibility: Provide switchboard products that are new, and from the same manufacturer for each building or job. Switchboard components shall be from the same manufacturer or listed as an assembly thereof.

D. The manufacturer shall confirm and state the measure of and the set of the features that support the ease and speed of which corrective maintenance (CM) and preventive maintenance (PM) can be conducted on the proposed system. The Mean Time To Repair (MTTR), the measure used to quantify the time required to perform CM and Mean Preventive Maintenance Time (MPMT), a measure commonly used to quantify the time required to perform PM are to be confirmed by the manufacturer.

E. Provide services of factory-trained Service Technician, specifically trained on type of equipment specified:

1. Service Technician must be present on site for all items listed below. Person-day requirements listed are exclusive of travel time, and do not relieve Contractor of the obligation to place equipment in operation as specified. Times listed are for each switchboard.

2. Installation: Inspect grouting, location of anchor bolts; setting, leveling, alignment and field erection:

   a. 2 person-days

3. Functional Testing: Check alignment and perform a functional test. Tests to include all items specified.

   a. 2 person-days

4. Testing: Field performance test equipment specified.

   a. 2 person-days

5. Credit to the Owner, all unused service person-days specified above, at the manufacturer’s published field service rate.

6. Any additional time required of the factory trained service technician to assist in placing the equipment in operation, or testing or to correct deficiencies in installation, equipment or material shall be provided at no additional cost to the Owner.

   a. Service-inspections during first year of operation, for use at Owner's request, and exclusive of repair, malfunction or other trouble-shooting service calls:

      (1) 1 person-day - switchboard

1.07 DELIVERY AND STORAGE

A. Shipping:

1. Ship equipment, and materials, except where partial disassembly is required by transportation regulations or for protection, complete with identification and quantity of items.

2. Pack spare parts in containers bearing labels clearly designating contents and pieces of equipment for which intended.

3. Deliver spare parts at same time as pertaining equipment. Delivery to Owner after completion of work.

4. Channel bases:

   a. For front and rear, minimum of 1-1/2 inch (37 mm) by 3 inch (74 mm) standard channel with suitable holes for mounting switchboard, and holes for grouting and flow of concrete.

   b. Shipped in advance with accurate template of switchboard mounting holes or dimension layout drawing for embedding in concrete pad, floor slab, or securing to floor. Coordinate with all contractors.

5. Attach lifting angles to main frame of structure to distribute weight equally. Deflection or distortion is cause for rejection.

6. Provide heavy plastic envelope directly over switchboard to protect against dust, dirt, and moisture. Provide lifting angles outside of envelope.

B. Storage:

1. Inspection and inventory items upon delivery to site.

2. Store and safeguard equipment, material and spare parts.

1.08 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace switchboard that fail in materials or workmanship within specified warranty period.

1. Switchboard Warranty Period: 18 months from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers acceptable contingent upon products' compliance with the specifications:

1. Eaton

2. ABB

3. Siemens Corp.

4. Schneider/Square D.

2.02 SWITCHBOARD EQUIPMENT

A. Structure:

1. Totally enclosed switchboard dead front, free standing, front and rear aligned with front accessibility only required.

2. General purpose switchboard with frame-work of UL gauge formed steel and channels and secured together to support all cover plates, bussing and component devices during shipment and installation. Formed removable closure plates on the front, rear and sides. Closure plates shall be single tool, screw removable.

3. Refer to contract documents for NEMA enclosure type.

4. Ventilation provided when required.

5. Each section includes a single-piece removable top plate.

B. Incoming Line; devoted to the main service entrance utility supply.

1. Utility line section consists of:

a. Device:

(1) Main RMS sensing, disconnect device shall be a solid state, true RMS adjustable trip, insulated case, circuit breaker. The main breaker shall be provided fixed style.

(2) In conjunction with the main device, provide undervoltage capacitor trip, phase failure and phase reversal protection, alarm switch, auxiliary switches, long time, short time, instantaneous trip and selective coordination ground fault protection with downstream ground fault protective devices.

(3) Provide “push to trip” push button on circuit breaker to allow manual trip with risking exposure to live parts.

(4) Provide trip indicator to identify type of fault, and indicate OVERLOAD, SHORT CIRCUIT or GROUND FAULT on display.

(5) Main breaker to be provided with capability of locking in the open position.

(6) The trip unit shall include local setup and readout of trip settings and digital display metering of:

(a) 3-phase volts

(b) frequency

(c) KW

(d) KVA

(e) amps

b. Cable termination suitable for cable entry from below, located at bottom section.

c. Line side terminals fitted with two-hole, compression-type lugs for four copper cable conductors per phase.

d. Provide section for Utility service meter and CTs. Verify size of section with Utility equipment.

e. Tinned bus of suitable rating and bracing.

f. Tinned copper ground bus 1/4-inch x 2 inch (6 mm x 50 mm) extended and tied through to all adjoining sections.

C. Power Monitor:

1. Provide microprocessor-based monitoring device to provide local and remote monitoring of the electrical system.

a. Voltage input of 120 volts using voltage transformers.

b. Current input from current transformers, phase A, B, C and ground.

2. Comply with ANSI C12.16, Class 10.

3. Display data:

a. Current A, B, C, Average, Neutral, Ground.

b. Voltage - Phase to phase

(1) Phase to neutral

(2) 2) Phase to ground

(3) 3) Average values

c. Power - Watts

(1) Vars

(2) VA

(3) Phases A, B, C and System

d. Energy - KWH

(1) KVARH

e. Frequency

f. Demand - System current

(1) KW

(2) KVAR

(3) KVA

g. Power Factor - Phases A, B, C, System

h. Percent THD Current - Phases A, B, C, N

i. Percent THD Voltage:

(1) Phase to phase

(2) Phase to neutral

j. Minimum and maximum values

k. Monitor past events and thresholds.

4. Provide power monitor with Ethernet connection and capable of communicating using Modbus TCP/IP protocol.

D. Group Mounted Branch Sections:

1. The switchboard group-mounted circuit breaker branch devices shall be totally front accessible and front connectable.

2. The circuit breaker connections to the distribution panel bussing shall be such that the connections grip the bus bars firmly under high-fault conditions.

3. Provide wiring gutters of sufficient space to allow cable termination.

4. Provide covers for gutter space and future breaker space with formed sheet steel.

5. Provide circuit breakers as indicated on the one-line diagram.

E. Enclosure - General Requirements:

1. Switchboard shall be completely self-supporting structure of the required number of vertical sections bolted together to form one metal-enclosed switchboard 90 inch (2.29 m) high.

2. Sides, top and rear covers shall be code gauge steel, bolted to the switchboard structure.

3. The frame structure members shall be die-formed, 12-gage steel bolted together and reinforced at corners with rugged gussets internal and external to the structure members.

4. The switchboard shall be completely front accessible for all installation and maintenance activities.

5. At the main service entrance section, the sheet steel panels located on the exterior and side of the section shall be removable for servicing the section.

6. The switchboard frame shall be mounted to sills embedded in a concrete housekeeping pad.

7. The switchboard and devices are fully rated at minimum short circuit rating of 65,000 rms symmetrical Amperes. Refer to contract documents for additional requirements.

8. Switchboard shall include all protective devices depicted on contract drawings and as specified in these specifications with necessary interconnection, instrumentation and control wiring.

9. Main breaker shall be individually mounted.

10. All buses are tin plated copper, supported with high impact, non-tracking insulating material, and braced to withstand mechanical forces exerted during short circuit conditions. All bus connections shall utilize silver plated bus bar surfaces.

11. The current density of the bus shall be determined from UL-891 heat rise testing and shall be rated for 1000 amperes per square inch cross-section.

12. A tinned copper, 1/4-inch x 2 inch (6 mm x 50 mm) ground bus shall furnished and secured to structure.

13. A-B-C type bus arrangement (left-to-right, top-to-bottom, front-to-rear) is to be used throughout to assure convenient and safe testing and maintenance.

14. The vertical main bus bars are furnished for future branch devices. Device mounting bolts and bus connecting straps are supplied with future unit devices. Full height bus bars shall be supplied.

15. All vertical sections comprising the switchboard are rear-aligned.

16. All steel surfaces shall be chemically cleaned and pre-treated with an iron-phosphate pre-treatment or equivalent process, providing a bond between paint and metal surfaces to help prevent the entrance of moisture and formation of rust under the paint. The switchboard exterior shall be finished with ANSI-61 light gray paint. Provide touch-up paint for coatings nicks and scratches after installation and testing.

17. Control wiring, fuse blocks and terminal blocks within the switchboard shall be furnished when required. All control wires leaving the switchboard shall be provided with terminal blocks with numbering strips.

18. All hardware used on conductors shall have a high tensile strength, and a protective finish.

19. Switchboard shall be provided with lifting means, and capable of being rolled or moved into installation position and bolted directly to floor sills.

20. Make provision for conduit and cable entrance from top or bottom as indicated on the drawings.

2.03 SWITCHBOARD SILLS

A. Provide steel channel sills with drilled holes for mounting, aligning and bolting switchboard in place. Method of mounting as indicated. Provide in size recommended by switchboard manufacturer and acceptable to Engineer.

B. Shop paint completed sills with two coats of a polyamide epoxy coating with a minimum dry film thickness of 2.5 mils (0.6 mm) per coat or before setting in place.

1. Surface preparation shall conform to paint manufacturer’s printed instructions.

2. Provide additional coating for field touch-up specified in paragraph 3.01.

2.04 SWITCHBOARD INSTRUMENT TRANSFORMERS

A. Switchboard section for main breaker shall include three 480 to 120-volt potential transformers, and one 480 to 120/240 volt single phase control power transformer. Control and potential transformers to be connected ahead of main circuit breaker and to include current limiting primary fuses. Mount transformers in isolated compartment within secondary bus transition section. Also provide, on main bus for each main breaker four window type 3000/5A current transformers for metering phase and neutral current and one 200/5A current for monitoring ground currents.

B. Tie all instrument transformer outputs to power monitor.

2.05 FEEDER PROTECTIVE DEVICES

A. All feeder protective devices shall be molded case circuit breakers with inverse time tripping characteristics as indicated on the contract documents and in this specification.

B. Circuit breakers shall be operated by a toggle-type handle and shall have a quick-make, quick-break over-center switching mechanism that is mechanically trip-free. Automatic tripping of the breaker shall be clearly indicated by the handle position. Contacts shall be non-welding silver alloy and arc extinction shall be accomplished by means of DE-ION arc chutes. A push-to-trip button on the front of the circuit breaker shall provide a local manual means to exercise the trip mechanism.

C. Circuit breakers shall have a minimum symmetrical interrupting capacity as indicated on the contract documents.

D. Circuit breakers to be either draw-out or fixed mounted, as indicated on contract documents

E. Circuit breakers shall have microprocessor-based rms sensing trip units as specified below:

1. All electronic trip molded case circuit breakers shall be equipped with a true RMS sensing, solid-state tripping system consisting of at least three current sensors microprocessor-based trip device and trip actuator. The trip unit shall use microprocessor-based technology to provide the basic adjustable time-current protection.

2. Provide trip units with integral arc flash reduction mode for 1200A frame and above. The breakers shall have an input for an external switch to set in arc flash reduction mode. Provide a blue LED indicating light on front of enclosure to indicate in arc flash reduction mode. The use of zone selective interlocking to emulate this feature does not meet the intent of these specifications and will not be allowed.

3. System coordination shall be provided by adjusting rotary switches for the following microprocessor-based time-current curve shaping adjustments:

a. Adjustable long-delay pick-up setting with minimum of 10 settings

b. Adjustable long-delay time - 0.5 to 24 seconds

c. Adjustable short-delay pick-up setting – 1.5x to Max allowable by frame

d. Adjustable short-delay time 0.0 sec up to 0.5 sec depending on frame with selectable flat or I2t curve shaping

e. Adjustable instantaneous setting 2x to Max allowable by frame

f. Where indicated, adjustable ground fault current pickup (0.2 – 1.0 x In in 0.10x increments) and time (0.1 – 1.0 sec in 0.10 sec increments), with selectable flat or I2t curve shaping. Provide switch selectable options for GF OFF, GF alarm, or GF trip.

4. Trip units shall be capable of metering phase, neutral, and ground current with an accuracy of +/- 2.0% of the reading.

5. Trip units shall collect and store pertinent information to the trip unit and circuit breaker health and event history. The trip unit shall also include diagnostic features to allow the user to investigate events and dynamically monitor the health of the trip unit and the breaker.

   a. Number of operations (load and no-load)

   b. Number of trips (overload trips, short circuit trips)

   c. Run time

   d. Breaker ambient temperature.

   e. Breaker remaining life - The trip unit shall utilize an algorithm that applies a weighted value to monitored information to determine the remaining life of the breaker. The remaining life of the breaker shall be displayed or communicated in calculated percentage of life remaining.

   f. All breaker health information shall be accessible via micro-USB port on front of trip unit and via embedded communications

6. Trip unit shall perform a waveform capture on trip, alarm, or user-initiated events.

   a. Any breaker trip event shall capture a 10-cycle waveform. The trip unit shall store the most recent trip event waveform.

   b. Any alarm event or user-initiated waveforms shall capture a 1-cycle waveform.

   c. Waveform events shall capture and store all phase, neutral and ground currents.

2.06 SWITCHBOARD FACTORY TESTS

A. The switchboard shall be completely assembled, wired, adjusted, temporarily powered and tested at the factory. Provide test results for acceptance.

B. The fully assembled switchboard shall be given operational, dielectric, and all other standard tests.

2.07 MISCELLANEOUS DEVICES

A. Kirk Key interlocks shall be provided as indicated on the drawings.

B. Arc Flash Reduction Maintenance Switch

1. Provide switch where indicated on the plans or one-line diagrams.

2. Provide selector switch which illuminates BLUE when engaged.

3. Switch shall have a flip-up cover to operate.

4. Switch shall be NEMA 4X rated.

5. Provide label to read “Maintenance Mode” on top with “ON” and “OFF” indication. Label to read “Arc Flash Reduction Maintenance Switch” on bottom.

C. Provide internally Surge Protection Devices as indicated on the drawings. Reference Section 26 43 00 “Surge Protection Devices” for requirements.

2.08 WIRING

A. Conductors: Copper; size as required by load, except that no control wire is smaller than 14 AWG. Use insulation that is flame retardant, and moisture and heat resistant.

B. Cables and conductors: Bundled and tie wrapped securely in wireways furnished.

C. Identify internal wiring at terminations by T&B wire markers or equivalent.

D. All spare auxiliary contacts shall be wired to terminal blocks.

E. Terminal Blocks:

1. Rated 600 volt for power with current rating as required by loads.

PART 3 - EXECUTION

3.01 INSTALLATION

A. After inspection, and prior to energizing, provide 250 watts of heat within each Section.

B. Install equipment in accordance with manufacturer’s printed instructions and as indicated and specified. Install equipment on channels set flush with floor or on concrete bases. Interconnect equipment as a complete operating system.

1. After installation, field touch-up the shop painting finish on the channels with a similar and compatible coating, including color.

C. Have installed equipment field-checked by manufacturer's service engineer, who perform following services:

1. Check installed equipment for proper assembly and connections, including interwiring to external equipment.

2. Set adjustable devices per the approved electrical coordination study.

3. Assist Contractor in conducting equipment acceptance tests.

3.02 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, reprogram, and maintain the equipment.

B. Training shall be a minimum of four (4) hours in operation and maintenance for up to five (5) Owner representatives. Schedule training with at least five (5) working days advance notification.

3.03 FIELD QUALITY CONTROL

A. Perform tests and inspections.

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

B. Acceptance Testing Preparation:

1. Test insulation resistance for each bus, component, connecting supply, feeder, and control circuit.

2. Test continuity of each circuit.

C. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers and low-voltage surge arrestors stated in NETA ATS, Paragraph 7.6 Circuit Breakers and Paragraph 7.19.1 Surge Arrestors, Low-Voltage. Certify compliance with test parameters.

2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3. Perform the following infrared scan tests and inspections and prepare reports:

a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchboard.

Remove front panels so joints and connections are accessible to portable scanner.

b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchboard 11 months after date of Substantial Completion.

c. Instruments and Equipment:

(1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

D. Switchboards will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results, with comparisons of the two scans. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.04 CONTRACT CLOSEOUT

A. Provide in accordance with Section 01 77 00 “Execution and Closeout Requirements”.

END OF SECTION

SECTION 26 24 19

MOTOR CONTROL CENTERS

PART 1 - GENERAL

1.01 DESCRIPTION

A. Provide motor control center, totally enclosed, free-standing, cabinet-type structure with motor starters, circuit breakers and/or fused switches and other equipment, as indicated and specified. Motor control center to operate at 480-volt, 3-phase, 4-wire, 60-Hertz as indicated and in compliance with Contract Documents.

B. Complete motor control center to be designed, assembled, wired, and tested at the point of manufacture in accordance with the latest NEMA, UL, and ANSI standards.

C. Use manufacturer's standard when data is not specified.

D. Provide Surge Protection Devices (SPD) as indicated, and as specified in Section 26 43 00 “Surge Protection Devices”.

1.02 REFERENCES

A. General:

1. The following documents form part of the Specifications to the extent stated. Where differences exist between codes and standards, the one affording the greatest protection shall apply.

2. Unless otherwise noted, the edition of the referenced code or standard that is current at the time of the “date of record” for the Work shall be considered the effective code or standard for the duration of the project.

3. Refer to Division 01 Section "General Requirements" for the list of applicable regulatory requirements.

4. Refer to specific Division 26 Sections for additional referenced codes and standards.

B. American National Standards Institute (ANSI):

1. C39.1: Electrical Analog Indicating Instruments

C. Institute of Electrical and Electronic Engineers (IEEE):

1. C57.13: Standard Requirements for Instrument Transformers

D. National Electrical Manufacturers Association (NEMA):

1. AB 1: Molded Case Breakers

2. ICS 2: Industrial Controls and Systems Controllers, Contactors, and Overload Relays Rated 600 Volts.

3. KS 1: Enclosed Switches

E. National Fire Protection Association (NFPA):

1. 70: National Electric Code (NEC).

F. Underwriters' Laboratories, Inc. (UL):

1. 489: Molded-Case Breakers, Molded-Case Switches, and Circuit Breaker Enclosures

2. 508: Industrial Control Equipment.

3. 845: Standards for Motor Control Centers

4. 1008: Standard for Automatic Transfer Switches

5. 1066: Low Voltage AC and DC Power Circuit Breakers Used in Enclosures

G. Electrical Safety Program, Electrical Equipment Safety Program, and Lockout/Tagout Program of NTMWD.

1.03 SUBMITTALS

A. Submit shop drawings and manufacturers' product data in accordance with the requirements of Section 26 05 10.

B. Complete list of equipment and materials, including manufacturer's descriptive and technical literature, catalog cuts, installation instructions.

C. Complete wiring and schematic diagrams for the equipment furnished. Each wiring diagram shall be legible and not reduced from the original design drafted format. Provide a list of equipment on each wiring diagram for which it is applicable.

D. Equipment layout.

E. Time versus current curves for protective devices.

F. Data sheets for all devices provided as part of the assembly.

G. All other details required to demonstrate that system has been coordinated and will properly function as a unit.

H. Spare Parts Data: Provide a list of recommended spare parts for the material and equipment to be provided, including current unit prices and source of supply (indicate which supplies are furnished at no extra cost with purchase of equipment) and in accordance with Section 01 78 23 “Operation and Maintenance Data”.

I. Operating and Maintenance Instruction Manuals:

1. Furnish:

a. Operating instruction manuals outlining step-by-step procedures required for system startup and operation and in accordance with Section 01 78 23 “Operation and Maintenance Data”.

b. Manufacturer's name, model number, service manual parts list.

c. Brief description of equipment and basic operating features.

d. Maintenance instruction manuals outlining maintenance procedures, for all devices, including compartment installation, circuit breakers, motor starters and fuses.

e. Troubleshooting guide listing possible breakdown and repairs.

f. As-built wiring diagrams for the system.

J. Performance Test Reports: Upon completion of installed system, submit in booklet form all field tests performed to prove compliance with specified performance criteria including final position of controls.

K. Load-Current and Overload-Relay Heater List: Compile after motors have been installed and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.

1.04 SEISMIC DESIGN REQUIREMENTS:

A. Conform to the requirements specified in Section 01 41 20.

B. It shall be the responsibility of manufacturer and supplier along with the Electrical Contractor to conform to the seismic design requirements for this project and for the work of this specification section.

1.05 QUALITY ASSURANCE

A. Provide in accordance with Section 01 43 00 “Quality Requirements” and as specified.

B. Ensure that conduit size and wire quantity, size, and type are suitable for the equipment supplied. Review the proper installation of each type of device with the equipment supplier prior to installation.

C. The manufacturer shall confirm and state the measure of and the set of the features that support the ease and speed of which corrective maintenance (CM) and preventive maintenance (PM) can be conducted on the proposed system. The Mean Time To Repair (MTTR), the measure used to quantify the time required to perform CM and Mean Preventive Maintenance Time (MPMT), a measure commonly used to quantify the time required to perform PM are to be confirmed by the manufacturer.

D. Provide services of factory-trained Service Technician, specifically trained on type of equipment specified:

1. Service Technician must be present on site for all items listed below. Person-day requirements listed are exclusive of travel time, and do not relieve Contractor of the obligation to place equipment in operation as specified. Times listed are for each MCC installed.

2. Assist in location of devices, methods of mounting, field erection, etc.

    a. 2 person-day

3. Functional Completion testing.

    a. 2 person-days

4. Startup.

    a. 2 person-days

5. Commissioning.

    a. 2 person-days

6. Service-inspections during first year of operation, for use at Owner's request, and exclusive of repair, malfunction or other trouble-shooting service calls:

    a. 2 person-days

7. Person-day is defined as one 8-hour day, excluding travel time.

8. Credit to the Owner, all unused service person-days specified above, at the manufacturer’s published field service rate.

9. Any additional time required of the factory trained service technician to assist in placing the equipment in operation, or testing or to correct deficiencies in installation, equipment or material shall be provided at no additional cost to the Owner.

1.06 DELIVERY, STORAGE AND HANDLING

A. Provide in accordance with Section 01 66 10 “Delivery, Storage and Handling” and as specified.

B. Shipping:

1. Ship equipment, and materials, except where partial disassembly is required by transportation regulations or for protection, complete with identification and quantity of items.

2. Pack spare parts in containers bearing labels clearly designating contents and pieces of equipment for which intended.

3. MCCs shall be separated into shipping blocks no more than three vertical sections each. Each shipping block shall include a removable lifting angle, to allow attachment by suitable lifting equipment.

4. Deliver spare parts at same time as pertaining equipment. Delivery to Owner after completion of work.

5. Channel bases:

a. For front and rear, minimum of 1-1/2 inch by 3 inch (38 mm by 76 mm) standard channel with suitable holes for mounting motor control center, and holes for grouting and flow of concrete.

b. Shipped in advance with accurate template of motor control center mounting holes or dimension layout drawing for embedding in concrete pad, floor slab, or securing to floor.

6. Attach lifting angles to main frame of structure to distribute weight equally. Deflection or distortion is cause for rejection.

7. If the equipment cannot be placed into service after its receipt, store in a closed building or structure, in a clean, dry and ventilated area free from temperature, dirt and moisture extremes. Acceptable storage temperatures are from 0 degrees C (32 degrees F) to 40 degrees C (104 degrees F) with temporary heaters provided within enclosures to prevent condensation. Provide heavy plastic envelope directly over motor control center to protect against dust, dirt, and moisture. Provide lifting angles outside of envelope.

C. Storage:

1. Inspection and inventory items upon delivery to site.

2. Store and safeguard equipment, material, and spare parts.

1.07 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.

3. Indicating Lights: Two of each type and color installed.

4. Auxiliary Contacts: Furnish one spare for each size and type of magnetic controller installed.

5. Power Contacts: Furnish three spares for each size and type of magnetic contactor installed.

1.08 WARRANTY AND SERVICE

A. Guarantee components, parts, and assemblies supplied by manufacturer against defects in materials and workmanship for a period of 12 months.

B. Ensure that equipment manufacturer has local branch office staff with trained, full-time employees who are capable of performing testing, inspecting, repair, and maintenance services.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. The equipment manufacturer shall be ISO 9001 or 9002 certified.

B. Manufacturer’s acceptable contingent upon products' compliance with the specifications.

1. ABB.

2. Siemens Energy & Automation, Inc.

3. Schneider/Square D Company.

4. Eaton.

2.02 COMPONENTS

A. Motor control center construction: Comply with UL 845.

B. Starters: Comply with the requirements of NEMA ICS 2.

C. Instruments: Comply with ANSI C39.1.

D. Enclosures:

1. Enclosures for motor control centers: NEMA Type 1 gasketed, unless otherwise indicated on the Contract Drawings.

2. Motor control centers: NEMA Class II-S, Type B wiring.

3. Outline dimensions of motor control centers and arrange equipment and devices as indicated.

4. The minimum depth of a motor control center is 20 inch (508 mm). Arrange motor control centers for back-to-back mounting of the starter units where indicated.

5. Each MCC shall consist of one or more vertical sections of heavy gauge steel bolted together to form a rigid, free-standing assembly. A removable 7 gage structural steel lifting angle shall be mounted full width of the MCC shipping block at the top. Removable 7 gage bottom channel sills shall be mounted underneath front and rear of the vertical sections extending the full width of the shipping block. Vertical sections made of welded side-frame assembly formed from a minimum of 12 gage steel. Internal reinforcement structural parts shall be of 12 and 14 gage steel to provide a strong, rigid assembly. The entire assembly shall be constructed and packaged to withstand normal stresses included in transit and during installation.

E. Buses:

1. Locate main horizontal bus at top with ampere rating as indicated. Isolate bus from both front and back compartments.

2. Neutral bus if required: Rated at full capacity.

3. Main, vertical, and ground buses: 98 percent conductivity tinned copper bars of suitable size carried on supports fabricated from an acceptable insulating material.

4. Short circuit bus bracing: As indicated.

5. Vertical buses: A minimum rating of 300 amperes for front only units, a minimum rating of 600 ampere for back-to-back units. Insulate or isolate vertical buses.

6. Provide continuous 2 inch by 1/4 inch (50 mm by 6 mm) tinned copper ground bus along length of the motor control center.

7. Contact surfaces of bar-to-bar connections and lug-to-bar connections: Silver plated.

8. Phase rotation of vertical buses: Make same when viewed from front or from either side of motor control center.

9. Bolts and other hardware: Galvanized or stainless steel or equal.

10. Provide horizontal wireways at top and bottom of each vertical section. Provide vertical wireways with wire supports for each vertical section. Interconnect all wireways.

11. Provide standard corrosion resistant fasteners for unit doors hardware which operate without special tools.

F. Barriers:

1. All power bussing and splice connections shall be isolated from the unit compartments and the wireways. The horizontal bus shall be mounted onto a glass filled polyester support assembly that braces the bus against the forces generated during a short circuit. The horizontal bus shall be isolated from the top horizontal wireway by a two-piece rigid non-conductive barrier. The barrier design shall allow qualified personnel to slide the barriers both left and right, to allow access to the bus and connections for maintenance without having to remove the barrier. Barrier sliding shall occur via an upper and lower track system.

2. The vertical bus shall be housed in a molded glass-filled polyester support that provides bus insulation and braces the bus against the forces generated during a short circuit. These supports shall have openings every 3 inch (75 mm) for unit stab-on connections. Each opening shall be provided with an automatic shutter to close off the stab opening. These shutters shall be attached to the structure so that when they are removed (to allow a stab connection) they are retained in the structure and are readily accessible for use should a plug-in unit be removed from the MCC.

3. Barriers shall be provided in the vertical structure and unit designs to prevent the contact of any energized bus or terminal by a pull wire routed through the conduit or wireway areas.

G. Motor Control Center Units:

1. Motor control center units: Drawout type. Units larger than NEMA Size 4 having bolt-in construction. Provide fully interchangeable removable units of same size and type.

2. Interlock disconnect devices with associated doors, to prevent closing the disconnect device with the door open unless a tool is used or a defeater device is operated.

3. Furnish disconnect devices capable of being locked in either the open or closed position.

4. Arrange each unit so that when its starter has been removed, its door may be closed to cover the opening.

H. Motor Control Center Starter Units:

1. Unless otherwise indicated, use minimum NEMA Size 1 combination starter, consisting of a circuit breaker, or motor circuit protector and magnetic starter, as indicated. Momentary and interrupting ratings of circuit breakers, and motor circuit protectors coordinated with main bus bracing. Type of starters, i.e., full voltage, reduced voltage, reversing, non-reversing, two-speed, etc., are as indicated. Furnish magnetic starters with thermal overload protection on each phase with external manual reset.

2. Solid-State Overload Relay:

    a. Provide a solid-state overload relay for protection of the motors.

    b. The overload relay shall provide high accuracy through the use of state-of-the-art microelectronic packaging technology. The relay shall be suitable for application with NEMA Size 1 through Size 7 motor starters.

    c. The overload relay shall be modular in design, be an integral part of family of relays to provide a choice of levels of protection, be designed to directly replace existing electromechanical overload relays, and be listed under UL Standard 508.

    d. he overload relay shall have the following features:

        (1) Self-powered.

        (2) Class 10 or 20 fixed tripping characteristics.

        (3) Manual or automatic reset 4.

        (4) Phase loss protection. The relay shall trip in 2 seconds or less under phase loss condition when applied to a fully loaded motor.

        (5) Visible trip indication.

        (6) One normally open and one normally closed isolated auxiliary contact.

        (7) Test button that operates the normally closed contact.

        (8) Test trip function that trips both the normally and normally closed contacts.

        (9) A current adjustment range of 3.2:1 or greater.

        (10) Ambient temperature compensated.

        (11) Ground fault protection. Relay shall trip at 50 percent of full load ampere setting.

(12) Jam/Stall protection. Relay shall trip at 400 percent of full load ampere setting, after inrush.

3. Verify type (single- or 2-winding) of two-speed motor being installed. Furnish type of motor starter necessary for control of motor. Furnish decelerating, time-delay relay for each two-speed starter.

4. Provide reduced voltage solid-state type starters (RVSS) with thyristor (SCR) bridge consisting of at least two SCRs per phase to control the starting and stopping of industry standard motors.

   a. The soft start shall provide torque control for linear acceleration without external feedback independent of motor load or type of application.

   b. The gating of the thyristors will be controlled in such a manner to ensure smooth and stable acceleration ramp.

   c. The soft start shall be controlled by a microprocessor that continuously monitors the current and controls the phasing of the SCRs. Analog control algorithms shall not be allowed.

   d. All soft start power ratings will utilize the same control board/module.

   e. A shorting contactor shall be supplied with the soft start controller units. Protective features and deceleration control options integral to the soft start shall be available even when the shorting contactor is employed.

   f. The soft start controller unit shall be designed to operate from an input voltage between minus 10 percent and plus 10 percent of nominal voltage rating.

   g. The soft start controller unit shall operate from an input voltage frequency range of plus or minus 5 percent. By configuration, it shall be capable of operation at a supply line frequency that can vary by plus or minus 20 percent during steady state operation.

   h. The soft start shall be capable of supplying 400 percent of rated full load current for 23 seconds at maximum ambient temperature.

   i. All soft start controller unit power and control devices shall be rated heavy duty and capable of 5 evenly spaced starts per hour at 400 percent of full rated current for 25 seconds per start without tripping.

5. Furnish starter operating coils suitable for operation on 120 volt, single-phase, 60 Hertz.

6. Furnish each starter with at least one normally open and one normally closed auxiliary contact. Furnish additional normally open and/or normally closed auxiliary contacts for indicating lights, interlocking and other requirements as indicated.

7. Motor horsepower indicated on Contract Drawings may not be same as furnished, if larger motors are furnished, circuit breakers, fused switches, starters, wire and conduits of larger capacity may be necessary and, if so, furnish them at no additional cost.

8. Furnish within each starter compartment a control transformer with primary fuses and secondary fuse. Secondary voltage 120 VAC, unless otherwise indicated. Determine load of each motor control circuit including equipment and devices provided under the other specification sections and furnish control circuit transformer 2-winding, dry-type of suitable volt-ampere rating, but not less than 75 volt-amperes. Control circuit loads may consist of but not be limited to solenoid operators, motorized valves, motorized dampers, relays, motor heaters, etc.

9. Provide RVSS with Ethernet connection and capable of communicating using Modbus TCP/IP protocol.

I. Variable frequency drives (VFDs) shall be provided in MCCs where indicated. VFDs shall be in accordance with Section 26 29 23 “Variable Frequency Drives”, and include 5 percent input reactors, and dV/dt output filters.

J. Circuit Breakers:

1. Main, tie, and feeder breakers to be molded case circuit breaker with auxiliary contact for alarm on open or trip condition.

2. Unless otherwise indicated, furnish manually operable circuit breakers and provide thermal-magnetic, inverse-time-limit overload, and instantaneous, short-circuit protection. U.L. listed circuit breakers conforming to NEMA Std. AB-1 and UL Std. 489.

3. Breakers: Molded case type, rated 480 volts, 2 or 3 pole and having 100 ampere or larger frames. Minimum interrupting rating equal to bus bracing required. Furnish current limiting type, where indicated.

4. Furnish overload protection on all poles with trip settings as indicated. Breakers of 225 ampere frames and larger with interchangeable trip units and adjustable magnetic trip elements.

5. Furnish time-current characteristic curves and other necessary information and data for each size of breaker furnished.

6. Circuit breakers shall be operated by a toggle-type handle and shall have a quick-make, quick-break over-center switching mechanism that is mechanically trip-free. Automatic tripping of the breaker shall be clearly indicated by the handle position. Contacts shall be non-welding silver alloy and arc extinction shall be accomplished by means of DE-ION arc chutes. A push-to-trip button on the front of the circuit breaker shall provide a local manual means to exercise the trip mechanism.

7. Circuit breakers shall have microprocessor-based rms sensing trip units as specified below:

    a. All electronic trip molded case circuit breakers shall be equipped with a true RMS sensing, solid-state tripping system consisting of at least three current sensors microprocessor-based trip device and trip actuator. The trip unit shall use microprocessor-based technology to provide the basic adjustable time-current protection.

    b. Provide trip units with integral arc flash reduction mode for 1200A frame and above. The use of zone selective interlocking to emulate this feature does not meet the intent of these specifications and will not be allowed.

    c. System coordination shall be provided by adjusting rotary switches for the following microprocessor-based time-current curve shaping adjustments:

        (1) Adjustable long-delay pick-up setting with minimum of 10 settings

        (2) Adjustable long-delay time - 0.5 to 24 seconds

        (3) Adjustable short-delay pick-up setting – 1.5x to Max allowable by frame

        (4) Adjustable short-delay time 0.0 sec up to 0.5 sec depending on frame with selectable flat or I2t curve shaping

        (5) Adjustable instantaneous setting 2x to Max allowable by frame

        (6) Where indicated, adjustable ground fault current pickup (0.2 – 1.0 x In in 0.10 x increments) and time (0.1 – 1.0 sec in 0.10 sec increments), with selectable flat or I2t curve shaping. Provide switch selectable options for GF OFF, GF alarm, or GF trip.

8. Trip units shall be capable of metering phase, neutral, and ground current with an accuracy of +/- 2.0% of the reading.

9. Trip units shall collect and store pertinent information to the trip unit and circuit breaker health and event history. The trip unit shall also include diagnostic features to allow the user to investigate events and dynamically monitor the health of the trip unit and the breaker.

    a. Number of operations (load and no-load)

    b. Number of trips (overload trips, short circuit trips)

    c. Run time

    d. Breaker ambient temperature.

e. Breaker remaining life - The trip unit shall utilize an algorithm that applies a weighted value to monitored information to determine the remaining life of the breaker. The remaining life of the breaker shall be displayed or communicated in calculated percentage of life remaining.

f. All breaker health information shall be accessible via micro-USB port on front of trip unit and via embedded communications

10. Trip unit shall perform a waveform capture on trip, alarm, or user-initiated events.

a. Any breaker trip event shall capture a 10-cycle waveform. The trip unit shall store the most recent trip event waveform.

b. Any alarm event or user-initiated waveforms shall capture a 1-cycle waveform.

c. Waveform events shall capture and store all phase, neutral and ground currents.

K. Motor Circuit Protectors:

1. Motor circuit protectors being completely enclosed molded case devices with current sensing coil in each of 3 poles having adjustable magnetic trip setting by means of single knob on front. Motor circuit protector manually operable. Protector designed to meet NEC requirement concerning motor full load and locked-rotor current. Minimum interrupting rating equal to bus bracing required.

2. Where indicated, current limiters, completely enclosed in molded case, bolted to load end of motor circuit protector to provide at least 100,000 amperes symmetrical interrupting rating at 600 volts. Limiters coordinated with protector so at low level short circuit, protector interrupts circuit without limiter operation. Faults interrupted by limiter also trip the protector and open all 3 poles. Equip each limiter with an indicator to show that the limiter has interrupted a fault.

L. L. Contactors:

1. Contactors for electric heating and other non-motor loads: Similar to motor starters except without overload relays or heaters. NEMA size as indicated, except 30 amperes minimum rating, tungsten lampload.

2. Contactors for lighting loads: Mechanically held. Ampere ratings as indicated, except 30 amperes minimum rating tungsten lampload.

M. Control Devices:

1. Control relays: Heavy-duty, industrial or machine tool type with at least two normally open and two normally closed contacts. Coils 120 volts, 60 Hertz.

2. Contacts: Rated 10 amperes, 250 volt alternating current.

3. Time-delay relays: Adjustable, pneumatic type, range 2 to 60 seconds and operated on 120 volts, 60 Hertz, with at least one normally open and one normally closed timed contact.

4. Pushbuttons and instrument selector switches: Heavy-duty, oil tight units, 30 mm, rated 10 amperes continuous current at 120 volts.

5. Indicating lights: LED type, heavy-duty, oil-tight, 30 mm units with push-to-test features.

6. Control and selector switches: Rotary type with enclosed contacts. Equip each switch with rectangular escutcheon and pistol-grip handle, except handles for instrument phase selector switches equipped with round knurled or slotted handles. Switch contacts rated 10 amperes continuous, 600 volts.

N. Harmonic Equipment:

1. An active harmonic filter shall be provided to perform electronic cancellation of load produced harmonic currents such that the upstream power harmonic current and voltage shall be reduced below the IEEE 519 guidelines for load demand and voltage distortion limits. Performance of the filter shall be independent of the impedance of the power source, AC lines or back-up generator(s). Necessary current transducers, reactors, and operator interfaces shall be supplied with the MCC. A factory certified start-up technician shall be used to start up each harmonic filter to achieve optimum system performance.

O. Nameplates: Furnish each motor control center and each unit of motor control center with engraved nameplate. Nameplates of laminated sheet plastic, 1/16 inch (1.6 mm) thick, engraved to provide black letters on white background. Fasten nameplates in place with corrosion-resistant screws.

P. Instruments:

1. Instruments: Panel type, approximately 3-1/2 inch (89 mm) or 4-1/2 inch (114 mm) square as indicated, semi-flush mounted. Accurate within 1 percent of full scale. Select scales so full load readings occur at approximately 70 percent of full scale. U.L. listed instruments conforming to ANSI C39.1.

2. Furnish suitable instrument transformers. Conforming to ANSI C57.13.

a. Current transformers of window type and insulated for 600 volts.

b. Furnish potential transformers with current limiting primary fuses.

c. Current transformers for meters shall be metering accuracy.

d. Terminate the secondary of all current transformers on shorting type terminal blocks before proceeding to any other device.

3. Running time meters: Mechanical style, panel-mounted, round, UL Certified, nonreset type, 3-1/2 inch (89 mm) with register to indicate hours and tenths of hours up to 99,999.9 hours. Meters to operate on 120 volts, 60 Hertz. Provide with 3-hole bezel mount.

4. Furnish current and potential test blocks with plugs where indicated. Clearly identify current, voltage and phase for blocks and plugs.

Q. Power Monitor:

1. Provide microprocessor-based monitoring device to provide local and remote monitoring of the electrical system.

a. Voltage input of 120 volts using voltage transformers.

b. Current input from current transformers, phase A, B, C and ground.

2. Comply with ANSI C12.16, Class 10.

3. Display data:

a. Current A, B, C, Average, Neutral, Ground.

b. Voltage - Phase to phase

(1) Phase to neutral

(2) Phase to ground

(3) Average values

c. Power - Watts

(1) Vars

(2) VA

(3) Phases A, B, C and System

d. Energy - KWH

(1) KVARH

e. Frequency

f. Demand - System current

(1) KW

(2) KVAR

(3) KVA

g. Power Factor - Phases A, B, C, System

h. Percent THD Current - Phases A, B, C, N

i. Percent THD Voltage:

(1) Phase to phase

(2) Phase to neutral

j. Minimum and maximum values

k. Monitor past events and thresholds.

4. Provide power monitor with Ethernet connection and capable of communicating using Modbus TCP/IP protocol.

2.03 WIRING

A. Conductors: Copper; size as required by load, except that no control wire is smaller than 14 AWG. Use insulation that is flame retardant, and moisture and heat resistant.

B. Cables and conductors: Bundled and tie wrapped securely in wireways furnished.

C. Identify internal wiring at terminations by T&B wire markers or equivalent.

D. All spare starter auxiliary contacts to be wired to terminal blocks.

E. Terminal Blocks:

1. Rated 600 volt for power with current rating as required by loads.

2.04 MISCELLANEOUS DEVICES

A. Kirk Key interlocks shall be provided as indicated on the drawings.

2.05 SPARE PARTS

A. Furnish following spare parts for each motor control center:

1. Twelve lamps for indicating lights.

2. One coil for each size of starter furnished for each motor control center.

3. One complete set of fuses for each size furnished.

4. One set of contacts for each size of starter furnished.

5. One control transformer for each volt-ampere capacity unit furnished.

B. Package items in suitable containers bearing labels clearly indicating contents and equipment with which used.

2.06 FINISH

A. Finish motor control centers with ANSI No. 61, light-gray enamel over rust-resistant undercoat.

B. Furnish instruments and control devices with standard black finish.

C. Use, mixing, application, and curing of paint on items requiring painting in accordance with paint manufacturer's written recommendations.

2.07 FACTORY TESTS

A. The entire MCC shall go through a quality inspection before shipment, verifying the equipment to the factory shop drawings. This inspection will include:

1. Physical inspection and verification of:

a. Structure including verification of all bolted connections,

b. Electrical conductors, including:

(1) Bussing including verification of all bolted connections.

(2) Wiring.

(3) Unit compartments.

2. Electrical Tests:

a. Electrical tests include:

(1) Power circuit phasing.

(2) Control circuit wiring and verification of satisfactory operation of all relays and other devices.

(3) Instrument transformers.

(4) Meters.

(5) Ground fault system.

(6) Device electrical operation.

b. AC dielectric tests shall be performed on the power circuit.

3. Markings/Labels, include:

a. Instructional and warning type labels.

b. Underwriters Laboratory (UL)

c. Inspector's stamps.

4. The manufacturer shall use integral quality control checks throughout the manufacturing process to ensure that the MCC meets operating specifications.

B. Equipment that is shipped without evidence of the required tests being performed to verify satisfactory operation will be subject to non-acceptance.

C. If the MCC cannot be placed into service reasonably soon after its receipt, store it in a clean, dry and ventilated building free from temperature extremes. Acceptable storage temperature is from 0 degrees C (32 degrees F) to 40 degrees C (104 degrees F).

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install steel channel sills that have suitable drilled holes for mounting, aligning, and bolting each motor control center in place. Method of mounting, as indicated. Size and arrangement of sills, as recommended by motor control center manufacturer and acceptable to Engineer. Paint completed sills with two coats of aluminum paint or other acceptable corrosion-resistant finish before being set in place. Properly set and level channel sills.

B. If motor control center equipment pads are located on concrete floor slabs, furnish painted steel channel mounting sills and anchor bolts, in time for placing concrete for construction of concrete equipment pads.

C. Install items in accordance with manufacturers' printed instructions.

D. Verify all loads on the motor control center including equipment and devices provided under the other electrical and non-electrical specification sections. Provide information to motor control center manufacturer for sizing of buses, control transformers, and protective devices. Verify that cables and conduits for loads are sized for the actual equipment provide in accordance with the NEC.

E. Set motor circuit protectors and circuit breakers based on load installed.

F. Check and provide a thermal overload on each phase of a starter unit. Match overloads to motor being installed.

G. Deliver spare parts to Owner.

H. Provide conduit, wiring, and grounding interconnections.

I. Perform continuity and operational tests on circuits to demonstrate that motor control center is operationally safe and functionally correct.

J. Provide one set of manufacturer wiring diagrams marked with all changes made in the field.

3.02 TESTING

A. Factory authorized technician shall witness all testing as required by Section 26 08 13 “Field Inspection and Acceptance Tests”.

B. Adjust and verify all settings and inputs to meters and relays.

3.03 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, reprogram, and maintain the equipment.

B. Training shall be a minimum of four (4) hours in operation and maintenance for up to five (5) Owner representatives. Schedule training with at least five (5) working days advance notification.

3.04 CONTRACT CLOSEOUT

A. Provide in accordance with Section 01 77 00.

END OF SECTION

SECTION 26 27 17

CONTROL PANELS

PART 1 - GENERAL

1.01 DESCRIPTION

A. This section describes materials and installation of custom control panels as indicated and in compliance with Contract Documents.

1.02 REFERENCES

A. General:

1. The following documents form part of the Specifications to the extent stated. Where differences exist between codes and standards, the one affording the greatest protection shall apply.

2. Unless otherwise noted, the edition of the referenced code or standard that is current at the time of the “date of record” for the Work shall be considered the effective code or standard for the duration of the project.

3. Refer to Division 01 Section "General Requirements" for the list of applicable regulatory requirements.

4. Refer to specific Division 26 Sections for additional referenced codes and standards.

B. Underwriters' Laboratories, Inc., (UL):

1. 486A: UL Standard for Safety Wire Connectors and Soldering Lugs for Use with Copper Conductors

2. 508: Electrical Industrial Control Equipment.

3. 508A: Industrial Control Panels.

4. 1059: Safety Terminal Blocks.

C. Electrical Safety Program, Electrical Equipment Safety Program, and Lockout/Tagout Program of Provo Public Works.

1.03 SUBMITTALS

A. Submit shop drawings and manufacturers' product data in accordance with the requirements of Section 26 05 10 “Electrical Work – General”.

B. Submit a complete list of equipment, materials, and any details required to demonstrate that the equipment will function properly as a unit. This material shall include:

1. System configuration with single-line diagrams.

2. Detailed descriptions of equipment including weights, dimensions, installation requirements, and heat dissipations.

3. Internal panel layouts indicating spacing and dimensions.

4. Panel front layouts.

5. Comprehensive panel construction bill of materials.

6. Catalog cuts of devices used.

7. Control schematics, ladder diagrams, and interconnection drawings.

8. Nameplates.

1.04 MANUFACTURER'S SERVICES

A. Services of Manufacturer’s Representative as stated in Section 01 43 00 “Quality Requirements” and as specified herein.

1.05 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.

3. Indicating Lights: Two of each type and color installed.

4. Auxiliary Contacts: Furnish one spare for each size and type of magnetic controller installed.

5. Power Contacts: Furnish three spares for each size and type of magnetic contactor installed.

6. Control relays: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.

PART 2 - PRODUCTS

2.01 DIAGRAMS

A. Schematic diagrams shall show the equipment serial or tag number, the Owner's drawing number, contract number, or similar identification which will indicate the particular equipment to which the diagrams apply. Diagrams shall show all equipment in the electrical system including internal wiring of subassemblies. Diagrams of subassemblies may be furnished on separate sheets.

B. Identify each device by a unique number or number-letter combination.

C. Conductor Identification: Identify each conductor by a unique number, letter, or number-letter combination. Consecutive numbering is preferred. Conductors connected to the same terminal or tie point shall have the same identification. Where multiconductor cable is used, a color code may be used to supplement the above identification. Where color-coded multiconductor cable is used for wiring identical components, such as limit switches, the color code used shall be consistent and charted on related diagrams.

D. Provide a schematic diagram for each electrical system. The schematic diagram shall be drawn between vertical lines that represent the source of control power. Show control devices between these lines. Show actuating coils of control devices on the right-hand side. Show contacts between the coils and the left vertical line.

1. Where the internal wiring diagrams of subassemblies are furnished on separate sheets, they shall be shown as a rectangle in the schematic diagram with external points identified and cross-referenced to the separate sheets of the control circuit. Show coils and contacts internal to the subassemblies in the rectangle connected to their terminal points.

    a. Exception No. 1: Where relay and electronic circuits are mixed, diagrams may be drawn between horizontal lines that represent the source of control power.

    b. Exception No. 2: Overload relay contacts may be connected to the right of the coil (common) if the conductors between such contacts and the coils of the magnetic devices do not extend beyond the control enclosure.

2. For clarity, show control device symbols in the order in which the controls are positioned on the diagram.

3. Use a cross-referencing system in conjunction with each relay coil so that associated contacts may be readily located on the diagram. Where a relay contact appears on a sheet separate from the one on which the coil is shown, describe the purpose of the contact on the same sheet.

4. Show spare contacts.

5. Show limit, pressure, float, flow, temperature sensitive, and similar switch symbols on the schematic diagram with utilities turned off (electric power, air, gas, oil, water, lubrication, etc.) and with the equipment at its normal starting position.

6. Show contacts of multiple contact devices, e.g., selector switches, on the line of the schematic diagram where they are connected in a circuit. Indicate a mechanical connection between the multiple contacts by a dotted line or arrow. This does not apply to control relays, starters, or contactors.

7. Additional charts or diagrams may be used to indicate the position of multiple contact devices such as drum, cam, and selector switches.

8. Show the purpose or function of switches adjacent to the symbols.

9. Show the purpose or function of controls such as relays, starters, contactors, solenoids, subassemblies, and timers on the diagram adjacent to their respective symbols. Show the number of positions of solenoid valves adjacent to the valve solenoid symbol.

10. Show values of capacitors and resistors on the diagram.

11. Descriptive terms for command and status functions shall be in the present or past tense. For example, Raise Transfer-Transfer Raised; Advance Transfer-Transfer Advanced. Do not use terms such as "Transfer Up."

E. The panel front and internal layouts shall show the general physical arrangement of components on the control panel. Identify devices with the same marking as used on the schematic diagram. Spare panel space shall be dimensioned. The drawings shall include a layout of the operator's console or push-button station, but terminal numbers need not be shown.

2.02 CONTROL ENCLOSURES

A. Design and test control enclosures in conformance with UL 508. Enclosure types shall be as follows unless noted otherwise in the drawings:

Indoor Use	NEMA Type 12 SST
Outdoor Use	NEMA Type 4X SST
Indoor or Outdoor Use, Corrosive Area	NEMA Type 4X SST

B. The depth of the control enclosure or compartment shall be a minimum consistent with the maximum depth of the control devices plus the required electrical clearance. In no case shall the depth of the enclosure be less than 8 inches.

C. Provide mounting panel for mounting of interior components. Panel finish shall be white enamel.

D. Where heating from control devices results in a temperature rise which is detrimental to the contained equipment or its operation, provide louvers or forced air ventilation. Design ventilating openings to prevent the entrance of any deleterious substance. When forced air ventilation is required, the cabinets shall be pressurized. Air filters shall be of commercially available types and sizes.

E. Where installed outside, provide panel with a sunshield cover to completely protect and enclose the control panel. Ensure the control panel HMI screen, where provided, is continuously shaded during operation such that the sunshield cover does not require removal to access the HMI.

F. Provide a permanent metal data pocket attached to the inside of the enclosure. If space permits, the pocket shall be at least 10 1/2 inches (267 mm) wide and of depth and thickness to accommodate electrical diagrams.

G. Enclosure construction shall be minimum 316 stainless steel. Finish shall be white enamel inside. Provide continuous hinges for enclosure doors with a single handle three-point latch system with padlocking provisions. Provide hasp and staples for padlocking.

2.03 CONTROL WIRING

A. 120-volt control wiring shall be Type MTW, THWN, or THHN. Conductors shall not be smaller than No. 14 AWG. Ampacity shall be in accordance with the NEC.

B. Instrumentation signal cables shall be of the type used for field wiring.

2.04 MARKING

A. Identify wire terminations with a number to correspond with the schematic diagrams. Identification tags shall be preprinted white heat-shrinkable tubing, Raychem Thermofit TMS or equal.

B. Plainly and permanently identify control and power devices using the same identification as shown on the schematic diagrams. Show identification for devices inside the enclosure on a plate adjacent to, not on, the device.

1. Exception No. 1: Where the size or location of the devices make individual identification impractical, such as on electronic assemblies, use group identification.

2. Exception No. 2: Where panel layouts do not permit mounting identification plates adjacent to components, such as relays, place the permanent relay identification on the relay where it is plainly visible, and provide a second identification on the top of the panel wireway cover directly below the relay. Identify the wireway covers to show their proper location.

C. Identification plates for devices mounted inside and outside the control enclosure shall be one of the following:

1. Laminated phenolic for engraving stock; white background with black lettering, a minimum of 0.062 inch (1.57 mm) thick. Hold plates in place with metallic drive screws or the equivalent. Use permanent adhesives for attaching nameplates to wireway covers.

2. Noncorrodible metal; a minimum of 0.031 inch (0.78 mm) thick for engraving stock or 0.012 inch (0.30 mm) thick for embossing stock. Hold plates in place with metallic drive screws.

2.05 SUPPLY CIRCUIT DISCONNECTING MEANS

A. Provide a supply circuit disconnect for each control panel. Disconnect shall be a circuit breaker mounted within the control enclosure operated by a variable depth flange-mounted circuit breaker operating mechanism.

2.06 PLC AND OIT EQUIPMENT

A. Refer to Section 40 62 43 Programmable Logic Controllers.

B. Each new PLC panel assembly is to include a constant voltage regulating transformer suitably sized for the panel load equal to Sola Hevi-Duty MCR series and incoming power transient surge suppression equal to Sola Hevi-Duty STV100K series. Connect the surge suppressor dry contacts to a PLC input at each panel and notify the control system integrator/programmer.

2.07 UNINTERRUPTIBLE POWER SUPPLY (UPS)

A. Control panels shall be equipped with a UPS for surge protection and battery backup of critical process control equipment. The UPS shall be panel mountable, and each control panel shall be appropriately sized to fit the unit. The UPS shall be a double-conversion system.

B. Each UPS shall be sized for, and capable of, running the connected load for a minimum of 30 minutes. UPS shall be sized for 80% of rated load at maximum connected load.

C. UPS Electrical Input Specifications

1. Nominal Voltage: 120VAC

2. Voltage Range: 80-144VAC

3. Input Power Factor: > 0.95

4. Frequency: 60 Hertz +/- 3 Hertz.

D. UPS Electrical Output Specifications

1. Voltage Regulation: +/- 3 percent of Nominal

2. Efficiency: > 85 percent

3. Frequency Regulation: +/- 3 Hertz on utility, +/- 1 Hertz on battery

E. UPS Communications Specifications:

1. A USB port shall be available for monitoring and configuring the UPS. An appropriate cable shall be supplied to connect to the UPS with a PC.

2. An Ethernet port shall be available with the ability to monitor the UPS utilizing the SNMP protocol.

3. A UPS Trouble normally closed contact shall be provided from the UPS and shall be connected to a PLC discrete input channel for notification and alarming.

F. UPS Battery Specifications:

1. All batteries shall be sealed, lead-acid batteries and shall be maintenance free. Batteries shall be hot-swappable. The UPS will indicate when the battery is weak and needs to be replaced.

2. The UPS shall be able to accept additional battery modules to extend the runtime of the UPS.

G. Acceptable Manufacturers:

1. Powerware 5 or 9 Series.

2. Liebert GTX Series.

3. APC Smart-UPS Series.

2.08 CONTROL DEVICES

A. Provide 120-volt control circuit transformer if incoming power supply is not 120 volts. Provide minimum volt-ampere spare capacity that is in addition to the loads specified. Fuse one side of secondary winding and ground other side. Provide primary winding fuses on both lines.

B. Provide indicator lights, selector switches, push buttons, meters, etc., as shown in the schematic diagrams, single-line diagrams, and as required for correct operation. Mount on the front panel of the control enclosure.

C. Push buttons and selector switches shall be NEMA Type 4X. Provide with quantity of contact blocks required for correct operation. Units shall be UL listed with NEMA A600 rated contacts.

D. Push buttons shall be standard size, round, flush head with momentary contacts.

E. Selector switches shall be round with standard operator.

F. Indicating lights shall be round, transformer type, NEMA Type 13, complete with color of lens indicated in drawings or as required and legend plate. Lamps shall be high-density LEDs. Indicating lights shall be push-to-test type.

G. Control relays shall be magnetically held and shall have convertible contacts. Control relays shall be UL listed with NEMA A300 rated contacts and coil voltage, number of poles, and pole arrangement as indicated in the drawings. All relays shall be of the same manufacturer. Relays shall be Allen-Bradley Bulletin 700 or equal.

H. Time delay relays shall be UL listed with contacts rated 10 ampere noninductive load, 120 volts, with coil voltage, number of poles, pole arrangement, and maximum timing adjustment as indicated in the drawings. Relays shall be plug-in, solid-state type with timing knob adjustment. Provide Potter Brumfield, Syracuse Electronics, ISSD, Allen-Bradley Type RT, or equal.

I. Mechanically held relays shall have coil voltage, number of poles, and pole arrangement and rating as shown in the drawings. Provide integral coil clearing contacts.

J. DC power supplies shall have ratings as required by the powered equipment. Provide integral overcurrent protection.

2.09 TERMINAL BLOCKS

A. Provide terminal blocks for incoming and outgoing control wires. Wire and mount terminal blocks so that internal and external wiring do not cross over the terminals. Do not terminate more than two conductors at each terminal connection.

B. Field wiring shall terminate on the "field side" of the terminal blocks. Do not connect internal panel wiring to the "field side" of the terminal blocks. Do not connect field wiring to the "panel side" of the terminal blocks.

C. Terminal blocks shall be modular, rail mounted, rated at 20 amperes, 600 volts capable of terminating wire sizes No. 12 through No. 24 AWG and constructed of polyamide thermoplastic. Terminal blocks shall be UL listed in accordance with UL 486A and UL 1059. Current-carrying parts shall be copper or brass electroplated with tin/lead. Terminal connection shall be a screw clamp pressure plate connection, designed such that the clamping screw does not clamp the screw directly to the wire.

D. Provide symmetrical steel assembly rails, end brackets, jumper bars, and other accessories as required for a complete terminal block assembly.

E. Consecutively number terminal blocks from top to bottom with preprinted marking tags. Tags shall be white polyamide and hot printed with black symbols so that the print is permanent.

2.10 WIRING METHODS

A. Panel wiring shall be neatly contained in panel wireways, including incoming and outgoing field control wiring. Panelways shall be white or light gray colored, restricted slot design, with matching snap-on covers. Provide panelways with mounting holes and nylon "push" rivets or machine screws for mounting. Panelways material shall be PVC or noryl.

B. Provide minimum 2 inches (50 mm) of clearance between panelway and wire terminations to allow for clear viewing of wire identification marking.

C. Tie wiring run to control devices on the front door together at short intervals and secure to the inside front door with adhesive mounts. Mounts shall be adjustable releasable-clamp type for wire bundles 0.69 inch (17 mm) in diameter or smaller or releasable nylon cable ties for bundles larger than 0.69 inch (17 mm) in diameter. Attach mounts to front panel with adhesive.

2.11 FACTORY TESTS

A. Inspect and test control panel for correct operation. Test each circuit for continuity, short circuits, and fault grounds.

PART 3 - EXECUTION

3.01 FIELD TESTS

A. Test control panel with field wiring connected. Set adjustable set points and time delays for proper operation of equipment. Check operation of control panel and field devices to verify correct operation. Perform required adjustments for correct operation.

3.02 CLOSEOUT ACTIVITIES

A. Provide in accordance with Section 01 77 00 “Execution and Closeout Requirements”.

END OF SECTION

SECTION 26 27 26

WIRING DEVICES

PART 1 - GENERAL

1.01 DESCRIPTION

A. Provide field test, and place in operating condition, wiring devices as indicated and in compliance with Contract Documents.

B. Provide exterior lighting control as indicated and in compliance with Contract Documents.

1.02 REFERENCES

A. Federal Specifications (FS):

1. W-C-596-F: Plug, Electrical Connector, Receptacle, Electrical.

2. W-S-896-F: (1P-2P-3W) Switch, Toggle, Single Unit with wall plates.

B. National Electrical Manufacturers Association (NEMA):

1. WD 1: General Requirements for Wiring Devices

2. WD 6: Wiring Devices – Dimensional Requirements

C. National Fire Protection Association (NFPA):

1. 70: National Electrical Code (NEC).

D. Underwriters' Laboratories, Inc. (UL):

1. 20: General Use Snap Switches.

1.03 SUBMITTALS

A. Submit shop drawings and manufacturer's product data in accordance with requirements of Section 26 05 10 “Electrical Work – General”.

PART 2 - PRODUCTS

2.01 MANUFACTURER’S COMPLIANCE

A. Manufacturer’s acceptance contingent upon products compliance with specifications.

B. Provide all devices with UL label.

2.02 MANUFACTURERS

A. Allen-Bradley Co.

B. Appleton Electric Co.

C. Cooper Wiring Devices.

D. Crouse-Hinds Co.

E. Hubbell Electrical Products.

F. Pass & Seymour, Legrand.

G. OZ Gedney.

H. Nelson Electric.

I. Wattstopper.

J. Greengate.

2.03 MATERIALS AND COMPONENTS

A. Wall Switches:

1. Provide alternating current, general-use, snap switches, in flush device boxes or on outlet box covers, totally enclosed in composition case, with insulated mounting yoke and sidewired, binding screw-type terminals. Single-pole, 2-pole, 3-way, or 4-way switches rated 20 amperes at 120/277 volts AC. Switch to meet Fed. Spec. W-S-896-F and UL-20.

2. Switches for controlling lighting:

a. Cooper Wiring Device Cat. No. 2221, 222, 2223, or 2224.

b. Hubbell Cat. No. 1221, 1222, 1223 or 1224.

c. Bryant Electric Cat. No. 4901, 4902, 4903 or 4904.

d. Pass & Seymour, Cat. No. 20AC1, 20AC2, 20AC3 or 20AC4

3. Provide pilot type lighting for switches controlling lights in seldom frequented locations.

B. Watertight Switches:

1. Provide watertight switches consisting of flush mounting switches in NEMA Type 4 gasketed cast metal boxes. Switch operable through shaft in matching cast metal cover, twenty-ampere, 120/277-volt switch enclosures:

a. Crouse-Hinds Type MC or MCC.

b. Appleton Cat. No. WDM 175 and WVG1.

c. OZ Gedney Cat. No. WSP and WCT120.

C. Occupancy Sensors:

1. Provide Occupancy Sensors as indicated on the plans. Provide power packs as need.

a. Low-Voltage Dual-Technology Ceiling Sensor: Wattstopper DT-305 or equal by Greengate.

b. Line-Voltage PIR Wall Sensor Switch, Wattstopper PW-301 or equal by Greengate.

c. Line-Voltage Dual-Technology Wall Sensor Dimmer, Wattstopper DW-311 or equal by Greengate.

d. Low-Voltage Dual-Technology Corner-Mount Sensor, Wattstopper DT-205 or equal by Greengate.

D. Flush Receptacles:

1. Provide 20-ampere, 125-volt flush receptacles constructed in flush device boxes, and of grounding type in composition case with insulated mounting yoke, side-wired, binding screw-type terminals. Receptacles to conform to Fed. Spec. W C 596-F.

2. Duplex receptacles:

a. Cooper Wiring Devices Cat. No. 5362.

b. Hubbell Cat. No. 5362.

c. Bryant Electric Cat. No. 5362.

d. Pass & Seymour Cat. No. 5342.

3. Duplex GFCI Type Receptacles:

a. Harvey Hubbell, Inc. Cat. No. CR5352.

b. Cooper Wiring Devices Cat. No. GF20.

c. Leviton Manufacturing Company Cat. No. 6899.

4. Single receptacles:

a. Cooper Wiring Devices Cat No. 5361.

b. Hubbell Cat. No. 5361.

c. Pass & Seymour Cat. No. 5351.

E. Special Receptacles:

1. Provide weatherproof while-in-use devices rated 20 ampere, 125-volt, consisting of duplex GFI receptacles with diecast powder costed aluminum, soft-gasketed hinged covers with stainless steel hardware. Covers as follows:

a. Hubbell Cat. No. WP26E.

b. Crouse-Hinds Cat. No. WIUMV-1X.

2. Provide in corrosive areas (NEMA 4X) a 20 ampere, 125-volt, consisting of duplex GFI receptacles with spring-loaded, soft-gasketed hinged covers with stainless steel spring. Device described above. Cover as follows:

a. Crouse-Hinds Cat. No. WLRS-1-S752.

3. Provide watertight, gasketed cast-metal enclosures with covers in areas subject to hose-down, meeting requirements, and either standard single or duplex type:

a. Appleton Electric Cat. No. AEE3382 and AEP3361, Style 2.

b. Crouse-Hinds Cat. No. ARRH33 and APJ3385, Style 2.

4. Provide receptacles with matching plug or cord cap designed to meet NEMA 4 requirements when plug, cord and receptacle are assembled.

5. Provide surface mounted “tombstone” style receptacles on laboratory island as shown on the plans. Provide die cast aluminum housing with minimum 3/4" conduit opening, two duplex GFI receptacles (one on each side) and stainless steel coverplates. For date outlets, provide the correct mounting for number of data connections shown.

F. Outlet Boxes and Enclosures:

1. Provide outlet boxes and enclosures conforming to Section 26 05 33 “Raceway and Boxes for Electrical Systems” and enclosure schedule on the drawings unless otherwise indicated.

G. Device Plates:

1. Provide device plates suitable for type of outlet boxes and enclosures used. Plates for flush-mounting by device manufacturer. Plates for surface-mounting boxes by either device manufacturer or box manufacturer.

2. Provide flush device plates of high corrosion resistant, Type 302 stainless steel.

3. Provide flush device plates of material and finish indicated, in certain designated areas.

H. Exterior Lighting Control Panel:

1. Provide Lighting Control Panel as indicated on the plans. Panel shall be UL listed and consist of the following:

a. Enclosure/Tub: NEMA 1.

b. Cover: Surface, hinged, lockable and shall restrict access to line voltage section.

c. Interior: Barrier for separation of high voltage (class 1) and low voltage (class 2) wiring. It shall include intelligence boards, power supply and control relays. Clock display and keypad shall be mounted on interior cabinet door for easy user access and programming.

2. Features:

a. Panel shall accept up to eight single pole relays. Relays shall be individual latching relays with 20 Amp load contacts for LED lighting loads. Provide isolated auxiliary contacts for pilot light switching. Relays shall use quick connectors and be individually replaceable to facilitate ease of use.

b. Panel shall provide a stagger up delay, override push buttons, pilot light outputs, and LED status light indicators for each relay or contactor control channel.

c. The clock shall have a backlight display, user keypad and shall provide 8 channels of time or astronomical control. Time clock shall provide up to 42 holidays, automatic daylight savings adjustment, astronomic coordinates by major cities, and help screens. Program memory shall be non-volatile and clock shall retain time keeping during power outages for at least 48 hours. Preprogrammed lighting control scenarios shall include:

(1) Scheduled On/Off

(2) Manual On/Scheduled Off

(3) Manual On/Automatic Switch Sweep Off

(4) Astronomic Or Photocell On/Off and Astronomic or Photocell Control With Scheduled On/Off.

d. The panel shall have 8 universal switch inputs that are low voltage, self-configuring and shall not require programming to accept momentary on/ momentary off switch, push button switch (cycling), maintained switch or 24VDC signals from occupancy sensors, photocells or other interfacing devices.

3. Manufacturer:

a. Provide Wattstopper LP8S-8-115 Surface Mount with photocell EM-2-A2 or equal by Greengate.

PART 3 - EXECUTION

3.01 GENERAL

A. Perform all work in accordance with the NEC.

3.02 CONNECTION

A. Securely and rigidly attach wiring devices in accordance with regulating agency, and as indicated, avoiding interference with other equipment.

B. Securely fasten nameplates using screws, bolts, or rivets and centered under or on the device, unless otherwise indicated.

3.03 GROUNDING

A. Ground all devices in accordance with NEC.

B. Ground switches and their metal plates through switch mounting yoke, outlet box, and raceway system.

C. Ground flush receptacles and their metal plates through positive ground connection to outlet box and grounding system. Maintain ground to each receptacle by spring-loaded grounding contact to mounting screw, or by grounding jumper, both making positive connection to outlet box and grounding system at all times.

D. Ground explosion proof receptacles and plugs by making contact between the metal shells, and also by using a grounding pin to make contact before power contacts are made.

3.04 LABELING

A. All wall plates to be engraved with the panelboard alpha-numeric identifier and circuit breaker number.

1. Characters to be 5/16 inch (8 mm) in size and black in color.

2. All engravings to match panelboard typed circuit breaker directories.

3.05 CONTRACT CLOSEOUT

A. Provide in accordance with Section 01 77 00 “Execution and Closeout Requirements”.

END OF SECTION

SECTION 26 29 23

VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.01 DESCRIPTION

A. Provide complete simplex type Variable Frequency Drive (VFD) units and appurtenances including drive reactors, DC chokes, harmonic filters, enclosures, and certain auxiliary items, as indicated and as specified, to provide a complete operating system as indicated and in compliance with Contract Documents.

B. If not installed in Motor Control Center, VFD units shall be furnished by the driven equipment manufacturer (pump, fan, etc.) supplier unless otherwise noted. Installation of the units shall be the responsibility of the General Contractor. All conduit and wire installations associated with each VFD shall be provided under Division 26.

C. Provide individual stand-alone VFD units for the High Service Pumps as indicated on the plans and in this specification.

D. VFD units shall be manufacturer's standard technology and in production for a minimum of 2 years.

E. Provide control system operation, input and control signals, status signals and devices in accordance with Section 40 99 90 “Package Control Systems”.

F. Each VFD unit shall exhibit less than 3 percent voltage total harmonic distortion and less than 3 percent voltage distortion on each harmonic at their immediate upstream distribution bus as verified by calculation and testing. Harmonic current distortion to be in accordance with Table 26 29 23-1. This bus shall be referred to as the point of common coupling (PCC).

G. Ratings shall be based on an altitude of approximately 4500’.

1.02 REFERENCES

A. General:

1. The following documents form part of the Specifications to the extent stated. Where differences exist between codes and standards, the one affording the greatest protection shall apply.

2. Unless otherwise noted, the edition of the referenced code or standard that is current at the time of the “date of record” for the Work shall be considered the effective code or standard for the duration of the project.

3. Refer to Division 01 Section "General Requirements" for the list of applicable regulatory requirements.

4. Refer to specific Division 26 Sections for additional referenced codes and standards.

B. ASTM International (ASTM):

1. D178: Standard Specification for Rubber Insulating Matting

C. National Electrical Manufacturers Association (NEMA):

1. ICS 2: Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 Volts.

2. ICS 6: Enclosures for Industrial Controls and Systems.

3. AB 1: Molded-Case Circuit Breakers, Molded Case Switches, and Circuit-Breaker Enclosures.

4. KS 1: Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).

5. MG 1: Motors and Generators.

D. National Fire Protection Association (NFPA):

1. 70: National Electrical Code (NEC).

E. Underwriter's Laboratories Inc. (UL):

1. 198C: High-Intensity Capacity Fuses; Current-Limiting Types

2. 489: Molded-Case Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.

3. 508: Electrical Industrial Control Equipment.

4. 1066: Low Voltage AC and DC Power Circuit Breakers Used in Enclosures.

F. National Electrical Contractors Association (NECA)

1. NECA Standard of Installation

G. Electrical Safety Program, Electrical Equipment Safety Program, and Lockout/Tagout Program of NTMWD.

1.03 SUBMITTALS

A. Submit shop drawings and manufacturers' product data in accordance with the requirements of Section 26 05 10 “Electrical Work – General”.

B. Complete list of equipment and materials, including manufacturer’s descriptive and technical literature, catalog cuts, and installation instructions for all major components.

C. Complete wiring and schematic diagrams for the equipment furnished. Each wiring diagram shall be legible and not reduced from the original design drafted format. Provide a list of equipment on each wiring diagram for which it is applicable.

D. Panel layout and front view drawings.

E. Time versus current curves for protection devices.

F. Data sheets for all devices provided as part of the assembly.

G. All other details required to demonstrate that system has been coordinated and will properly function as a unit.

H. Provide enclosure drawings and details showing all dimensions and construction details.

I. Submit information relative to location and expertise of local service office and personnel.

J. Submit a Statement of Compliance indicating conformance to the Seismic Requirements specified. Certificate shall be signed and sealed by a Professional Structural Engineer holding current registration in the state for work of this project.

K. For informational purposes only, submit manufacturer’s printed installation instructions.

L. Spare Parts Data: Submit a list of spare parts for the equipment specified.

M. Operating and Maintenance Instruction Manuals:

1. Furnish:

a. Operating instruction manuals outlining step-by-step procedures required for system startup and operation.

b. Manufacturer's name, model number, service manual parts list.

c. Brief description of equipment and basic operating features.

d. Maintenance instruction manuals outlining maintenance procedures.

e. Troubleshooting guide listing possible breakdown and repairs.

f. Point-to-point connection wiring diagram for the system.

g. Performance Test Reports: Upon completion of installed system, submit in booklet form all shop and field tests performed to prove compliance with specified performance criteria.

N. Submit Pump, Motor and VFD Statement of Compliance Coordinate Certificate.

1.04 QUALITY ASSURANCE

A. Provide in accordance with Section 01 43 00 “Quality Requirements” and as specified.

B. Provide VFDs in accordance with UL 508A, supplement SB, and Article 409 of the National Electrical Code (NEC). All VFD units shall be provided with a UL label.

C. The manufacturer shall confirm and state the measure of and the set of the features that support the ease and speed of which corrective maintenance (CM) and preventive maintenance (PM) can be conducted on the proposed system. The Mean Time To Repair (MTTR), the measure used to quantify the time required to perform CM and Mean Preventive Maintenance Time (MPMT), a measure commonly used to quantify the time required to perform PM are to be confirmed by the manufacturer.

D. Review the proper installation of each type of VFD unit with the equipment supplier prior to installation.

E. Services of Service Engineer, specifically trained on type of equipment specified. Person-day requirements listed exclusive of travel time. Times listed are per VFD not mounted in a Motor Control Center (MCC).

1. Assist in location of devices, methods of mounting, field erection, etc.

a. 2 person-days

2. Functional Completion Testing

a. 2 person-days

3. Startup.

a. 2 person-days

4. Commissioning.

a. 2 person-days

5. At the end of start-up service provide for a maximum of six members of the owners staff at the facility site to receive training from the startup/testing service Engineer.

a. 1 person-day

6. Service-inspections during first year of operation, for use at Owner's request, and exclusive of repair, malfunction or other trouble-shooting service calls:

   a. 2 person-days

7. Person-day is defined as one 8-hour day, excluding travel time.

1.05 DELIVERY, STORAGE AND HANDLING

A. Provide in accordance with Section 01 66 10 “Deliver, Storage and Handling” and as specified.

B. Shipping:

1. Ship equipment and materials, except where partial disassembly is required by transportation regulations or for protection, complete with identification and quantity of items.

2. Pack spare parts in containers bearing labels clearly designating contents and pieces of equipment for which intended.

3. Deliver spare parts after installation but as specified before start-up of drives. Deliver to Owner after completion of work.

C. Storage:

1. Inspect and inventory items upon delivery to site.

2. Store and safeguard equipment, material and spare parts.

   a. If the equipment cannot be placed into service after its receipt, store in a closed building or structure, in a clean, dry and ventilated area free from temperature, dirt and moisture extremes. Acceptable storage temperatures are from 32 degrees F (0 degrees C) to 104 degrees F (40 degrees C) with temporary heaters provided within enclosures to prevent condensation. Provide heavy plastic envelope directly over motor control center to protect against dust, dirt, and moisture. Provide lifting angles outside of envelope.

1.06 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.

3. Indicating Lights: Two of each type and color installed.

4. Auxiliary Contacts: Furnish one spare for each size and type of magnetic controller installed.

5. Power Contacts: Furnish three spares for each size and type of magnetic contactor installed.

1.07 WARRANTY AND SERVICE

A. Guarantee components, parts, and assemblies supplied by manufacturer against defects in materials and workmanship for a period of 24 months after turning the equipment over to the Owner, and in this time period include onsite, parts and labor warranty. All labor to be performed by local factory trained service engineers.

B. Ensure that equipment manufacturer has local branch office staff with trained, full-time employees who are capable of performing testing, inspecting, repair, and maintenance services.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Manufacturer shall have at least five years commercial experience in the manufacture, operation and servicing of equipment of type, size, quality, performance, and reliability equal to that specified.

B. Variable Frequency Drive Units:

1. ABB Drives.

2. Eaton.

3. Schneider/Square D Company.

4. Siemens Inc.

2.02 HARMONIC ANALYSIS

A. Each VFD unit shall be designed such that there is less than 3 percent voltage total harmonic distortion at the PCC. Current distortion at the PCC will be in accordance with Table 26 29 23-1. For the purpose of the analysis, it will be assumed that the facility transformer feeding the electrical system is at a lightly (50 percent) loaded condition.

Table 26 29 23-1 **Maximum Harmonic Current** **Distortion in Percent Il**

Odd Harmonic						
Ratio	**5 to 9**	**11 to 15**	**17 to 21**	**23 to 33**	**35 +**	**TDD**
Less than 20	4.0	2.0	1.5	0.6	0.3	5.0
20 to 50	7.0	3.5	2.5	1.0	0.5	8.0
50 to 100	10.0	4.5	4.0	1.5	0.7	12.0
100 to 1000	12.0	5.5	5.0	2.0	1.0	15.0
1000 +	15.0	7.0	6.0	2.5	1.4	20.0

Notes:
1. Even harmonics are limited to 25 percent of odd harmonics.
2. DC offset distortions not allowed.
3. Ratio = Isc/IL where:
   Isc = Maximum short circuit current at PCC.
   IL = Maximum demand load current at PCC (fundamental frequency component)

B. For each VFD unit, provide a harmonic analysis study at the point of connection to the immediate upstream distribution bus (PCC), based on pre-submittal data.

1. Each VFD unit shall be designed such that there is less than 3 percent voltage total harmonic distortion and less than 3 percent voltage distortion on each harmonic at the PCC. Current distortion to be within the limits of Table 26 29 23-1. For the purpose of the analysis, it will be assumed that the electrical system is at a lightly loaded condition, 50 percent load. If the VFD loads exceed 50 percent system loading, assume system is loaded at VFD full load ratings.

2. At each PCC, where more than one type or size VFD unit is to be connected, provide the following:

   a. Contractor shall have the supplier of the largest drive (in Hp) provide a harmonic study for each point of common coupling based on pre-submittal information

3. The Contractor shall supply the following pre-submittal information to the largest VFD supplier to complete the harmonics study.

   a. Full load fundamental current for each VFD unit.

   b. Harmonic currents on per unit basis of full load fundamental for each VFD unit.

   c. Available fault current information from the electric utility and upstream transformer data.

   d. Distribution transformer sizes and impedances, if any.

e. VFD input line reactor and/or isolation transformer sizes and impedances from the utility source to the VFD units.

f. Conductor information between transformer secondary or generator terminals to the distribution buses and VFDs.

g. Generator kW, impedance, subtransient reactance generator constants for the condition when the electrical system is powered from the generator.

4. The results of the harmonics study shall verify that the levels of total harmonic voltage at each point of common coupling are less than 5 percent and that the voltage distortion on each harmonic is less than 3 percent. In addition, harmonic currents at the PCC will be within the limits of Table 26 29 23-1. The study shall separately consider each VFD distribution bus as points of common connection (PCCs). The study shall specify additional equipment required (e.g., filters) at each harmonic where harmonic reduction is required to ensure compliance.

C. The study shall consider the following conditions:

1. The electrical system shall be powered by the electric utility, case 1, or solely by local generation, case 2.

2. The study shall include an explanation of all assumptions, sources of data, methodologies and formulas used in the study and a summary of the study results.

3. The Contractor shall supply all equipment required as a result of the final accepted harmonics study to comply with the requirements of Paragraph 1.01 F.

2.03 SYSTEM DESCRIPTION

A. General Requirements for VFDs:

1. VFDs and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2. Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508C.

B. Application: Constant torque and variable torque. Provide as required for the application.

C. VFD Description: Variable Frequency Drive, consisting of power converter that employs pulse-width-modulated inverter, factory built and tested in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and adjustable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.

1. Units suitable for operation of NEMA MG 1, Design A and Design B motors, as defined by NEMA MG 1, Section IV, Part 30, "Application Considerations for

Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General Purpose Motors Used with Adjustable-Voltage or Adjustable-Frequency Controls or Both."

2. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."

3. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.

D. Design and Rating: Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

E. Output Rating: Three phase; 10 to 66 Hz, with torque constant as speed changes; maximum voltage equals input voltage.

F. Unit Operating Requirements:

1. Input AC Voltage Tolerance: Plus 10 and minus 10 percent of VFD input voltage rating.

2. Input AC Voltage Unbalance: Not exceeding 3 percent.

3. Input Frequency Tolerance: Plus or minus 3 percent of VFD frequency rating.

4. Minimum Efficiency: 96 percent at 60 Hz, full load.

5. Minimum Displacement Primary-Side Power Factor: 96 percent under any load or speed condition.

6. Minimum Short-Circuit Current (Withstand) Rating: 22 kA, refer to plans for higher ratings as required.

7. Ambient Temperature Rating: Not less than 32 deg F (0 deg C) and not exceeding 104 deg F (40 deg C).

8. Humidity Rating: Less than 95 percent (noncondensing).

9. Altitude Rating: Not exceeding 3300 feet (1000 m).

10. Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.

11. Speed Regulation: Plus or minus 5 percent.

12. Output Carrier Frequency: Selectable; 0.5 to 15 kHz.

13. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.

G. Inverter Logic: Microprocessor based, 16 bit, isolated from all power circuits.

H. Isolated Control Interface: Allows VFDs to follow remote-control signal over a minimum 40:1 speed range.

1. Signal: Electrical.

I. Internal Adjustability Capabilities:

1. Minimum Speed: 5 to 25 percent of maximum rpm.

2. Maximum Speed: 80 to 100 percent of maximum rpm.

3. Acceleration: 0.1 to 999.9 seconds.

4. Deceleration: 0.1 to 999.9 seconds.

5. Current Limit: 30 to minimum of 150 percent of maximum rating.

J. Self-Protection and Reliability Features:

1. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.

2. Under- and overvoltage trips.

3. Inverter overcurrent trips.

4. VFD and Motor-Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFDs and motor thermal characteristics, and for providing VFD overtemperature and motor-overload alarm and trip; settings selectable via the keypad.

5. Critical frequency rejection, with three selectable, adjustable deadbands.

6. Instantaneous line-to-line and line-to-ground overcurrent trips.

7. Loss-of-phase protection.

8. Reverse-phase protection.

9. Short-circuit protection.

10. Motor-overtemperature fault.

K. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.

L. Bidirectional Autospeed Search: Capable of starting VFD into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.

M. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

N. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

O. Integral Input Disconnecting Means and OCPD: UL 489, instantaneous-trip circuit breaker with pad-lockable, door-mounted handle mechanism.

1. Disconnect Rating: Not less than 115 percent of VFD input current rating.

2. NO alarm contact that operates only when circuit breaker has tripped.

P. To avoid damage of output IGBT components or slamming to motors, an E-stop operation shall trigger a freewheel stop on the drive before the main 3 phase contacts open from the E-stop.

2.04 PERFORMANCE REQUIREMENTS

A. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified."

2.05 CONTROLS AND INDICATION

A. Refer to control diagrams on plans for additional requirements.

B. Status Lights: Door-mounted LED indicators displaying the following conditions, as a minimum:

1. Power on.

2. Run.

3. Overvoltage.

4. Line fault.

5. Overcurrent.

6. External fault.

C. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English-language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.

1. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.

2. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.

    a. Control Authority: Supports at least four conditions: Off, local manual control at VFD, local automatic control at VFD, and automatic control through a remote source.

D. Historical Logging Information and Displays:

1. Real-time clock with current time and date.

2. Running log of total power versus time.

3. Total run time.

4. Fault log, maintaining last four faults with time and date stamp for each.

E. Indicating Devices: Digital display mounted flush in VFD door and connected to display VFD parameters including, but not limited to:

1. Output frequency (Hz).

2. Motor speed (rpm).

3. Motor status (running, stop, fault).

4. Motor current (amperes).

5. Motor torque (percent).

6. Fault or alarming status (code).

7. PID feedback signal (percent).

8. DC-link voltage (V dc).

9. Set point frequency (Hz).

10. Motor output voltage (V ac).

F. Control Signal Interfaces:

1. Electric Input Signal Interface:

    a. A minimum of two programmable analog inputs: 4-20mA dc.

b. A minimum of six multifunction programmable digital inputs.

G. Output Signal Interface: A minimum of two programmable analog output signal(s) 4-20mA dc, which can be configured for any of the following:

1. Output frequency (Hz).

2. Output current (load).

3. DC-link voltage (V dc).

4. Motor torque (percent).

5. Motor speed (rpm).

6. Set point frequency (Hz).

H. Remote Indication Interface: A minimum of six programmable dry-circuit relay outputs (120-V ac, 1 A) for remote indication of the following:

1. Motor running.

2. Set point speed reached.

3. Fault and warning indication (overtemperature or overcurrent).

4. PID high- or low-speed limits reached.

5. Drive in remote.

I. Provide an Ethernet port for network connection.

1. VFD shall be capable of communicating via Modbus TCP/IP protocol.

2. Network to allow a selection of standard and custom register values to communicate drive parameters, including:

a. Drive fault

b. Overload

c. Trip

d. Loss of control power

e. Speed

f. Power (kW)

g. Amps (Phase A, B and C)

h. Voltage (Phase A-B, B-C, C-A)

3. Provide all components and drive programming to allow network interface with control system.

2.06 MOTOR PROTECTION RELAY

A. For each High Service Pump VFD, provide a definite purpose microprocessor-based Motor Protective Relay (MPR) for protection, control and monitoring of the motors. The MPR shall meet UL 1053 standard.

B. The true rms current into the motor shall be constantly monitored, and by means of a protective algorithm, separated into positive and negative sequence components. These components shall be used to determine the heating effects on the stator and rotor of the motor to provide maximum motor protection and utilization. The relay shall be capable of being connected by three-wire conductor or fiber optic to a remote Universal Resistance Temperature Detection Module (URTDM) located at the motor to monitor up to six motor winding, four bearing and one auxiliary RTD inputs or the relay shall be able to be direct connected to the RTD inputs. The MPR shall integrate the temperature input data from the URTDM with the protective algorithm. The protective curve algorithm shall be adaptive based on the motor temperature as measured by the URTD. The protective algorithm shall provide faster trip times for higher temperatures providing maximum motor protection and shall operate with a longer trip time for lower temperatures allowing maximum motor utilization. The MPR shall provide the following protective functions:

1. Motor running time overcurrent protection (IEEE Device 49/51).

2. Adjustable instantaneous overcurrent protection (IEEE Device 50) with adjustable start delay in one-cycle increments.

3. Adjustable current unbalance protection (IEEE Device 46 -adjustable in percent unbalance).

4. Rotor protection.

5. Underload trip with start and run time delays (IEEE Device 37/2).

6. Jam trip with start and run time delays.

7. Auxiliary overtemperature protection with URTDM.

8. Zero sequence ground fault protection (IEEE Device 50/51G) with adjustable start delay and run delay in one-cycle increments.

9. Stator protection with URTDM (IEEE Device 49).

10. Motor bearing over temperature protection with URTDM (IEEE Device 38)

11. Load bearing over temperature protection with URTDM (IEEE Device 38).

C. Only the following settings shall be needed to define the motor thermal protection curve.

1. Motor full load amperes (FLA)

2. Locked Rotor Current in percent of FLA

3. Locked rotor stall time in seconds

4. Ultimate trip current based on motor service factor.

D. The following control functions shall be provided by internal solid-state based timers or relays:

1. Incomplete sequence delay (IEEE Device 2/19).

2. Limitation on number of starts per time period in minutes (IEEE Device 66).

3. Anti-backspin time delay (IEEE 2).

4. Programmable transition relay based on current and/or time.

5. Time between starts.

6. Number of cold starts.

7. Mechanical load shedding and restore function with timers.

8. Zero speed switch input timer for use with long accelerating time motors.

E. The MPR shall have a real-time clock for time tagging of events, operations and history. The relay shall have quick and easy access to monitored values, view settings, motor history and motor log records. The relay shall monitor and display the following:

1. Motor currents: Average current (Iave), individual phase and ground current in primary amperes and percent of full load and percent phase unbalance.

2. Motor RTD: Individual winding, motor bearing, load bearing and auxiliary temperatures.

3. Motor: Percent I2t (thermal accumulation), time until next start can occur, remaining number of starts, and time left on oldest start.

F. The MPR shall be capable of accommodating external current transformers with ranges from 10/5 through 4000/5 amperes. Provide three current transformers sized per manufacturer’s recommendations based on motor full-load amperes and service factor.

Where ground fault protection is specified, it shall be from an independent measuring circuit that utilizes either a separate zero sequence current transformer (50/51G) or residual scheme utilizing the three-phase current transformers (50/51N). For zero sequence ground fault protection, provide 50/5-ampere zero sequence transformer.

G. Two user-programmable discrete inputs shall be provided for external control or trip functions. Programmable input functions shall be included for shutdown based on external contacts for incomplete sequence of operation and remote trip, remote reset, differential trip, motor stop, reset disable, zero speed switch or emergency override.

H. The MPR shall be capable of providing a 4 to 20 mA output signal proportional to either the average of the three-phase currents, hottest winding RTD temperature or I2t level.

I. The unit shall draw its power from a control power transformer located in the starter.

J. Provide separately mounted RTDM, mounted near the motor, to provide up to six stator RTDs, two motor bearing RTDs, and two load bearing RTDs and one auxiliary RTD.

K. The device shall have separate Form C (NO/NC) Trip, two programmable Form C (NO/NC) Alarm and Auxiliary contacts. All contacts shall have ratings of 10-amperes at 115/240 Vac or 30 Vdc resistive. The alarm and auxiliary relay output contacts shall be programmable to operate from any internal protection function or from a discrete input signal such as differential trip or remote trip. All contacts shall be programmable to function in either a mode 1 (non-fail-safe) or mode 2 (fail-safe) operation. The device shall be capable of providing a 4 to 20 mA output signal proportional to one of the following user-selectable parameters:

1. Average of the three-phase currents.

2. Hottest winding RTD temperature

3. I2t level.

L. The relay shall be capable of monitoring electrical current, receiving commands from remote sources either by contact closures or digital data, giving commands by means of contact closure to the motor starters and other devices under its control. The MPR shall be capable of displaying information by alphanumeric display to the operator or by digital communication signals to a remote location.

1. The combination relay and operator panel shall be mounted on the door of the starter. Specific data entry to suit the actual motor application shall be programmed into the device by means of the operator panel pushbuttons

2. Entered data shall be stored in non-volatile memory so as not to require battery backup. Non-volatile memory shall be capable of storing all setup information even after power failure, all monitored information at the time of a trip, and cause of trip even after power failure. Access to all programmed set points shall be restricted by means of a secured and sealed access cover.

3. Alphanumeric display shall read out (in English) complete description of all protective functions e.g., “instantaneous overcurrent” and all monitored and programmable data such as “percent of full load in amps” and “motor bearing temperature”.

4. The MPR shall be user-selectable as to being programmable while the motor is running or require a motor shutdown for programming. If configured for programming while the motor is running, the protection shall stay active while programming is based on previous settings. Upon the user exiting the programming mode, the new settings shall take effect.

5. The MPR shall have a user-selectable emergency override feature to reset I2t thermal accumulation and de-active start inhibit timers for emergency starting of the motor. The emergency override feature shall be capable of being activated from an access-restricted button, communications or via a contact input into the MPR.

6. The MPR shall provide a programmable control function for reduced voltage applications for the transition from reduced to full voltage starting. The transition shall be programmable based on current, time current, and time.

M. The MPR shall provide the following data logging and display capability for history including the date and time from when the history was last reset and counting began. The history shall include:

1. Resettable motor history for operational counter, run time, highest starting and running currents, highest percent phase unbalance, maximum winding, bearing and load RTD temperature, and number of emergency overrides.

2. Re-settable Trip history for number of trips for ground faults, overloads, instantaneous overcurrent, JAM, underload, phase unbalance, RTDs, phase reversal, incomplete sequence, remote differential, communication, starts exceeded, time between starts, and transition.

3. Re-settable Alarm history for number of alarms, for ground faults, overloads, JAM, underload, phase unbalance, RTDs, starts exceeded.

4. A permanent history record which cannot be reset shall include total trips, run time and operations count.

5. A log book including a chronological list of events or operations as detected by the MPR, such as, starts, stops, setting change, emergency override, trips, alarms or changes in the state of discrete inputs.

6. An event log providing detailed information on trips and alarms including phase and ground currents, percent phase unbalance, maximum RTD temperatures, and cause of trip or alarm.

7. A start log providing information on the four most recent starts including maximum phase, and ground starting current, maximum percent unbalance, time from start to transition, current at transition, and time from start to run or trip.

N. The MPR shall be provided in a quick release drawout case. The MPR shall have a user-programmable armed/disarmed feature with alarm indication. The disarmed mode shall permit relay installation while the motor is running with the trip outputs blocked. The draw-out case shall have a spare self-shorting contact to allow for continuous motor running or relay removed alarm functions.

O. Provide a network communications card capable of changing set points, real time temperature for each RTD, transmitting all data, including trip/alarm data, a starting profile of the average phase current for the two most recent starts, all on MODBUS TCP/IP over Ethernet to the SCADA system.

2.07 LINE CONDITIONING AND FILTERING

A. All VFDs shall include 3% effective impedance. If integral to the VFD, a DC choke shall be used. External line reactors must be used if no DC Choke is integral to the VFD.

B. All VFDs shall include 5% effective line impedance. If integral to the VFD, a DC choke may be used in series with a 3% reactor. An external 5% impedance reactor must be used if no DC Choke is integral to the VFD.

C. For VFD rated 480 volts, 50 horsepower and below 300 horsepower, supply an 18-pulse design using a multiple bridge rectifier with integral reactor and phase shifting transformer. The 18-pulse configuration shall result in a multiple pulse current waveform that approximates near sinusoidal input current waveform. The power section shall be insensitive to phase rotation of the AC line.

D. For VFD rated 480 volts, 300 horsepower and up, supply with an Active Harmonic Filter (AHF). Provide a AHF in the same enclosure and sized for each VFD. The VFD and AHF shall come as a packaged unit with no additional cabling between units.

2.08 ENCLOSURES

A. VFD Enclosures: NEMA 250, to comply with environmental conditions at installed location.

1. Dry and Clean Indoor Locations: Type 1.

2. Outdoor Locations: Type 4X.

3. Other Wet or Damp Indoor Locations: Type 4X.

4. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.

2.09 SHOP TESTING

A. Provide in accordance with Section 01 43 00.

B. Provide a factory performance test for each variable frequency drive unit. The test to consist of simulating the expected load to be driven. The drive to operate the actual motor load through the expected speed ranges. Test length to be a minimum of two hours.

C. Provide a factory burn-in test for 24 hours minimum and a control and alarm test on each drive unit by simulating each control signal and each alarm function to verify proper and correct drive unit action.

D. Provide typical prototype factory test data for short circuit testing of each type of drive supplied. Data to verify that each drive can be started into a line-to-line fault and line-to-ground fault on the drive terminals. Each drive can be operating at full load and be subjected to a line-to-line fault and line-to-ground fault on the drive terminals. All phases (A, B & C) to be included in test data.

E. Provide certified documentation of all tests performed.

F. Provide above stated tests in addition to routine factory tests.

PART 3 - EXECUTION

3.01 INSPECTION

A. Examine VFD location for satisfactory preparation. Check conduits and raceway location for connection to units.

B. Visually inspect delivered unit(s) and accessories for conformance with specification and drawings.

C. Verify availability of appropriate pacing signal.

D. Maintain variable frequency drive in upright position at all times.

E. Protect adjustable frequency drive against damage. Store drive in clean, dry environment with temperature and humidity within range as specified by drive manufacturer. Energize space heaters during storage as recommended by manufacturer.

3.02 INSTALLATION

A. Erect, install, and start-up equipment.

B. The VFDs shall be installed as shown on the drawings, in accordance with the manufacturer’s installation instructions, and accepted shop drawings.

C. Install VFDs to allow complete door swing required for component removal. This is specifically required where a VFD is set in the corner of a room.

D. Factory-trained service personnel, other than sales representatives, shall supervise field installation, inspect, make final adjustments and operational checks, make functional checks of spare parts, and prepare a final report for record purposes. Adjust control and instrument equipment until this equipment has been field tested.

3.03 RUBBER MATS

A. For stand-alone units, three foot wide rubber mats shall be furnished and installed on the floor and in front of each VFD assembly. The mats shall be long enough to cover the full length of each VFD system. The mats shall be 1/2-inch (12 mm) thick with beveled edges, canvas back, solid type with corrugations running the long way, and shall be guaranteed extra quality, free from cracks, blow holes or other defects detrimental to their mechanical or electrical strength. The mats shall meet the requirements of ASTM D178 for Type II, Class 4 insulating matting.

3.04 FIELD TESTING

A. Provide in accordance with Section 01 43 00 “Quality Requirements”.

B. Perform testing checkout, and start-up for VFD equipment under technical direction of manufacturer's service engineer. Under no circumstances energize any portion of the drive system without authorization from manufacturer's technical representative.

C. Field Tests:

1. Test each drive over the total speed range that it will be required to operate through for the load being driven for a minimum of two hours. Determine for each drive, motor, and load combination the following at minimum speed, maximum speed, and at 1/3 and 2/3 points between the minimum and maximum speeds:

   a. Input power (kW), voltage, current and RMS power factor on the line side of the drive isolation device.

   b. Output to the driven load in kilowatts.

   c. For each drive, measure the harmonic voltage distortion and harmonic current distortion for each harmonic at the main distribution bus for maximum and minimum load conditions.

   d. Measure the total harmonic voltage distortion and total harmonic current distortion at each PCC for maximum and minimum load conditions.

2. Test each drive by using the actual control signal for remote and local operation.

3. Test each drive’s alarm functions.

4. Perform all tests in the presence of the Owner's representative.

5. Perform the above test in addition to the manufacturer's normal field tests.

6. Submit final test report with summary comparing field test data with harmonic analysis design calculated values for each drive.

7. Testing determined not in compliance with Contract documents shall be repeated by the Contractor at no additional cost to the Owner.

3.05 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, reprogram, and maintain the equipment.

B. Training shall be a minimum of four (4) hours in operation and maintenance for up to five (5) Owner representatives. Schedule training with at least five (5) working days advance notification.

3.06 CONTRACT CLOSEOUT

A. Provide in accordance with Section 01 77 00 “Execution and Closeout Requirements”.

END OF SECTION

SECTION 26 32 13

ENGINE GENERATORS

PART 1 - GENERAL

1.01 DESCRIPTION

A. Provide and test ready for operation, three (3) natural gas engine-generator sets complete with appurtenances as indicated and in compliance with Contract Documents.

B. The unit shall be provided in an outdoor, weatherproof, sound attenuated enclosure.

C. The units shall have a 1000 kW (1250 kVA) power rating, standby, at .80 lagging power factor, three-phase, 60-Hertz, 480/277 volt, three-wire, four-wire alternating current generator. Rating shall be based on an altitude of approximately 4500'.

D. The units shall be arranged for automatic starting and stopping, and load transfer upon failure of the normal source of power through automatic throw over system. The engine generator sets shall exhibit less than 20 percent voltage dip and less than 5 percent frequency dip during starting of the connected loads shown on the Contract Drawings one-line diagrams.

E. The engine-generator package shall be complete in all respects and shall include all equipment and controls necessary for a fully operational standby power supply system.

F. Provide galvanized steel platform and steps, with railing system at both sides of the engine generator sets to allow servicing the units from a raised platform.

1.02 REFERENCES

A. Electrical Generating Systems Association (EGSA):

1. 101P: Engine Driven Generator Sets.

B. Institute of Electrical and Electronics Engineers (IEEE):

1. 1: General Principles for Temperature Limits in the Rating of Electric Equipment and for the Evaluation of Electrical Insulation.

2. 43: Recommended Practice for Insulation Testing of Large AC Rotating Machinery

3. 112: Test Procedures for Polyphase Induction Motors and Generators.

4. 120: Master Test Guide for Electrical Measurements in Power Circuits.

C. National Electrical Manufacturers Association (NEMA):

1. AB 1: Molded-Case Circuit Breakers, Molded Case Switches, and Circuit-Breaker Enclosures.

2. ICS 2: Standard for Industrial Control and Systems: Controllers, Contractors, and Overload Relays Rated Not More than 2000 Volts AC or 750 Volts DC: Part 8 - Disconnect Devices for Use in Industrial Control Equipment.

3. ICS 6: Standard for Industrial Controls and System Enclosures.

4. MG 1: Standard for Motors and Generators.

5. PB 1: Standard for Panelboards.

6. SG 6: Standard for Power Switching Equipment.

7. MW36-C: Magnet wire.

D. National Fire Protection Association (NFPA):

1. 30: Flammable and Combustible Liquids Code.

2. 37: Installation and Use of Stationary Combustion Engines and Gas Turbines.

3. 70: National Electrical Code (NEC).

4. 110: Standard for Emergency and Standby Power Systems.

E. Society of Automotive Engineers International (SAE):

1. ARP892: DC Starter-Generator, Engine.

2. J537: Storage Batteries

F. Underwriters Laboratories (UL):

1. 142: Steel Aboveground Tanks for Flammable and Combustible Liquids.

2. 489: Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures.

3. 508A: Industrial Control Panels.

4. 1236: Standard for Safety Battery Charges for Charging Engine-Starter Batteries.

5. 1446: Systems of Insulations Materials.

6. 2200: Stationary Engine Generator Assemblies.

G. Lateral Force Design Criteria as per applicable requirements for place of installation

1.03 SUBMITTALS

A. Submit shop drawings and manufacturers' product data in accordance with the requirements of Section 26 05 10 “Electrical Work – General”.

B. Submit shop drawings to show physical arrangements, connections, finishes, provisions for connections, access requirements for installation and maintenance, physical size, mechanical and electrical characteristics and ratings, foundation and support details, and equipment weights, where such details are not indicated on the catalogue cuts. The drawings and sketches shall be prepared in the latest version of AutoCAD. Within thirty (30) days after award, the vendor shall submit a complete set of shop drawings and product data. Provide specific data on the following:

1. Outline drawings showing overall assembly and drawings illustrating arrangement (plan, front, and side views) and lifting provisions.

2. Certified outline plan, general arrangement (setting plan), and anchor bolt details, including locations, sizes and model numbers of seismic isolators. Drawings shall show the total weight and center of gravity of the assembled engine-generator set on the structural steel sub-base.

3. Arrangement detail of exhaust duct and muffler piping systems and the natural gas piping systems.

4. Arrangement, size, and location of all electrical interface points and detailed elementary, schematic, wiring, and interconnection diagrams of the generator, exciter, governor, and other integral devices. Provide a wiring diagram including a complete schematic diagram.

5. Dimensional drawings or catalog cuts of the exhaust silencer, oxidation catalyst, intake filter, pumps, starting equipment, battery chargers, batteries, battery racks, generator enclosure (if required) and dBA rating, and other auxiliary equipment.

6. Arrangement or assembly drawings showing location of major auxiliary equipment in relation to the engine-generator set and details of fabricating all supports and connections thereto.

7. Piping schematics for natural gas oil showing pipe sizes and valve locations.

8. Engine-generator control panel.

9. Specifications for a suitable fuel showing consumption performance using this fuel.

10. Certified factory test.

C. A copy of this specification section with addenda and all referenced specification sections with addenda, with each paragraph check-marked to indicate specification compliance.

1. Failure to include a copy of the marked-up specification sections will result in return of the entire submittal without further review and consideration until the marked-up specification are resubmitted with the entire package.

D. Outline equipment and enclosure drawings, equipment catalog cuts, wiring and connection diagrams and other documents required to completely describe the systems and equipment being furnished. Elevation drawings with shipping splits and estimated weights identified.

E. Identification, description and dimensions.

F. Engine-generator skid base drawings including spring vibration isolators. Drawings shall indicate size and location of anchor bolts, and conduit electrical device locations.

G. Performance specifications of all items of equipment.

H. Control panel layout drawings, dimensions, and component bill of materials. Outline drawings showing conduit entry areas and anchoring information. Description of control including operation of interface equipment.

I. Complete electrical, instrumentation, control and wiring diagrams in sufficient detail to allow installation of instrumentation and controls and electrical components.

J. Provide certificate of conformance to UL Standard 2200, Stationary Engine Generator Assemblies.

K. Attenuation curve for the silencing equipment as offered to accomplish the required silencing for this installation.

L. Information on the proposed jacket water treatment and procedures for flushing of the cooling systems.

M. Operations and Maintenance Manuals, covering all equipment furnished, annotated to reference only the specific model numbers supplied. Include parts lists and parts prices current to the date of submittal; include information relevant to part supply and ordering. Submit prior to the startup and testing of the engine/generator units. Submit in accordance with Section 01 33 00 “Submittals”, 01 78 23 “Operation and Maintenance Data” and as specified herein.

N. Maintenance Manuals:

1. Submittals shall include, but not be limited to, five (5) copies of the items listed below. Electronic files of all drawings and sketches using the latest version of AutoCAD. In addition, the vendor shall include any additional procedures judged necessary by the manufacturer to insure the maximum performance and service reliability for the engine-generator set.

2. The engine shop manual(s) including complete service instructions.

3. Parts list with the manufacturer's or interchangeable part number.

4. Drawings of the engine-generator set with center of gravity clearly indicated.

5. Schematic and wiring diagrams of all power and control circuits for the engine-generator set and all its appliances and options.

6. Fuel system piping diagram.

O. Manufacturer's certified shop test record of complete engine driven generator unit.

P. As-built drawings and material summary shall be shipped with the equipment.

Q. Engine generator loading calculation, per the requirements of the connected loads shown on the one-line diagrams and other Contract Drawings.

R. Data to be provided by engine generator system supplier:

1. Submit generator loading calculations and data for engine, generator, and accessories: (for rated kW capacity).

a. Engine Data:

(1) Manufacturer.

(2) Model.

(3) Number and arrangement of cylinders:

(a) RPM.

(b) Bore X stroke.

(c) Maximum power at rated RPM.

(d) BMEP at rated kW (including any parasitic loads and generator efficiency).

(e) Piston speed, feet per minute.

(f) Make and model of governor.

(g) Make and model of overspeed shutdown device.

b. Generator Data:

(1) Manufacturer.

(2) Model.

(3) Rated kVA.

(4) Rated kW.

(5) Voltage.

(6) Temperature rise above 40 degrees C ambient. Stator by thermometer and field by resistance in degrees C.

(7) Class of insulation.

(8) Generator efficiency including excitation losses at 80 percent PF:

(a) Full load.

(b) Three quarters load.

(c) Half load.

(9) Generator subtransient reactance in ohms and Per Unit value.

c. Guaranteed maximum fuel consumption rate at generator terminals:

(1) Full load.

(2) Three-quarters load.

(3) Half load).

d. Generator unit and accessories.

e. Weight of complete unit, with break down by engine-generator set.

f. Exhaust gas emissions data, maximum values at full load, 3/4 load, 1/2 load, and 1/4 load:

(1) Temperature in degrees F (degrees C).

(2) Flow in ACFM (mass and volume) (L/s).

g. Combustion air requirement in CFM (L/s).

h. Cold cranking amperes rating of engine starting batteries (CCA) at 0 degrees F (-18 degrees C).

S. Performance Test Reports: Upon completion of installed system, submit in booklet form all field tests performed to prove compliance with specified performance criteria including final settings of devices.

1.04 QUALITY ASSURANCE

A. Provide in accordance with Section 01 43 00 “Quality Requirements” and as specified.

B. Contractor to ensure that conduit size and wire quantity, size, and type are suitable for the equipment supplied. Contractor to review the proper installation of the equipment and of each type of device with the equipment supplier prior to installation. The following service times are per generator.

1. Services of Service Engineer, specifically trained on type of equipment specified. Person-day requirements listed exclusive of travel time.

a. Assist in location of devices, methods of mounting, field erection, etc.

(1) 1 person-day

b. Start-up and testing.

(1) 10 person-days

c. Service-inspections during first year of operation, for use at Owner's request, and exclusive of repair, malfunction or other trouble-shooting service calls:

(1) 2 person-days

d. Person-day is defined as one 8-hour day, excluding travel time.

C. Anchorage of the system shall be designed to comply with the current applicable seismic source within 2 kilometers of the place of installation. The dead load assumed to resist overturning shall not exceed 0.75W.

D. Manufacturer's Representative: Furnish the services of a qualified field engineer, experienced in the installation and operation of the type of systems being provided, to supervise the installation, testing, adjustment of the system, and to provide training for personnel.

E. Manufacturer's Responsibility:

1. The engine-generator set shall be manufactured by a single manufacturer who has been regularly engaged in the production of engine-generator sets for a minimum of 10 years. The emergency generator system described herein, including these components shall be factory built, factory-tested at rated load, starting duty and power factor, and shipped by this single manufacturer, so there is one source of supply and responsibility for guarantee, parts, and service. This manufacturer shall

have a local representative in the Provo, UT Area who can provide factory-trained servicemen, required stock of replacement parts, and technical assistance.

2. The emergency generator system shall meet all requirements of NFPA 110, Level 2, including design specifications, prototype tests, one-step full load pickup, and installation acceptance.

3. The responsibility for performance to this Section in its entirety shall not be split up among individual suppliers of components comprising the system but shall be assumed solely by the engine-generator set manufacturer. All controls shall be the standard of the engine-generator set manufacturer. Control parts shall be identified by parts numbers of this manufacturer and shall have second source listing where applicable. Control systems that are supplied by a vendor and not incorporated within the documentation drawings of the engine-generator set manufacturer are not acceptable.

1.05 DELIVERY, STORAGE AND HANDLING

A. Provide in accordance with Section 01 66 10 “Delivery, Storage and Handling” and as specified.

B. Protect all equipment placed into storage from weather, humidity and temperature variations, dirt, dust, and other contaminants.

1.06 REGULATORY REQUIREMENTS

A. Local State and City Air Pollution Control Laws.

B. Provide all required data and information for a Title V local air pollution control district operating permit.

C. Federal Clean Air Act (42 United States Code (U.S.C.) 7401 et. seq.)

D. Federal Air Pollution Control Regulations: 40 Code of Federal Regulations (CFR) Parts 50-99, as amended by the Federal Register.

E. Furnish to the Owner, within 15 working days of the date of any request, all documents and other information required to verify compliance with permit and applicable air pollution control laws and regulations, including EPA Tier 2 emission requirements in effect at the bid date of the project.

1.07 WARRANTY AND SERVICE

A. Provide in accordance with Section 01 78 36.

B. Guarantee all components, parts, and assemblies supplied by manufacturer against defects in materials and workmanship for a period of 24 months.

C. Ensure that equipment manufacturer has local branch office staff with trained, full-time employees who are capable of performing testing, inspecting, repair, and maintenance services.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Cummins Power Generation Inc.

B. Caterpillar Inc.

C. MTU.

D. Kohler.

2.02 GENERAL

A. Engine-generator set shall be a factory-assembled unit that is a standard production unit with existing torsional analysis data. Mixing and matching engine and generator by a third-party supplier is not acceptable. The engine and generator shall be directly connected with a flexible coupling, shall be free from injurious torsional or other vibration.

B. The engine and generator shall be directly connected.

C. The engine-generator set shall allow easy access to the various parts for maintenance purposes.

D. The engine-generator set shall be pre-piped and pre-wired.

E. The complete engine-generator unit shall be free from harmful torsional or other vibration throughout the entire operating range of speed and load. The engine manufacturer shall provide an analysis of the complete engine-generator unit, which shall show where any critical speed will be encountered, together with the order, the frequency and magnitude of any critical speed.

F. The engine-generator set operating in an ambient temperature of 40 degrees C shall have a standby power capacity of not less than that indicated at 0.80 power factor, and shall operate at a speed not to exceed 1,800 rpm. It shall be rated 480/277 volt, as indicated, 3 phase, 4 wire, 60 Hertz.

G. Frequency regulation shall not exceed 3 Hertz for step load from no load to rated load. Frequency variation shall not exceed plus or minus 0.3 Hertz for constant loads from no load to rated load.

H. Voltage regulation for step load from no load to rated load shall be within +/- 4 percent of rated voltage for units up to and including 25 kW and within +/- 5 percent or percent of

rated voltage for units rated 30 kW or higher. Voltage variation shall be within +/ 1 percent of the mean value for constant loads from no load to rated load.

I. The engine generator set shall be mounted on a heavy steel sub-base with spring type vibration isolators.

2.03 GENERATOR

A. Generator shall be rated for continuous duty; shall be rotating field, engine-driven, direct-connected, synchronous type with amortisseur winding. Generator frame shall be dripproof with all openings guarded. Bearings shall be sleeve or sealed ball type. The generator shall be mechanically and torsionally matched to the engine driver and shall be provided to withstand inherent pulsating torques of the engine. Full load efficiency of the combined generator, exciter and regulator shall be not less than 95 percent. The generator windings, insulation and excitation system shall be braced to withstand any possible short-circuit stresses.

B. Generator insulation shall be Class H or F in accordance with NEMA Standard MG1-1.65. Temperature rise shall be in accordance with NEMA Standard MG1-22.40 for continuous duty at all output ratings.

C. Voltage regulator shall be an automatic, temperature compensated, solid-state type with a manual adjustment range of plus or minus 5 percent of rated voltage. The generator windings, insulation and excitation system shall be braced to withstand any possible short-circuit stresses.

D. Exciter shall be PMG type. Minimum rating of exciter shall be as indicated in NEMA Std. MG-1-22.16.

E. Components for field flashing and field discharge shall be included, if required. Fast acting fuses or other protective devices shall be incorporated where failure of regulator or exciter components could result in damage to the generator field or exciter windings.

F. Voltage regulator and static exciter shall be mounted in generator control panel or elsewhere so as to protect from and isolate from vibration.

G. The generator shall conform to the applicable parts of the following standards, unless otherwise specified:

1. NEMA MG1, Motors and Generators.

2. IEEE 43, Recommended Practice for Insulation Testing of Large AC Rotating Machinery.

3. CSA C22.2- No. 100, Motors and Generators.

4. Testing shall be in accordance with IEEE-115 and NEMA MG-1 standards

H. The stator frame shall be fabricated bar and plate steel construction.

1. All insulation materials used in the stator shall have a temperature rating of Class H per IEEE Standard 1. The coils shall be of a formed coil construction using a magnet wire meeting NEMA MW36-C specifications.

2. The complete stator shall be wound with a 2/3 stator winding pitch and processed in a vacuum pressure impregnation chamber. Encapsulation of the stator shall be accomplished with a two-part epoxy system.

I. Generator lead terminal box shall be of ample size to accept and terminate connecting cables as indicated on the drawings. Generator leads shall be furnished with terminal connectors suitable for the customers connecting cables.

J. Provide generator stator winding heater with thermostat wired at 120 VAC to prevent formation of condensation.

2.04 ENGINE

A. Heavy-duty compression-ignition, cold-starting natural gas type arranged for direct connection to an alternating current generator. It shall be a current model of a type in a regular production by a manufacturer regularly engaged in building this type of engine. Engine shall have at least a published intermittent brake horsepower rating at specified generator speed required by generator at rated full load output and shall operate without undue heating, vibration, or wear.

B. Engine may be a two-cycle or four-cycle and may be naturally aspirated, scavenged, or turbocharged.

2.05 ENGINE ELECTRICAL SYSTEM

A. Electrical system shall include a battery, starting motor, voltage and current-regulated charging generator or alternator, and a separate battery charger. Battery shall be of suitable capacity to start engine at conditions specified and shall be guaranteed for three years.

B. Battery charger shall be automatic, two rate type providing for equalizing charge and continuous taper charging. Output characteristics shall match requirements of battery furnished. Provide charger suitable for operation on 120 volt, single-phase, 60 Hertz current to be rated not less than 10-amp direct current. Furnish battery charger with following features:

1. Direct current voltage regulation: +/- 2 percent for variations in line voltage of +/ 10 percent.
2. Direct current voltmeter and direct current ammeter, each with suitable scales.
3. Automatic surge suppressor.
4. Automatic current limiting to prevent overloading due to engine cranking, shorted output or reversed battery connections.
5. Alternating current line fusing.

6. Equalize charge rate with manually set timer.
7. Integral protection to prevent battery discharge through charger on loss of alternating current line voltage.
8. Terminal block with terminals for all external connections.
9. Dry contacts to indicate charger failure.

C. Provide battery rack to accommodate starting batteries and supporting rack for battery charger. Rack shall be mounted in the enclosure.

D. Provide 120 VAC battery pad heater with thermostat.

2.06 ENGINE APPURTENANCES

A. Furnish engine with following appurtenances:

1. Combustion air cleaner of oil bath type or dry replaceable filter type. A tube shall connect crankcase breather with air cleaner to prevent accumulation of objectionable smoke and fumes.

2. Critical grade exhaust silencers complete with drains and flexible stainless-steel connection. The entire exhaust system shall be insulated.

B. Governors:

1. Provide electronic type governor capable of maintaining engine speed from no load to full load within 3 percent of synchronous speed.

2. Provide governors equipped with load sensing and load sharing controls.

2.07 CONTROL PANELS

A. Provide a fully solid-state, microprocessor based, generator control panel wired, tested and shock mounted on the generating set by the manufacturer of the generating plant.

B. Provide the following functionality integral to the control panel:

1. A minimum 64 x 240 pixel white backlight graphical display with text based alarm/event descriptions.
2. A minimum of 3-line data display.
3. Audible horn for alarm and shutdown with horn silence switch.
4. Standard ISO labeling
5. Multiple language capability
6. Remote start/stop control. Provide for multiple start/stop signals on separate inputs.
7. Local run/off/auto control integral to system microprocessor
8. Cool down timer
9. Speed adjust
10. Lamp test
11. Push button emergency stop button

12. Voltage adjust
13. Voltage regulator V/Hz slope – adjustable
14. Power Factor Control for paralleling units
15. Password protected system programming
16. Paralleling functions, including automatic and manual synchronizing, dead bus arbitration, load sharing, and load sense/load demand (LSLD).
17. Paralleling up to 16 generator sets (MGDL operation) or up to 8 generator sets (hard wired operation)
18. Automatic transfer/ Auto mains failure (AMF) functionality
19. Single generator to utility paralleling operation for temporary and extended utility paralleling operation.

C. Provide the panel with the following Digital indications:

1. AC voltage, 3-phase (L-L and L-N)
2. AC amps (3-phase and total)
3. KW (total and per phase)
4. KVA (total)
5. KVAR (total)
6. KWHR (total)
7. KVARHR (total)
8. PF (average total and 3-phase)
9. % of rated (total)
10. Frequency
11. DC voltage
12. System diagnostic
13. Excitation voltage
14. Excitation current
15. Engine oil pressure
16. Engine oil temperature
17. Engine coolant temperature
18. Engine RPM
19. Battery volts
20. Engine hours
21. Engine crank attempt counter
22. Engine successful start counter
23. Service maintenance interval
24. Real time clock
25. Oil filter differential pressure
26. Fuel temperature
27. Fuel pressure
28. Fuel filter differential pressure
29. Fuel consumption rate
30. Total fuel consumed
31. Engine intake manifold temperature
32. Engine intake manifold pressure
33. Engine crankcase pressure

34. Air filter differential pressure
35. Boost pressure
36. Oil filter differential pressure

D. Provide alarm indication and subsequent shutdown for the following conditions (Store in the control panel the first and last occurrences of all alarms and shutdowns with a time, date, and engine hour stamp):

1. Low oil pressure alarm/shutdown
2. High coolant temperature alarm/shutdown
3. Loss of coolant shutdown
4. Overspeed shutdown
5. Overcrank shutdown
6. High intake manifold temperature alarm/shutdown
7. High exhaust manifold temperature alarm/shutdown
8. High crankcase pressure alarm/shutdown
9. High air inlet temperature alarm/shutdown
10. Emergency stop depressed shutdown
11. Low coolant temperature alarm
12. Low battery voltage alarm
13. High battery voltage alarm
14. Control switch not in auto position alarm
15. Battery charger failure alarm
16. Generator over voltage
17. Generator under voltage
18. Generator over frequency
19. Generator under frequency
20. Generator reverse power
21. Generator overcurrent
22. Loss of excitation alarm/shutdown
23. Instantaneous over excitation alarm/shutdown
24. Time over excitation alarm/shutdown
25. Rotating diode failure
26. Loss of sensing
27. Loss of PMG

E. Provide accessible through a single electronic service tool all engine, voltage regulator, control panel and accessory units. Provide the following maintenance functionality:

1. Engine running hours display
2. Service maintenance interval (running hours or calendar days)
3. Engine crank attempt counter
4. Engine successful starts counter
5. 20 events are stored in control panel memory
6. Programmable cycle timer that starts and runs the generator for a predetermined time. The timer shall use 14 user-programmable sequences that are repeated in a 7-day cycle. Each sequence shall have the following programmable set points:

a. Day of week
b. Time of day to start
c. Duration of cycle

F. Provide Ethernet port for communication with SCADA system via Modbus TCP/IP.

G. Parallel Engine Generators:

1. Automatic reactive output power control and load sharing between engine generators operated in parallel.
2. Automatic regulation, automatic connection to a common bus, and automatic synchronization, with manual controls and instruments to monitor and control paralleling functions.
3. Protective relays required for equipment and personnel safety.
4. Paralleling suppressors to protect excitation systems.
5. Reverse power protection.
6. Loss of field protection.

2.08 CIRCUIT BREAKER

A. Provide circuit breaker with solid-state adjustable instantaneous and short time delay features and ground-fault protection.

2.09 ENGINE COOLING SYSTEM (RADIATOR COOLED)

A. Provide a unit-mounted radiator with integral jacket water circulating pump, and thermostatic control for cooling system.

B. Provide radiator of sufficient capacity to operate engine at full rated generator load at 120 degrees F (50 degrees C) ambient temperature.

C. Provide radiator with flange for connection to exhaust duct specified under Heating and Ventilating.

D. Provide engine coolant heater rated 208V, single phase, with thermostat.

E. Engine cooling system shall be charged with inhibited ethylene-glycol solution to provide antifreeze protection to -10 degrees F.

2.10 ENGINE LUBRICATION

A. Provide full pressure system, supplying oil to all surfaces requiring lubrication. Circulation shall be by positive displacement pump. Full flow-type filters or filters with bypass feature shall be included. Filter elements shall be replaceable without disconnecting oil piping. Provide an oil cooler, if recommended by engine manufacturer, to properly lubricate engine at full rated generator load. Provide full charge of new oil after tests have been completed.

2.11 ENGINE GENERATOR SET ENCLOSURE

A. Provide sound attenuated, weather-proof outdoor, walk-in type enclosure.

B. Rigidity wind test equal to 120 mph.

C. Roof load equal to 30 psf.

D. Rain test equal to 5 inches per hour.

E. Certified to meet following codes:

1. IBC Code.

F. Building to consist of roof, two side walls, and two end walls of pre-painted aluminum stressed-skin construction, door and door frame, lifting rings, mounting frame, insulation, electrical package, louvers, exhaust fan, muffler mounting bracket, and other appurtenances to make complete installation.

1. Roof:

a. One piece combered roof sheet, min. 0.040 inch thick aluminum alloy, with extruded recessed side and end rails.

b. Roof bows, extruded "I" beams, spaced as required to carry loads.

2. Walls:

a. Posts to be extruded aluminum sections, sized and spaced as required to carry loads.

b. Panels to be min. 0.045 inch thick aluminum sheet, mill-pre-painted, inside and outside, and riveted to posts.

3. Door and Door Frame:

a. Provide welded aluminum door frame of extruded aluminum alloy, riveted to side panels.

b. Provide personnel door gasketed to form weathertight seal, panic bar hardware with three-point stainless steel locks and opening from inside in locked condition.

4. Lifting Rings:

a. Provide four lifting rings, two in each side of roof, for lifting shelter only. Capacity of lifting rings to match load.

5. Mounting Frame:

    a. Provide steel perimeter mounting frame for mounting onto concrete pad.

6. Insulation:

    a. Provide semi-rigid fiberglass thermoacoustic insulation.

7. Sound Attenuation:

    a. Provide sound attenuating features in the enclosure to maintain a maximum sound pressure level of 70 dBA at 7 meters with the generator operating at full load.

8. Electrical Package:

    a. All equipment and devices UL listed. Provide 120/208V, 1-phase, 4-wire, with 60-amp main breaker. Provide eight (8) 20 amp branch circuit breakers. Panelboards shall conform to the latest NEMA standards, National Electrical Code and Underwriters Laboratories, Inc.

    b. Circuits as follows:

        (1) No. 1 - Lighting
        (2) No. 2 - Receptacles
        (3) No. 3 - Electric Heater
        (4) No. 4 - Exhaust Fan
        (5) No. 5 - Engine and Battery Heaters
        (6) No. 6 - Battery Charger
        (7) No. 7 - Motorized Dampers
        (8) No. 8 - Spare

    c. Electric heater, control stations, and thermostat shall be as recommended by the manufacturer, subject to review by the Engineer.

    d. Receptacles shall be duplex, 20-amp, 125-volt, 3 pole, 2 wire and shall be a ground fault interrupter receptacle.

    e. Light switch shall be toggle type, 15-amp, 120-volt, single pole.

    f. Light fixtures shall be a ceiling or pendant mounted enclosed and gasketed vapor tight LED type with acrylic lens.

9. Manual Motor Starters:

    a. Provide manual motor starters where indicated and for 120 volt, 60-Hertz fractional horsepower motors that do not have built-in thermal overload devices.

b. Manual starters within sight of motors, as defined by NEC.

10. Louvers:

a. Provide louvers and dampers for engine generator inlet and exhaust and ventilation air.

b. Fixed louvers, all aluminum construction, riveted into aluminized steel frame to form rigid, water resistant assembly. Motorized dampers as specified hereinafter.

c. Properly size louvers and dampers to allow sufficient engine combustion air, radiator cooling air, and ventilation air with maximum 0.5-inch water (125 Pa) restriction. Coordinate with engine generator manufacturer.

11. Muffler Mounting Bracket:

a. Provide suitable bracket to secure critical grade generator silencer within the enclosure.

b. Coordinate with engine generator supplier as required.

2.12 PAINT

A. Paint for exterior surfaces of equipment shall be two coats of acceptable oil- and heat-resistant paint, applied after surfaces have been thoroughly cleaned and prepared with suitable priming coat.

B. Provide touch-up paint in a quart container to Owner for use in field.

2.13 TOOLS

A. Provide in accordance with Section 01 66 10.

B. Provide all special tools required for maintenance and repair of unit in metal box complete with lock and keys.

2.14 FACTORY TESTING

A. The complete engine-generator sets with enclosure shall be factory tested at full load using a 0.8 power factor reactive load bank to simulate a complete and integrated system prior to shipment.

B. Provide all details of the proposed testing, including arrangements, test instruments and calibration, and procedures to be used to verify controls and alarms. The completed certified test record shall be submitted within 30 days after the completed test.

C. Tests shall verify that unit will operate successfully and meet all specified operational requirements and verify adequate means of enclosure ventilation is provided.

D. The factory test shall include four continuous hours of operation at full load and rated power factor. Voltage and frequency regulation and transient response shall be tested and recorded to show full compliance with this specification. During the factory test, readings shall be taken and recorded every thirty minutes for each of the following:

1. Time.
2. Ambient temperature.
3. Volts for each phase.
4. Load:
    a. Amps for each phase.
    b. kW.
    c. Power factor.
    d. Frequency.
5. Engine jacket water temperature.
6. Lubricating oil pressure.
7. Exhaust gas temperature.
8. Fuel consumption.
9. Noise Level measured 3 feet from source (dB)

E. The procedure for the factory test of the engine shall include the engine manufacturer's standard practice.

PART 3 - EXECUTION

3.01 COORDINATION

A. Coordinate with ventilation, fuel supply, and exhaust, to provide an efficient, well-coordinated layout.

3.02 INSTALLATION

A. Install unit complete and make operational.

B. Install muffler horizontally on spring type compensating hangers in generator enclosure.

C. Provide 1/2-inch (12 mm) copper drain with draincock from bottom of muffler to nearest floor drain for periodic draining of muffler.

D. Install engine at sufficient height above base to permit dropping oil pan without removing unit.

E. Provide vibration isolation of exhaust equipment to prevent transfer of vibration into building components enclosing the standby power system.

F. External conduit and wiring and transfer switch will be furnished and installed under applicable electrical sections, but all conduit, wiring and connections between the engine and its control panel and generator and its control panel, is included herein.

G. Mount engine-generator set on a structural steel frame or skid. Provide vibration isolators suitable to prevent transmission of vibration to building structure between set and frame, and securely anchored to the concrete foundation. Obtain from supplier of engine-generator set a drawing giving location and size of foundation bolts for unit proposed, in sufficient time to be available when needed to place foundation. Galvanized anchor bolts shall be furnished by engine-generator set manufacturer.

H. Electrical equipment and materials shall be listed by UL wherever standards have been established by that agency.

3.03 WIRING AND CONNECTIONS

A. Provide conduit, wiring, and connections required and recommended by unit supplier. All conduit shall be terminated with flexible conduit. All wiring shall be multi-stranded.

B. Connect neutral point of generator and generator frame to ground by green insulated copper conductor of adequate size.

C. Connect motorized dampers in cooling and exhaust equipment to auxiliary contact on transfer controls to open dampers when unit is energized.

3.04 EQUIPMENT START-UP

A. Operate the unit to demonstrate ability to operate continuously without vibration, jamming, leaking or overheating and to perform specified functions, after installation and after manufacturer's representative check of installed equipment.

B. Comply with manufacturer's operating and maintenance instructions during start-up and operation.

C. Make all final adjustments necessary to place the equipment in working order. Prior to any testing or operation of the units, the manufacturer's service representative shall inspect the installation, and shall certify, in writing, that the assemblies are, in all ways, ready for operation. Start-up shall not commence without the presence of the manufacturer's representative.

3.05 FIELD TEST

A. Upon completion of the installation and as soon as conditions permit, the engine driven generator, including the engine, generator, electrical circuit controls, transfer controls other devices shall be tested in the presence of the Owner by the service representative for the manufacturer of the engine driven generator unit to verify that the system functions as specified.

1. Perform load test with 0.8 power factor reactive load bank connected to the generator for a full load nameplate test. Run the test for a duration of four hours. Take system data readings each 20 minutes. Contractor to provide load bank for testing.

2. The manufacturers' representatives shall make such changes in wiring or connections and such adjustments, repairs or replacements to make the circuit, device or control system function as specified and comply with the Contract Documents.

3. Acceptance of test will be verified when the unit operates without alarm or abnormal conditions for the duration of the entire test. Retest if this requirement is not met until acceptance criteria has been verified.

B. Record in 20-minute intervals during four-hour test:

1. Kilowatts
2. Amps
3. Voltage
4. Coolant temperature
5. Air temperature
6. Frequency
7. Oil pressure

C. As part of the field test, each of the automatic shutdown devices shall be tested and the respective values recorded at which the devices will stop engine. Any adjustments required shall be made in the devices to make the operating values correspond to those recommended by the engine manufacturer and as recorded during the stop test.

3.06 CONTRACT CLOSEOUT

A. Provide in accordance with Section 01 77 00 “Execution and Closeout Requirements”.

END OF SECTION

SECTION 26 32 14

LOAD BANK

PART 1 - GENERAL

1.01 DESCRIPTION

A. This specification contains the minimum requirements for the design, manufacture and testing of outdoor weatherproof resistive load bank.

1.02 REFERENCES

A. The equipment covered by this specification shall be designed with the latest applicable NFPA-70, NEMA, NEC, IEEE, and ANSI standards.

B. The load bank certified to a Nationally Recognized Training Laboratory (NRTL) such as UL.

1.03 SUBMITTALS

A. Submit shop drawings and manufacturers' product data in accordance with the requirements of Section 26 05 10 “Electrical Work – General”.

B. The manufacturer shall submit for review technical data including features, performance, electrical characteristics, physical characteristics, ratings, accessories, and finishes.

C. Shop drawings shall include dimensional plans and mounting details sufficient to properly install the load bank. Load bus configuration and load connections termination area shall be clearly identified.

D. Electrical schematic drawings shall be provided to detail the operation of the load bank and the provided safety circuits. Over-current protection and control devices shall be identified and their ratings marked. An interconnection drawing shall be included for control wiring related to the load bank.

E. Performance Test Reports: Upon completion of installed system, submit in booklet form all field tests performed to prove compliance with specified performance criteria including final settings of devices.

1.04 QUALITY ASSURANCE

A. Provide in accordance with Section 01 43 00 “Quality Requirements” and as specified.

B. Contractor to ensure that conduit size and wire quantity, size, and type are suitable for the equipment supplied. Contractor to review the proper installation of the equipment and of each type of device with the equipment supplier prior to installation.

C. Manufacturer's Representative: Furnish the services of a qualified field engineer, experienced in the installation and operation of the type of systems being provided, to supervise the installation, testing, adjustment of the system, and to provide training for NTMWD personnel.

1. Services of Service Engineer, specifically trained on type of equipment specified. Person-day requirements listed exclusive of travel time.

a. Assist in location of devices, methods of mounting, field erection, etc.

(1) 1 person-day

b. Start-up and testing.

(1) 2 person-days

c. Person-day is defined as one 8-hour day, excluding travel time.

1.05 DELIVERY, STORAGE AND HANDLING

A. Provide in accordance with Section 01 31 00 “Project Management and Coordination” and as specified.

B. Protect all equipment placed into storage from weather, humidity and temperature variations, dirt, dust, and other contaminants.

1.06 WARRANTY AND SERVICE

A. Provide in accordance with Section 01 31 00 “Project Management and Coordination”.

B. Guarantee all components, parts, and assemblies supplied by manufacturer against defects in materials and workmanship for a period of 12 months.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. ASCO.

B. Approved Equal.

2.02 GENERAL

A. The following specification is based on Model 3110 as manufactured by ASCO and is named to establish standards of quality. Equal products of other manufacturers conforming to these specifications may be provided as approved by the Engineer.

2.03 RATINGS

A. The total capacity of the load bank system shall be rated at a minimum of 1000 kW 480 Volts, 3-Phase, 4-Wire, 60 Hertz, at 0.8 pf.

B. The duty cycle shall be continuous, and the load bank shall operate in an ambient temperature of 40°C (102°F).

C. Load steps are in minimum increments of 1 kW switchable to 100% of load.

2.04 ENCLOSURE CONSTRUCTION

A. The load bank is packaged in an enclosure.

B. The frame of the load bank is constructed from 2mm ‘Zintec’ steel, folded and welded to form a monocoque construction.

C. Double skinned recessed doors allow easy access to the separate enclosures for control, switch gear and power connections.

D. The double skinned, horizontal discharge duct with aluminised steel heat shield contains the resistive load elements and the cooling fan.

E. Provide stainless-steel mesh screens on the main air inlet and outlet to provide protection against access to hazardous parts to IP1X.

F. All electrical enclosures are to IP54.

G. Provide a four-point lifting frame with corner tie bars to connect the frame to the fork base.

H. High quality two-pack industrial acrylic paint system applied to an electro-plated zinc base and low-bake finish. Grey is color (RAL7042).

2.05 RESISTIVE ELEMENTS

A. Provide with replaceable, non-finned sheathed elements. The outer sheath is made from stainless steel to give good corrosion resistance. The heating element shall be an 80/20 nickel-chrome wire embedded in compacted magnesium oxide powder, providing good thermal and insulation properties.

B. The elements shall be conservatively rated and have no need for cooling fins to dissipate the heat into the airflow.

C. The elements shall be designed to operate continuously at up to 800°C (red/orange). The operating temperature shall be below 500°C (dull red).

D. Load tolerance shall be within 2-1/2% of total capacity.

E. Elements shall be continuously rated at the specific voltage. Short-term tests with fluctuations up to 10% above rated voltage shall be permissible. Tests at lower voltages, with a corresponding reduction in overall rating, may be carried out. Power is proportional to voltage squared.

2.06 PROTECTION

A. Provide with an emergency stop/disconnect switch with full isolation of the fan and control supply.

B. A 110 Volt AC control circuit transformer provides isolation and operator safety.

C. Provide with Stop/start buttons to ensure the load bank will not automatically restart.

D. The fan motor shall be fully protected with fuses and a thermal overload.

E. Each element group and its associated contactor shall be protected by an HRC fuse.

F. The load contactors shall be interlocked with the fan controls to ensure load can be applied only when the fan is running.

G. Internal access hall be restricted by key operated door catches. Polycarbonate screens behind the doors prevent accidental contact with live parts.

2.07 LOAD BANK CONTROL SYSTEM

A. The system shall be controlled by a microprocessor-based module with non-volatile memory, specifically developed for load bank control and protection.

B. All instrumentation measurements shall be made from high accuracy voltage and current transformers located within the load bank.

C. To compensate for the voltage drop between supply and load bank, provision shall be made for remote voltage sensing via terminals.

D. Load bank calibration and configuration shall be software controlled.

E. The system shall have full three phase true RMS instrumentation.

F. A load correction facility shall compensate for any voltage variation to ensure that the correct load is always applied.

G. The system shall be capable of controlling up to 14 load banks including a mixture of resistive/ reactive units with proportional load sharing from one hand-held controller or a single PC.

H. Control shall provide three phase instrumentation to class 0.5 accuracy.

I. Control system shall provide 1kW load step resolution.

2.08 FACTORY TESTING

A. The complete load bank with enclosure shall be factory tested at full load prior to shipment.

B. Provide all details of the proposed testing, including arrangements, test instruments and calibration, and procedures to be used to verify controls and alarms. The completed certified test record shall be submitted within 30 days after the completed test.

C. Tests shall verify that unit will operate successfully and meet all specified operational requirements and verify adequate means of enclosure ventilation is provided.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install unit complete and make operational.

B. Securely anchor to the concrete foundation. Obtain from supplier of load bank a drawing giving location and size of foundation bolts for unit proposed, in sufficient time to be available when needed to place foundation.

3.02 WIRING AND CONNECTIONS

A. Provide conduit, wiring, and connections required and recommended by unit supplier. All conduit shall be terminated with flexible conduit. All wiring shall be multi-stranded.

3.03 EQUIPMENT START-UP

A. Operate the unit to demonstrate ability to operate continuously without vibration, jamming, leaking or overheating and to perform specified functions, after installation and after manufacturer's representative check of installed equipment.

B. Comply with manufacturer's operating and maintenance instructions during start-up and operation.

C. Make all final adjustments necessary to place the equipment in working order. Prior to any testing or operation of the units, the manufacturer's service representative shall inspect the installation, and shall certify, in writing, that the assemblies are, in all ways, ready for operation. Start-up shall not commence without the presence of the manufacturer's representative.

3.04 FIELD TEST

A. The load bank shall be fully tested using a test specification written by the supplier. Tests shall include electrical functional testing, verifying conformance to assembly drawings and specifications.

3.05 CONTRACT CLOSEOUT

A. Provide in accordance with Section 01 77 00 “Execution and Closeout Requirements”.

END OF SECTION

SECTION 26 36 23

AUTOMATIC TRANSFER SWITCHES

PART 1 - GENERAL

1.01 DESCRIPTION

A. This section includes materials and installation of bypass-isolation automatic transfer switches with bypass as indicated and in compliance with Contract Documents.

1.02 REFERENCES

A. National Fire Protection Association (NFPA):

1. 70: National Electrical Code (NEC).

B. National Electrical Manufacturers Association (NEMA):

1. ICS 2: Industrial Controls and Systems Controllers, Contactors, and Overload Relays Rated 600 Volts.

C. Underwriters Laboratories (UL):

1. 1008: Automatic Transfer Switches.

D. Lateral Force Design Criteria as per applicable requirements for place of installation.

1.03 SUBMITTALS

A. Submit shop drawings and manufacturers' product data in accordance with the requirements of Section 26 05 10 “Electrical Work – General”.

B. Submit manufacturer's descriptive data including ratings, circuit diagrams, dimensional data, conduit entry restrictions, and a list of accessories.

1.04 SEISMIC DESIGN REQUIREMENTS:

A. Conform to the requirements indicated on the structural drawings and as specified in Section 01 41 20.

B. Conform to the requirements specified in Section 01 41 20.

C. It shall be the responsibility of manufacturer and supplier along with the Electrical Contractor to conform to the seismic design requirements for this project and for the work of this specification section.

1.05 OPERATION AND MAINTENANCE MANUALS

A. Submit operation and maintenance manuals in accordance with Section 01 78 23 “Operations and Maintenance Data”.

1.06 MANUFACTURER'S SERVICES

A. Provide manufacturer's services at the jobsite for the minimum labor days listed below, travel time excluded:

1. Two labor days to check the installation and advise during start-up, testing, and adjustment of the transfer switches.

PART 2 - PRODUCTS

2.01 TRANSFER SWITCH MANUFACTURERS

A. The transfer switch shall be as manufactured by:

1. Automatic Switch Company (ASCO).

2. Russelectric Co.

3. Zenith (ZTS).

2.02 TRANSFER SWITCH

A. Transfer switch shall be as shown in the drawings. Transfer switch shall have number of poles, amperage, and voltage ratings as shown in the drawings. Withstand current rating shall not be less than 65,000 ampere rms symmetrical.

B. Switch shall be listed per UL 1008 as a recognized component for emergency systems and be rated for all classes of loads.

C. Automatic Open-Transition Transfer Switch: Interlocked to prevent the load from being closed on both sources at the same time.

1. Sources shall be mechanically and electrically interlocked to prevent closing both sources on the load at the same time.

D. Operation shall be inherently double throw where normal and emergency contacts operate simultaneously with a momentary delay in a mid-position. An overload or short circuit shall not cause the switch to go to a neutral position. Do not use main contact structures not originally manufactured for transfer switch service (molded case circuit breakers or contactors). Inspection and replacement of all contacts (stationery and arcing) shall be possible from the front of the switch without any disassembly of operating linkages or power conductors. Provide a handle to permit no-load manual operation.

E. Transfer switches with neutral controls shall have fully rated neutral transfer contacts that momentarily interconnect the neutrals of the two sources during the transfer/retransfer operations. The neutrals shall remain interconnected until the power source contacts close on the source to which the load is being transferred.

F. The automatic transfer switch shall be mechanically held double-throw with a uni-directional drive mechanism. The transfer action shall be completely electrical and shall not rely on springs or counterweights. Operating coils shall be momentarily energized from the source to which the load is being transferred. The switch shall be interlocked electrically and mechanically to prevent simultaneous feeding of the load from both normal and emergency power sources. The transfer switch shall not have an intermediate position. A handle shall be provided to operate the transfer switch mechanism manually in case of automatic drive mechanism failure.

G. Transfer switch shall be draw-out type with automatic secondary disconnects remove control power as switch is withdrawn and automatic shutters isolate bus when the transfer switch is withdrawn.

H. Bypass-Isolation Switch Features

1. Bypass switch and transfer switch have identical electrical ratings.

2. Mechanical interlocks prevent unintended operation.

3. Bypass contacts carry current only during bypass operation.

4. Draw-out design eases transfer switch maintenance.

5. The bypass switch has dead-front quick-make, quick-break operation for transferring loads between live sources.

6. Bypass switch is rated for use as a 3-position manual transfer switch.

7. Bypass-Isolation Handles are permanently mounted

8. Mechanical indicators show bypass and transfer switch positions.

2.03 ACCESSORIES

A. Provide a solid-state sensing and control logic panel. Include the following operational characteristics:

1. Adjustable (0.5 to 6.0 seconds) time delay on engine starting to override momentary dips in normal source, set at 1 second.

2. Full phase voltage relay supervision of the normal source with at least one close differential relay to detect "brownout" condition, set at 70 percent dropout and 90 percent pickup.

3. Voltage/frequency lockout relay to prevent premature transfer, set at 90 percent voltage and 90 percent frequency.

4. Engine starting control contacts. Provide for multiple start control contacts. Provide a minimum of two normally open and two normally closed.

5. Adjustable (2 to 25 minutes) time delay on retransfer to normal, set at 20 minutes.

6. Unloaded running time delay for generator cool down (adjustable 0.1 to 10 minutes), set at 5 minutes.

7. Transfer to emergency time delay (adjustable 1 to 300 seconds), set at 1 second.

B. Provide a system test switch (momentary type) on the front of the enclosure.

C. Manual push button to bypass the time delay on retransfer.

D. Indicating lights to indicate source to which the load is connected.

E. Indicating light to indicate presence of normal power source.

F. Auxiliary contacts for remote indication of switch position, one normally open and one normally closed contact for normal and emergency position. Auxiliary contacts for remote indication of switch failure.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Secure transfer switch rigidly to wall and floor or mounting pad with anchor bolts or Phillips Drill Company concrete anchors. Anchor bolts or concrete anchors shall be Type 316 stainless steel.

3.02 FIELD TESTING

A. Field test per manufacturer's recommended standard test procedure.

B. Field test and calibrate timing and monitoring logic. All adjustments shall be within 5 percent of the previously specified set points.

C. The transfer switch shall be tested under full load rating with external load in accordance with Codes and Standards as specified. The Subcontractor shall be responsible for providing test equipment required for testing under full load rated condition.

D. The transfer switch shall be full load tested. Controls shall be tested under modes of operations.

E. The switch testing shall be performed by the Subcontractor.

F. The Subcontractor shall be responsible for correcting any deficiency found during testing of the unit at no cost to the owner.

G. The Subcontractor shall provide the owner the factory certified test report within five (5) days of the completion of testing.

3.03 CONTRACT CLOSEOUT

A. Provide in accordance with Section 01 77 00 “Execution and Closeout Requirements”.

END OF SECTION

SECTION 26 41 13

LIGHTNING PROTECTION FOR STRUCTURES

PART 1 - GENERAL

1.01 DESCRIPTION

A. Provide lightning protection system on each building and structure consisting of air terminals, conductors, ground terminals, interconnection conductors, arresters, and other connectors or fittings required for a complete system as indicated and in compliance with Contract Documents.

B. All systems are to be designed, furnished and installed by a Lightning Protection Contractor.

1.02 REFERENCES

A. American National Standards Institute/Institute of Electrical and Electronics Engineers (ANSI/IEEE):

1. 837: Standard for Qualifying Permanent Connections Used in Substation Grounding.

2. 70: National Electrical Code (NEC).

3. 780: Lightning Protection Code.

B. Underwriters' Laboratories, Inc. (UL):

1. 96: Lightning Protection Components.

2. 96A: Installation Requirements for Lightning Protection Systems.

1.03 SUBMITTALS

A. Submit shop drawings and manufacturers' product data in accordance with the requirements of Section 26 05 10 “Electrical Work – General”.

B. Shop Drawings:

1. Consisting of a complete list of equipment and materials, including manufacturer's descriptive and technical literature, catalog cuts, installation instructions.

2. Shop drawings indicating type, placement, and location of protection devices, including cable attachments, grounding, mounting and any other details integral with the system.

C. Spare Parts Data: Provide a list of recommended spare parts for the material and equipment to be provided, including current unit prices and source of supply (indicate which supplies are furnished at no extra cost with purchase of equipment).

D. Inspection and Maintenance: Provide a written recommended inspection and maintenance procedure, including periodicity of inspections.

E. Record Drawings: Provide a complete set of "as-constructed" drawings showing the location of all grounds as well as a detailed layout of type, size, location and method of installation of all downleads, roof cables, bonding leads and connections, air terminals, etc., and in the case where structural steel is used for downleads, the method and location of all roof and ground connections to the steel must be clearly detailed.

1.04 QUALITY ASSURANCE

A. Ensure that conduit size and wire quantity, size, and type are suitable for the equipment supplied.

B. Services of Manufacturer's Representative as stated in Section 01 43 00 “Quality Requirements” and as specified herein.

C. Provide systems designed, furnished and installed by a Lightning Protection Contractor.

D. Provide a "Certificate of Compliance" for work performed after completion. The certificate should state that the following has been done:

1. The Contractor has complied with all requirements of Underwriters' Laboratories, Inc. Master Label Service as outlined in UL 96A including the completion and execution of the Master Label application form and the procurement and delivery of the U/L "C" plate to the Owner or his representative.

2. The lightning protection system ground system has been tested and interconnected to the facility grounding system as required by NFPA 70.

3. Record drawings have been turned over to the Owner or his representative.

E. Use UL listed components.

1.05 REQUIREMENTS OF REGULATORY AGENCIES

A. Conform to UL 96 and 96A and NFPA 780.

1.06 DELIVERY, STORAGE AND HANDLING

A. Comply with the requirements specified in Section 01 66 10 “Delivery, Storage and Handling”.

B. Shipping:

1. Ship equipment and materials, complete with identification and quantity of items.

2. Pack spare parts in containers bearing labels clearly designating contents and pieces of equipment for which intended.

3. Deliver spare parts at same time as pertaining equipment. Delivery to Owner after completion of work.

C. Storage:

1. Inspection and inventory items upon delivery to site.

2. Store and safeguard equipment, material and spare parts.

1.07 WARRANTY AND SERVICE

A. Guarantee components, parts, and assemblies supplied by manufacturer against defects in materials and workmanship for a period of 12 months.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Thompson Lightning Protection Company, St. Paul, MN.

B. Heary Brothers Lightning Protection Company, Springville, NY.

C. American Lightning Rod Co., Dover, NH.

2.02 MATERIALS

A. Class I Materials: Provide conductors, fittings, and fixtures necessary to protect ordinary buildings and structures not exceeding 75 feet (23 m) in height.

B. Materials, Class I. Table I gives minimum sizes and weights for air terminals, and main and secondary conductors. Secondary conductors which are used for bonding and interconnecting metallic bodies to the main conductor, and which will not be required to carry the main lightning current, may be reduced in size but not less than No. 6 AWG copper or equivalent. Provide main conductor size for interconnection to metal water systems, steam or hot water heating systems, or other metallic masses having a low resistance to ground.

C. Table I: Class I Material Requirements.

Type of Copper Conductor		Standard	Metric
Air Terminal, Solid	Min. Diameter	3/8-inch	9.5 mm
Air Terminal, Tubular	Min. Diameter Min. Wall Thickness	 0.032 inch	15.9 mm 0.8 mm
Main Conductor, Cable	Min. Size ea. Strand Wgt. per Length Cross Sect. Area	17 AWG 187 lbs/1000 ft. 57,400 cm	 278 g/m 29 square mm
Main Conductor, Solid Strip	Thickness Width	16 AWG 1 inch	 25.4 mm
Secondary Conductor Cable	Wire Size Number of Wires	17 AWG 14	 14
Secondary Conductor Solid Strip	Thickness Width	16 AWG 1/2 inch	 12.7 mm

D. Class II Materials: Provide conductors, fittings and fixtures necessary to protect ordinary buildings and structures exceeding 75 feet (23 m) in height; or one of any height which has a structural steel frame that may be substituted for lightning down conductors. Table II give minimum sizes and weights for air terminals and secondary conductors for Class II structures.

E. Table II: Class II Material Requirements.

Type of Copper Conductor		Standard	Metric
Air Terminal, Solid	Min. Diameter	1/2-inch	12.7 mm
Main Conductor, Cable	Min. Size ea. Strand Wgt. per Length Cross Sect. Area	16 AWG 375 lbs/1000 ft. 115,000 cm	 558 g/m 58 square mm
Secondary Conductor Cable	Wire Size Number of Wires	17 AWG 14	 14
Secondary Conductor Solid Strip	Thickness Width	16 AWG 1/2-inch	 12.7 mm

F. Where any part of a protection system is exposed to mechanical injury, provide protection by covering it with molding or tubing. If ferrous metal pipe or tubing is used around the conductor, connect the conductor electrically to the pipe or tubing at both ends.

G. Furnish conductors made of stranded copper.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Provide all material, equipment, and labor to install the lightning protection system as indicated and as specified.

B. No bend of conductor is to form an included angle of less than 90 degrees nor have a radius of bend less than 8 inches (203 mm).

C. Interconnect all conductors, air terminals to form a two-way path from each air terminal horizontally or downward to connections with ground terminals.

D. Conductors may be coursed through air without support for a distance of 3 feet (900 mm) or less. With a 5/8-inch (15.9 mm) rod or its equivalent as a support, securely fastened at each end, a conductor may be coursed through air for a distance not to exceed 6 feet (1800 mm).

E. Install roof conductors to interconnect all air terminals and provide a two-way path to ground horizontally or downward from the base of each terminal.

F. Install at least two down conductors on any kind of structure. Location depends on placement of air terminals, size of structure, most direct coursing, security against displacement and location of metallic bodies, water pipes, and ground conditions. Separate down conductors as widely as practicable. For structures over 200 feet (60 m) in perimeter, install one additional down conductor for each additional 100 feet (30 m) of perimeter or fraction thereof.

G. Terminate each down conductor at a ground terminal.

H. Bond radio and television masts of metal, located on a protected building, to the lightning protection system with a main-size conductor and fittings.

I. Use connector fittings on all lightning conductors at "end-to-end" "tee" or "Y" splices. Attach them so as to withstand a pull test of 200 pounds (890 N). Make fittings for connection to metal tracts, gutters, downspouts, ventilators, chimney extensions, or other metal parts about the structure tight to the object by compression under bolt heads. Both crimp type and exothermic weld splicers of stamped or cast metal are acceptable under Class I requirements. Do not use crimp type clamps and splicers in Class II installations.

J. Securely attach conductors to the building or other object upon which they are placed. Use fasteners not subject to breakage. Furnish nails, screws and bolts, with which fasteners are secured, of the same material as the conductor or of such nature that there will be no electrolytic corrosion in the presence of moisture because of contact between the different parts. Space conductor fasteners not more than 3 feet (900 mm) apart on all conductors.

K. All requirements covering exposed systems apply to concealed installations. Conductors are coursed the same except that they may be coursed behind the exterior wall facing, in concealed or embedded conduit, or embedded directly in concrete.

L. L. In a concealed installation where conductors are embedded in concrete, bond the reinforcing steel to the cable with a main size conductor. Bond reinforcing steel at the top and bottom of each embedded downlead.

M. Materials, installation methods and procedures are to be in accordance with UL 96 and 96A, NFPA 780, NEC, and local electrical codes. Provide for and obtain a "Certificate of Compliance" for the work performed.

3.02 CLOSEOUT ACTIVITIES

A. Provide in accordance with Section 01 77 00 “Execution and Closeout Requirements”.

END OF SECTION

SECTION 26 43 00

SURGE PROTECTION DEVICES

PART 1 - GENERAL

1.01 DESCRIPTION

A. Provide Surge Protection Devices (SPD) components either integral to or in combination with the electrical distribution system equipment as indicated and in compliance with Contract Documents. The distribution system includes switchboards, motor control centers, 480V distribution panels and 120V panelboards.

B. The components shall provide protection for electrical and electronic devices against the damaging effects of surges, transients and electrical line noise.

C. Where indicated on the electrical contract drawings, provide separate, modular components from the electrical distribution equipment enclosures. Provide conduit, cable and all associated components for a complete SPD system installation. It shall be the Electrical Contractor's responsibility to verify adequate space for locating modular SPD equipment adjacent to associated electrical distribution equipment.

1.02 REFERENCES

A. American National Standard Institute (ANSI)/Institute of Electrical and Electronics Engineers (IEEE):

1. C62.41.1: IEEE Guide on the Surges Environment in Low-Voltage (1000V and Less) AC Power Circuits

2. C62.45: Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000 V and Less) AC Power Circuits

B. Military Standard (MIL):

1. 220A: Radio Frequency Interference and Electromagnetic Interference

C. National Electrical Manufacturers Association (NEMA):

1. 250: Enclosures for Electrical Equipment (1000 volts maximum)

2. LS 1: Low Voltage Surge Protection Devices

D. National Fire Protection Association (NFPA):

1. 70: National Electrical Code (NEC).

E. Underwriters Laboratory (UL):

1. 1449: Standard for Safety, Surge Protective Devices - Fourth Edition.

2. 1283: Standard for Safety, Electromagnetic Interference Filters

1.03 SUBMITTALS

A. Shop drawings, manufacturer's product data, and component ratings in accordance with this section and the requirements of Section 26 05 10 “Electrical Work – General”.

B. SPD type, model number, system voltage, phases, modes of protection, Maximum Continuous Operating Voltage (MCOV) Voltage Protection Rating (VPR), Short Circuit Current Rating (SCCR), and Nominal Discharge Current (In).

C. Provide outline drawings and internal wiring diagrams.

D. List all required installation criteria including circuit breaker trip rating to meet UL 1449, Four Edition.

E. Identify all cable sizes, distance limits and accessory devices when SPD units are to be provided in separate enclosures, where applicable.

F. For informational/purposes only, submit installation instructions and separate from all other submittals.

G. UL 1449 listing and summary of factory test data.

1.04 QUALITY ASSURANCE

A. SPD units and all components shall be designed manufactured and tested in accordance with the latest applicable UL Standard ANSI/UL 1449 Third Edition.

1.05 DELIVERY, STORAGE AND HANDLING

A. Provide in accordance with Section 26 05 10 “Electrical Work – General” and as specified.

B. Shipping:

1. Ship equipment and materials, except where partial disassembly is required by transportation regulations or for protection, complete with identification and quantity of items.

2. Pack spare parts in containers bearing labels clearly designating contents and pieces of equipment for which intended.

3. Deliver spare parts after installation but before start-up of system as specified. Deliver to Owner after completion of work.

C. Storage:

1. Inspect and inventory items upon delivery to site.

2. Store and safeguard equipment, material and spare parts.

1.06 WARRANTY AND SERVICE

A. The SPD manufacturer is to warranty the components against defective materials and workmanship for a period of five years following delivery from the manufacturer.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Surge Protection Device Components.

1. Eaton/Cutler-Hammer.

2. Schneider/Square D

3. Siemens.

4. General Electric Company.

2.02 PROVISIONS

A. Environmental Requirements:

1. Operating Temperature: minus 40 degrees C to 60 degrees C.

2. Relative Humidity: 5 to 95 percent.

3. Operating Altitude: 0 to 12,000 Feet (0 to 3,660 meters).

4. Audible Noise: Less than 35 dBA at 3 feet (1 m).

B. Electrical Requirements:

1. The maximum continuous operating voltage of all suppression components utilized is not to be less than 115 percent of the nominal operating voltage at the installed location.

2. ANSI/UL 1449 3rd Edition Voltage Protection Rating (VPR) – The maximum ANSI/UL 1449 3rd Edition VPR for the device shall not exceed the following:

Volts	L-N	L-L	N-G
208Y/120	460V	1000V	700V
480Y/277	1100V	1800V	1000V

3. The ANSI/IEEE C62.41.1-1991 Category C3 let through voltages shall not exceed the following

Volts	L-N	N-G
208Y/120	550V	470V
480Y/277	900V	920V

4. The SPD components are to be rated as follows:

480V Service Entrance at each Structure	250 kA per phase 125 kA per mode
480V Distribution Panels	160 kA per phase 80 kA per mode
120/208V Panelboards	120 kA per phase 60 kA per mode

5. The mode of operation is to protect against surges and transients as follows:

System Configuration	Protection Mode
Single Phase, Two Wire (L,N) + Ground	L to G,L to N, and N to G
Single Phase, Two Wire (L,L) + Ground	L to L, and L to G
Split Phase, Three Wire + Ground	L to L, L to G,L to N, and N to G
Three Phase, Three Wire (Delta) + Ground	L to L, and L to G
Three Phase, Four Wire (Wye) + Ground	L to L, L to G,L to N, and N to G

2.03 OPERATION

A. The suppression system shall incorporate a hybrid designed Metal-Oxide Varistors (MOV) surge suppressor. The system shall not use silicone avalanche diodes, air gaps or other methods of suppression.

B. Each unit shall include a high-performance EMI/RFI noise rejection filter. Noise attenuation for electric line noise shall be 50 dB at 100 kHZ.

C. SPD shall provide surge current diversion between each phase conductor and the neutral conductor, between each phase conductor and ground and between the neutral conductor and ground. For delta systems, the SPD shall have components directly connected between each phase conductor and between each phase conductor and ground.

D. The SPD shall provide a low impedance path for surge current using oversized conductors with equal impedance paths to each suppression element. Plug-in style connections or printed circuit boards for use in the path of surge current shall not be used.

E. Operating Parameters:

1. The maximum response time shall not exceed 1 nanosecond.

2. Provide with a noise filtering system capable of managing noise levels produced by electro-magnetic interference and radio frequency interference. The noise filtering system shall reject a minimum of 50db at 100 kHz as measured by the 50 Ohm Insertion Loss Method (Military Standard 220A).

3. The parallel system components shall operate over a minimum frequency range of 47 Hertz to 63 Hertz.

4. The SPD components shall limit total harmonic distortion produced by the SPD to less than one percent.

5. SPD component ratings to be per UL 1449.

6. Each unit shall be factory tested at the maximum continuous operating voltage and short circuit tested, prior to delivery.

F. Product Components:

1. Protection and Filtering Elements:

a. The SPD components shall consist of replaceable protection modules designed to suppress and divert transient voltages and surge currents. Each protection module shall contain one or more individually fused metal oxide varisters capable of withstanding over 1000 surges of Category C (IEEE/ANSI C62.41.1) current rated at 10,000 amperes.

b. Each protection module shall contain filtering elements capable of providing noise attenuation.

c. The SPD components shall substantially limit transient waveform rise-time characteristics. The components are to be configured as parallel connected, current carrying elements designed to enhance the surge suppression and diversion performance of the protection modules.

2. Provide individual fusing to allow the SPD to be isolated during fault conditions.

3. Provide red and green solid-state status lights which indicate operational status of each unit and visual diagnostic monitoring of each component and module. Provide audible alarm to activate on fault condition, with a silence switch and push-to-test alarm switch.

4. Provide surge counter with battery backup to retain memory upon loss of AC power.

5. Provide remote status monitoring with form C dry contacts monitoring all phases.

2.04 SHOP TESTING

A. Perform factory performance testing on each unit. The test to consist of the following:

1. High voltage impedance test.

2. Current test.

B. Tests shall be in accordance with the following standards:

1. ANSI/IEEE C62.41.1 Cat. A, B, & C.

2. ANSI/IEEE C62.45.

3. Military Standard 220A.

4. Underwriters Laboratory UL 1449.

C. Submit certified documentation of all factory tests performed.

D. Perform above tests in addition to standard factory tests.

2.05 SPARE PARTS

A. Provide in accordance with Section 01 78 23 “Operation and Maintenance Data” and as specified.

B. Provide one spare protection module of each type for on-site spare parts purposes.

PART 3 - EXECUTION

3.01 INSPECTION

A. Visually inspect delivered unit(s) and accessories for conformance with drawings and specifications. Replace all components found to exhibit defects.

3.02 INSTALLATION

A. Install unit in compliance with the manufacturers printed instructions. All electrical installation work shall be in accordance with UL Listing Requirements and applicable National or Local Electrical Codes.

B. For units mounted adjacent to electrical distribution equipment, verify conduit and wire for the SPD components are as specified by the SPD manufacturer and installed in strict accordance with the National Electrical Code.

C. Verify UL 1449, fourth edition, label is provided on each unit.

3.03 CONTRACT CLOSEOUT

A. Provide in accordance with Section 01 77 00 “Execution and Closeout Requirements”.

END OF SECTION

SECTION 26 50 00

INTERIOR LIGHTING

PART 1 - GENERAL

1.01 DESCRIPTION

A. Provide complete indoor lighting systems as indicated and in compliance with Contract Documents.

B. Light fixture schedules are provided on the Contract Drawings. These Specifications are to be considered supplementary to the information contained in the light fixture schedule. In areas of conflict the scheduled items shall be provided.

C. Fixtures shall be “Energy Star” rated.

D. Provide a Ultraviolet (UV) Surface Disinfection Lighting System as stated in the specifications and as shown on the plans.

1.02 DEFINITIONS

A. Emergency Lighting Unit: Fixture with integral emergency battery-powered supply and means for controlling and charging battery. Also known as an emergency light set.

B. Fixture: Complete lighting unit, exit sign, or emergency lighting unit. Fixtures include lamps and parts required to distribute light, position and protect lamps, and connect lamps to power supply. Internal battery-powered exit signs and emergency lighting units also include battery and means for controlling and recharging battery. Emergency lighting units include ones with and without integral lamp heads.

1.03 REFERENCES

A. American National Standards Institute (ANSI):

1. C78.377: Chromaticity of Solid-State Lighting Products.

B. Design Lights Consortium (DLC)

C. National Fire Protection Association (NFPA):

1. 70: National Electrical Code (NEC).

2. 101: Life Safety Code.

D. Underwriters' Laboratories, Inc., (UL):

1. 773: Standard for Plug-In Locking Type Photo Controls for use with Area Lighting.

2. 773A: Nonindustrial Photo Electric Switches for Lighting Control.

3. 924: Standard for Emergency Lighting and Power Equipment.

4. 1598: UL Standard for Safety Luminaires

5. 8750: Light Emitting Diode (LED) Equipment for Use in Lighting Products.

E. Illuminating Engineering Society of North America (IESNA or IES):

1. LM-79: IESNA Approved Method for the Electrical and Photometric Measurements of Solid-State Lighting Products

2. LM-80: IESNA Approved Method for Measuring Lumen Maintenance of LED Light Sources

1.04 SUBMITTALS

A. Submit shop drawings and manufacturer's product data with installation instructions in accordance with the requirements of Section 26 05 10 “Electrical Work – General”.

B. Submit manufacturer's shop drawings including photometric laboratory test data to show that luminaires proposed are of same type, construction and quality as those indicated. Luminaires are to be listed and labeled by Underwriters' Laboratories.

C. Submit manufacturer’s data for each ballast provided. Include detailed information for each luminaire showing wattage, voltage, and full load amp draw for each.

D. Submit photometric calculations based on maintained lighting foot candle levels for areas where lighting fixtures are substituted. Substituted fixtures must provide similar lighting performance and energy usage as those scheduled, and must be constructed of similar quality and materials.

1.05 QUALITY ASSURANCE

A. Provide in accordance with Section 01 43 00 “Quality Requirements” and as specified.

B. Provide hangers and supports to resist failure from earthquake damage in accordance with NEC and all local and State codes.

C. Lighting fixtures to be provided with dedicated supporting systems.

D. Comply with the Code for Buildings and all local and State energy laws and regulations.

1.06 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed, are packaged with protective covering for storage, and are identified with labels describing contents.

1. Plastic Diffusers and Lenses: 1 for every 100 of each type and rating installed. Furnish at least 1 of each type.

2. Globes and Guards: 1 for every 20 of each type and rating installed. Furnish at least 1 of each type.

PART 2 - PRODUCTS

2.01 GENERAL

A. Metal Parts: Free from burrs, sharp corners, and edges.

B. Sheet Metal Components: Steel, except as indicated. Form and support to prevent warping and sagging.

C. Doors, Frames, and Other Internal Access: Smooth operating, free from light leakage under operating conditions, and arranged to permit relamping without use of tools. Arrange doors, frames, lenses, diffusers, and other pieces to prevent accidental falling during relamping and when secured in operating position.

D. Reflecting Surfaces: Minimum reflectance as follows, except as otherwise indicated:

1. White Surfaces: 85 percent.

2. Specular Surfaces: 83 percent.

3. Diffusing Specular Surfaces: 75 percent.

4. Laminated Silver Metallized Film: 90 percent.

E. Lenses, Diffusers, Covers, and Globes: 100 percent virgin acrylic plastic or water white, annealed crystal glass, except as otherwise indicated.

1. Plastic: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

2. Lens Thickness: 0.125 inches minimum; except where greater thickness is indicated.

F. Fixture Support Components:

1. Single Stem Hangers: 1/2 inches steel tubing with swivel ball fitting and ceiling canopy. Finish same as fixture.

2. Twin Stem Hangers: Two, 1/2-inch steel tubes with single canopy arranged to mount a single fixture. Finish same as fixture.

3. Rod Hangers: 3/8 inch minimum diameter, zinc plated, threaded steel rod.

4. Hook Hanger: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking type plug.

G. Provide EMI filters in each light fixture mounted in shielded enclosures.

1. Filters shall be integral to the fixture assembly with one filter per ballast.

2. Filters shall suppress electromagnetic interference in the AM radio band from 500 to 1700 kHz.

2.02 LED FIXTURES

A. Provide fixtures on the Design Lights Consortium (DLC) Qualified Products List.

B. Thermal Management: Liquids or other moving parts shall be clearly indicated in submittals, and shall be consistent with product testing.

C. Color Rendering Index (CRI): >70.

D. Correlated Color Temperature: 4000K.

E. Minimum luminaire efficacies: 85 lumens per watt. Nominal input wattage shall account for nominal applied voltage and any reduction in driver efficiency due to sub-optimal driver loading.

F. Fully enclosed wiring and LED diodes enclosed to prevent penetration of dust, insects, and other debris into the lamp and driver compartment.

G. Driver/LED combined system shall have rated life based on IESNA LM-80-2008 (or latest) of 50,000 hours at 70% lumen maintenance.

H. Driver is high efficiency type with THD < 20 percent and power factor > 0.90.

2.03 EMERGENCY LIGHTING AND EXIT LIGHTING UNITS

A. Exit Signs: Conform to UL 924 and following:

1. Sign Colors: Conform to local code.

2. Minimum Height of Letters: Conform to local code.

3. Arrows: Include as indicated.

B. Emergency Lighting Units: Conform to UL 924. Provide self-contained units with following features:

1. Battery: Sealed, maintenance free, lead acid type with minimum 10-year nominal life and special warranty. Battery shall be sized for a minimum of 90 minutes run time.

2. Charger: Minimum 2 rate, fully automatic, solid-state type, with sealed transfer relay.

3. Operation: Relay automatically turns lamp on when supply circuit voltage drops to 80% of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep discharge level. Relay disconnects lamps and battery and automatically recharges and floats on trickle charger when normal voltage is restored. Provide test switch and operation light indication.

4. Wire Guard: Where indicated, provide heavy chrome plated wire guard arranged to protect lamp heads or fixtures.

5. Time Delay Relay: Provide time delay relay in emergency lighting unit control circuit arranged to hold unit ON for fixed interval after restoration of power after outage. Provide adequate time delay to permit HID lamps to restrike and develop adequate output.

2.04 ULTRAVIOLET SURFACE DISINFECTION LIGHTING SYSTEM

A. Manufacturer:

1. PURO Lighting

2. Approved Equal

B. Manufacturer and models are shown to establish standards. Equal products can be submitted for approval.

C. Lights:

1. Provide ceiling mounted, 120V, 60W, hard wire UV light with 24”x24” flange kit for drop-in ceiling mount.

2. PURO Helo F1 - H-F1-6-FC-COM-110 with H1-GA-24.

D. Control System:

1. Provide disinfection control system with Ethernet connectivity, motion detector, main control box, and two touch screens (one inside the lab and one on the wall outside the lab).

a. Main Control Box: Provide junction box with system controller, power supply, relay modules, and terminal blocks.

b. Motion Sensor: Provide wide-angle motion sensor with CAT5 connectivity.

c. In-Room Screen: Provide 3.5” x 5.25” minimum touch screen located in the room. Screen shall connect to the system via CAT5.

d. External Screen: Provide 10” minimum touch screen located external to the room. Screen shall connect to the system via CAT5.

2. PURO Disinfection Control System - DCS-E-DT-x with motion detector(s) and touch screens.

E. Commissioning:

1. Provide commissioning by manufacturer approve and trained representative.

F. Layout:

1. The layout shown on the plans is for design intent only. Vendor shall provide calculations and layout which incorporates the lab layout with all equipment including all obstructions.

2. Layout and calculations shall be submitted for approval including wiring diagram.

G. Manufacturer's Warranty:

1. Manufacturer agrees to repair or replace system components that fail in materials or workmanship within specified warranty period.

2. Warranty Period: 60 months from date of Substantial Completion.

PART 3 - EXECUTION

3.01 LUMINAIRES AND LAMPS

A. Install types and sizes indicated, complete. Deliver lamps of proper type, wattage and voltage rating to site and install in luminaires prior to completion of project.

B. Install all luminaires to comply with applicable provisions of National Electrical Code. Suspend pendant luminaires by means of suitable outlet box cover-type aligners, each having flexible joint permitting unit to hang plumb.

1. Provide hangers capable of supporting twice the combined weight of fixtures supported by hangers.

2. Provide with swivel hangers to ensure a plumb installation. Hangers shall be cadmium-plated steel with a swivel-ball tapped for the conduit size indicated.

3. Brace pendants 4 feet or longer to limit swinging.

4. Single-unit suspended fixtures shall have twin-stem hangers.

5. Multiple-unit or continuous row fixtures shall have a tubing or stem for wiring at one point and a tubing or rod suspension provided for each unit length of chassis, including one at each end.

6. Rods shall be a minimum 3/8-inch diameter.

C. Use aligners of shock absorbing type, where indicated.

D. Use vaportight aligners with vaportight luminaires.

E. Install each explosion-proof pendant luminaire having stem longer than 12 inches, with explosion-proof swivel or flexible fitting permitting luminaire to hang plumb. Luminaires with stems shorter than 12 inches aligned by level outlet box mounting, explosion-proof swivels, or other acceptable means.

F. Install luminaires with adjustable fittings to permit alignment with ceiling panels. Install luminaires in fire-resistive type of suspended ceiling construction, equipped with fireproofing boxes constructed of materials of same fire rating as ceiling panels. Materials in conformance with UL approved building materials list.

G. Support for Recessed and Semi-recessed Grid Type Fixtures: Support Units from suspended ceiling support system. Install ceiling support system rods or wires at minimum of 4 rods or wires for each fixture, located not more than 6 inches from fixture corners.

1. Install support clips for recessed fixtures, securely fastened to ceiling grid members, at or near each fixture corner.

2. Fixtures Smaller than Ceiling Grid: Install minimum of 4 rods or wires for each fixture and locate at corner of ceiling grid where fixture is located. Do not support fixtures by ceiling acoustical panels.

3. Fixtures of Sizes Less than Ceiling Grid: Center in acoustical panel. Support fixtures independently with at least two 3/4-inch metal channels spanning and secured to ceiling tees.

H. Install accessories such as straps, mounting plates, nipples, or brackets necessary for proper installation.

I. Connect emergency light units to the unswitched branch circuit powering the luminaires in the same space.

3.02 CONTRACT CLOSEOUT

A. Provide in accordance with Section 01 77 00 “Execution and Closeout Requirements”.

END OF SECTION

SECTION 26 56 00

EXTERIOR LIGHTING

PART 1 - GENERAL

1.01 DESCRIPTION

A. Provide complete outdoor lighting systems as indicated and in compliance with Contract Documents.

B. Light fixture schedules are provided on the Contract Drawings. These Specifications are to be considered supplementary to the information contained in the light fixture schedule. In areas of conflict the scheduled items shall be provided.

C. Fixtures shall be “Energy Star” rated.

1.02 REFERENCES

A. ASTM International (ASTM):

1. A500/A500M: Cold Formed Welded and Seamless Carbon Steel Structural Tubing.

2. B209/B209M: Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate

3. B429/B429M: Standard Specification for Aluminum-Alloy Extruded Structural Pipe and Tube

B. Institute of Electrical and Electronics Engineers (IEEE):

1. C62.41.1: IEEE Guide on the Surges Environment in Low-Voltage (1000V and Less) AC Power Circuits

2. C62.41.2: IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

C. National Fire Protection Association (NFPA):

1. 70: National Electrical Code (NEC).

D. Underwriters' Laboratories, Inc. (UL):

1. 773: UL Standard for Safety Plug-In Locking Type Photocontrols for Use with Area Lighting-Fourth Edition

2. 844: UL Standard for Safety Luminaires for Use in Hazardous (Classified) Locations-Twelfth Edition

3. 1029: Standard for Safety High Intensity Discharge Lamp Ballasts.

4. 1598: UL Standard for Safety Luminaires

1.03 DEFINITIONS

A. Fixture: Complete lighting device. Fixtures include lamp or lamps and parts required to distribute light, position and protect lamps, and connect lamps to power supply.

B. Lighting Unit: Fixture or assembly of fixtures with common support, including pole or bracket plus mounting and support accessories.

C. Luminaire: Fixture.

1.04 SUBMITTALS

A. Submit shop drawings and manufacturer's product data with installation instructions in accordance with the requirements of Section 26 05 10 “Electrical Work – General”.

B. Submit manufacturer's shop drawings including photometric laboratory test data to show that luminaires proposed are of same type, construction and quality as those indicated. Luminaires are to be listed and labeled by Underwriters' Laboratories.

C. Submit manufacturer’s data for each ballast provided. Include detailed information for each luminaire showing wattage, voltage, and full load amp draw for each.

D. Submit photometric calculations based on maintained lighting foot candle levels for areas where lighting fixtures are substituted. Substituted fixtures must provide similar lighting performance and energy usage as those scheduled, and must be constructed of similar quality and materials.

E. Product Data:

1. Describe fixtures, lamps, ballasts, poles, and accessories. Arrange Product Data for fixtures in order of fixture designation. Include data on features, poles, accessories, finishes, and following:

a. Outline drawings indicating dimensions and principal features of fixtures and poles.

b. Electrical Ratings and Photometric Data: Certified results of laboratory tests for fixtures and lamps.

F. Operating and Maintenance Data (O&M): Maintenance data for products to include operation and maintenance information.

1.05 QUALITY ASSURANCE

A. Comply with IEEE C2.

B. Items provided under this section shall be listed or labeled labelled by UL or other Nationally Recognized Testing Laboratory (NRTL).

1. Term “NRTL” shall be as defined in OSHA Regulation 1910.7.

2. Terms “listed” and “labeled” shall be as defined in National Electrical Code (NEC), Article 100.

C. Regulatory Requirements:

1. National Electrical Code (NEC): Components and installation shall comply with National Fire Protection Association (NFPA) 70.

D. Fixtures for Hazardous Locations: Conform to UL 844. Provide units that have Factory Mutual Engineering and Research Corporation (FM) certification for indicated class and division of hazard.

1.06 STORAGE AND HANDLING OF POLES

A. Store poles on decay resistant treated skids at least 12 inches (300 mm) above grade and vegetation. Support pole to prevent distortion and arrange to provide free air circulation.

B. Metal Poles: Retain factory applied pole wrappings until just before pole installation. For poles with nonmetallic finishes, handle with web fabric straps.

1.07 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed, are packaged with protective covering for storage, and are identified with labels describing contents.

1. Glass and Plastic Lenses, Covers, and Other Optical Parts: 1 for every 100 of each type and rating installed. Furnish at least one of each type.

2. Globes and Guards: 1 for every 20 of each type and rating installed. Furnish at least one of each type.

PART 2 - PRODUCTS

2.01 FIXTURES AND FIXTURE COMPONENTS

A. Metal Parts: Free from burrs, sharp edges, and corners.

B. Sheet Metal Components: Corrosion resistant aluminum, except as otherwise indicated. Form and support to prevent warping and sagging.

C. Housings: Rigidly formed, weather and light tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed fixtures.

D. Doors, Frames, and Other Internal Access: Smooth operating, free from light leakage under operating conditions, and arranged to permit relamping without use of tools. Arrange doors, frames, lenses, diffusers, and other pieces to prevent accidental falling during relamping and when secured in operating position. Provide for door removal for cleaning or replacing lens. Arrange for door opening to disconnect ballast.

E. Exposed Hardware Material: Stainless steel.

F. Reflecting Surfaces: Minimum reflectances as follows, except as otherwise indicated:

1. White Surfaces: 85 percent

2. Specular Surfaces: 83 percent

3. Diffusing Specular Surfaces: 75 percent

G. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

H. Lenses and Refractors: Materials as indicated. Use heat and aging resistant, resilient gaskets to seal and cushion lens and refractor mounting in fixture doors.

2.02 LED FIXTURES

A. Provide fixtures on the Design Lights Consortium (DLC) Qualified Products List.

B. Thermal Management: Liquids or other moving parts shall be clearly indicated in submittals, and shall be consistent with product testing.

C. Color Rendering Index (CRI): >70.

D. Correlated Color Temperature: 4000K.

E. Minimum luminaire efficacies: 85 lumens per watt. Nominal input wattage shall account for nominal applied voltage and any reduction in driver efficiency due to sub-optimal driver loading.

F. Fully enclosed wiring and LED diodes enclosed to prevent penetration of dust, insects, and other debris into the lamp and driver compartment.

G. Driver/LED combined system shall have rated life based on IESNA LM-80-2008 (or latest) of 50,000 hours at 70 percent lumen maintenance.

H. Driver is high efficiency type with THD < 20 percent and power factor > 0.90.

I. Outdoor fixtures capable of reliable operation in temperature range of -30 degrees C to +40 degrees C minimum.

2.03 FIXTURE SUPPORT COMPONENTS

A. Pole Mounted Fixtures: Conform to AASHTO LTS-6.

B. Wind load strength of total support assembly, including pole, arms, appurtenances, base, and anchorage, is adequate to carry itself plus fixtures indicated at indicated heights above grade without failure, permanent deflection, or whipping in steady winds of 100 mi./h (160 km/h) with gust factor of 1.3.

C. Arm, Bracket, and Tenon Mount Materials: Match poles' finish.

D. Mountings, Fastenings, and Appurtenances: Corrosion resistant items compatible with support components. Use materials that will not cause galvanic action at contact points. Use mountings that correctly position luminaire to provide indicated light distribution.

E. Poles: As indicated in Lighting Fixture Schedule.

F. Pole Bases: Anchor type with galvanized steel hold-down or anchor bolts, leveling nuts, and bolt covers.

G. Concrete for Pole Foundations:

1. Comply with Section 03 30 00 "Cast-in-Place Concrete".

2. Use 3000 psig (20 MPa) strength, 28 day concrete.

2.04 FINISHES

A. Metal Parts: Manufacturer's standard finish, except as otherwise indicated, applied over corrosion resistant primer, free of streaks, runs, holidays, stains, blisters, and similar defects.

B. Other Parts: Manufacturer's standard finish, except as otherwise indicated.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Set units plumb, square, level, and secure according to manufacturer's written instructions and accepted submittals.

B. Concrete Foundations: Construct according to Section 03 30 00 "Cast-in-Place Concrete".

1. Comply with details and manufacturer's recommendations for reinforcing, anchor bolts, nuts, and washers. Verify anchor bolt templates by comparing with actual pole bases furnished.

2. Finish: Trowel and rub smooth parts exposed to view.

C. Pole Installation: Use web fabric slings (not chain or cable) to raise and set poles.

D. Fixture Attachment: Fasten to indicated structural supports.

E. Fixture Attachment with Adjustable Features or Aiming: Attach fixtures and supports to allow aiming for indicated light distribution.

F. Lamp fixtures with indicated lamps according to manufacturer's written instructions. Replace malfunctioning lamps.

3.02 GROUNDING

A. Ground fixtures and metal poles according to Section 26 05 26 "Grounding and Bonding for Electrical Systems".

1. Poles: Install 10 feet (3 m) driven ground rod at each pole.

2. Nonmetallic Poles: Ground metallic components of lighting unit and foundations. Connect fixtures to grounding system with No. 6 AWG conductor.

3.03 FIELD QUALITY CONTROL

A. Inspect each installed unit for damage. Replace damaged fixtures and components.

B. Tests and Observations:

1. Give advance notice of dates and times for field tests.

2. Replace or repair damaged and malfunctioning units, make necessary adjustments, and retest. Repeat procedure until units operate properly.

3.04 ADJUSTING AND CLEANING

A. Clean units after installation. Use methods and materials recommended by manufacturer.

3.05 CONTRACT CLOSEOUT

A. Provide in accordance with Section 01 77 00 "Execution and Closeout Requirements".

END OF SECTION